

**FINAL REPORT**

**OF THE**

**PUBLIC SAFETY WIRELESS**  
**ADVISORY COMMITTEE**

TO THE

FEDERAL COMMUNICATIONS COMMISSION  
Reed E. Hundt  
Chairman

AND

THE NATIONAL TELECOMMUNICATIONS  
AND INFORMATION ADMINISTRATION  
Larry Irving  
Assistant Secretary of Commerce  
for Communications and Information

September 11, 1996

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## VOLUME I

This *Final Report* of the Public Safety Wireless Advisory Committee is divided into two volumes.

**Volume I** contains the main body of the report, including summaries of the various subcommittee reports.

**Volume II** contains the full text of the subcommittee reports along with their supporting documents, where available.

## LIST OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
ACCOLC	Access Overload Class
ADP	Automated Data Processing
AFCEA	Armed Forces Communications and Electronics Association
AHS	Automated Highway System
ALARS	Automobile License and Registry System
ALI	Automatic Location Identification
AMPS	Advanced Mobile Phone System
AMSC	American Mobile Satellite Corporation
ANI	Automatic Number Identification
ANSI	American National Standards Institute
APCO	Association of Public Safety Communications Officials - International, Inc.
API	American Paging, Inc.
APL	Automatic Personnel Location
ARQ	Automatic repeat ReQuest
AT&T	American Telephone and Telegraph
ATM	Asynchronous Transfer Mode
ATV	Advanced Television (HDTV)
AVC	Automatic Vehicle Classification
AVI	Automatic Vehicle Identification
AVL	Automatic Vehicle Location
AVM	Automatic Vehicle Monitoring
AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
BIFC	Boise Inter-agency Fire Cache
BPA	Bonneville Power Administration
BTA	Basic Trading Area
CAD	Computer-Aided Dispatch
CAI	Common Air Interface
CAP	Competitive Access Provider
CBP	Community Based Policing
CCITT	Consultative Committee on International Telephony and Telegraphy
CD-ROM	Compact Disk - Read Only Memory
CDF	California Department of Forestry and Fire Protection
CDMA	Code Division Multiple Access
CDPD	Cellular Digital Packet Data
CELP	Coded Excited Linear Predictive
CFR	Code of Federal Regulations
CGSA	Cellular Geographic Service Area
CHP	California Highway Patrol
CLEC	Competitive Local Exchange Carrier
CMRS	Commercial Mobile Radio Services

CMSS Commercial Mobile Satellite Systems  
 COG Council of Governments  
 COMSAT Commercial Mobile Satellite Systems  
 COPE Coalition of Private Users of Emerging Multimedia Technologies  
 COTS Commercial-off-the-shelf  
 COW Cell Sites on Wheels  
 CPAS Cellular Priority Access Service  
 CPC Channel Performance Criterion  
 CTIA Cellular Telecommunications Industries Association  
 CVSD Continuously Variable Slope Delta (modulation)

DAQ Delivered Audio Quality  
 DCI Data Collection Instrument  
 DGPS Differential Global Positioning Systems  
 DMAT Disaster Medical Assistance Team  
 DMV Department of Motor Vehicles  
 DOD Departement of Defense  
 DOE Department of Energy  
 DPI Dots Per Inch  
 DRAM Dynamic Random Access Memory  
 DSP Digital Signal Processing  
 DSRC Dedicated Short Range Communications  
 DTMF Dual-Tone-Multi-Frequency  
 DTRS Digital Trunked Radio System

ECC Emergency Communications Center  
 EDACS Enhanced Digital Access Communication System  
 EDI Electronic Data Interchange  
 EDIS Emergency Digital Information System  
 EMD Emergency Management and Disaster Services  
 EMRS Emergency Medical Radio Service  
 EMS Emergency Medical Services  
 EOC Emergency Operations Center  
 EOD Explosive Ordinance Disposal  
 ESMR Enhanced Specialized Mobile Radio  
 ETTM Electronic Toll and Traffic Management  
 EVM Emergency Vehicle Management

FCC Federal Communications Commission  
 FCCA Forestry Conservation Communications Association  
 FCRS Forestry-Conservation Radio Service  
 FDMA Frequency Division Multiple Access  
 FEC Forward Error Correction  
 FEMA Federal Emergency Management Agency  
 FFSR Fast Forward Signal Regeneration  
 FHWA Federal Highway Administration

FLEWUG	Federal Law Enforcement Wireless Users Group
FM	Frequency Modulation
FMARS	Fire Mutual Aid Radio System
FPLMTS	Future Public Land Mobile Telecommunications Systems
FQPSK	Feher's Quadrature Phase Shift Keying
FRS	Fire Radio Service
GETS	Government Emergency Telecommunications System
GHz	Gigahertz
GIF	Graphic Image Format
GIS	Geographic Information System
GLONASS	Global Navigation Satellite System
GMF	Government Master File
GMSK	Gaussian Minimum Shift Keying
GOS	Grade of Service
GPS	Global Positioning System
HAZMAT	Hazardous Materials
HDTV	High Definition Television (ATV)
HF-SSB	High-frequency Single-sideband
HIDTA	High Intensity Drug Trafficking Area
HMRS	Highway Maintenance Radio Service
HOV	High Occupancy Vehicle
IACP	International Association of Chiefs of Police
IAFC	International Association of Fire Chiefs
IAFIS	Integrated Automated Fingerprint Identification System
IC	Integrated Circuit; Incident Commander
ICO	Intermediate Circular Orbit
ICP	Interoperability Communication Plan
ICS	Incident Command System
ICSAR	Interagency Committee on Search and Rescue
iDEN	Integrated Digital Electronic Network
IEEE	Institute of Electrical and Electronics Engineers
IMO	International Maritime Organization
IMSA	International Municipal Signal Association
IMTS	Improved Mobile Telephone Service
INMARSAT	International Maritime Satellite Organization
INS/CECOM	Immigration and Naturalization Service/U.S. Army Communications and Electronics Command
IOC	Initial Operating Capability
IP	Internet Protocol
IPR	Intellectual Property Right
IRAC	Interdepartment Radio Advisory Council
ISC	Interoperability Subcommittee
ISO	International Standards Organization

ISTEA	Intermodal Surface Transportation Efficiency Act
ITS	Intelligent Transportation Systems
ITU	International Telecommunication Union
IVHS	Intelligent Vehicle and Highway Systems
JPEG	Joint Photographic Expert Group
JSMS	Joint Spectrum Management System
KB/S (KBPS)	Kilobytes per Second
KHz	Kilohertz
LAN	Local Area Network
LATA	Local Access Transport Area
LEO	Low Earth Orbit
LGRS	Local Government Radio Service
LMCC	Land Mobile Communications Council
LMR	Land Mobile Radio
LMS	Location and Monitoring Service
LOGIS	Local Government Information System
LPD	Low Probability of Detection
LPI	Low Probability of Intercept
MAP	Mutual Aid Plan
MARISAT	Maritime Satellite
MDT	Mobile Data Terminals
MHz	Megahertz
MMST	Metropolitan Medical Strike Team
MPEG	Motion Picture Expert Group
MPEG-1	Motion Picture Expert Group
MPEG-4	Motion Picture Expert Group
MSA	Metropolitan Statistical Area
MSC	Mobile Switching Center
MSS	Mobile Satellite Systems
MTA	Major Trading Area
MTA-NYCT	Metropolitan Transportation Authority - New York City Transit
MTBF	Mean Time Between Failure
MTSO	Mobile Telephone Switching Office
NAM	Number Assignment Module
NASNA	National Association of State Nine-One-One Administrators
NASTD	National Association of State Telecommunications Directors
NATO	North Atlantic Treaty Organization
NCIC	National Crime Information Center
NCIC-2000	National Crime Information Center Project 2000
NENA	National Emergency Number Association
NFPA	National Fire Protection Association

NIRSC	National Incident Radio Support Cache
NIST	National Institute of Standards and Technology
NITF	National Image Transfer Format
NLETS	National Law Enforcement Telecommunications System
NPR	National Performance Review
NPSPAC	National Public Safety Planning Advisory Committee
NSA	National Security Agency
NSEP	National Security and Emergency Preparedness
NSTAC	National Security Telecommunications Advisory Committee
NTIA	National Telecommunications and Information Administration
NTIAOA	National Telecommunications and Information Administration Organization Act
NTSC	National Television Systems Committee
NTSC	National Television Systems Committee
NTT	Nippon Telegraph and Telephone Corp.
NYCDoITT	New York City Department of Information, Technology, and Telecommunications
OASD	Office of the Assistant Secretary of Defense
OIC	Officer-In-Charge
OMS	Operations and Management Systems
ORBCOMM	Orbital Communications
ORSC	Operational Requirements Subcommittee
OTAR	Over The Air Rekey
PACA	Priority Access and Channel Assignment
PBX	Private Branch Exchanges
PCS	Personal Communications Services
PDA	Personal Digital Assistant
PDT	Portable Data Terminal
PLMR	Private Land Mobile Radio
PMARS	Police Mutual Aid Radio System
PMO	Program Management Office
POTS	Plain Old Telephone System
PPM	Parts Per Million
PRS	Police Radio Service
PSA	Protected Service Area
PSAM	Pilot Symbol Assisted Modulation
PSAP	Public Safety Answering Point
PSCC	Public Safety Communications Council
Ψ(psi)-CELP	Ψ (psi) Coded Excited Linear Predictive
PSRS	Public Safety Radio Services
PSTN	Public Switched Telephone Network
PSWAC	Public Safety Wireless Advisory Committee
PSWN	Public Safety Wireless Network

QPSK	Quadrature Phase Shift Keying
RACES	Radio Amateur Civil Emergency Service
RF	Radio Frequency
RMA	Ranally Metropolitan Area
RPV	Remotely Piloted Vehicle
RSA	Rural Service Area
RZ SSB	Real Zero Single Sideband
SAR	Search And Rescue
SCADA	Supervisory Control and Data Acquisition
SDO	Standards Developing Organization
SERS	Special Emergency Radio Service
SERS	Special Emergency Radio Service
SMR	Specialized Mobile Radio
SOLAS	Safety of Life at Sea
SOP	Standard Operating Procedure
SPEN	State Police Emergency Network
SRSC	Spectrum Requirements Subcommittee
SSB	Single Sideband
SWAT	Special Weapons and Tactics
TAB	Tone Above Band
T/R	Transmit/Receive
TCP/IP	Transmission Control Protocol/Internet Protocol
TCP	Transmission Control Protocol
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TESC	Technology Subcommittee
TIA	Telecommunications Industry Association
TMC	Traffic Management Center
TRSC	Transition Subcommittee
TSAR	Technical Search and Rescue
TTAB	Transparent Tone Above Band
TTIB	Transparent Tone In Band
TX	Transmit
UDP	User Datagram Protocol
UHF	Ultra High Frequency
USAR	Urban Search and Rescue
USART	Urban Search and Rescue Team; United States Search and Rescue Team
USCG	U.S. Coast Guard
USFS	U.S. Forest Service
USGS	United States Geological Service
UTAM	Unlicensed Transition and Management
UTC	Utilities Communications Council

VHF	Very High Frequency
VOCODER	Voice enCODER
VPAS	Vehicle Proximity Alerting Systems
VSAT	Very-Small Aperture
VSELP	Vector Sum Excited Linear Predictive
VTS	Vehicular Technology Society
WAPA	Western Area Power Administration
WARC	World Administrative Radio Conference
WAWAS	Washington Area Warning and Alerting System
WIM	Weight In Motion
WMATA	Washington Metropolitan Area Transit Authority

## EXECUTIVE SUMMARY

*Our Nation's highways are one of the major conduits for interstate travel and commerce. Recently, a dramatic, quadruple fatality vehicle accident occurred on a section of one of these interstate highways. A semi tractor/trailer was traveling northbound in the middle lane next to a car moving in the same direction. The car moved out of its lane and became wedged under the tractor/trailer. Subsequently, the truck lost control, crossed the median, and struck another vehicle traveling in the opposite direction. This caused a chain reaction which involved several additional vehicles, and resulted in the closing of the interstate. Due to the severity of the incident, several police agencies, fire rescue units, ambulances and helicopters were involved in the rescue, extrication, and management of the incident. The coordination of the incident was routed through several dispatch facilities and created a major communications challenge to those involved. Having to close the interstate while the situation was cleared resulted in massive traffic jams. Rerouting traffic and ensuring the safety of the traveling public was a priority of the agencies involved.*

These types of situations occur at a moment's notice in every city and town across the country. The ability of Public Safety agencies involved in such incidents to communicate is vital to the safety and welfare of the citizens they represent. In times of emergencies, the public looks to government, particularly their Public Safety officials, to act swiftly and correctly and do the things which must be done to save lives, help the injured, and restore order. Most disasters occur without warning, but people still expect a rapid and flawless response on the part of government. There is no room for error. Whether a vehicle accident, crime, plane crash, special event, or any other Public Safety activity, one of the major components of responding to and mitigating a disaster is wireless communications. These wireless communications systems are critical to Public Safety agencies' ability to protect lives and property and the welfare of Public Safety officials.

This report represents the best efforts of the Public Safety community to define and document its critical need for communications resources and the spectrum which will support them — now and through the year 2010.

At the most basic level, radio-based voice communications allow dispatchers to direct mobile units to the scene of a crime and allow firefighters to coordinate and to warn each other of impending danger at fires. Radio systems are also vital for providing logistics and command support during major emergencies and disasters such as earthquakes, riots, or plane crashes. Systems are now being designed to allow transmission of video and broadband data, enabling paramedics to send pictures of injuries to trauma centers while en route, permitting the use of remote controlled robotics to defuse explosives, and making viable the tracking of wildland fires. Thus, radio-based technologies are critical to the effective discharge of Public Safety agencies' obligations, providing a lifeline connecting Public Safety officials to assistance and delivering vital information to help in their critical mission. In an era where technology can bring news, current events, and entertainment such as the Olympics to the

farthest reaches of the world, many police officers, firefighters, and emergency medical service personnel working in the same city cannot communicate with each other. Congested and fragmented spectral resources, inadequate funding for technology upgrades, and a wide variety of governmental and institutional obstacles result in a critical situation which, if not addressed expeditiously, will ultimately compromise the ability of Public Safety officials to protect life and property.

The nation's Public Safety agencies face several important problems in their use of radio communications:

- ▶ *First*, the radio frequencies allocated for Public Safety use have become highly congested in many, especially urban, areas. Usable spectrum for mobile operations is limited, and Public Safety agencies are not able to meet existing requirements, much less to plan for future, more advanced communications needs. Not only does the shortage of spectrum jeopardize the lives and health of Public Safety officials, it threatens their ability to fully discharge their duty to protect the lives and property of all Americans.
- ▶ *Second*, the ability of officials from different Public Safety agencies to communicate with each other is limited. Yet interoperability is key to success in day-to-day operations, joint task force and mutual aid operations, and many other intra- and inter-jurisdictional activities. Interoperability is hampered by the use of multiple frequency bands, incompatible radio equipment, and a lack of standardization in repeater spacing and transmission formats.
- ▶ *Finally*, Public Safety agencies have not been able to implement advanced features to aid in their mission. A wide variety of technologies — both existing and under development — hold substantial promise to reduce danger to Public Safety personnel and to achieve greater efficiencies in the performance of their duties. Broadband data systems, for example, offer greater access to databases and information that can save lives and contribute to keeping criminals “off the street.” Video systems promise better surveillance capabilities, increased use of robotics in toxic and hazardous environments, and better monitoring and tracking of both personnel and equipment.

The *Final Report* concludes that, **unless immediate measures are taken to alleviate spectrum shortfalls and promote interoperability, Public Safety agencies will not be able to adequately discharge their obligation to protect life and property in a safe, efficient, and cost effective manner.**

To address these and other problems, the Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA) established the Public Safety Wireless Advisory Committee (PSWAC or Advisory Committee) to evaluate the wireless communications needs of federal, state, and local Public Safety agencies through the year 2010 and recommend possible solutions. The membership of the PSWAC encompassed a broad range of Public Safety agencies (federal, state, and local), public service providers,

equipment manufacturers, commercial service providers, and the public at large. This *Final Report*, drawn from the five attached subcommittee reports on Operational Requirements, Interoperability, Technology, Spectrum Requirements, and Transition, embodies the findings and recommendations of the PSWAC developed over the past year.

Implementing the requirements identified in the report, including transitioning to new bands and meeting minimal interoperability requirements, will require different levels of commitment from various user groups, and close cooperation and open dialogue with regulating officials and the manufacturing community. The recommendations made in the report recognize the substantial embedded infrastructure currently being used by the Public Safety community, the budgetary constraints Public Safety agencies face, and the critical lack of additional funding available to most Public Safety entities as a matter of course. To meet the immediate and future needs of the Public Safety community, the Steering Committee makes the following observations and recommendations:

- ▶ More spectrum is required.
  - ▶ Immediately, 2.5 MHz of spectrum should be identified for interoperability from new or existing allocations.
  - ▶ In the short term (within 5 years), approximately 25 MHz of new Public Safety allocations are needed. The present shortages can be addressed by making part of the spectrum presently used for television broadcast channels 60-69 available as soon as possible.
  - ▶ Over the next 15 years, as much as an additional 70 MHz of spectrum will be required to satisfy the mobile communication needs of the Public Safety community.
- ▶ Improved interoperability is required. Present limitations can be eased by establishing bands of frequencies for interoperability purposes, encouraging the development and use of shared systems, and building gateways between technically incompatible systems.
- ▶ More flexible licensing policies are desirable. The current approach, focused primarily on continuous narrow banding, does not provide the Public Safety community the flexibility of selecting or obtaining the most efficient technology to meet user-defined needs. Policies should encourage the use of the most spectrally efficient approaches while remaining technology neutral.
- ▶ More sharing and joint use should be encouraged. Some states and regions are experiencing considerable success in pooling spectral and other resources. In many instances, perceived losses in terms of independence of operation are more than offset by improvements in function and efficiency. Policies designed to streamline cooperative use of federal and non-federal spectrum should be adopted.

- ▶ The use of commercial services and private contracts should be facilitated, provided the essential requirements of coverage, priority access and system restoration, security, and reliability are met. These services must be provided on a competitive basis.
- ▶ A continuing consultative process should be established to permit the Public Safety community and the FCC and NTIA to adjust to new requirements and new opportunities. The rapid changes in technology, among other things, make imperative, timely adjustments in the policies and requirements of the government agencies managing spectrum. An arrangement that facilitates continuing consultation between and among institutions responsible for, and interested in, Public Safety will help assure that opportunities for improvement are not missed.
- ▶ Funding limitations will remain a major obstacle in the adoption of needed improvements in Public Safety communications systems. At a time when government budgets are tight, alternative methods of funding future Public Safety communications systems must be identified. Otherwise, the substantial benefits afforded by technology will not be realized.

The Steering Committee believes that no single solution will solve the telecommunications problems confronting Public Safety. Rather, solutions must be tailored to meet the unique needs of each Public Safety agency and the public they serve. The Public Safety community must continue to work together to present its views and make its communications needs known.

## 1. INTRODUCTION AND BACKGROUND

- 1.1 No responsibility is more fundamental and reflective of the nation's values than that of its Public Safety agencies. The citizens' legitimate expectation is that when their life or property is endangered, their government will respond. Vast federal, state, and local resources are committed to ensure this obligation is met. The effectiveness of police officers, fire fighters, emergency medical services (EMS) personnel, and other Public Safety officials is inextricably tied to communications capability. Today's communications environment, however, impedes meeting this responsibility. Rescuing victims of the World Trade Center bombing, who were caught between floors, was hindered when police officers could not communicate with fire fighters on the very next floor. Similarly, the inability to communicate among the agencies that had rushed to the Oklahoma City bombing site required resorting to runners to relay messages. The lack of sufficient, quality radio spectrum suitable for Public Safety use deters technological innovation, diminishes the responsiveness and effectiveness of Public Safety, and ultimately compromises the safety of the responding officers and of the very individuals seeking their help.
- 1.2 The importance of radio communications to the Public Safety community cannot be overestimated. In a large-scale disaster such as an earthquake, forest fire, or flood, hundreds of agencies and thousands of individuals come together to provide emergency medical assistance, fire suppression, rescue operations, infrastructure repair, crowd control and security, food and shelter, and to begin the process of rebuilding. At a time when other means of communication are likely to be inoperable, Public Safety radio communication systems must provide the lifeline that connects each responder to his or her agency and to each other.
- 1.3 While high profile incidents receive the most attention, even the less dramatic and routine, day-to-day situations require effective radio communications. A trauma victim's ability to survive depends upon receiving prompt medical attention — usually within minutes. Emergency medical providers desire the ability to transmit images and other vital statistics about the injured from the paramedic unit back to trauma centers or hospitals to aid in diagnosis and pre-arrival treatment. Fire officials desire the ability to obtain weather forecasts, building blueprints/designs, information as to the types of hazardous or combustible material that may be on the scene, and other vital information while en route. This information is needed by firefighters for the prompt and safe removal of occupants. Undercover officers must be able to coordinate an ongoing operation or, more rudimentary, call for immediate assistance. A host of other government users, public service providers, and utilities operate radio systems to maintain the infrastructure and services on which the public depends.
- 1.4 Because of the special nature of their missions, Public Safety officials often have unique communication needs. Many users, especially in the Federal government, require secure or encrypted communications to protect their operations. Coverage is also important; Public Safety agencies must be able to communicate throughout their jurisdictions — no matter how remote or congested. Systems must provide immediate

- and reliable communications when lives are at stake and time is critical. Finally, Public Safety agencies must be able to communicate with each other. Whether as part of day-to-day operations or when disasters strike, cooperation is critical to ensuring that help is rapidly and effectively rendered. Interoperable communications systems are an absolute requirement.
- 1.5 Today, however, the radio systems used by the Public Safety community are laboring under increasing burdens. Equipment is old and funding for new equipment is often scarce. The radios used by different local agencies or different jurisdictions often cannot communicate with each other. The radio frequencies that Public Safety users rely on are heavily congested in many areas. As a result, assistance can be delayed and response efforts can be inefficient, which ultimately jeopardizes lives, both those of the officers and of the public at large. In addition to these current problems, as technology advances, new services, including advanced data and image/video applications, are becoming available that could enhance the Public Safety community's ability to fulfill its mission. The limited radio frequency spectrum allocated to Public Safety users, however, will make such new services impossible to implement.
- 1.6 To address these problems, the Federal Communications Commission (FCC or Commission) and the National Telecommunications and Information Administration (NTIA) of the Department of Commerce established the Public Safety Wireless Advisory Committee (PSWAC or Advisory Committee).

## **The Public Safety Wireless Advisory Committee (PSWAC)**

### **History**

- 1.7 The establishment of the PSWAC followed a long history of efforts by Congress, the FCC, the NTIA, and Public Safety organizations to address the spectrum requirements of Public Safety agencies. In 1983, Congress included as part of the FCC Authorization Bill a requirement that the Commission study Public Safety spectrum needs.<sup>1</sup> The Commission's Private Radio Bureau subsequently completed a Future Public Safety Telecommunications Requirements report which included projections of the amount of additional Public Safety spectrum that would be required in 21 metropolitan areas by the year 2000. The projections ranged from 12.5 MHz in Pittsburgh to 44.6 MHz in Los Angeles/San Diego. The FCC sought public comment on the report in PR Docket No. 84-232, but never took any further action in that docket.<sup>2</sup> In a separate proceeding, the Commission did allocate 6 MHz for Public

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<sup>1</sup> *FCC Authorization Act of 1983, H.R. Report NO. 356* , 98th Cong., 1st Sess. 27 (1983).

<sup>2</sup> *Notice of Inquiry in PR Docket No. 84-232* , 49 Fed. Reg. 9754 (Mar. 15, 1984).

Safety in the 800 MHz band.<sup>3</sup> There have been no further nationwide Public Safety allocations since that time.<sup>4</sup>

- 1.8 In 1993, as part of the legislation authorizing the use of spectrum auctions, Congress required the FCC to complete a study by February 9, 1995 of the current and future spectrum needs of State and local government Public Safety agencies through the year 2010, and develop a specific plan to ensure that adequate frequencies are made available to Public Safety licensees. On February 9, 1995, the FCC submitted to Congress a Report and Plan, Meeting State and Local Government Public Safety Agency Spectrum Needs Through the Year 2010. The Report and Plan did not contain specific conclusions or recommendations regarding Public Safety spectrum, but merely indicated that further study was necessary.
- 1.9 On March 22, 1995, during a hearing on FCC and NTIA appropriations, House Appropriations Subcommittee Chairman Harold Rogers expressed concern as to whether the Report and Plan was a sufficient response to Congressional concerns as expressed in the Omnibus Budget Reconciliation Act.<sup>5</sup> He asked the FCC and the NTIA to develop a plan addressing the issue in much greater detail, which led to a letter from NTIA Administrator Larry Irving proposing the establishment of a joint advisory committee on Public Safety spectrum issues.<sup>6</sup> As a direct result of that letter, the FCC and NTIA established the PSWAC on June 25, 1995, to provide advice on the specific wireless communications requirements of Public Safety agencies through the year 2010 and make recommendations for meeting those needs.

### Charter

- 1.10 The PSWAC is chartered in accordance with the requirements of the Federal Advisory Committee Act.<sup>7</sup> Its membership consists of senior members of Public Safety agencies, representatives of Public Safety organizations, and members of the private sector. The Advisory Committee is chaired by Philip L. Verveer, a partner with the firm of Willkie Farr & Gallagher. The members of the Steering Committee of the Advisory Committee are: the Honorable Louis Freeh, Director, Federal Bureau of

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<sup>3</sup> *Report and Order in GEN Docket No. 84-1233*, 2 FCC Rcd 1825 (1986).

<sup>4</sup> The only exception to this statement is the fact that ten (10) 5 KHz channels in the 220 MHz band were granted in the mid 1990's as a block allocation of channels for use by Public Safety.

<sup>5</sup> Hearings Before the House Committee on Appropriations, Subcommittee on the Departments of Commerce, Justice, and State, the Judiciary, and Related Agencies, 104th Cong., 1st Sess., Part 6, Telecommunications Issues, at 410 (March 22, 1995) (“*Hearings*”).

<sup>6</sup> Letter from Larry Irving, Assistant Secretary of Commerce to the Honorable Harold Rogers (Apr. 14, 1995) (reprinted in *Hearings* at 417-19).

<sup>7</sup> 5 U.S.C. Appendix 2.

Investigation; the Honorable Howard Safir, Police Commissioner of the City of New York [William Bratton served until his resignation in the Spring of 1996]; the Honorable Michael Freeman, Fire Chief of Los Angeles County, California; the Honorable Alan D. Bersin, United States Attorney for the Southern District of California; Raymond W. Kelly, Undersecretary for Enforcement, Department of the Treasury [Ronald K. Noble served until his resignation in 1996]; Harlin McEwen, Deputy Assistant Director, Federal Bureau of Investigation and senior official of the International Association of Chiefs of Police; Cindy Raiford, Deputy Director of Communications, Department of Defense; Steven Proctor, Technical Manager for Communications, State of Utah and past president of the Association of Public Safety Communications Officials International, Inc.; Dennis Connors, Vice President, Ericsson, Inc.; and Fred Kuznik, Vice President, Motorola, Inc.<sup>8</sup> The Advisory Committee was chartered to:

- 1.10.1 ▶ Advise the FCC and NTIA of specific operational wireless needs of the community including improvement of basic voice, data and E9-1-1 services, and the implementation of new wide-area, broadband telecommunications technologies for transmission of mugshots, fingerprints, video, and other high-speed data.
- 1.10.2 ▶ Advise the NTIA and FCC on options to provide for greater interoperability among federal, state, and local Public Safety entities.
- 1.10.3 ▶ Advise the FCC and NTIA on options to accommodate growth of basic and emerging services, including bandwidth vs. functional requirement trade-offs, technical options, and other options.
- 1.10.4 ▶ Advise the NTIA and FCC on the total spectrum requirements for the operational needs referred to above, including frequency band options, shared/joint spectrum use options, and other options.<sup>9</sup>

### **Structure of the Committee**

- 1.11 The PSWAC consists of a Steering Committee and five (5) functional subcommittees. The Steering Committee exercised overall direction of the work of the subcommittees

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<sup>8</sup> Several members of the Steering Committee were represented on occasion by alternates. The alternates for the members of the Steering Committee of the Advisory Committee are: Tyrel W. Hayton, Federal Bureau of Investigation, for Director Freeh; Michael Amarosa, Deputy Commissioner for Technology and System s Development, Police Department of the City of New York, for Commissioner Safir; Raymond A. Barnett , United States Secret Service, Department of the Treasury, for Undersecretary Kelly; and Debra A. Gross , Commander, USN, Office of the Assistant Secretary of Defense Command, Control, Communications an d Intelligence, for Deputy Director Raiford.

<sup>9</sup> Charter of the Public Safety Wireless Advisory Committee (filed June 26, 1995).

and was responsible for reviewing their output. The subcommittees were created to address specific areas of concern:

Table 1-1

<p><i>Operational Requirements Subcommittee</i></p> <p>(ORSC)</p>	<p>The Operational Requirements Subcommittee was chaired by Mr. Paul H. Wieck, Commissioner, Iowa Department of Public Safety. The alternate for Commissioner Wieck was Mr. Craig Allen, Lieutenant, Illinois State Police. This subcommittee was charged with identifying the communication needs of the Public Safety community to the year 2010. It focused on requirements that are currently unmet or suffer from reliability, quality, or coverage deficiencies. The subcommittee also examined the new services being made available by advances in both wide- and narrowband technology.</p>
<p><i>Technology Subcommittee</i></p> <p>(TESC)</p>	<p>The Technology Subcommittee was chaired by Mr. Alfred Mello, Chairman of the Public Safety Communications Council. The alternate for Mr. Mello was Mr. Richard DeMello, Forestry Conservation Communications Association. This subcommittee reviewed the technologies now used by Public Safety and identified the emerging technologies that may serve Public Safety agencies' needs in the future. A special focus was on those technologies that offer advances in spectral efficiency or new services to meet the community's growing needs.</p>
<p><i>Interoperability Subcommittee</i></p> <p>(ISC)</p>	<p>The Interoperability Subcommittee was chaired by Mr. James E. Downes of the U.S. Department of Treasury. This subcommittee defined "Public Safety" and "interoperability" for purposes of the <i>Final Report</i> and examined the specific problems of interoperability between Public Safety agencies. The group detailed the needs for interoperability among and between Public Safety agencies and the varying circumstances in which it must be available.</p>
<p><i>Spectrum Requirements Subcommittee</i></p> <p>(SRSC)</p>	<p>The Spectrum Requirements Subcommittee was chaired by Mr. Richard N. Allen of the Federal Bureau of Investigation. Based on the work of the above subcommittees, this subcommittee was charged with determining the specific spectrum requirements that will need to be met in order for Public Safety agencies to perform their missions in the most effective manner. It evaluated current spectrum allocations and usage, and made recommendations on future allocations and use.</p>
<p><i>Transition Subcommittee</i></p> <p>(TRSC)</p>	<p>The Transition Subcommittee was chaired by Mr. James R. Rand, Executive Director of the Association of Public Safety Communications Officials International, Inc. The alternate for Mr. Rand was Mr. Ali Shahnam, Association of Public Safety Communications Officials International, Inc. The assistant to Mr. Rand was Mr John Ramsey, also of the Association of Public Safety Communications Officials International, Inc. This subcommittee was charged with examining the mechanisms necessary to improve Public Safety wireless communications over the next 15 years. The subcommittee addressed spectrum management practices, funding alternatives, and regulatory changes necessary to effect the goals of the Advisory Committee.</p>

- 1.12 The meetings of the Steering Committee and the subcommittees were open to the public. Steering Committee and subcommittee meetings were held in various locations around the country to encourage maximum public participation. Over 480 individuals, representing all areas of the manufacturing, service, the Public Safety user communities, and the general public participated in the work of the subcommittees.
- 1.13 The drafting of the *Final Report* was supervised by Michael Amarosa, Deputy Commissioner for Technology and Systems Development, Police Department of the City of New York; Raymond A. Barnett, United States Secret Service, Department of the Treasury; and Steven Proctor, Technical Manager for Communications of the State of Utah and past president of the Association of Public Safety Communications Officials International, Inc.

### **The PSWAC *Final Report***

- 1.14 This *Final Report* of PSWAC to the FCC and NTIA represents the views of the PSWAC Steering Committee. The *Final Report* is predicated upon the work of the subcommittees, but departs from the various subcommittee reports in some respects. It examines the problems confronting the Public Safety community now and identifies the wireless communication needs of the community to the year 2010. The *Final Report* also discusses the technologies available, now and in the future, to meet those needs, the spectrum and interoperability requirements of the community, and the transition mechanisms that will be required to bring Public Safety communications up to expected levels of performance, efficiency, and effectiveness. The recommendations embodied in this report are advanced with varying degrees of certitude. Some, especially those susceptible to near term implementation, are quite specific. Some are more general. Overall, they represent the Steering Committee's collective judgement with respect to changes necessary to maintain and improve Public Safety communications functions in the United States. The work of each subcommittee is summarized later in this report, and the full reports from each are included as appendices.

## **Federal Regulation of Public Safety Radio Services**

### **Congressional Mandates to Regulate Public Safety Spectrum**

- 1.15 By statute, the NTIA manages the Federal government's use of the spectrum, while the FCC manages all non-federal spectrum usage. The two agencies are charged with jointly developing the National Table of Frequency Allocations and a comprehensive long-range plan for improved management of all radio spectrum resources. NTIA's policies and procedures are described in the Manual of Regulations and Procedures for Federal Radio Frequency Management (NTIA Manual), with similar guidance for the FCC contained in Title 47 of the Code of Federal Regulations.

- 1.16 NTIA policy and technical analysis responsibilities include the development of long range spectrum planning and policy, the review of proposed federal radio communication systems to make sure that sufficient spectrum is available for their compatible operation, the analysis and resolution of interference problems involving federal radiocommunication systems, and the analysis of spectrum use in selected bands. These responsibilities hold both internationally, through a leadership role in the preparations for conferences/meetings of the International Telecommunication Union (ITU), and domestically, where NTIA chairs, and provides administrative and analytic support to the Interdepartment Radio Advisory Committee (IRAC). The IRAC, established in 1922, comprises representatives of the major spectrum-using federal agencies as well as a representative from the FCC to provide liaison with non-federal users of the spectrum. The IRAC provides the primary advice to NTIA regarding issues of concern to the Federal government spectrum-using community.
- 1.17 Congress has directed both the FCC and NTIA to effectuate reforms in the mobile services spectrum each manages. Section 332(a) of the Communications Act requires the FCC to reduce regulatory burdens on spectrum users, improve efficient spectrum use and overall efficiency, increase interservice sharing opportunities between mobile providers and other services, encourage competition, and ensure the safety of life and property.<sup>10</sup> The Telecommunications Authorization Act of 1992 imposed similar obligations on the NTIA to ensure efficient use of Federal government spectrum.<sup>11</sup> The recommendations contained in this report parallel these mandates. The Steering Committee believes that the FCC should avoid regulatory structures that emphasize service classifications and particular use. The FCC has done so in other areas.<sup>12</sup> Except where a particular objective should be pursued, such as interoperability, Public Safety agencies should be committed substantial discretion to determine the most efficient and effective means to transmit information. The Steering Committee's recommendations seek to foster an environment where innovation and competition will respond directly to Public Safety's needs, instead of evolving from the regulatory process. Moreover, the Steering Committee believes that in this environment Public Safety agencies will more likely undertake efficiency efforts themselves.

### **Current Public Safety Service Categories**

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<sup>10</sup> 47 U.S.C. 332 (a). See also section 1 of the Communications Act, which emphasizes similar policy objectives.

<sup>11</sup> 47 U.S.C. 903 (d)(1)

<sup>12</sup> Amendment of the Commission's Rules to Permit Flexible Service Offerings in the Commercial Mobile Services. First Report and Order and Further Notice of Proposed Rulemaking in WT Docket 96-6, FCC 96-283 (released August 1, 1996).

1.18 The Public Safety Radio Services (PSRS) of the FCC form the backbone of state and local Public Safety communications systems, and include the following specific services:

Table 1-2

<b><i>Police Radio Service (PRS)</i></b>	The PRS is used for mobile communications to handle police operations ( e.g., dispatching units, coordinating tactical operations, and administrative matters). Any territory, possession, state, county, city, town, and similar governmental entity is eligible in the PRS.
<b><i>Fire Radio Service (FRS)</i></b>	The FRS can be used for emergency dispatch services and administrative functions. Governmental entities and persons or organizations charged with specific fire protection activities are eligible in the FRS to operate radio stations for transmission of communications essential to these responsibilities. Where a fire department has responsibility for providing rescue squad and ambulance service, FRS frequencies may be used for the dispatch of ambulances, the communication of medical information to personnel at the site of an emergency, and the transmission of information from the emergency site or the ambulance to hospital emergency personnel.
<b><i>Highway Maintenance Radio Service (HMRS)</i></b>	Communications related to highway activities, such as directing highway crews and vehicles to meet changing priorities due to road and weather emergencies, may be transmitted on HMRS frequencies. These frequencies are used for general road maintenance and paving operations, as well as in critical situations for communications related to ice and snow removal, accidents, removal of disabled vehicles and patrols of tunnels, bridges and turnpikes.
<b><i>Forestry-Conservation Radio Service (FCRS)</i></b>	Spectrum in the FCRS is used for many natural resource agency functions, the most visible being the suppression of forest wildfires, law enforcement ( e.g., park police and rangers enforcing fish, game, and environmental laws), fire prevention control, and emergency medical services. A non-federal governmental agency and any entity charged with specific forestry-conservation activities are eligible in the FCRS.
<b><i>Local Government Radio Service (LGRS)</i></b>	The LGRS addresses the day-to-day communications needs of territories, possessions, states, cities, counties, towns and similar governmental entities. These frequencies are also used to report the condition of public facilities such as reservoir levels, as well as for a variety of Public Safety and welfare uses. All Public Safety entities, including law enforcement, corrections, fire protection, lifeguard and rescue service users, also are permitted to use the LGRS spectrum.
<b><i>Emergency Medical Radio Service (EMRS)</i></b>	The EMRS was established to improve the communications capabilities of entities engaged in providing life support services, allowing transmissions between rescuers at the scene of an accident or disaster and physicians at a hospital, as well as the dispatch of emergency medical providers transporting injured persons to hospitals and trauma centers. Eligibility is limited to entities engaged in the provision of basic or advanced life-support services on an ongoing basis.

Table 1-2

<p><i>Special Emergency Radio Service (SERS)</i></p>	<p>The SERS frequencies may be used by medical services, rescue organizations, physically handicapped persons, veterinarians, disaster relief personnel, school bus operators, beach patrols, persons or organizations in isolated areas where public communication facilities are not available, communications standby facility operators, and personnel providing emergency repair of public communications facilities. Entities not meeting these eligibility criteria may be licensed in this service solely to provide service to SERS eligibles on one-way paging-only frequencies below 800 MHz.</p>
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1.19 Federal government Public Safety wireless communication uses are similar to that of state and local governments, except with respect to communications supporting national security operations and the geographic area of coverage. Federal Public Safety responsibilities encompass law enforcement, transportation, natural resources, emergency and disaster, and medical and administrative duties. In nearly all cases, the equipment is the same as that used by state and local Public Safety agencies. The broad categories of federal Public Safety wireless communications are generally mirrored by the structure delineated by the FCC with regard to state and local Public Safety agencies.

**Public Safety Use of Radio Technology Today**

1.20 Public Safety operations have evolved over the years to be critically dependent on the use of the FM radio system as the only reliable and effective means of communication. The radio system is designed for general broadcast purposes, that is one Public Safety officer will talk and many can hear the transmission simultaneously. This method of operation is vitally important in fast moving situations such as a surveillance or hot pursuit, or the dispatch of fire rescue services, as many can hear the single broadcast and respond appropriately. This description of the radio system is extremely simplified. However, the technical components supporting this system are very sophisticated and without radio spectrum, it can't exist.

1.21 Typical Public Safety communications from mobile sources are of relatively short duration — usually less than a minute. As a result, channels often are shared by several independent users with specific audio sub-audible tones used to permit any combination of mobile radios to receive a radio transmission. In “conventional” voice and data systems, a single channel or a pair of channels is employed, which may require an end user to wait for a break to seize the channel. In “trunked” systems, multiple channel pairs are integrated into a single system. When a user wants to transmit a message, the trunked system will automatically select a currently unused channel pair and assign it to the user, decreasing the probability of having to wait for a free channel for a given channel loading.

- 1.22 Public Safety agencies also use fixed (non-mobile) services to provide communications between designated endpoints (point to point), *e.g.*, police headquarters to a district police station. Typical links operating in the microwave bands involve communications between one fixed transmitter and one fixed receiver, and links are generally paired to provide a two-way path. Point-to-multipoint services are also occasionally used, which involve multiple transmitters or receivers at fixed locations. Microwave spectrum is generally shared with other private land mobile users, as well as broadcast service users, common carrier users, and aviation and marine service users.

### **The Unique Operational Requirements of Public Safety Users**

- 1.23 Public Safety users have operational requirements that differ substantially from other classes of wireless users. Unlike others, the responsibilities of Public Safety users to meet their mission critical obligations require, among other things, (1) dedicated capacity and/or priority access available at all times (and in sufficient amounts) to handle unexpected emergencies, (2) highly reliable (redundant) networks which are engineered and maintained to withstand natural disasters and other emergencies; (3) ubiquitous coverage within a given geographic area; (4) and unique terminal equipment (mobile or portable units) designed for quick response in emergency situations. These unique operational requirements limit the potential for extensive substitution of commercial services for the dedicated networks currently owned and operated by Public Safety entities.
- 1.24 The Public Safety community, while composed of users with varying and distinct Public Safety duties, have some common, overarching needs. All individual Public Safety users need the ability to communicate with agency control centers. They all need to be able to communicate directly with each other as well, in many cases. These common operational requirements include dispatch communications, transmission of operational and tactical instructions, and communication of administrative information.
- 1.25 Agencies also have specialized requirements based on their specific missions and operating environments. Correctional facilities, for example, are compact geographical areas, but their concrete and steel structures pose unique radio communications and administrative problems. Forestry organizations need to communicate over long distances where foliage is a problem for higher frequency systems. Some agencies need reliable coverage inside buildings in urban areas, while others need effective long range communications that can cover hundreds of miles. For example, a state highway patrol requires wide-area coverage of highways whereas a metropolitan police department may need high reliability in-building coverage, system propagation characteristics that are often contradictory.
- 1.26 The operational needs of Federal government Public Safety agencies are quite similar to state and local agencies in terms of voice, data, and video communications and the functions they serve, law enforcement, transportation, natural resources, emergency

and disaster services, etc. Federal government Public Safety needs, however, do differ in their wider, national or even international, scope, and their greater need for multiple levels of secure communications to protect national security interests. Federal responsibilities also require that frequencies be available for voice, data, and video applications nationwide, so that when an emergency situation arises, the necessary spectrum resources are available when federal assistance is deployed.

**Current Public Safety Spectrum Allocations**

- 1.27 Public Safety spectrum use has evolved as technology and needs changed over time. Initially, almost all two-way communications were confined to the frequency range 30-50 MHz. As technology advanced, however, transmission at higher frequencies became possible, offering a temporary solution for congestion and crowding. Now, Public Safety users operate in a wide variety of bands, including 150 MHz, 450 MHz, and 800 MHz spectrum. While these additional allocations added needed capacity to existing systems, they also resulted in the fragmentation that characterizes the Public Safety spectrum today. Many agencies use two or more frequency bands for a single system, resulting in vehicles having to be equipped with multiple radios.
- 1.28 As shown in the following table, state and local Public Safety agencies have a total of 941 channels in six frequency bands, and some additional spectrum in major metropolitan areas:

Table 1-3

<b>EXISTING STATE AND LOCAL PUBLIC SAFETY SPECTRUM ALLOCATIONS</b>			
<b>Band (MHz)</b>	<b>Channels</b>	<b>MHz (est.)</b>	<b>Comments</b>
25-50	315	6.3	VHF Low Band. Generally used for conventional, non-trunked dispatch voice communications. The band is in use by state highway patrols for wide-area coverage. Future use of the band is questionable as equipment availability is limited.
150-174	242	3.6	VHF High Band. Generally used for conventional, non-trunked dispatch voice communications.
220-222	10	0.1	220 MHz SMR Band. This allocation is fairly recent, and requires very narrow (5 kHz) channelization. New equipment is limited for this band.
450-470	74	3.7	UHF Low Band. Generally used for conventional, non-trunked dispatch voice communications.

Table 1-3

<b>EXISTING STATE AND LOCAL PUBLIC SAFETY SPECTRUM ALLOCATIONS</b>			
<b>Band (MHz)</b>	<b>Channels</b>	<b>MHz (est.)</b>	<b>Comments</b>
470-512	*	*	UHF TV Sharing. Various bandwidth have been made available in 11 metropolitan areas for private land mobile radio use, including Public Safety use.
806-821 851-866	70	3.5	800 MHz Band. Used for both conventional and trunked systems.
821-824 866-869	230	6	800 MHz Band. Used for both conventional and trunked systems
	<b>941</b>	<b>23.2</b>	<b>TOTAL</b>

- 1.29 Various frequencies from 2 to 25 MHz (the HF band) are also available for disaster communications but, due to propagation factors, are not generally used for routine day to day needs. For fixed systems, Public Safety agencies are eligible for licensing in the Private Operational-Fixed Microwave Service and many Public Safety agencies have point-to-point communications systems near 2 GHz, 6 GHz and other bands.<sup>13</sup>
- 1.30 Federal government non-military and military non-tactical land mobile spectrum requirements are accommodated primarily in five radio frequency ranges: 30-50 MHz, 138-150.8 MHz, 162.0125-174 MHz, 220-222 MHz and the 406.1-420 MHz bands. However, in each of these ranges, portions are allocated either for exclusive Federal government/non-Federal government use or on a shared basis between Federal government and non-Federal government. These allocations total 6.36 MHz in the 30-50 MHz band, 6.75 MHz in the 138-150.8 MHz band for a myriad of military applications including non-tactical land mobile as well as fixed and other mobile systems, 11.78 MHz in the 162-174 MHz band, 13.9 MHz in the 406.1 to 420 MHz band, and 10 channels in the 220-222 MHz band. It is *extremely important* to note that all Federal government mobile bands are allocated on a co-primary basis with the fixed service, and these bands are used extensively for fixed systems in addition to mobile systems, including fixed point-to-point, fixed point-to-multipoint, aeronautical mobile, and maritime mobile systems.

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<sup>13</sup> Public Safety and other private operational fixed microwave licensees are relocating from the 2 GHz bands to accommodate the reallocation of those bands for new emerging technologies.

- 1.31 In the following table, Federal government Public Safety spectrum allocations are outlined:

Table 1-4

<b>EXISTING FEDERAL PUBLIC SAFETY SPECTRUM ALLOCATIONS</b>			
<b>Band (MHZ)</b>	<b>Total Govt Allocation (MHZ)</b>	<b>Public Safety Allocation (portion) (MHZ)</b>	<b>Comments</b>
30-50	6.36	3.8	VHF Low Band. Used extensively by the Military and other Fed Agencies for fixed, land/maritime/aeronautical mobile services.
138-150.8	6.75	4.0	VHF Military Band. Used extensively for Military non-tactical mobile systems. Heavy use by fixed, aero mobile and maritime mobile.
220-222	0.1	0.1	220 SMR Band. Very narrowband. May be used for some ITS requirements.
162-174	11.78	8.25	VHF High Band. Primary Public Safety band. Used for land mobile systems. Includes fixed and other uses.
406.1-420	13.9	8.3	UHF Low Band. Federal growth band. Used for wide variety of land, maritime, aero mobile. Heavily used for fixed service. Most Fed govt trunked systems.
	<b>38.89</b>	<b>24.45</b>	<b>TOTAL</b>

## 2. KEY FINDINGS AND RECOMMENDATIONS

- 2.1 The establishment of the Public Safety Wireless Advisory Committee provided an unprecedented opportunity for the Public Safety community to recommend changes on a national basis to improve the methods of allocation and administration of radio spectrum for Public Safety support. In consideration of the above, the key findings of this effort are:

## Key Findings

- 2.1.1 ▶ Voice services, including dispatch (*i.e.*, central control to mobile units), one-to-many communications, and monitoring, remain — and are likely to remain — the central and most critical communications modes for Public Safety users.
- 2.1.2 ▶ Public Safety radio systems must be highly reliable to withstand natural disasters, possess high capacity to ensure sufficient communications paths at peak usage in the event of major disasters, and provide high Delivered Audio Quality (DAQ), a factor that subsumes time delay, coverage, and other qualitative criteria.
- 2.1.3 ▶ Different Public Safety agencies also have varied and unique mission-specific requirements (*e.g.*, encryption for drug interdiction activities), operating environments (*e.g.*, foliage penetration needs of forestry service versus building penetration for correctional officers), and geographic coverage needs (wide area for state highway patrol systems, national and international for some federal and national security agencies).
- 2.1.4 ▶ Interoperability between Public Safety users in the past has been hampered by an interdependent set of factors that includes widely dispersed and fragmented spectrum allocations that cannot be covered by multiband radios, nonstandard frequency spacings and system access methods, and the lack of clear, nationwide channels allocated solely for interoperability.
- 2.1.5 ▶ Interoperability among and between different classes of users and different jurisdictions is critical to the effective discharge of Public Safety duties. PSWAC has identified separately needs for *day-to-day* (*e.g.*, communications between concurrent jurisdictions such as a county sheriff and state highway patrol), *mutual aid* (*e.g.*, riots and wildland fires where little pre-planning can occur), and *task force* (*e.g.*, a federal, state, and county drug interdiction operation) requirements to allow Public Safety agencies to intercommunicate effectively.
- 2.1.6 ▶ The Federal government is addressing the issue of interoperability through the National Performance Review process and has recommended the development of a Public Safety Wireless Network for use by federal, state and local agencies.
- 2.1.7 ▶ Broad based efforts that evaluate cost effective, spectrally efficient radio systems, as well as those addressing wireless communications issues in general, such as projects on the state and regional level seeking to coordinate, consolidate, or study operations, and on the federal level by the Federal Law Enforcement Wireless Users Group, are critical to articulating the needs of

Public Safety as well determining the most efficient and effective means to meet these requirements.

- 2.1.8 ▶ Interoperability (or the lack thereof) is often affected by non-technical factors including reluctance to adopt new approaches and funding limitations. Contending with the human factor is another critical element in achieving interoperability.
- 2.1.9 ▶ Guidelines established through the National Public Safety Planning Advisory Committee (NPSPAC) process are enabling a level of interoperability, spectrum efficiency, and cost savings in the 800 MHz band.
- 2.1.10 ▶ The currently allocated Public Safety spectrum is insufficient to meet current voice and data needs, will not permit deployment of needed advanced data and video systems, does not provide adequate interoperability channels, and will not meet future needs under projected population growth and demographic changes.
- 2.1.11 ▶ Reallocating all Public Safety users to a single new band is not feasible due to the need to maintain different propagation characteristics for different Public Safety missions, the cost of replacing the embedded base of Public Safety radio equipment, and the lack of any single spectrum block of sufficient size to accommodate all Public Safety users.
- 2.1.12 ▶ Increased federal/non-federal sharing and improved spectrum management are critical to ensuring future efficiency and spectrum availability for Public Safety. But these measures alone are not sufficient to fully address Public Safety users' capacity needs in the near future.
- 2.1.13 ▶ The availability of efficient and effective radio technologies is necessary for Public Safety agencies to protect the lives and property of the country's citizens in a safe and economical manner.
- 2.1.14 ▶ New technologies generally produce two important, but counterbalancing effects for the Public Safety community. First, improvements in technology such as digital transmission and advanced modulation techniques permit users to increase the amount of traffic that can be transmitted over any given amount of spectrum. This phenomenon, considered alone, would minimize the requirements for new spectrum. However, the second corresponding effect of technology advances is the creation of a new range of functions and features. These additional capabilities such as high speed data and video transmission require additional spectrum to fully exploit.
- 2.1.15 ▶ Data communication needs are becoming as varied as voice needs, and are expected to grow rapidly in the next few years. New services and technologies (*e.g.*, data systems enabling firefighters to obtain remote access to building

plans and video systems for robotics-controlled bomb disposal) that are critical for Public Safety users to continue to fulfill their obligation to preserve life and property are now becoming available.

- 2.1.16 ▶ Wireless video needs are expected to expand in Public Safety applications.
- 2.1.17 ▶ Public Service providers require interoperable radio communications with Public Safety agencies.
- 2.1.18 ▶ The migration to new technologies will be driven by the life cycle of existing equipment, the need for additional communications capacity, and advanced services and features required by Public Safety agencies.
- 2.1.19 ▶ Flexible mandates are needed in order to encourage the rapid deployment of new technologies.
- 2.1.20 ▶ The current method of licensing coordination between federal and non-federal users is inefficient and should be reviewed.
- 2.1.21 ▶ Funding for acquisition of new spectrum-efficient technologies and/or relocation to different frequency bands is likely to be a major impediment to improving Public Safety wireless systems.
- 2.1.22 ▶ Digital technology will be the key technology for the future.
- 2.1.23 ▶ The implementation of the FBI's National Crime Information Center - Project 2000 (NCIC-2000) program will have a significant impact on Public Safety radio systems — both in the near term and in the future.
- 2.1.24 ▶ Commercial wireless systems, such as cellular, Personal Communications Services (PCS), mobile satellite, paging, data, and network applications, are evolving rapidly and may offer tangible and reasonable alternatives to the demand for additional spectrum to meet present and future Public Safety requirements.

### **Key Recommendations**

- 2.2 The Steering Committee has extensively reviewed the subcommittee reports and has formulated, in conjunction with our Charter, the following recommendations:

#### **Spectrum**

- 2.2.1 ▶ The Steering Committee agrees with the findings that voice is the principal need of the Public Safety community and also agrees with the conclusion that

there will be a significant increase in the use of data, imagery, and video. The Steering Committee concluded that, in the short term, voice and data operations require approximately 25 MHz of new Public Safety allocations. By the year 2010, as much as an additional 70 MHz may be needed for these applications, including image and video requirements. The Steering Committee supports 2.5 MHz of spectrum for interoperability in the VHF and UHF bands between 138 MHz and 512 MHz. It also recommends a management structure in order to oversee the operation of the interoperability spectrum.

- 2.2.2 ▶ Given the technical constraints on Public Safety users and existing spectrum usage, the Steering Committee recommends the following priority actions to assure sufficient Public Safety spectrum availability in 2010:
- 2.2.2.1 ▶ Public Safety users should be granted access to portions of the unused spectrum in the 746-806 MHz band (UHF TV Channels 60-69);
  - 2.2.2.2 ▶ To the extent feasible, Public Safety users should be granted immediate spectrum relief by permitting increased sharing on unused TV channels nationwide below 512 MHz;
  - 2.2.2.3 ▶ The FCC should consider the reallocation of channels which may become available from private radio services as a result of the refarming mandates;
  - 2.2.2.4 ▶ Public Safety users should be allowed to share the 1710-1755 MHz band with federal users and that band should be reallocated on a permanent basis to Public Safety users upon termination of federal use on January 1, 2004;
  - 2.2.2.5 ▶ The 4635-4685 MHz band should be allocated for Public Safety systems; and,
  - 2.2.2.6 ▶ The proposed allocation at 5850-5925 MHz for intelligent transportation systems should be finalized.
  - 2.2.2.7 ▶ The Steering Committee examined 380-399.9 MHz, which is presently committed to military use. The Department of Defense (DoD) relates that in NATO, two 5 MHz pieces (380-385 and 390-395 MHz) are being considered for sharing with cross border emergency services on non-interference basis. This sharing arrangement would be on a country by country basis, in accordance with individual national priorities, and in compliance with criteria set forth by NATO, mainly that any system in this band be on a non-interference basis to military systems and accept interference from military frequency hopping radios. The Department of Defense objects to any reallocation of this

spectrum to Public Safety, even on a shared basis.<sup>14</sup> DoD states that this band is standardized with U.S. military allies in Europe and elsewhere throughout the world for interoperability during combined actions and that national security considerations preclude its use domestically. Detailed discussions of this issue were limited because of the classified nature of some of the information. The Steering Committee recommends that individuals within the Executive Branch and the FCC with appropriate security clearances undertake discussions with representatives of DoD to pursue this matter further;

- 2.2.2.8 ▶ To the extent possible and consistent with National Security requirements and Department of Defense needs, sharing opportunities in the 138-144 MHz military band should be explored.
- 2.2.3 ▶ The Steering Committee supports block allocations of spectrum for Public Safety use. The Steering Committee believes the current method of allocation, focused primarily on narrow banding, does not provide the Public Safety community the flexibility of selecting or obtaining the most spectrally efficient technology to meet user defined requirements. The Steering Committee recommends the FCC pursue the development of a Public Safety management structure based on block allocations.
- 2.2.4 ▶ The Steering Committee agrees that the FCC licensing process should be further streamlined through the increased utilization of electronic filing.
- 2.2.5 ▶ The Steering Committee agrees with a flexible regulatory environment which encourages the development of shared system infrastructure supporting Public Safety communications.
- 2.2.6 ▶ The Steering Committee supports coordinated planning at the federal, state and local levels of government in order to facilitate interoperability. The development, provision and utilization of interfaces/gateways between and among remaining independent Public Safety and public service infrastructures and between Public Safety and commercial infrastructures should be encouraged.
- 2.2.7 ▶ The Steering Committee recognizes that flexible mandates need to be established to promote orderly transition to new spectrum. However, the committee recognizes that these must be incentive-oriented based on the availability of funding.

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<sup>14</sup> See Letter of Honorable Emmet Paige, Jr., Assistant Secretary of Defense, to Philip L. Verveer, dated July 29, 1996.

- 2.2.8 ▶ The Steering Committee believes that committing broader discretion to users is essential to affording incentives for advanced technologies. It should fall to the user to determine what information to send, what technology to use, the quality of the transmission demanded, and the speed required. Present proceedings or initiatives at the FCC should recognize this premise. In context of those proceedings that do focus on a narrowband perspective, Public Safety agencies should be afforded opportunity to obtain exclusive areas or “Protected Service Areas” affording protection from interference and incentive where advanced technologies can be more readily pursued.
- 2.2.9 ▶ The Steering Committee recommends a follow-up effort be continued to give advice and counsel to the FCC and NTIA with regards to issues surrounding Public Safety wireless communications.

### **Interoperability**

- 2.2.10 ▶ The Steering Committee is encouraged by the trend of deployment and utilization of shared/consolidated systems.
- 2.2.11 ▶ The Steering Committee adopts the following general recommendations of the Interoperability Subcommittee:<sup>15</sup>
  - 2.2.11.1 ▶ A minimum baseline standard is required for unit-to-unit Public Safety radio equipment operating in the same band.
  - 2.2.11.2 ▶ The development, provision, and utilization of interfaces/gateways between and among independent Public Safety and Public Service infrastructures and between Public Safety and commercial infrastructures should be encouraged.
  - 2.2.11.3 ▶ These standards and connections should be developed by a fair and open process that encourages industry to cooperate in order to provide the tools and technology needed by the Public Safety community.

### **Transition**

- 2.2.12 ▶ The Steering Committee recognizes that any transition to new technology or spectrum will impose costs on the Public Safety community. The Steering Committee recommends investigating the establishment of alternative funding

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<sup>15</sup> Although various technologies and standards were addressed, the PSWAC decided to keep its report technology neutral. The failure to recommend any specific technology or standard should not be construed as either a lack of support for, or a rejection of, any of the available technologies or standards.

sources such as: appropriations through spectrum auction revenues, non-Public Safety spectrum user fees, amendments to asset forfeiture law, matching funds, and block grants to supplement traditional funding sources for Public Safety relocations and system upgrades.

### **E9-1-1**

- 2.2.13 ▶ PSWAC supports existing efforts as established in FCC Docket 94-102 for upgrading 9-1-1 systems and services. We also support future rulemakings addressing compatibility of Private Branch Exchanges (PBX's) with E9-1-1 systems.<sup>16</sup>

### **Commercial Services**

- 2.3 The Steering Committee recognizes the changing role of commercial services in supporting Public Safety communications. It is incumbent upon Public Safety agencies to establish needs and priorities based on their requirements, and utilize those commercial services which fill that need. Commercial service providers need to recognize the critical nature and priority placed on Public Safety communications and provide a market basket of products based on those requirements.
- 2.4 The subcommittee reports reflect several perspectives with regarding the use of commercial wireless systems. Commercial systems offer a valuable opportunity to meet some present and expanding needs. Yet, Public Safety has historically resisted commercial services, particularly for mission critical requirements. Public Safety agencies have operated land mobile radio systems long before there was a commercial wireless industry. They have a vast investment in the existing plant, with technology and systems developed to meet specific Public Safety needs. The close match of the embedded systems to Public Safety needs makes it difficult for commercial systems to become effective competitors. In this context, minimum baseline requirements for *mission critical* applications are not met by any existing or planned commercial offerings. However, a range of *non-mission critical* communications can be satisfied by commercial systems. Indeed, commercial systems offer unique capabilities that will

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<sup>16</sup> The PSWAC did not specifically address the E9-1-1 issue. However, it recognizes that in the United States, 9-1-1 has become synonymous with a call for help from law enforcement, fire units, emergency medical services, or other Public Safety provider. The public has little knowledge of the complex systems behind this seemingly easy way to get help when it is needed. In addition, the explosive growth of public wireless communications has resulted in even easier access to emergency services. The improved ability of a citizen to request help coupled with the changing demographics in our country has resulted in an ever increasing pressure on the 9-1-1 dispatch centers to dispatch emergency help and provide fast and accurate information about the situation, possible hazards, and to manage the resources the dispatch center has available. As a result, there is an increasing pressure for additional communications capability between responders and a dispatch. Unfortunately, in many places, communications systems cannot grow because there is no available spectrum.

be important in the future, including nationwide coverage by satellite systems and near universal urban area coverage by commercial data service providers.

- 2.5 The Steering Committee believes that the availability of commercial systems as a reasonable alternative depends on satisfying several essential requirements. These are: 1) high reliability coverage throughout the area designated by the agency; 2) affordable cost; 3) priority access during peak periods and crisis circumstances; 4) secure transmission, including, in particular cases, encryption; 5) sufficient reserve capacity; 6) reliability comparable to dedicated systems; and 6) mobile and portable units distinguished by the durability and ergonomic factors required by field personnel.
- 2.6 The Steering Committee believes that clear standards, such as those enumerated in paragraph 2.5 above, will allow Public Safety agencies and commercial service providers to work together to determine if alternatives exist to develop features and capabilities needed by Public Safety agencies in both mission critical and non-mission critical areas. With technology and innovation advancing rapidly, and markets becoming more competitive and focused, historic experience will not necessarily accurately reflect the potential of commercial services to meet Public Safety's needs. The ability of government agencies to contract with an increasingly large and competitive commercial wireless industry for particular features and functions offers a basis for optimism that eventually many Public Safety requirements can be met by commercial mobile radio services companies. If and to the extent that government procurement requirements inhibit the writing of such contracts, reforming those requirements could produce material benefits.

### 3. CONCLUSION

- 3.1 This report identifies a number of approaches that can provide Public Safety with enhanced communications capabilities — higher quality transmission, access to emerging technologies, and availability of a broader range of services — immediately and in the long term. The first is allocation of additional spectrum for Public Safety. This entails reallocating spectrum from other uses and/or adding Public Safety uses to already allocated bands through sharing. Second is the more efficient use of present spectrum. This approach relies on the use of advanced technology to bring increased capacity and quality. Greater sharing, both within the Public Safety community and with other users, improves spectral efficiency and enhances interoperability. The third encourages Public Safety agencies to make greater use of commercial services. None of these elements alone will meet Public Safety communications needs by itself; and, to choose only one course embodies substantial risk. Rather, a combination of these methods is likely to produce the most improvement. Allowing individual agencies to choose the best combination of elements will guarantee that the most effective and efficient system will be developed.
- 3.2 This report recommends the adoption of several baseline standards designed to meet both short- and long-term interoperability needs. It is clear that additional contributions from the user community are necessary for the development of satisfactory, evolving standards to govern the opportunities afforded by the emerging digital environment. In this regard, the report recommends that the FCC and NTIA sponsor an ongoing consultative effort to address these important needs.
- 3.3 Implementing the recommendations in this report requires different levels of commitment from various user groups, along with close cooperation and open dialogue between regulating officials and the manufacturing community. The recommendations made in the *Final Report* with respect to transition mechanisms recognize and account for the substantial embedded infrastructure currently being used by the Public Safety community, the unique budgetary constraints imposed upon the Public Safety community, and the critical lack of additional funding available to most Public Safety agencies. These critical areas will require further attention at all levels of government.

#### 4. SUMMARY OF SUBCOMMITTEE REPORTS

- 4.1 Operational Requirements Subcommittee Summary (ORSC)
- 4.2 Technology Subcommittee Summary (TESC)
- 4.3 Interoperability Subcommittee Summary (ISC)
- 4.4 Spectrum Requirements Subcommittee Summary (SRSC)
- 4.5 Transition Subcommittee Summary (TRSC)

#### **NOTICE**

*The following summaries of the subcommittee reports capsule the work and eventual output of each of the subcommittees. The full text of the subcommittee reports appears as Appendix A through Appendix E of this report. Readers may note that the Steering Committee findings and recommendations may differ from the subcommittee findings and recommendations. The failure by the Steering Committee to include, or the decision by the Steering Committee to exclude, a specific subcommittee finding or recommendation should not be construed by the reader as either a lack of support for, or a rejection of, any subcommittee finding or recommendation.*

## 4.1 OPERATIONAL REQUIREMENTS SUBCOMMITTEE SUMMARY

### Overview

- 4.1.1 The general charter of the Operational Requirements Subcommittee (ORSC) was to identify the wireless communication needs of the Public Safety community through the year 2010. The subcommittee was also tasked to examine current operational requirements that are unmet or suffer reliability, quality, or coverage deficiencies. Needs were to be prioritized as to necessity for proper functioning of the Public Safety community.
- 4.1.2 The subcommittee's report provides a snapshot of operational capabilities that Public Safety providers require, now and in the future, in order to fulfill their mission of protecting lives and property. The subcommittee analyzed the needs of a broad range of Public Safety entities according to the type of service (voice, data, image, and video) and quantity of service (number of channels) required.<sup>17</sup> The bulk of the subcommittee's report discusses these requirements in detail. General requirements for the quality of transmission were also developed, and are contained in Annex A of the subcommittee's report. The subcommittee was asked to provide input data to the spectrum model developed in the Spectrum Requirements Subcommittee, and this input is included as Annex B. Finally, the subcommittee notes the need for interagency communications of both an incident-based and routine operational nature. These interoperability requirements were input to the Interoperability Subcommittee for their consideration.
- 4.1.3 In addition to future needs, the report includes observations and recommendations regarding current problems meeting communication requirements. In particular, the report discusses communication needs that are unmet or suffer from capacity, reliability, quality, or coverage deficiencies. The report cites continuing difficulty with frequency interference from users in foreign countries, insufficient path or channel availability, inadequate coverage inside buildings, and multipath interference. The subcommittee observes the efficiencies available through trunked, data-only and vehicle location-only systems, and strongly encourages sharing of such systems when possible.

### General Observations

- 4.1.4 While all Public Safety users have some common needs, different Public Safety users also have unique, mission-specific requirements. General requirements include dispatch communications, transmission of operational and tactical instructions, and

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<sup>17</sup> The Subcommittee divided its work into 11 working groups, based on the function or mission of the agencies involved. The 11 working groups were: Transport Mechanisms; Criminal Justice; Fire, Emergency, Medical and Related Life and Property Protection Services; Emergency Management and Disaster Services; Highway Maintenance; Intelligent Transportation Systems; Forestry; General Government; Public Mass Transit; Public Service; and Federal.

- communication of administrative information. All individual users, for example, need to communicate with their agency control centers or supervisors, but they also need to be able to communicate directly with each other in many cases. Agencies identify high reliability and capacity sufficient to respond to major disasters as important requirements.
- 4.1.5 Agencies also have specialized requirements based on their specific mission and operating environments. For example, a state highway patrol requires wide-area coverage of highways whereas a metropolitan police department may need high reliability in-building coverage; in each case, system propagation characteristics are often contradictory. Correctional facilities, for example, are compact geographic areas, but their concrete and steel structures pose unique radio communication and administrative problems. Forestry organizations need to communicate over long distances where foliage is a problem for higher frequency systems. The subcommittee investigated both the common and mission-specific operational requirements of Public Safety users in great detail.
- 4.1.6 The operational needs of Federal government Public Safety agencies are quite similar to state and local agencies, both in terms of the kinds of communications they require, voice, data, and video, and the functions they serve, law enforcement, transportation, natural resources, emergency and disaster services, etc. Federal government Public Safety needs, however, do differ in their wider, national or even international, scope, and their greater need for multiple levels of secure communications to protect national security interests. Because of the wider area served, the Federal government makes greater use of satellite communications than do state and local governments; transportable satellite dishes are especially useful in disaster response. The wide geographic scope of federal responsibilities also require that frequencies be available for voice, data, and video applications nationwide, so that when an emergency situation arises, the necessary spectrum resources are available when federal assistance is deployed.
- 4.1.7 For many years, the communications needs of the Public Safety community centered around voice communications; for dispatching officers, coordinating activities at the scene of an accident or during large-scale emergencies, as well as peer-to-peer communications. Today, advances in technology are providing a wealth of new capabilities and applications that can substantially aid Public Safety agencies in the performance of their duties. As a result, wireless communication needs once limited to voice frequencies are now expanding rapidly to encompass new data and video services. These new applications and services make up a significant portion of the community's need for new spectrum.
- 4.1.8 Voice communications remain the primary form of communication for Public Safety agencies. Current voice communication needs are highly varied and include: dispatch, tactical and command, direct unit-to-unit, air-to-ground, special operations communication, and communication with other agencies. Travel channels are also needed to allow units to communicate while operating out of their home systems.

- Interstate transportation of prisoners is one example. Voice is the primary method of communication, especially during emergency situations. Many different groups are often required to respond to fires and hazardous materials incidents, and in large-scale incidents such as a forest fire, up to 150 separate voice paths may be needed to effectively direct and manage the fire-fighting effort. Coordination of these groups is critical as they may involve police, fire, ambulance, hospitals, utilities, and federal/state/local government responsibilities.
- 4.1.9 Data communication needs are becoming as varied as voice needs, and are expected to grow rapidly in the next few years as new data-based systems, such as the Integrated Automated Fingerprint Identification System, which will allow officers in the field to check fingerprints instantly, are implemented. Many types of data needs are identified, including text (information on a chemical involved in a spill), graphics (blueprints, maps, images), and data (position information, patient vital signs and diagnostic data). Other potential uses include geographic location data to track personnel and vehicles — important for safety as well as control, emergency signaling (officer in trouble), remote transmission of (accident, arrest, investigative, patient) reports, electronic messaging, remote device monitoring — such as perimeter detection systems in prisons, road/weather conditions, and emergency vehicle traffic signal control. The International Association of Chiefs of Police estimates that as many as 75 percent of officers could be equipped with Mobile Data Terminals (MDTs) by the year 2010.
- 4.1.10 Video communication needs are limited now, but are expanding as technology advances. Current uses include on-scene incident video, surveillance and monitoring (including aerial), robotics control for bomb disposal and fire fighting, and on-site patient care. In the future, two-way video communication between remote vehicles and central control stations may become common. Both point-to-point and broadcast applications are envisioned.
- 4.1.11 Currently allocated spectrum does not provide adequate spectrum to meet today's channel requirements. This conclusion was reached in all the working groups analyzing Public Safety needs across a range of activities and missions. Channel shortages are especially noticeable in voice communications, but shortages exist in some parts of the country for point-to-point microwave links, and the subcommittee found that existing allocations will not support future data or video communication needs. Growth of operations, combined with the need for new applications to support Public Safety, will make current conditions of congestion even worse.

### **Specific Findings**

- 4.1.12 ▶ Quality of communication is a critical factor in Public Safety communication. Personnel have come to rely on voice communications systems that permit immediate connections and a high degree of clarity. Data and video needs are similarly time-sensitive, and quality is still a concern. The subcommittee adopted transmission quality recommendations based on the standards contained in a report by the Telecommunications Industry Association and the

Institute of Electrical and Electronics Engineers.<sup>18</sup> The subcommittee recommends that a minimum Delivered Audio Quality (DAQ) of 3.4 or better be achieved in Public Safety systems. A level of 3.4 is defined to mean that speech is understandable without repetition, with some noise or distortion allowed. The full discussion of and specific recommendations for audio quality, including intelligibility, coverage, reliability, and delay, is contained in Annex A to the subcommittee report.

- 4.1.13 ▶ Operational fixed links, using microwave or lower frequencies, are a vital part of Public Safety communication networks, and are used to carry voice, data, and video. They connect the control center(s) with the various base stations that transmit to mobile/portable units. While some of these links are provided by commercial (leased line) service providers, some sites are too remote or expensive to employ this type of service. In these cases, privately owned systems are required. Agency control is also an important consideration.
- 4.1.14 ▶ Large-scale events (Olympics) and disasters such as hurricanes, floods and earthquakes put serious strains on Public Safety communication systems. One major problem is capacity. In events such as these, many Public Safety personnel and agencies have to respond, and each will need radios to do its part of the job. Further, interoperability becomes a serious problem when trying to link together all the disparate agencies. To the extent possible, such events need to be planned for so that adequate spectrum resources are available when needed. Specific recommendations on numbers of channels needed for various agencies (search and rescue, medical assistance, utilities, and non-Public Safety organizations such as the Red Cross, Civil Air Patrol, and Salvation Army) in support of these needs can be found in section 4.4.3 of the subcommittee report. A nationwide channel for distributing information to the media and the public is also recommended.
- 4.1.15 ▶ Development of Intelligent Transportation Systems will entail provision of a wide range of new services, many of which will depend on radio communications. Some new spectrum may be required, as well as sharing with Public Safety and other radio services. Section 4.7.4 of the subcommittee report describes the needs in detail.
- 4.1.16 ▶ Interoperability with other agencies is a critical need for a variety of day-to-day, emergency, and special operations. Especially in large disaster situations, the effective coordination of multiple agencies (fire, police, local government, utilities) and jurisdictions is largely dependent on interoperable communications systems. Thousands of individuals may be involved. The

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<sup>18</sup> Telecommunications Industry Association and the Institute of Electrical and Electronics Engineers, "A Report on Technology Independent Methodology for the Modeling, Simulation, and Empirical Verification of Wireless Communications Systems Performance in Noise and Interference Limited Systems Operating in Frequencies Between 30 and 1500 MHz."

1993 fire in Malibu, California required 458 agencies from 12 states to bring it under control. Interoperability requirements are discussed more fully below.

- 4.1.17 ▶ Public service providers, such as transportation companies and utilities rely extensively on radio communications in their day-to-day operations, which involve safeguarding safety and preventing accidents from occurring. These entities also play important roles in supporting first responders once an incident does occur. In all their operations, they have many of the same needs as Public Safety agencies. Additional information on the communications requirements of public service providers is provided in Annex C of the subcommittee report.
- 4.1.18 ▶ Encryption is becoming increasingly important for both voice and data communications, especially in criminal justice operations. The Federal government generally identifies a greater need for secure, encrypted communications than do state and local agencies (excepting law enforcement).
- 4.1.19 ▶ Public Safety systems need quick expandability to accommodate peak use. Although normal day-to-day operations may not require high capacity, in times of disaster, for example, many new users may come on a system simultaneously. Expansion capacity must be engineered into systems. This is especially true of emergency management and disaster services, which are characterized by very low usage patterns on a day-to-day basis, but extremely high use during a major event such as an earthquake, hurricane or flood.
- 4.1.20 ▶ Interference is a problem along international borders. Public Safety entities operating in these areas report interference on both VHF and UHF frequencies.

### **Recommendations**

- 4.1.21 ▶ A system of mutual aid links should be available based on the following priorities:
  - 1) Disaster and extreme emergency operations for mutual aid and interagency communications;
  - 2) Emergency or urgent operations involving imminent danger to life or property;
  - 3) Special event control, generally of a preplanned nature;
  - 4) Single agency secondary communications.
- 4.1.22 ▶ Current frequency allocations to Public Safety in the HF bands should be maintained to provide for long-range communications, but limitations on intrastate use, and “day/night” restrictions should be removed.

**4.2 TECHNOLOGY SUBCOMMITTEE SUMMARY**

**Overview**

4.2.1 The Technology Subcommittee (TESC) was chartered to review the technologies now used by Public Safety agencies and identify the emerging technologies that may serve Public Safety agencies' needs in the future. A special focus was on those technologies that offer advances in spectral efficiency or new services to meet the community's growing needs.

**General Observations**

4.2.2 Wireless communications, mobile and portable, provide an essential resource for Public Safety operations. The revolution in microelectronics and computers has brought and will continue to bring enormous improvements in the performance of these systems. Improved electronic systems also change the ways Public Safety agencies can use wireless communications systems, offering advanced data and video systems that can lead to tangible improvements in saved lives and property. In assessing the role of technology in Public Safety communications, the subcommittee evaluated the benefits of technological trends and the impact of technology on spectrum requirements.

4.2.3 In evaluating technology effects, the subcommittee examined a range of specific technology advances, as shown in the following table:

Table 4-2-1

<b>Expected Advances in System Building Blocks</b>	
<b>Technology Building Block</b>	<b>Observations</b>
Digital Integrated Circuits	Integrated circuit progress is expected to continue at historical rates with a factor of ten improvement every five years. These advances will allow designers to incorporate more processing, more storage, better compression algorithms, and more efficient modulation techniques into radios. These advances will also permit building complementary equipment (such as affordable personal digital cameras) which will require additional communications resources.
Batteries and other RF Generation Equipment	Batteries are expected to become lighter. Battery saving technology, such as sleep modes, is expected to become more effective and widespread. Oscillator stability will improve. In some applications, antennas will be replaced by smart antennas which will reduce interference and allow for lower-power operation, greater range, or greater frequency reuse.

Table 4-2-1

<b>Expected Advances in System Building Blocks</b>	
<b>Technology Building Block</b>	<b>Observations</b>
Source Coding (Compression)	Trends indicate that we will be able to compress voice and image signals significantly more than is possible today.
Modulation	Trends indicate that we will be able to transmit more information in each unit of bandwidth.
Multiple Access Techniques	<p>A variety of techniques are used today to access channels including:</p> <p style="text-align: center;">FDMA (frequency-division multiple access),            TDMA (time-division multiple access), and            CDMA (code-division multiple access).</p> <p>Each channel access technology has its specific advantages and disadvantages. The subcommittee does not project that any new multiple access technique would be of significant importance during the next fifteen years.</p>
Error Correction Coding	<p>The land mobile radio channel is challenging. Received digital signals normally contain some bits with errors. Error correcting coding allows these bit errors to be corrected or detected.</p> <p>The Technology Subcommittee projected the widespread use of error-correcting coding technology in land mobile communications.</p>

### Specific Findings

- 4.2.4 **General:** The revolution in microelectronics and computers has brought and will continue to bring enormous improvements in the performance of wireless technology. Improved electronic systems also will change the ways Public Safety agencies can use wireless communications systems. There was no need for wireless access to digital messaging systems until digital messaging systems came into being. While voice communications has been, and remains today, by far the most important Public Safety application of wireless technology, it appears highly likely that non-voice communications, most importantly data and image communications, will become increasingly important and will account for a major portion of all Public Safety wireless communications by the year 2010.
- 4.2.5 In the year 2010, a great many of our requirements will be served by some technology which has not yet even emerged from the research labs. Remember that the first

- trunking systems were only deployed in the very late 70s, and the first cellular systems went commercially on-line in the early 80s. The most pervasive technology of the year 2010 may be just emerging, or may not yet have emerged. But undoubtedly, the cutting edge technologies of today will still be employed for 15 years.
- 4.2.6 **Voice:** Most Public Safety communications systems use analog FM technology operating in 25 or 30 kHz channels to carry their voice signals. Public Safety communications systems normally operate using a variant of one of two basic methods: repeater and trunked. The key attributes of voice communications systems are availability, delay and clarity. Public Safety systems are designed to maximize availability and minimize delay. Clarity, the ability to recognize the individual speaking, is an important feature.
- 4.2.7 While digital voice is a technological reality, it is little used today in Public Safety communications. It is expected that more digital voice systems will be offered by several manufacturers in the Public Safety market in the next few years.
- 4.2.8 Increasingly, voice is transitioning to digital transmission. High quality digital speech in land mobile channel bandwidths could not be implemented in affordable technology until recently. Digital transmission provides mechanisms to combat the familiar static and pop effects that radio reception impairments traditionally caused to analog transmission. Digital signals can be encrypted to prevent interception far more easily, reliably and effectively than can analog signals.
- 4.2.9 **Data:** Today data communications capabilities are used in Public Safety for such purposes as digital dispatch and checking computer data bases for information associated with wanted persons/property and vehicle registration license plates. Data today is typically sent over the voice channel or by a separate radio. Many of the early Public Safety data communications systems used circuitry much like telephone modems to create a voice-like signal which could both carry the data and travel over the analog voice paths of the Public Safety radio communication systems. Such hybrid systems are still widely used today.
- 4.2.10 With the growth in the use of computers and associated reductions in the cost of computing equipment has come an increased demand for data communications capabilities. Data rates range from 0.3 to 19.2 kbps in a 25 kHz channel. Use of mobile data terminals (MDTs) is growing rapidly. More recently, manufacturers have begun to provide radio systems that are fully digital and that can carry data directly on the radio channel.
- 4.2.11 Key attributes of data communications systems are message/file size, reliability, error control, and encryption. Transmitting high speed data reliably on mobile radio channels is an enormous engineering challenge as compared to transmitting via wire, cable, microwave, fiber optics or other similar carriers.

- 4.2.12 **Image:** Images represent a special category of data that is a numeric representation of a picture. Still images include snapshots such as accidents, and crime scenes, mug shots, fingerprints, and a wide variety of other images. Today, there is relatively little use of still image transmission to and from the field in Public Safety. The rapid increase in use of “wire-line” based facsimile transmission and similar image technologies within the Public Safety services has paralleled that within the broader economy. It is expected that such systems will be deployed in ever increasing numbers over the next decade and a half.
- 4.2.13 Emergency medical providers desire the ability to transmit images of the injured from paramedic units back to trauma centers or hospitals to aid in diagnosis and pre-arrival treatment. Fire agencies desire the ability to transmit building plans and copies of permit and other data for fire prevention and protection. Law enforcement agencies need to quickly transmit fingerprints from field units back to federal, state, and local databases; units need the capability to receive mugshots and drivers license photographs to aid in identifying people in the field.
- 4.2.14 Key attributes of image communications systems include resolution, B/W vs color, compression, and error control. The subcommittee report outlines existing standards for facsimile and snapshots. Medical services will need high resolution imaging.
- 4.2.15 The typical passport photo of 2 inch square black and white results in only 1 or 2 kilobytes, while a full-color still from a video camera may exceed a few hundred kilobytes, and a high-definition (several hundred dpi) scan of a color photo can easily reach several megabytes. Image translation can convert higher resolution into a smaller form for transmission, although the reverse is not generally achievable. A notable exception is the emerging technology known as fractal image coding. It promises highly compressed image formats which are rescalable without loss of quality at the destination.
- 4.2.16 **Video:** Wireless video systems have seen limited use in state and local Public Safety services to date primarily due to a lack of available Public Safety spectrum over which to implement these systems. Video is used in Public Safety today primarily for surveillance of crime scenes and of highways. The fire service uses full motion video extensively in some areas, primarily to monitor wildland fire scenes from airborne platforms, providing real-time video back to emergency command centers. Law enforcement agencies, particularly at the federal level and which have spectrum available for video, have long used video for surveillance purposes. State and local agencies have only recently begun to implement similar systems for monitoring areas of high crime and drug use. State and local transportation agencies have implemented wireless video systems to monitor traffic flow and detect collisions and hazards on roadways in congested metropolitan areas. There is a growing need for full motion video for use with robotic devices in bomb, hostage, hazard avoidance and hazardous materials situations.

- 4.2.17 Key attributes of video communications systems include frame rate, resolution and color level, error control, and compression. Today, video images are normally transmitted using analog modulation. Wideband channels (several megahertz) are normally used to carry full-motion, high-quality video. However, only very limited spectrum is available to state and local agencies. In the future, we expect that most Public Safety video communications will be digital. Currently, however, compression equipment is still expensive and standards are changing rapidly. The coming of affordable digital video cameras and affordable digital compression can be expected to lead to substantial growth in the requirements for Public Safety video communications.
- 4.2.18 **System Fundamentals: Digital Integrated Circuits.** The fundamental technology thrust through the year 2010 will be, as it has been in the recent past, that of semiconductor technology. The improvements in semiconductor processing and materials have resulted in roughly an order of magnitude advance every five years. Rapid advancement is also observed in the progress of microprocessor technology over the last two decades.
- 4.2.19 Batteries. The batteries required to operate portable communications equipment are usually heavy, provide limited hours of operation, and can be expensive. A number of developments in battery technology are alleviating this situation. Some involve new technologies, such as nickel-metal-hydride and lithium-ion batteries. Another development is a zinc-air battery that draws oxygen from the atmosphere to extend its life. Power saving solutions that make more efficient use of battery power by communications equipment hold promise for extending battery life further; more power efficient amplifiers and more efficient sleep modes are examples of ways in which battery life may be increased.
- 4.2.20 Oscillators. Spectrum efficiency is improved if more communication channels can be placed within a given band of spectrum. In the past, the ability to decrease the channel size has been limited by both the transmission bandwidth and frequency stability concerns. Frequency stability in land mobile radio has also benefitted from improvements in semiconductors. Improvements in frequency stability can be used to enhance spectrum efficiency even when channel spacing is not reduced because the guard bands around the occupied bandwidth of each transmission can be reduced. The information content of the transmitted signal can be increased while maintaining acceptable adjacent channel splatter. This is important because reductions in guard bandwidth are limited by adjacent channel splatter considerations.
- 4.2.21 Antennas. Smart antennas is a term applied to a family of technologies that generally integrate active antenna elements with microprocessor technology. By changing the current distribution of the array, the shape of the beam can be changed electronically in real-time.
- 4.2.22 Diversity is a commonly used technique for improving the quality of both digital and analog signals. When the new technique of single sideband is employed the use of multiple antennas becomes a virtual necessity, as when the vehicle is traveling at high

- speed, signal will become distorted due to phase shift. The most common form of diversity is space diversity, which is implemented using two appropriately spaced antennas. Another method being researched is a one-piece diversity antenna system that uses two antenna elements that performs the signal combining function in the antenna base. Maximal ratio diversity combining is a third diversity technique which is used to combat fading. The advantages of these techniques must be weighed against the disadvantages.
- 4.2.23 Source Coding. Using today's systems, additional traffic demands can only be met by increases in the available spectrum. However, the demands can, at least in part, be offset by utilizing semiconductor advances to make more efficient use of the limited spectrum resources. Information compression allows reduction in the amount of information which must be transmitted on the communications channel. Digital speech encoding has received significant attention of late. This means of transmitting speech leads naturally to encryption which is one very important aspect in many Public Safety communications scenarios. Looking to the future, it can be expected that increasingly powerful digital signal processing IC's will facilitate the introduction of more powerful and effective methods for reducing the amount of information that must be transmitted on the communication channel.
- 4.2.24 As digital processing capability improves, higher complexity compression algorithms will become viable, increasing the compression ratios possible for these services. Thus, by the year 2010, compression schemes more than ten times as complex as those of today should be viable for Public Safety radio. As a result, an assumption of a 3:1 increase in source coding efficiency for fax by 2010 seems reasonable. For full-motion video, a 2:1 improvement over today's compression ratios, or roughly 0.25 bits/pel, should be achievable by the year 2010. For slow video, a 3:1 increase in slow video coding efficiency is indicated when we it is assumed that MPEG-4 will be implemented by 2010.
- 4.2.25 Modulation. Another method of improving improved spectrum efficiency is to increase the amount of information that the communication channel can support. Nonlinear constant-envelope systems have approached 1.28 bit/sec/Hz, considered to be the limit for those systems. Linear modulation, based on newer SSB-based techniques, is expected to be able to improve this efficiency to approximately 5 bit/sec/Hz by the year 2010; while such linear modulation narrowband techniques have long been used in other applications, the engineering challenges of matching them to mobile communications channels have only recently been overcome in commercially available products.
- 4.2.26 Multiple Access Techniques. FDMA, TDMA, CDMA, and TDD are different channel access methods. In FDMA (Frequency Division Multiple Access), different conversations are separated onto different frequencies. In TDMA (Time Division Multiple Access), different conversations are separated into different time slots. In CDMA (Code Division Multiple Access), all conversations are separated by code space. And in TDD (Time Division Duplexing multiple access), a single channel is

shared in time to achieve full duplex operation. Each has specific strengths and weaknesses.

- 4.2.27 Error Correction Coding. In radio systems the primary goal is to reliably deliver communications. In digital communications systems this equates to maximizing the ability to successfully receive digitally coded messages. One method of improving signal reception that is specific to digital communications is to employ error control that add bits to the data stream in a precise fashion. Two types of error control techniques are Forward Error Correction (FEC), which provides the ability to receive a correct message even in the presence of transmission errors, and error detection employed in concert with Automatic Repeat reQuest (ARQ), which uses a return channel to request retransmission of corrupted data. FEC is more commonly used in voice communications or one-way error detection and ARQ are more commonly used in two-way data communications.
- 4.2.28 Software Radios. Software programmable radios, in which applications are configured under software control, makes it possible to implement multiple military, law enforcement, and commercial air interface standards in a single radio, despite different physical layers (modulation, frequency bands, forward error correction), link layers (link acquisition protocols, link maintenance, frame/slot processing), network layers (network protocols, media access protocols, network time maintenance), upper layers (source coding), timebases and bandwidths. There are many challenges, however, to producing a practical and economical software programmable radio for law enforcement applications; software radios are now much more expensive than hardware-based radios, with the market being largely confined to military applications. It has been projected that, within a few hardware generations, software radios will sufficiently leverage the economics of advancements in microelectronics, and provide seamless communications at a vest-pocket and palmtop level of affordability and miniaturization.
- 4.2.29 Backbone Systems. Most Public Safety mobile communications systems need a reliable backbone to carry signals to and from the base station sites to the control points. Historically, many of these links have been provided over microwave connections operated by the Public Safety agency. Leased lines obtained from the local telephone companies have also been used. It is expected that the future supply of backbone system elements will look much like the past but with two major exceptions. First, the lowest microwave frequencies (2 GHz) are no longer available for such backbone systems. The second exception is the supply of facilities by the local carriers; historically, only one firm, the local telephone company, provided telecommunications services for hire. However, changes in law and technology have led to the entry of new competitors in many markets and the probability of extensive further entry. Considering all these factors it is reasonable to conclude that these commercial fiber systems could provide valuable backbone alternatives for many Public Safety communication needs. However, the use of any ground-based carrier for Public Safety systems in earthquake-prone areas may be undesirable. In contrast, in

areas affected by hurricanes, such as the southeastern coastal areas, an in-ground fiber network could be preferred.

- 4.2.30 Performance Modeling. As wireless communications systems evolve, the complexity in determining compatibility among different types of such systems increases. Geography, frequency, modulation method, antenna type, and other such factors impact compatibility. Spectrum managers, system designers and system maintainers have a common interest in utilizing the most accurate and repeatable modeling and simulation capabilities to determine likely wireless communications system performance. The Telecommunications Industries Association TR-8 WG-8.8 Technology Compatibility Committee is working under a charter and mission statement to address these technical challenges.
- 4.2.31 Many present and future technological capabilities are (or will be) developed for large commercial service providers or government systems. Public Safety agencies often utilize the existing commercial services as an adjunct to the systems which they have developed to provide their essential services. Those essential services (such as voice dispatch) may have unique operational, availability, or security needs, or may be more economically feasible and desirable. In the future, as usage of and dependence on these services increase, Public Safety agencies might elect to “partner” with commercial services (for customized services or features), or develop their own systems utilizing similar technologies.
- 4.2.32 Mobile Satellite Systems. Satellite systems support thousands of voice channels and in many spot beams are used so that some frequency reuse is possible. Satellite services can be completely digital thereby facilitating encryption systems, as well as commercial voice privacy alternatives. Public Safety agencies and others may lease dedicated channel(s) for their exclusive use. Dispatch, push-to-talk, and “party line” talk group services are available. Priority designations will be lost when communications enter the Public Switched Telephone Network (PSTN) as they are currently configured unless dedicated lines are provided between gateway stations and public service agencies.
- 4.2.33 Cellular. Current cellular telephone systems have several attributes which limit their appeal to Public Safety users. They are designed to provide adequate capacity during most peak periods, but they are still vulnerable to overload and abuse during large incidents or special activities. In spite of these limitations, cellular telephones are able to meet certain aspects of Public Safety communications needs. They are useful for communications between Public Safety field personnel and the public being served. Cellular telephones are also preferred by many Public Safety agencies as an alternative to carrying telephone interconnect traffic (and consuming large percentages of available capacity) on essential voice channels.
- 4.2.34 Cellular Digital Packet Data (CDPD). Even with the proliferation of analog cellular systems, circuit switched communications are still not popular for general data applications. Circuit switched usage fees are based on connect time, not data volume.

- Short interruptions during hand-offs between cell sites are often imperceptible during voice conversations, but most data communications equipment sends (and expects to receive) a continuous carrier signal. Cellular Digital Packet Data (CDPD) systems were developed to transport data to (or between) cellular users without the need to set up a traditional call. Without some method to provide priority access, CDPD users are subject to the same delays or unavailability of service during peak periods that traditional voice users encounter.
- 4.2.35 Personal Communications Systems (PCS). PCS are an emerging commercial technology. Due to propagation characteristics of the band, most 2 GHz systems are expected to be developed using a micro-cellular architecture, serving the most populous metropolitan areas using a network of closely spaced stations. Service in lower demand areas will be provided by systems with antenna heights, output power levels, and coverage areas which are more in line with today's cellular systems. Both are intended to provide subscribers with enhanced features and untethered access to the public switched telephone network. Personal Communications Services are under development as of this writing, but indications are that the successful licensees will select and implement differing technologies, even for similar systems in adjacent areas or bands; thus limiting not only competition, but interoperability and mobility as well. The lack of standards is likely to impede the ability of some PCS users to roam nationwide using "local subscriber equipment," or to select between carriers to the extent that current cellular telephones allow.
- 4.2.36 Specialized Mobile Radio (SMR) services were established by the FCC in the mid-1970's with the allocation of a portion of the 800 MHz band for private land mobile communications system. SMR systems are characterized by a single high-power, high-elevation base station for maximum coverage. The versatility of the SMR industry and its relationship to Public Safety because of the dependence of both on dispatch as a primary service will continue to be attractive as the SMR industry becomes more sophisticated and integrated.
- 4.2.37 Enhanced SMR. The latest systems, based on digital technology, are known as Enhanced SMR (ESMR) or wide-area SMR systems. ESMR systems are typically characterized by a network of base stations in a cellular-type configuration. They are several times as spectrum efficient as SMR systems and offer enhancements including the consolidation of voice dispatch, telephone interconnect and data services into a single portable/mobile subscriber unit. Regardless of the type of SMR/ESMR service, the Public Safety agency must insure that the coverage, security, priority access and reliability factors associated with each service provider/operator will meet the requirements of the applying agency.
- 4.2.38 Paging. Today, over 27 million people use commercial paging services. Continued use and increased dependence are expected for many Public Safety functions. New higher speed, multi-level paging protocols have been developed to increase the efficiency of paging networks, while maintaining backward compatibility with existing (lower speed) devices. With increased transmission speeds, higher content messages

(such as facsimiles) can also be delivered to paging receivers with reasonable latency. Advanced paging systems being introduced today allow peer-to-peer communications between pagers, by allowing the initiation of messages from pagers to the network over the reverse channel. Future two-way paging applications are likely to include services like AVL and individual-based GPS services, telemetry services, and interoperable services on dual devices with other wireless providers.

## Findings

- 4.2.39 ▶ New technologies generally produce two important, but counterbalancing effects for the Public Safety community. First, improvements in technology such as digital transmission and advanced modulation techniques permit users to increase the amount of traffic that can be transmitted over any given amount of spectrum. This phenomenon, considered alone, would minimize the requirements for new spectrum. However, the second corresponding effect of technology advances is the creation of a new range of functions and features. These additional capabilities such as high speed data and video transmission require additional spectrum to fully exploit.
- 4.2.40 ▶ In the year 2010, a great many requirements will be served by some technology which has not yet even emerged from the research labs. However, several aspects of future technology are fairly well agreed upon by examination of technical trends, regardless of whatever specific technology may emerge within the next decade.
- 4.2.41 ▶ Technology is constantly improving spectrum efficiency. Improvements in semiconductor processing and materials have resulted in roughly an order of magnitude advancement every five years. Rapid advancements in microprocessor technology has also been observed over the last two decades. Although theoretically possible to approach gains of 8:1 based on 25 kHz analog by the year 2010, it is appropriate to set the factor to 4:1 for planning purposes. A 4:1 efficiency recognizes the practical limit of advances over the intervening years; that is, doubling (2:1) in five years, doubling again in another five (4:1), then doubling again in five more years (for a 8:1 improvement in 15 years). Further, within current Public Safety bands, there will be an established base of equipment that will have to be amortized and withdrawn from service before full benefits of any advanced technologies can be realized. Additionally, many of the emerging Public Safety technologies (video and high speed data, for example) will require significantly wider bandwidths than the current 25 kHz channel for analog voice.
- 4.2.42 ▶ Digital technology will be the key technology for the future. A digital signal format is assumed by most of the bandwidth efficient methods employed today. Digital is essential to data transmission. Digital appears to be superior for secure communications technology. Nevertheless, there is a vast investment in existing analog voice communications technology which meets

communications needs today and which will last for a long time. Analog equipment with 10 to 20 year lifetimes will continue to be installed for several years. Current Public Safety digital equipment offers approximately a 2:1 improvement in spectrum efficiency over 25 kHz analog. Consequently, the Public Safety community will operate with a mix of analog and digital equipment (a mix shifting towards digital) for the foreseeable future.

- 4.2.43 ▶ Trunking will become increasingly prevalent as the technology for trunking control becomes deployed and copied in what are currently known as conventional systems.
- 4.2.44 ▶ Improvement in technology unrelated to voice, such as data, will be driven by dramatic technology improvements in computers. It is quite conceivable that computer spectrum efficiency may be more important than voice spectrum efficiency in 2010. Imaging technology will be driven by improvements in digital signal processing (DSP) technology, which should also be dramatic in a decade.
- 4.2.45 ▶ Spectrum efficient technology includes low bit-rate speech coding. Speech coding trends have already left the concept of “waveform coding” behind, where the ability to reproduce the exact analog speech waveform is lost. This property, employed commonly in land-line telephony where wire bandwidth is less of an issue, permits voice to be converted back and forth from analog to digital at will without loss of quality. Low bit-rate speech coding also produces greater speech delay. Barring currently unexpected innovation in transcoding, this means that interoperability between systems with different speech coding technologies will likely suffer quality loss and increased speech delay, even when patched through infrastructure.
- 4.2.46 ▶ Direct interoperability over-the-air does not appear possible between systems with different speech coding technologies, bit rates, modulations, formats, access method, or any other attribute associated with the air-interface of a given RF system.
- 4.2.47 ▶ Without any significant coordination, disparate systems will achieve analog interoperability using a common base-line interoperability technology (analog FM). This can serve both analog speech or data that is converted to a speech bandwidth signal in a fashion similar to using modems over telephone. Data transmitted via analog transmission are subject to no more coordination than generally practiced today requiring compatible modems on both sides of a telephone link. Data speed is significantly less than compared to direct digital transmission.

### 4.3 INTEROPERABILITY SUBCOMMITTEE SUMMARY

#### Overview

- 4.3.1 Interoperability between and among wireless communications systems used by federal, state, and local Public Safety agencies is generally accepted to be not only desirable, but essential for the protection of life and property. Hence, a key activity of the PSWAC was to “advise the NTIA and FCC on options to provide for greater interoperability among federal, state, and local Public Safety entities.” Within the PSWAC structure, interoperability issues were addressed by the Interoperability Subcommittee (ISC).
- 4.3.2 In its deliberations, the Interoperability Subcommittee and ultimately the Steering Committee adopted the following formal definitions of *Public Safety*, *Public Service*, *Interoperability*, and *Mission Critical*:
- 4.3.2.1 ***Public Safety:*** *The public’s right, exercised through Federal, State or Local government as prescribed by law, to protect and preserve life, property, and natural resources and to serve the public welfare.*
- 4.3.2.1.1 ***Public Safety Services:*** *Those services rendered by or through Federal, State, or Local government entities in support of Public Safety duties.*
- 4.3.2.1.2 ***Public Safety Services Provider:*** *Governmental and public entities or those non-governmental, private organizations, which are properly authorized by the appropriate governmental authority whose primary mission is providing Public Safety services.*
- 4.3.2.1.3 ***Public Safety Support Provider:*** *Governmental and public entities or those non-governmental, private organizations which provide essential public services that are properly authorized by the appropriate governmental authority whose mission is to support Public Safety services. This support may be provided either directly to the public or in support of Public Safety services providers.*
- 4.3.2.2 ***Public Services:*** *Those services provided by non-Public Safety entities that furnish, maintain, and protect the nation’s basic infrastructures which are required to promote the public’s safety and welfare.*
- 4.3.2.3 The term *Public Safety*, as defined, extends to all applicable functions of government at the federal, state and local levels, including Public Safety operations on Department of Defense facilities. There are two levels of Public Safety providers. The *Public Safety Services Provider* definition is focused toward entities performing such duties as emergency first response and similar activities. The Interoperability Subcommittee Workgroup recognized that this

particular definition did not adequately cover the diverse Public Safety community and it was necessary to include another level of provider, the *Public Safety Support Provider*. This was in accordance with the question encountered by the Operational Requirements Subcommittee during the process to identify entity-specific needs. The Operational Requirements Subcommittee acknowledged that although a particular organization's primary mission might not fall within the classic Public Safety definition, some aspects of its operations could involve or impact Public Safety. The *Public Safety Support Provider* definition is meant to include entities whose primary mission is other than Public Safety services, but which may provide vital support to the general public and/or the Public Safety Service Provider.

- 4.3.2.4 The ISC also addressed Public Safety Service Providers that were non-governmental. Properly authorized non-governmental, private organizations performing Public Safety functions on behalf of the government are included in these definitions. The need for this portion of the definition is becoming more evident with the privatization of certain governmental services. For example, a number of local governments contract private organizations for emergency medical and/or ambulance service. Although private, these entities are authorized by the applicable government entity to provide life-saving functions on its behalf. Specific licensing concerns have been surfaced through this mode of operation and will be discussed in a later section of this report.
- 4.3.2.5 ***Interoperability:*** *An essential communication link within Public Safety and public service wireless communications systems which permits units from two or more different agencies to interact with one another and to exchange information according to a prescribed method in order to achieve predictable results.*
- 4.3.2.6 *The communications link, whether infrastructure dependent or independent, must satisfy one or both of the following requirements:*
- 4.3.2.6.1 ***Multi-jurisdictional:*** *Wireless communications involving two or more similar agencies having different areas of responsibility. Some examples include a fire agency from one city communicating with a fire agency from another city and the Federal Bureau of Investigation (FBI) communicating with a County Sheriff.*
- 4.3.2.6.2 ***Multi-disciplinary:*** *Wireless communications involving two or more different agencies. Some examples include a police agency communicating with a fire agency and a parks agency communicating with an emergency medical services agency.*
- 4.3.2.6.3 *The communications link may involve any combination of subscriber units and fixed equipment (e.g., repeaters, dispatch positions, data resources). The points of communication are dependent upon the*

*specific needs of the situation and any operational procedures and policies which might exist between the involved agencies.*

- 4.3.2.6.4 *The communications link may be classified as either of the following two types:*
- 4.3.2.6.5 *Infrastructure independent: The communications link occurs between subscriber units over a direct RF path. An example is portable-to-portable tactical communications at the scene of an incident.*
- 4.3.2.6.6 *Infrastructure dependent: The communications link requires the use of some items(s) of equipment, other than a subscriber unit, for establishment of the link and for complete subscriber operation. Some examples include a communications link for which a repeater station is required; a communications link which provides full system coverage for a visiting subscriber unit within a host trunked radio system; and a communications link which provides interconnectivity between two or more otherwise incompatible radio systems by cross-connecting the audio signals and/or appropriate signaling functions at some central point.*
- 4.3.2.7 *Mission Critical: A mission critical communication is that which must be immediate, ubiquitous, reliable and, in most cases, secure.*
- 4.3.2.7.1 *EXPLANATION: An “immediate” communication must be capable of being transmitted and received instantaneously, without waiting for a system to be set up, a clear channel or a dial tone. A “ubiquitous” communication is that which can be transmitted and received throughout the area that the mission requires. A “reliable” communication system must be designed, constructed and maintained such that short-term disruptions are minimal. Finally, security, while not currently available in many situations, is increasingly a requirement for law enforcement and other sensitive communications. In this case, “security” is provided with “voice privacy” encryption.*

### **General Observations and Specific Findings**

- 4.3.3 **Interoperability Needs of Public Safety:** The ISC identified requirements for three different types of interoperability missions in Public Safety communications — day-to-day, mutual aid, and task force. The ISC described the *day-to-day* requirement as the most commonly encountered type of interoperability and one which is typically associated with areas of concurrent jurisdiction where agencies need to monitor each other’s routine traffic. For example, the day-to-day requirement might arise when a county sheriff’s department wants to monitor the radio traffic on a police system operated by a large city within the county and *vice versa*. Such interoperability

- minimizes the need for dispatcher-to-dispatcher interaction in the exchange of information among units in the field.
- 4.3.4 The ISC described the *mutual aid* requirement as often involving interoperability among multiple agencies under conditions that allow little opportunity for prior planning for the specific event — *e.g.*, riots or wildland fires. In its description of this type of interoperability, the subcommittee noted that there is often a requirement to establish communications among numerous small groups with each group having its own individual talk group or frequency. Such communication is referred to as tactical, and once the responders are on the scene, it typically involves the use of portable radios.
- 4.3.5 The ISC described the *task force* requirement as often involving communications among agencies representing several layers of government (federal, state, and/or local) under conditions that typically allow for prior planning. In its description of this type of interoperability, the ISC noted that (i) it usually involves the use of portable and/or covert equipment, (ii) it often requires extensive close-range communications, and, (iii) due to the nature of the communications traffic involved, long range transmission is undesirable.
- 4.3.6 The subcommittee conducted much of its analysis in the context of the Incident Command System (ICS). The ICS is a standardized method of operation for Public Safety agencies during large-scale emergency incidents. It has a hierarchical structure which identifies lines of reporting (communications) throughout the organization. This, in turn, provides a framework for assessing communications needs. The Interoperability Subcommittee concluded that interoperability solutions for large scale events such as wildfires necessarily encompasses solutions for lesser events.
- 4.3.7 **Obstacles to Interoperability:** As part of its analysis, the ISC studied how interoperability requirements are being met today. As a result of that analysis and taking into account future interoperability needs, the subcommittee identified a number of obstacles to achieving interoperability under current conditions. The obstacles or constraints identified included, among others, (i) the diversity of spectrum resources (bands) utilized by Public Safety agencies, (ii) the sheer scarcity of channels for interoperability, (iii) certain human and institutional factors, (iv) the lack of common communications modes among different types of systems, (v) the lack of congruent coverage among different systems for which interoperability is desired, (vi) the limitations of current commercial systems in terms of their reliability, priority access and command and control characteristics in Public Safety applications, and (vii) the lack of an adequate nationwide mutual aid plan and incident command system to facilitate the interoperability.
- 4.3.8 ▶ The first obstacle, the diversity of spectrum resources, reflects the fact that Public Safety agencies, federal, state, and local, use a total of ten radio bands that range from a low of 30 MHz to over 800 MHz. No single, commercial grade radio is capable of operating in all of the bands utilized by different

agencies. Thus, individual agencies may be prevented from communicating with another agency simply because their individual radio systems operate in different frequency bands.

- 4.3.9 ▶ The second obstacle is the general lack of channels available for interoperability. In some cases this may stem from inadequate planning or an overriding need to utilize all available channels to satisfy routine operational demands, but in any event, the subcommittee observed that few channels have been designated and made available to satisfy interoperability requirements.
- 4.3.10 ▶ The third obstacle involves certain human and institutional limitations or constraints including the ability of a human operator to remember the specific channels assigned for interoperability and the reluctance of some agencies to allow their units to join another system when it jeopardizes their ability to maintain communications with their own personnel.
- 4.3.11 ▶ The fourth obstacle, the lack of a common communications mode, reflects the fact that, even if the units from different systems operate in the same band, they may not be able to communicate because they use different transmission or signaling techniques. For example, one system may use an analog modulation technique (*e.g.*, FM) while the other may use a digital modulation technique or the two systems may be using proprietary, trunked or digital radio systems provided by different manufacturers.
- 4.3.12 ▶ The fifth obstacle refers to the fact that, even with infrastructure dependent systems that employ some type of gateway to allow communications between units on their respective systems, they still may not always be able to communicate because the coverage areas of the two systems do not completely overlap.
- 4.3.13 ▶ The sixth obstacle, limitations of current commercial systems, reflects the fact that while in theory, commercial systems could be used to achieve interoperability, they currently lack certain characteristics that are deemed critical in Public Safety applications.
- 4.3.14 ▶ The seventh obstacle reflects the fact that, for numerous reasons, there is a lack of an adequate nationwide mutual aid plan and incident command system to facilitate the required degree of interoperability.
- 4.3.15 **Interoperability Solutions:** The ISC defined multiple levels of technological solutions to interoperability, both short term (defined to be within five years) and long term. These solutions can be categorized into infrastructure independent versus infrastructure dependent, both of which have ranges from simple to complex solutions. These solutions are not mutually exclusive and the optimum solution may use various combinations, especially as the interoperability requirement escalates from day-to-day to mutual aid or task force levels.

- 4.3.16 *Infrastructure independent methodologies* are communication links directly between radios over a direct RF path. These solutions are typically used for close proximity communications by multiple disciplines and jurisdictions converging on the scene to support the public needs. They are also used when radios are out of range of their infrastructure coverage, such as in rural areas or some in-building communications. Common analog FM technology and mutual aid frequencies allow users to communicate regardless of radio manufacturer. Widespread implementation of infrastructure independent interoperability is hindered by a number of significant issues discussed within the ISC report, including the diversity of radio frequency spectrum in which Public Safety agencies operate, the critical shortage of spectrum available and designated for interoperability, the introduction of new technology creating the risk that a common mode of interfacing over-the-air will hinder interoperability, and other factors discussed in the report.
- 4.3.17 More complex solutions include development of broad band, dual band and multi-band radios. Commercial viability of these approaches is yet to be proven.
- 4.3.18 *Infrastructure dependent methodologies* and technologies require the use of some item(s) of equipment, other than a subscriber unit (radio), to establish a communications link and for complete radio operation. These solutions are typically used for wide area communications, where individual users are not within direct range of each other, and for on the scene communications where they may not have a common operating channel. This interconnection can be a temporary or permanent connection and can be accessed through a number of locations using various access methods. Once a permanent solution is in place, it can be idle in standby mode and be activated immediately when required, if all participating systems are operational.
- 4.3.19 Gateways between two or more system infrastructures can provide viable infrastructure dependent solutions at various degrees of complexity and may be one of the few available solutions in the short term. They can interconnect systems operating in different frequency bands, modes of operation, and manufacturer protocols. Most trunked radio systems require predetermined user or "talk" groups to be identified and programmed into the system. As systems become larger and additional user groups are identified, the problem of interconnecting users from other systems or non-trunked users becomes more complex. Gateways may be one of few viable short term solutions that can be implemented without modifying existing radios to bridge the different Public Safety frequency bands.
- 4.3.20 Infrastructure dependent methodologies and technologies have several disadvantages. First is that each participating network must have similar geographic coverage because interoperability is limited to the common overlap areas of the participating systems. Interoperability fails if any infrastructure is damaged or otherwise inoperable. Networks must generally be in place prior to an incident requiring their use because most often there is neither time nor opportunity to set up these solutions during emergency incidents. Deployable infrastructures can mitigate this problem, however,

the degree of delay getting this equipment deployed often depends on the destruction severity of a disaster.

- 4.3.21 *Joint-use and Shared Systems* or consolidated systems covering the same geographic area, either conventional or trunked, readily provide interoperability to those agencies sharing the system. Consolidated systems allow multiple agencies to operate in the same frequency band using compatible equipment on the same infrastructure. These systems improve spectrum efficiency because they allow multiple agencies to interoperate without the need for additional spectrum.
- 4.3.22 However, unless non-resident radios are fully compatible with the system infrastructure, interoperability with other agencies not sharing this system will require a different methodology for achieving interoperability. Such interoperability is also subject to the same issues and disadvantages as the above solutions.
- 4.3.23 *New Interoperability Band:* Another solution approached by the ISC involves the creation of a single common Public Safety Interoperability Service (which is abbreviated as "PI") in one central band. The ISC feels this solution is both possible and practical. The band would be dedicated exclusively for interoperation applications but would require the user to have either dual band radios or two radio installations. This approach gives an absolute common technical solution to the common operating requirements of a mutual aid incident. A field unit (or hand-held) with the "PI" capability could interact with any other unit similarly equipped. This approach could offer a short term solution, depending on the frequency band that is selected by the Spectrum Requirements Subcommittee. This solution would likely require most Public Safety agencies to purchase an additional radio for the new "PI" band.
- 4.3.24 *Current Mutual Aid Channels:* The ISC supports the continued use of current Mutual Aid channels to support interoperability. Additionally, more channels must be designated in current bands to satisfy immediate needs. Moreover, the FCC and NTIA must allow more flexible licensing regulations regarding multi-government use of these channels.
- 4.3.25 *Commercial Services:* Public Safety agencies use commercial services, including cellular telephone, paging, satellite communications, Personal Communications Systems (PCS), specialized mobile radio (SMR) and enhanced specialized mobile radio (ESMR) systems as an adjunct or supplemental solution for their non-mission critical communications. They anticipate a continued increase in their use of commercial services in the future, particularly for administrative and non-mission critical applications. It has been concluded by the ISC that commercial service providers typically do not provide the required features, priority access and command and control required by Public Safety for mission critical communications and are not likely to meet all requirements within the Public Safety community. As new technologies emerge, objective experiments with and use of these systems will be necessary to determine the portion of Public Safety needs that can be satisfied.

## Recommendations

- 4.3.26 The ISC has concluded that the problems of interoperability cannot be resolved without additional spectrum allocated to Public Safety. Consolidating the number of bands used by federal, state, and local Public Safety agencies into fewer bands will enhance the opportunity for interagency interoperability but it must be offset by increases in the total amount of spectrum allocated to Public Safety use. To promote interoperability, such additional spectrum should be provided immediately adjacent to existing channels, and lend itself to possible consolidation in the Public Safety bands.
- 4.3.27 Specifically, the ISC recommends:
- 4.3.27.1▶ the establishment of a new Interoperability band. This solution may be a short term (less than five years) solution, depending on the availability of spectrum. This would require that a relatively free band of frequencies be identified, preferably central to existing Public Safety bands. Although the responsibility to identify spectrum rests with the Spectrum Requirements Subcommittee, the ISC suggests the UHF band below 512 MHz. Define specific frequencies and pairs of frequencies using developed Incident Command System (ICS) guidelines.
  - 4.3.27.2▶ that the FCC and the NTIA freely license these frequencies to all eligible Public Safety/service providers under operational as well as technical regulations and they restrict use to mutual aid interoperation.
  - 4.3.27.3▶ that the following interoperability links be established: 21 paired voice links and 20 simplex voice links within current bands. It is believed that existing designated interoperability frequencies can be used for 13.5 of the repeatered and 13 of the simplex voice links (i.e. an additional 7.5 paired and 7 simplex need to be designated in existing bands). Additionally, 31 repeatered voice, 70 simplex voice, 2 independent high speed data and 2 independent full motion video links must be provided in the new Public Safety Spectrum.
  - 4.3.27.4▶ that a national planning process be established as soon as possible to address a nationwide mutual aid plan, define operational policies and procedures, provide guidance and procedures for regional planning processes, and define incident command system requirements with all levels of government involved.
  - 4.3.27.5▶ that the minimum baseline technology for interoperability, for unit to unit voice communication, be 16K0F3E (analog FM), unless FCC and/or NTIA regulations stipulate a different emission in a specific operational band. This recommendation is applicable to Public Safety spectrum between 30 MHz and 869 MHz, and should be adopted as soon as possible by the FCC and NTIA. Effective January 1, 2005, the minimum baseline technology for interoperability, for unit to unit voice communication, should be mandated as 11K25F3E (analog FM) in Public Safety spectrum between 30 MHz and 512 MHz, unless

FCC and/or NTIA regulations stipulate a different emission in a specific operational band. The maximum allowable interoperability bandwidth in any new spectrum allocation should not be allowed to exceed the bandwidth established for operational communications within that new spectrum. It further recommends that a group comprising experts representing government, industry and users be organized to further address baseline technology for interoperability. This effort should be managed by a neutral third party with no vested interest in the outcome of the effort.

- 4.3.27.6▶ that any digital baseline standards for interoperability be open standards, developed/adopted in an open and fair process.
- 4.3.27.7▶ that, to allow multi-level government interoperability, FCC and NTIA regulations provide for equal access by both federal and non-federal Public Safety agencies.
- 4.3.27.8▶ that the regulatory aspects of the licensing by the FCC and NTIA of shared/consolidated systems by agencies covering the same geographic area be relaxed to allow for flexibility to encourage systems of this type.

## 4.4 SPECTRUM REQUIREMENTS SUBCOMMITTEE SUMMARY

### Overview

- 4.4.1 The mission of the Spectrum Requirements Subcommittee (SRSC) is to examine the overall spectrum requirements of both federal and non-federal Public Safety agencies through the year 2010. In order to accomplish this, the SRSC quantified a broad range of factors to develop a realistic model for spectrum needs in the year 2010 and tested its assumptions against other empirical data and models to ensure consistency and reliability. The results of the SRSC's efforts conclude that 129.3 MHz of mobile spectrum overall — including 95.3 MHz of *new* spectrum — will be required for Public Safety officials to continue to protect life and property efficiently and effectively in the year 2010. Of this spectrum, at least 25 MHz should be allocated immediately to satisfy existing demands. The SRSC also determined that at least 161 MHz of new point-to-point spectrum will be required to support Public Safety services in the year 2010, as well as additional 2.5 MHz of spectrum to support nationwide interoperability among federal, state, and local Public Safety agencies. Specific details on spectrum requirements for interoperability are contained in the Report of the Interoperability Subcommittee.

### General Observations

- 4.4.2 **Factors Affecting Demand for Public Safety Spectrum:** To develop quantitative inputs for its spectrum demand model, the SRSC identified the general trends and factors affecting future Public Safety spectrum needs. As discussed below, the SRSC determined that demand for additional spectrum is driven by predicted increases in the population of Public Safety officials utilizing spectrum, changes in the services available to Public Safety personnel to allow them to effectively discharge their duties, advances in radio technologies, and, to a certain degree, the ability to utilize non-dedicated Public Safety services provided by commercial entities. By coordinating with the other subcommittees of the PSWAC, the Spectrum Requirements Subcommittee quantified each of these factors to arrive at a model of spectrum usage that comprehensively estimates the needs of Public Safety in 2010.
- 4.4.3 The SRSC first calculated the number of Public Safety personnel that will be using spectrum resources in the year 2010. As a result of growth in the overall U.S. population and demographic changes, additional Public Safety resources will be needed to combat increases in crimes, fires, and other threats to the safety of life and property. The SRSC utilized the Census Bureau's population growth figures for key metropolitan areas and historical trend data on the number of Public Safety officials, and other supporting personnel, required *per capita*. The SRSC also adjusted this data based upon identified trends relating to increases and decreases in particular Public Safety activities (*e.g.*, increases in violent crimes, decreases in robberies), to arrive at an estimate of the total size of the Public Safety user base in 2010.

- 4.4.4 Next, in coordination with the Operational Requirements and Interoperability Subcommittees, the SRSC identified the total wireless channel capacity needed to support the population of Public Safety personnel that will exist in 2010. The SRSC considered the number of wireless channels necessary to serve the voice, data, and other communications needs of types of Public Safety officials and their associated command structures. The SRSC also adjusted these requirements to reflect the demand for day-to-day, mutual aid, and task force interoperability channels required to coordinate the productive joint use of Public Safety resources. In identifying services to support Public Safety officials, the SRSC also considered emerging services that will play a critical role in future Public Safety activities, including remote transmission of fingerprint and photographic identification information, mobile access to building structural information to assist in fire and hazardous materials emergencies, realtime color video transmission of potentially hazardous situations, and automatic vehicle location systems to allow more efficient deployment of Public Safety personnel.
- 4.4.5 The SRSC then considered potential advances in radio technologies to determine how much spectrum would be required to support the identified channel capacity needed for Public Safety activities. In other words, the SRSC compensated for future efficiencies in the transmission of information, including greater cell re-use, smaller channel sizes, and information compression schemes. The SRSC model of efficiency also considered the cyclic replacement of equipment, which results in an embedded base of equipment at any particular time that must be depreciated before newer, more efficient equipment can be deployed. Included in this factor is also implicit recognition of future spectrum management policies that will dictate or encourage the rapid introduction and adoption of more efficient technologies, such as the FCC's private radio refarming initiative and comparable federal efforts.
- 4.4.6 As a final matter, the SRSC considered the proportion of future spectrum needs that could reasonably be satisfied by commercial services using spectrum not specifically allocated for Public Safety. As discussed previously, though the SRSC determined that commercial systems can, and presently do, serve as complementary adjuncts to dedicated Public Safety systems, the minimum baseline requirements for *mission critical* applications are not met by any existing or planned offerings. However, the SRSC found that a range of *non-mission critical* communications can be satisfied by commercial systems. The SRSC therefore considered on a case-by-case basis how and where commercial systems may serve as replacement options for Public Safety needs and concluded that approximately 10 percent of future Public Safety demand could be served through commercial systems.
- 4.4.7 **The SRSC's Model of Spectrum Demand:** Spectrum demand is modeled by relating the predicted user population, service penetration, offered load (*i.e.*, demand), transmission content requirements, coding efficiencies, transmission rate, error control and overhead requirements, channel loading limitations, and geographic re-use factors. Because different types of spectrum use have different characteristics in this model (*e.g.*, the compression factor and offered load for video are different than voice), the SRSC essentially modeled spectrum demand for five "classes" of services, including

voice (e.g. dispatch, one-to-many communications, and monitoring), narrowband data (e.g., remote database access), status/messaging (e.g., paging, status messaging, location updates), wideband data (e.g., complex images, slow scan video, fingerprint and identification information), and special data (e.g., full scan color video). The total demand is thus the sum of the demands for individual classes of services, as shown in the table below. It must be stressed however that the aggregate spectrum requirement is more important than its constituent parts. The following table is shown mainly for illustrative purposes:

Table 4-4-1

<b>SPECTRUM NEEDS</b>	
<b>SERVICE</b>	<b>SPECTRUM (MHz)</b>
Voice	32.3
Narrowband Data	5.3
Status/Message	0.2
Wideband Data	40.8
Special Data	50.7
<b>TOTAL NEED IN 2010</b>	<b>129.3</b>

- 4.4.8 After compensating for the 23.4 MHz of spectrum that will be in use by Public Safety in 2010, and subtracting 10 percent (10.6 MHz) to be served by commercial providers, the SRSC estimates a total of 95.3 MHz of new spectrum will be needed in 2010 (not including interoperability channels). The SRSC also determined that at least 25 MHz of spectrum should be allocated *immediately* to alleviate capacity shortfalls for critical voice and data needs and to promote development of equipment for new services.
- 4.4.9 Federal government users indicated that future federal requirements could be satisfied in the currently allocated bands providing that: (1) no more federal allocations are lost through transfer to the FCC for commercial use; (2) the assumed spectrum-efficient technologies become available as needed; (3) funds are provided by appropriations to implement the spectrum-efficient technologies into federal radio systems.
- 4.4.10 The SRSC notes that its estimates of the expected technology level for the average installed system in 2010 are quite aggressive. Because these estimates are part of the basis for the modeling of spectrum usage, the SRSC's spectrum estimates are correspondingly conservative. For example, the technology forecast, based on the PSWAC Technology Subcommittee's input, estimated that the *average* Public Safety voice radio system in use in the year 2010 would require only 4 kHz of spectrum per

active conversation.<sup>19</sup> Realistically, this high level of efficiency could only be achieved by universal replacement of existing equipment with more spectrum efficient equipment and the widespread deployment of Public Safety systems more spectrum efficient than any on the market today or required by the FCC's *Refarming* docket. To put this requirement in perspective, assuming that the older one fourth of installed equipment in 2010 operates with a spectrum efficiency of 12.5 kHz per active conversation (the level required for new type acceptances today under the FCC's *Refarming* rules, but not yet in significant use in Public Safety), if the SRSC's forecasts are to be met, the other three-quarters of equipment must operate with a spectrum efficiency of 1.17 kHz per active conversation -- roughly *twenty* times more efficient than today's typical practice. Other forecasts were similarly aggressive in other areas such as data modulation, video coding improvement, *etc.* Notably however, the SRSC's model predictions are consistent with the FCC's 1985 staff study on Public Safety spectrum needs and other, more recent, studies by the NTIA, the Coalition of Private Users of Emerging Multimedia Technologies, and the Association of Public Safety Communications Officials International, Inc., in that all agree that additional spectrum for Public Safety services is necessary.<sup>20</sup>

### Specific Findings

- 4.4.11 Recognizing that Public Safety telecommunications infrastructure (e.g., fixed microwave systems) are vital to the operation of area-wide systems, the SRSC recommends that 161 MHz of additional allocations be made for this use. This figure was derived through analysis, recognizing that although landline technology, including fiber optics, offers increasing telecommunications capacity and can be used to off-load communications from spectrum-dependent systems, certain areas of the country that are susceptible to earthquakes cannot rely on ground-dependent systems since those systems often fail during severe earth movements. The SRSC expects that the future supply of backbone system elements will look much like the past, but with two major exceptions. First, the lowest microwave frequencies (2 GHz) are no longer available for backbone systems.<sup>21</sup> Second, the supply of facilities by local carriers historically has been limited to only one firm, the local telephone company. Changes in law and technology, however, have led to the entry of new competitors in many markets and the probability of extensive further entry.

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<sup>19</sup> The value of 4 kHz per voice channel is based on an offered load of 6 kb/s for digitized voice today, and by the year 2010, an improvement in coding of 2:1, the use of error correcting code and overhead that requires double the offered load, and a transmitted rate (or modulation efficiency) of 1.5 b/s/Hz.

<sup>20</sup> *Report on Future Public Safety Telecommunications Requirements*, Notice of Inquiry in P.R. Docket No. 84-232, 49 Fed. Reg. 9754 (March 15, 1984); *NTIA Spectrum Requirements Study*, Land Mobile Spectrum Planning Options, (October 19, 1995); *Petition for Rulemaking of the Coalition of Private Users of Emerging Multimedia Technologies* (filed December 23, 1993); *Public Safety Spectrum Needs Analysis and Recommendation* (Assoc. of Public Safety Comm. Officials International, Inc. 1994).

<sup>21</sup> This spectrum was reallocated for Personal Communications Systems.

**4.4.12 Frequency Band Selection:** In order to insure that Public Safety users have sufficient spectrum to perform efficiently and effectively their duty to protect life and property, the SRSC has identified, in the following table, a range of potential new spectrum bands that could potentially be allocated for Public Safety use between now and 2010. Due to a variety of factors, summarized below, not all of these bands are suitable for all classes of services. In addition, all of the identified bands are currently occupied by existing users, and thus in Section 10 of the subcommittee report, the SRSC has examined how existing users could be relocated or transitioned out of specific bands.

Table 4-4-2

Band	Current Use	Proposed Use	Comments
30-50 MHz	Private radio services (Part 90). Includes 315 PS channels.	Preserve current allocations for voice and narrowband data. Technical constraints impair further use.	Useful for wide area mobile coverage, but not technically suitable for urban areas. Limited amount of equipment available.
138-144 MHz	Gov't (DoD).	Potential for PS sharing for voice and narrowband data on a case-by-case basis.	Useful for wide area mobile coverage. Proper system design can compensate for building penetration difficulties in urban areas.
148-174 MHz	Gov't/non-gov't shared. Includes 242 PS channels between 150-174 MHz.	Retain current allocations for voice and narrowband data. PS should retain new channels created through refarming.	
174-216 MHz	VHF TV Channels 7-13	Potential for immediate PS sharing for additional voice and narrowband data. Parts of this band should be reserved for exclusive PS use.	
380-399.9 MHz	Gov't (DoD fixed, mobile and MSS).	Initiate discussions with DoD and U.S. Coast Guard to determine feasibility of reallocation or sharing with PS for voice and narrowband data.	Good technical characteristics. DoD states reallocating present users will be costly.

Table 4-4-2

<b>Band</b>	<b>Current Use</b>	<b>Proposed Use</b>	<b>Comments</b>
450-470 MHz	Private radio services (Part 90). Includes 74 PS channels.	Preserve current allocations for voice and narrowband data. PS should be allocated additional channels created through refarming.	Good technical characteristics. Reallocation of narrowband channels through refarming. Other channels difficult to reallocate.
470-512 MHz	UHF TV channels 14-20. This band is shared by private land mobile users in 13 metro areas.	Potential for new allocations in present areas by relocating non-PS users to PCS or ESMR systems. Additional PS allocations should be made in all areas.	This band can provide the quickest spectrum relief for frequency impacted areas.
746-806 MHz	UHF TV channels 60-69.	24 MHz should be reallocated to PS for all uses.	Channels 60-69 have relatively light use, and four channels should be reallocated for PS use.
806-902 MHz	Non-gov't mobile (Part 90, Part 22). Includes 300 PS channels.	Retain current allocations for voice and narrowband data.	Good urban propagation properties. No new allocations are feasible because of ongoing SMR regulatory changes.
1710-1755 MHz	To be reallocated for mixed gov't/non-gov't use on 1/1/04.	Primary band for future wideband data and video.	Early access (sooner than 2004) should be pursued.
1990-2110 MHz	Has been reallocated for emerging technologies	Could be used for Microwave or wideband data/video requirements.	Not yet designated for specific use
4635-4660 MHz	To be reallocated for non-gov't use on 1/1/97	Point-to-point systems or short range mobile video systems	

Table 4-4-2

Band	Current Use	Proposed Use	Comments
4660-4685 MHz	Tentatively allocated for GWCS.		4660-4685 MHz has already been allocated for a "General Wireless Communications Service."
5850-5925 MHz		Intelligent Transportation Systems	Spectrum already reserved for ITS.

4.4.13 The selection of particular new spectrum bands for Public Safety involves a complex balancing of many technical and economic factors. As a technical matter, spectrum band selection is constrained by the propagation limitations of various parts of the radio spectrum, because factors like the transmitter power to coverage distance ratio and building penetration characteristics may be more favorable in one band than another. Moreover, as the need for interoperability increases, the separation between existing bands and new bands becomes relevant because a single radio may be technically incapable of tuning between widely separated bands, which would necessitate the use of expensive, multiple transmitter elements in multi-band radios or the establishment of additional interoperability channels in each band, above and beyond the requirements already identified by the SRSC.

4.4.14 Spectrum allocation policies could also increase spectrum needs and affect radio costs by, for example, limiting economies of scale or scope critical to equipment manufacturing. By locating new spectrum bands for Public Safety near or adjacent to existing Public Safety bands or other comparable private uses, the development investment to produce radio equipment is lowered and volume production benefits can be gained. Similarly, allocation policies that create a large number of Public Safety bands scattered across the spectrum, as opposed to a few larger allocations, can result in inefficiencies by requiring additional interoperability channels. In addition, the more efficient management of existing spectrum has been presumed, including such measures as improvements in federal spectrum use, initiatives like the Commission's private radio refarming proceeding, and increased federal/non-federal sharing.

### Recommendations

4.4.15 As there are many competing interests for spectrum, many options are presented in this section. There is approximately 315 MHz of spectrum, not including new channels from refarming, identified to fully meet the Public Safety needs. The subcommittee offers these options to the FCC and NTIA so the needs of Public Safety for spectrum are fully met. To assist the FCC and NTIA in the regulatory changes required, the subcommittee recommends the following priority listing for each type of use.

**4.4.16 Voice, Data, and Video Requirements**

1. Immediate further sharing of TV channels in the 470-512 MHz band in all areas.
2. Reallocate all or part of 746-806 (broadcast channels 60-69) MHz band.
3. Immediate allocation of the VHF and UHF channels in other services created by the FCC's Refarming Proceeding (including TV sharing bands).
4. Eventual reallocation of all TV sharing channels in the 470 to 512 MHz band.
5. Immediate new sharing of the 174-216 MHz VHF TV band primarily outside of urban areas and for statewide systems.
6. Reallocation of the 380-399.9 MHz band.
7. Sharing of the 380-399.98 MHz band with DOD on a mutually agreeable basis to minimize interference to Public Safety operations.
8. Hold a portion of the 174-216 MHz band in reserve to meet future Public Safety needs, or needs not met by this effort.

**4.4.17 Wide Band Data and Video Requirements**

1. Allocations in the 1710-1755 MHz band.

**4.4.18 Short-Range Video Requirements**

1. Allocations in the 4635-4685 MHz band.

**4.4.19 Fixed Service Requirements**

1. Allocations in the 4635-4685 MHz band.
2. Allocations in the 1990-2110 MHz band.
3. Allocations in the 3700-4200 MHz band.

**4.4.20 Intelligent Transportation Systems**

1. Allocations in the 5850-5925 MHz band.

4.4.21 Only if these measures are undertaken promptly will Public Safety officials have access to wireless capabilities that are critical to their safety as well as their ability to effectively discharge their sworn duty to protect the life and property of our citizens.

## 4.5 TRANSITION SUBCOMMITTEE SUMMARY

### Overview and General Observations

- 4.5.1 The Transition Subcommittee (TRSC) pursued a strategy for moving to the environment recommended by the other subcommittees. Emphasizing the issues raised in the FCC's refarming docket,<sup>22</sup> the subcommittee considered proposals addressing the proceeding's goal of migrating toward greater efficiency and enhanced services.

### Recommendations

- 4.5.2 The FCC, in the refarming proceeding, promulgated rules directed toward obtaining increased efficiencies in spectrum below 512 MHz by private land mobile radio users, including Public Safety. The FCC established a new channel structure that embraced narrowband technologies via reduced channel spacing or equivalent spectral efficiency approaches. The subcommittee, in supporting all reasonable requirements to move rapidly toward more efficient spectrum technology, believes that doing so through the FCC's policy of type acceptance of new equipment may not be sufficient. Under type acceptance, only equipment embracing particular spectrum efficiencies would be accepted as of a certain date. Existing equipment would not be precluded from use. The imposition of a date certain for all equipment conformance should be considered, with the subcommittee recommending that urban areas convert to the new efficiency standards by 2005.
- 4.5.3 The Transition Subcommittee report addressed the merits of Public Safety agencies receiving an exclusive license for "Protected Service Areas" that embrace an agency's area of jurisdiction. Generally, Public Safety shares its spectrum. Notably, agencies essentially operate in a "de facto exclusivity" environment, through the frequency coordination process, where users are provided the largest degree of channel exclusivity possible to ensure channel availability in emergent circumstances. Non-interference is essential to vital communications. The subcommittee recommends that Public Safety agencies be permitted to convert their shared licenses to exclusive system licenses. An exclusive environment will not have to accommodate the potential for interference from shared users, which the subcommittee believes undermines any commitment to investing in advanced technologies. Obtaining exclusivity would be conditioned on committing to advanced technologies.
- 4.5.4 In the subcommittee's view, technical standards need to be developed for the migration to the more efficient technologies envisioned by the FCC's refarming docket. Providing a means to measure compatibility between various technologies and actually obtain efficiency is crucial. The benefits to be gained through refarming can only come about through coordination with adjacent license holders. The

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<sup>22</sup> *Replacement of Part 90 by Part 88 to Revise the Private Land Mobile Radio Services*, P.R. Docket No. 92-235, 10 FCC Rcd 10076(1995).

- subcommittee recommends that an initiative undertaken by APCO and LMCC, in requesting TIA to facilitate the accommodation of advanced technologies in a post refarming environment, be embraced. The subcommittee urges the FCC to seek comment on the validity of using TIA to establish the necessary parameters for the new environment.
- 4.5.5 The subcommittee recommends that Public Safety allocation and administration policies below 512 MHz remain as currently established, that the separate service allocations continue and the current method of frequency coordination be retained with the present coordinators. If present service pools are consolidated, the subcommittee recommended that three categories be established. These are 1) Public Safety, 2) Public Services, and 3) Business/Commercial, with the Public Safety frequencies identified by service. The services should be ranked according to their relative importance in performing essential Public Safety responsibilities and preserving the nation's infrastructure. Interservice sharing should be authorized only from higher ranked to lower categories, except in shared systems. Any consolidated pool should be serviced by the present coordinator. In the context of FCC licensing processes, the subcommittee urges consideration of assigning more authority and responsibility to frequency coordinators. Additionally, the subcommittee urges that more extensive electronic filing and processing be adopted.
- 4.5.6 The Transition Subcommittee urged greater effort toward the development of shared federal, state and local systems that facilitate closer cooperation between all levels of government. The expansion of large wide area land mobile communications systems would bring enhanced capability to all levels of government. The subcommittee noted that spectrum efficiency can be increased through spectrum sharing by multiple Public Safety agencies. Intensive regional planning for congested areas is an important element in this regard, with more generic plans for rural and less congested areas. The subcommittee would oppose linking access to any additional spectrum contingent on such planning efforts, however.
- 4.5.7 In addressing the issue of block licensing to states, the subcommittee noted that structures should be embraced that bring about state and local planning, ownership and operation of systems, where all users have an incentive to approach spectrum efficiency and enhanced services. Shared state or wide area systems are reflective of this goal. In this sense, spectrum management roles for state or political subdivisions must be reviewed carefully. The subcommittee recommended that the FCC remain the final arbiter of any dispute involving non-federal use of the spectrum by Public Safety.
- 4.5.8 In urging improved coordination between non-federal and federal Public Safety officials, the Transition Subcommittee noted that there are significant inefficiencies brought about by the separate and distinct licensing responsibilities. Improved coordination, or convergence of these functions under one regulatory structure, is recommended. Moreover, shared federal, state, and local systems would facilitate close cooperation and provide a broadened resource support base.

- 4.5.9 The subcommittee evaluated funding alternatives, including several traditional areas. It suggested that Congress and the FCC consider designating monies from the revenues raised from spectrum auctions be committed to interoperability efforts. Any scenario where Public Safety relinquishes spectrum and relocates, must be premised on all the costs of moving to and operating in other spectrum being paid.

## 5. GLOSSARY

### **Additive White Gaussian Noise (AWGN)**

Noise whose spectrum is “flat”, that is, constant as a function of frequency. It is characterized by an autocorrelation function that is a Dirac delta function.

### **Amplitude Modulation (AM)**

Process in which the amplitude of a carrier is varied about a mean value, linearly with a base band signal.

### **Analog Modulation Technique (e.g., FM)**

Process whereby message signal, which is the analog of some physical quantity, is impressed on a carrier signal for transmission through a channel.

### **Auto-Aid**

A concept in dispatching in which the closest available unit to an incident regardless of jurisdiction, is sent to a scene. This concept is beginning to take hold in the law enforcement community. Auto-aid is a preplanned response; it is not called for by an on-scene incident commander.

### **Automatic Repeat reQuest (ARQ)**

Data networks often provide return receipts back to the originator when the data is successfully delivered, coupled with repeated transmissions from the originator as needed. These are generally referred to as Automatic Repeat reQuest, or ARQ.

### **Availability**

Generally descriptive of the percent of time that a radio channel is available for use when needed.

### **Broadband Data Systems**

Form of data communications where several subscribers share and can simultaneously use one common communications line. Each subscriber's data are modulated over a carrier frequency, i.e., information is frequency-division multi-plexed. Generally, in contrast to baseband communications.

## **Busy**

The time waiting for a busy channel to become available in trunking systems. This is typically expressed as the average waiting time for only those occurrences where a busy condition occurred.

## **Clarity**

The ability to recognize the individual speaking.

## **Code Division Multiple Access (CDMA)**

A channel access method in which all conversations are separated by code space. CDMA is employed for widest-bandwidth in both single system applications such as cellular as well as distributed uncoordinated applications such as the Industrial, Medical, and Scientific band (ISM).

## **Command Post**

Designated as the CP, the Command Post is be the location from which all incident operations are directed. There normally should only be one Command Post for an incident.

## **Compandored Single Side Band**

Form of amplitude modulation in which only the upper sideband or lower sideband is transmitted. The compandor is used to reduce the level of strong talk spurts at the head end of the system without exceeding the system design level.

## **Conventional Voice and Data Systems**

Systems where a single channel or a pair of channels is employed, which may require an end user to wait for a break to seize the channel.

## **Delay**

Generally descriptive of (1) the time between when a radio channel is needed to when it is available, (2) the lag between when it is available to when it can begin serving useful communications, as well as (3) the start-up character of the service.

## **Delivered Audio Quality**

The principal metric involves recipient understanding and whether or not repetition is required. This metric is called Delivered Audio Quality and consists of a 5 point scale. The lowest value is one, referring to the worst case where the message is unreadable and therefore unusable. The highest is five, where speech is easily understood , no

repetition is necessary and noise or distortion components are not introduced in the communications channel. The intermediate values range in the ease of understanding and the frequency of repetition required as well as the nuisance contribution of noise and distortion components introduced along the way.

### **Digital Modulation Technique**

Technique for placing a digital data sequence on a carrier signal for subsequent transmission through a channel.

### **Encryption**

The process of scrambling or rendering transmissions unintelligible except to authorized listeners. Encryption is applicable for data transmissions in the same manner as for voice. Although the numeric representation of data is not intended to be converted into meaningful speech, the goal of data encryption is to prevent the unintended reception from being converted back into the data's original form.

### **Erlang Theory**

Measure of telephone traffic load expressed in units of hundred call seconds per hour (CCS). One erlang is defined as the traffic load sufficient to keep one trunk busy on the average and is equivalent to 36 CCS.

### **Error Control (ARQ)**

Error control refers to the same numerical techniques of error correction and error detection as described for voice. Data networks often provide return receipts back to the originator when the data is successfully delivered, coupled with repeated transmissions from the originator as needed. These are generally referred to as Automatic Repeat reQuest, or ARQ.

### **Fast Forward Signal Regeneration (FFSR)**

Provides the ability to receive a correct message even in the presence of transmission errors. Is used for improving the performance of TTIB.

### **Forward Error Correction (FEC)**

Provides the ability to receive a correct message even in the presence of transmission errors.

### **Frequency Division Multiple Access (FDMA)**

A channel access method in which different conversations are separated onto different frequencies. FDMA is employed in narrowest-bandwidth, multi-licensed channel operation.

### **Frequency Modulation (FM)**

Form of angle modulation in which the instantaneous frequency is varied linearly with the baseband signal.

### **Helibases**

Helibases are locations in and around the incident area at which helicopters may be parked, maintained, fueled, and loaded with personnel or equipment. More than one Helibase may be required on very large incidents.

### **Helispots**

Helispots are more temporary and less used locations at which helicopters can land and take off.

### **Incident Base**

The Incident Base is the location at which primary support activities are performed. The Base will house all equipment and personnel support operations. There should only be one Base established for each incident, and normally the Base will not be relocated.

### **Incident Command System (ICS)**

The ICS is a standardized method of operation for Public Safety agencies during large-scale emergency incidents. It has a hierarchical structure which identifies lines of reporting (communications) throughout the organization.

### **Infrastructure Dependent**

The communications link requires the use of some items(s) of equipment, other than a subscriber unit, for establishment of the link and for complete subscriber operation. Some examples include a communications link for which a repeater station is required; a communications link which provides full system coverage for a visiting subscriber unit within a host trunked radio system; and a communications link which provides interconnectivity between two or more otherwise incompatible radio systems by cross-connecting the audio signals and/or appropriate signaling functions at some central point.

**Interoperability**

An essential communication link within Public Safety and public service wireless communications systems which permits units from two or more different agencies to interact with one another and to exchange information according to a prescribed method in order to achieve predictable results.

**Latency**

In-to-out delay for an established channel. While analog was real-time, digital processing, transmission, blocking, vocoding, and other factors can produce higher latency.

**Linear Modulation**

Modulation technique in which the modulated carrier is a linear function of the message signal.

**Message/file size**

In data communications, the quantity of data to be transmitted via data communication is the first order differentiation of the type of data. The reliability goal for data is not to deliver as reliable a signal as possible in real time, but instead to deliver 100% error free data in as little time as possible. To this extent, data reliability generally refers to two separate attributes: (1) the percent of data that is not deliverable, and (2) the percent of data that is delivered with undiscovered error. The former may often be referred to as **reliability** while the later is often referred to as **falsing**.

**Mission Critical**

A mission critical communication is that which must be immediate, ubiquitous, reliable and, in most cases, secure. Mission critical communications require the highest level of assurance that the message will immediately be transmitted and received regardless of the location of the operating units within the designed coverage area. In such cases, system set-up or processing delays are unacceptable and coverage must extend to the operating location of the field units. Most public safety systems that are built for mission critical applications, are designed with extreme care to assure reliable operation in the face of a series of potential system element failures.

**Model of Spectrum Demand (Spectrum Requirements Subcommittee)**

Spectrum demand is modeled by relating the predicted user population, service penetration, offered load (*i.e.*, demand), transmission content requirements, coding efficiencies, transmission rate, error control and overhead requirements, channel loading limitations, and geographic re-use factors.

### **Multi-disciplinary**

Wireless communications involving two or more different agencies. Some examples include a police agency communicating with a fire agency and a parks agency communicating with an emergency medical services agency.

### **Multi-jurisdictional**

Wireless communications involving two or more similar agencies having different areas of responsibility. Some examples include a fire agency from one city communicating with a fire agency from another city and the Federal Bureau of Investigation (FBI) communicating with a County Sheriff.

### **Multi-site Simulcasting**

Used in “trunked” or conventional radio systems to cover wide areas or areas which are difficult to cover with normal radio transmission methods. Multiple transmitters are used on the same frequency and are synchronized by a common time or frequency standard architecture.

### **Nyquist Sampling**

Lowest rate at which a finite-bandwidth signal can be periodically sampled in order to reproduce the signal completely and faithfully. The Nyquist rate is equal to twice the bandwidth of the signal.

### **Over-The-Air-Rekey**

Where cryptographic protection is employed, federal, Department of Defense, state and local agencies require user friendly electronic key variable dissemination and management. Terms such as Over-The-Air-Rekey (OTAR) are often used to describe this process, often in conjunction with multi-key, which refers to the use of multiple cryptographic keys to facilitate interoperability.

### **Public Safety**

The public’s right, exercised through Federal, State or Local government as prescribed by law, to protect and preserve life, property, and natural resources and to serve the public welfare.

### **Public Safety Services**

Those services rendered by or through Federal, State, or Local government entities in support of public safety duties.

### **Public Safety Services Provider**

Governmental and public entities or those non-governmental, private organizations, which are properly authorized by the appropriate governmental authority whose primary mission is providing public safety services.

### **Public Safety Support Provider**

Governmental and public entities or those non-governmental, private organizations which provide essential public services that are properly authorized by the appropriate governmental authority whose mission is to support public safety services. This support may be provided either directly to the public or in support of public safety services providers.

### **Public Services**

Those services provided by non-public safety entities that furnish, maintain, and protect the nation's basic infrastructures which are required to promote the public's safety and welfare.

### **Rayleigh Multipath Fading**

In a flat fading mobile radio channel, where either the transmitter or the receiver is immersed in cluttered surroundings, the envelope of the received signal will typically have a Rayleigh distribution. Fading is caused by wave interference between two or more multipath components that arrive at the receiver while the mobile travels a short distance (a few wavelengths) or over a short period of time.

### **Resolution**

Expressed as image dimensions in terms of pixels, which each represent one PIXture cELl or dot. Any given image can variably be represented in higher resolution by using more pixels, resulting in a larger digital representation. Conversely lower resolution using fewer pixels results in a smaller digital representation.

### **Set-up**

The time necessary to make a channel available for service. The time waiting for a busy channel to become available is not included.

### **Staging Area**

Staging Areas are established for temporary location of available resources. Staging Areas will be established by the Operations OIC to locate resources not immediately assigned. A Staging Area can be anywhere in which personnel and equipment can be temporarily located awaiting assignment. Staging Areas may include temporary

sanitation services and fueling. Feeding of personnel would be provided by mobile kitchens or sack lunches. Staging Areas should be highly mobile.

### **Time Division Duplexing multiple access (TDD)**

A channel access method in which a single radio channel is shared in time to achieve full duplex operation. TDD is employed to achieve full duplex operation in a single radio channel.

### **Time Division Multiple Access (TDMA)**

A channel access method in which different conversations are separated into different time slots. TDMA is employed in exclusive license use, moderate bandwidth applications.

### **Transparent Tone In Band (TTIB)**

Applies corrections to the received signal as necessary to produce known pilot tone characteristics, and thus correct the accompanying information signal.

### **Truncation**

The amount of speech lost between when a voice service is requested to when it is set-up and conveying speech. Digital technology may trade-off truncation for latency.

### **Trunked Systems**

Systems where multiple channel pairs are integrated into a single system. When a user wants to transmit a message, the trunked system will automatically select a currently unused channel pair and assign it to the user, decreasing the probability of having to wait for a free channel for a given channel loading.

### **Tone Above Band (TAB)**

Similar to TTIB, but with the pilot tone placed above the information signal instead of at its center.

### **Type Acceptance**

Under type acceptance, only equipment embracing particular spectrum efficiencies would be accepted as of a certain date.

### **Voice Encoder (vocoder)**

The device used to convert the analog voice waveform to a numeric representation is called a vocoder, which is shorthand for VOICE CODER.

## VOLUME II

This *Final Report* of the Public Safety Wireless Advisory Committee is divided into two volumes.

**Volume I** contains the main body of the report, including summaries of the various subcommittee reports.

**Volume II** contains the full text of the subcommittee reports along with their supporting documents, where available.

**6. INDEX TO APPENDICES:**

- 6.1 APPENDIX A - Operational Requirements Subcommittee Report (ORSC Final Report)
- 6.2 APPENDIX B - Technology Subcommittee Report (TESC Final Report)
- 6.3 APPENDIX C - Interoperability Subcommittee Report (ISC Final Report)
- 6.4 APPENDIX D - Spectrum Requirements Subcommittee Report (SRSC Final Report)
- 6.5 APPENDIX E - Transition Subcommittee Report (TRSC Final Report)
- 6.6 APPENDIX F - Public Safety Wireless Advisory Committee Members and Participants

***PLEASE NOTE:***

*The following subcommittee reports are included in as much of their entirety as possible owing to the availability of electronic versions of some of the supporting documents. Where an electronic version was not available, it has been so noted and the reader has been referred to the appropriate FCC Docket, where the full text of all information relating to PSWAC is contained. The only changes to the subcommittee documents that have been made relate to formatting such as fonts and margins used in order to provide consistency throughout the PSWAC document. It should also be noted that some of the following subcommittee reports contain a Table of Contents with page numbers. These page numbers are not necessarily accurate due to the above formatting changes, however, none of the contents of the subcommittee reports have been changed, including their referenced page numbers.*

**6.1 APPENDIX A - Operational Requirements Subcommittee Report**

**FINAL REPORT**

**OPERATIONAL REQUIREMENTS SUBCOMMITTEE**

**PRESENTED TO**

**PUBLIC SAFETY WIRELESS  
ADVISORY COMMITTEE**

**NATIONAL TELECOMMUNICATIONS AND  
INFORMATION ADMINISTRATION**

**FEDERAL COMMUNICATIONS COMMISSION**

**As Submitted July 12, 1996**

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## 1.0 EXECUTIVE SUMMARY

This document constitutes the report of the Operational Requirements Subcommittee, Public Safety Wireless Advisory Committee, regarding operational requirements for the public safety communications community nationwide through the year 2010. With respect to each functional area of public safety communications, the report catalogs requirements according to the general nature of the information to be communicated. In addition, subcommittee observations and recommendations regarding current shortfalls, sharing of resources and interoperability issues are noted for such use as the other subcommittees may deem appropriate.

## 2.0 OPERATIONAL REQUIREMENTS SUBCOMMITTEE OVERVIEW

### 2.1 COMMITTEE OBJECTIVES & ORGANIZATION

The Public Safety Wireless Advisory Committee (the "Advisory Committee") was established in response to provisions of Title VI of the Omnibus Budget Reconciliation Act of 1993 directing that the Federal Communications Commission (FCC) and National Telecommunications and Information Administration (NTIA) coordinate more closely with the public safety community in planning for future spectrum needs.

The general mission of the Advisory Committee is to provide advice and recommendations to the Chairman, FCC and the Administrator, NTIA on operational, technical, and spectrum requirements of federal, state, and local public safety entities through the year 2010.

The Advisory Committee also is to advise the FCC and NTIA of opportunities for improved spectrum utilization and efficiency, facilitate negotiated rule making at the FCC regarding public safety spectrum, and support development and implementation of plans at NTIA regarding federal public safety spectrum policy.

Based on the assigned mission, the Advisory Committee elected to form five subcommittees. The four subcommittees other than Operational Requirements and their missions are as follows:

The Interoperability Subcommittee is charged with the mission of examining interoperability requirements between and among the various public safety entities, and reducing them to writing. All phases of interoperability, including command and control, are to be examined.

The Technology Subcommittee is charged with the mission of reviewing technology presently implemented, projected technology implementations, and trends in wireless technology. The subcommittee is expected to identify technologies related to each operational need and determine bandwidth required to meet that need. The Technology Subcommittee also is expected to identify spectrum limits for each bandwidth identified.

The Spectrum Subcommittee has the mission of taking the bandwidth and spectrum placement recommendations and recommending a spectrum allocation plan. The plan is expected to include current spectrum assignments and recommendations with regard to future allocations. A timetable is to be developed by the subcommittee based on recommendations received from the Transition Subcommittee.

The Transition Subcommittee has the mission to consider how to implement the new technologies and services in a timely, rational manner. Issues to be considered by this subcommittee include funding methods, migration plans, and time tables.

## 2.2 CHARTER OF THE OPERATIONAL REQUIREMENTS SUBCOMMITTEE

The general mission of the Operational Requirements Subcommittee (the "Subcommittee") is to enumerate the communication needs of the public safety community without regard to specific technology or spectrum. The needs are to be classified as to the type of service (e.g., real-time, full-motion video) and quantity of service (number of channels, e.g., two full-time video channels in every city, one for EMS use and one to be shared between fire and police). Each need additionally is to be prioritized as to necessity for proper functioning of the public safety community.

## 2.3 SCOPE OF THE SUBCOMMITTEE REPORT

This report of the Subcommittee is intended to provide a snapshot of operational capabilities that must be considered in the overall planning process. The Subcommittee also has examined operational requirements that are unmet or suffer from reliability, quality, or coverage deficiencies. This report of the Subcommittee will be forwarded to the Technology and Interoperability Subcommittees. Requirements for interoperability identified by this Subcommittee will be forwarded to the Interoperability Subcommittee for consideration.

Many public safety entities and organizations provided comment regarding the issues encompassed in the responsibilities of the Subcommittee. In many cases the comments received included topics outside the scope of the Subcommittee charter. The following limitations were observed in preparing this report.

Several comments included specific suggestions regarding the number of channels that should be devoted to particular applications in the commenting agency's particular geographic area of responsibility. The Subcommittee has elected not take a position on issues of spectrum allocation in particular jurisdictions. As a part of its charter, the Subcommittee does have the requirement to provide quantity recommendations of general application, however. Along with other subcommittees, the Operational Requirements Subcommittee therefore provided planning data for use in the quantity model developed with the assistance of engineers from Motorola. Further information regarding this quantity model and the Subcommittee's input is provided at Annex B. In addition, the Subcommittee identified basic quantity recommendations for certain common user lines of communication described in the narrative of the report. Finally, the Subcommittee has in the course of its work attempted to identify the basic complement of communications support that must be maintained by any

jurisdiction that provides the various public safety services involved in this report, along with priorities appropriate to each type of support. The priorities indicated should not be interpreted as indications the public safety community does not consider any indicated requirement essential to maintenance of the public's safety. Every requirement indicated in this report is deemed essential to the public safety mission. Priorities are intended only to indicate the comparative importance of each requirement.

Several comments included specific suggestions regarding the frequency range appropriate for particular requirements. The Subcommittee position is that issues of spectrum use fall within the purview of the Spectrum Requirements and Technology Subcommittees. No recommendations or commentary are included in this report regarding appropriate frequencies.

A few comments were received suggesting that the Subcommittee study and include in its report a catalog of specifications that equipment, for example portable radios, should meet in order to be suitable for public safety use. The Subcommittee considered performing such a study incident to its work, but concluded this topic was not germane to the basic mission of the Subcommittee and the Advisory Committee, which is oriented on spectrum.

### 3.0 SUBCOMMITTEE ORGANIZATION

#### 3.1 DEFINITION OF PUBLIC SAFETY

At the first meetings of the various subcommittees conducted in Washington, D.C. on September 29, 1995, considerable discussion occurred regarding the definition of "public safety" for purposes of the Advisory Committee. For purposes of this report, the Operational Requirements Subcommittee initially elected to use a very expansive definition, with the understanding that the Advisory Committee might at some future time adopt a less expansive definition for its purposes. The Subcommittee's initial approach was based on two observations. First, the Subcommittee recognized that although a particular constituency's primary business might not fall within a classic public safety definition, aspects of its operations could involve or impact matters of public safety. Second, the Subcommittee recognized that by providing an expansive catalog of requirements from the various constituencies, other subcommittees and ultimately the Advisory Committee would benefit from a broad perspective in determining precisely what requirements should be accommodated when spectrum and other issues are addressed.

Following adoption of definitions of public safety and related matters, the scope of the Subcommittee report was again discussed at the Berkeley meeting. At that time, the Subcommittee elected to include in this report and note its support for the definitions adopted by the Advisory Committee which follow:

**Public Safety:** The public's right, exercised through Federal, State or Local government as prescribed by law, to protect and preserve life, property, and natural resources and to serve the public welfare.

**Public Safety Services:** Those services rendered by or through Federal, State, or Local government entities in support of public safety duties.

**Public Safety Services Provider:** Governmental and public entities or those non-governmental, private organizations, which are properly authorized by the appropriate governmental authority whose primary mission is providing public safety services.

**Public Safety Support Provider:** Governmental and public entities or those non-governmental, private organizations which provide essential public services that are properly authorized by the appropriate governmental authority whose mission is to support public safety services. This support may be provided either directly to the public or in support of public safety services providers.

**Public Services:** Those services provided by non-public safety entities that furnish, maintain, and protect the nation's basic infrastructures which are required to promote the public's safety and welfare.

### 3.2 WORKING GROUPS

The Subcommittee elected to form seven working groups. The working group designations, along with their general areas of focus, are described as follows. Order of appearance in this report should not be considered any indication of priority as among the various working groups.

(1) **Transport Mechanisms.** Initially this working group was designated as the Infrastructure working group. At the Berkeley meeting, its title was changed to Transport Mechanisms to more accurately reflect the scope of its mission. The mission of the Transport Mechanisms working group is to catalog operational requirements for infrastructure communications needed to support other identified public safety communications requirements at federal, state and local levels.

(2) **Criminal Justice.** Initially this working group was designated the Law Enforcement working group. At the Scott Air Force Base meeting, its title was changed to Criminal Justice and the operational requirements for corrections were placed within the group's responsibilities. The mission of the Criminal Justice working group is to catalog operational requirements for law enforcement and corrections organizations at federal, state and local levels.

(3) **Fire, Emergency Medical and Related Life and Property Protection Services.** The missions of the Fire, Emergency Medical and Related Life and Property Protection Services working group is to catalog operational requirements for fire and EMS organizations at federal, state and local levels.

(4) **Emergency Management and Disaster Services.** The mission of the Emergency Management and Disaster Services (EMD) working group is to catalog operational

requirements for emergency management and disaster services at the federal, state and local levels.

(5) Public Service. The mission of the Public Service working group is to catalog operational requirements for public service entities at federal, state and local levels.

(6) Other. The mission of the "Other" working group is to catalog operational requirements for Highway Maintenance, Forestry, General Government, and Mass Transit organizations at federal, state and local levels. At the subcommittee meeting conducted in Berkeley, it was agreed that the Other working group's portion of the report should be separated into areas specific to the organizations involved, i.e. Highway Maintenance, Forestry, General Government and Mass Transit. This separation is reflected in the organization of the final subcommittee report.

(7) Matrix Refinement and Report. The mission of the Matrix Refinement and Report working group initially was development of a common matrix of data required to describe each operational requirement. As the subcommittee's deliberations continued, it became clear this initial matrix would not be required, and it therefore is not included in this report. This working group also was responsible for preparation of this report.

As the Subcommittee continued its deliberations, it became clear that additional working groups would be required in order to adequately capture the operational requirements of all interested public safety constituencies. Accordingly, working groups for federal requirements and intelligent vehicle and highway systems (IVHS) requirements were included in the Subcommittee's deliberations and report.

In addition to the work of the groups described above, the Subcommittee examined quantity and quality aspects of the operational requirements for public safety wireless communications. Quality aspects of these requirements are discussed in Annex A of the report. Quantity aspects of these requirements are reflected in the working group inputs to the planning model adopted by the various subcommittees in order to assist in projecting spectrum requirements. The working group inputs from this Subcommittee are included as Annex B of the report.

### 3.3 COMMITTEE DELIBERATIONS

An organizational meeting of the Subcommittee was conducted September 29, 1995 in Washington, D.C. At that meeting, discussion was conducted and consensus reached regarding the subcommittee mission and the public safety functional areas to be examined. Consensus also was formed regarding the working groups necessary to accomplish subcommittee purposes. An initial discussion was conducted regarding the composition of a matrix to be used to catalog each operational requirement identified by the working groups. Following the September meeting, work was completed on a draft version of the matrix.

The subcommittee met again on October 26, 1995 at Camp Dodge, outside Des Moines, Iowa. The principal matter on the agenda was review of the draft matrix. Considerable

discussion ensued, resulting in refinement of the matrix for use by the various working groups. Following the October meeting, the matrix was revised to reflect subcommittee deliberations and distributed to working group leaders. Working group leaders began formulating their proposals of operational requirements in each of the functional areas represented by the groups.

A special meeting was conducted in San Bernardino, California on November 17, 1995. Federal budget issues precluded attendance by a Designated Federal Officer, so the meeting was conducted as an informal review of subcommittee activities and progress. Considerable, wide-ranging discussion occurred. Attendance was heavily weighted toward users, suggesting that additional meetings in other regions of the United States would benefit the various subcommittees.

A regular meeting of the Subcommittee was conducted in Washington, D.C. on December 13, 1995. Interim reports were presented by the various working group chairs regarding their progress to date. A status report regarding the Subcommittee's activities was presented to the Advisory Committee at its regular meeting conducted December 15, 1995. Following the December 13th meeting, working group leaders continued work on their narratives of operational requirements. Their work was provided the Matrix Refinement & Report working group, which incorporated it in this report.

Additional regular meetings of the Subcommittee were conducted in Berkeley, California on January 10, 1996, Orlando, Florida on February 28, 1996, and San Diego, California on April 11, 1996. Copies of the draft report of the Subcommittee were made available to attendees at each meeting, and comments regarding its content were received. Following each meeting, revisions were made to the report to reflect the consensus of meeting attendees and those who commented by other means.

A regular meeting of the Subcommittee was conducted at Scott Air Force Base, Illinois on May 29, 1996. Copies of the final draft report of the Subcommittee were made available to meeting attendees, and comments regarding its content were received. Following the meeting, revisions were made to reflect consensus of meeting attendees.

A regular meeting of the Subcommittee was conducted at Washington, D.C. on June 26, 1996. Comments were received regarding the content of the report. As revised following this meeting, the report narrative is considered complete.

#### 4.0 WORKING GROUP REPORTS

This section of the report of the Subcommittee is a discussion of the operational requirements identified by each working group. In each case, the working group report is intended to present each operational requirement from the user point of view, categorized by the nature of the information to be communicated.

## 4.1 TRANSPORT MECHANISMS

4.1.1 Mission. The mission of the Transport Mechanisms working group is to catalog operational requirements for communications transport networks and infrastructure at federal, state and local levels.

4.1.2 Introduction. Transport networks consisting of microwave links, satellite links, and leased (copper or fiber-optic) circuits are crucial elements of the infrastructure for routing voice, data and video circuits between communication sites. Wireless links, primarily customer owned microwave networks, have been and will continue to be a primary distribution method for public safety communication systems.

There are also public safety requirements for operational fixed links in the VHF and UHF bands below microwave. Public safety has a definite need for fixed operational links which operate on frequencies between 70 MHz and 470 MHz. In rural mountainous areas high level sites are frequently required to provide wide area system coverage, such as for counties and states. Fixed links are frequently used to give remote base station control. Such links use 72-75 MHz, 150-174 MHz, 406-420 MHz or 450-470 MHz equipment for the link. These links carry signaling and voice to and from the fixed based station. They are necessary because of the unavailability or unreliability of leased control circuits in rural areas. They are also used because they are much more economical than using microwave, and the multi-circuit capability of microwave is not needed. Often there is no line of site between the dispatch or control point location and the base station to allow microwave control; multiple sites often cannot be used because of terrain which may be inaccessible or restricted through wilderness designation, or through unavailability of communications site use through federal agency management on federal lands. The only practical and cost effective solution often lies in the use of single frequency links which can diffract or bend over the intervening terrain. Seventy MHz is ideal for this purpose, but often a high power 450 MHz link may suffice. In some very remote long distance applications, VHF 150 MHz links may also be used. In some state and county low band systems, VHF high band links are frequently used over very long distances. There is also a second use for these lightly loaded, often single channel operational links. They may be used for such purposes as voting receiver connectivity or single transmitter control. Microwave links are not suited for these purposes, because of propagation problems, cost and because there is no need for the number of circuits possible with microwave. It would be very spectrum inefficient as well to use microwave for such very low density requirements. Public safety requires dedicated channels for these low density, control purposes. While this use is infrequent, it is highly important where it is needed. Present channels in VHF are heavily shared and very difficult to keep free of interference because of high channel usage when used as links in base and mobile systems. The 450 MHz 12.5 KHz off set links meanwhile have been converted to full power operation by refarming and their use as links will become difficult to impossible. These requirements must be considered in providing for public safety spectrum needs as there is no other viable solution. Where these links are required, there is no commercial service available to use as an alternative because they are for very remote applications.

Customer owned microwave links have proven to be the most reliable transport networks in disaster situations, such as earthquakes and fires. While fiber optic and copper cables are vulnerable to back hoe, fires and earthquakes, microwave links have survived in most disasters. Microwave links and redundantly configured systems, properly engineered to survive disasters, also provide the high reliability required for day-to-day public safety operations. While common carriers can and often do provide valuable services, there are regulatory and economic constraints that restrict their ability to provide reliability and service restoration at the high level required for many public safety applications. Traditional rate-of-return regulation weakens carriers' economic incentives to innovate and to specialize services for specific customers. Any commercial provider is eager to handle public safety traffic in the lucrative metropolitan areas, but they freely admit they will not provide any service to the remote, low density areas. Traditional common carrier regulation limits carriers' incentives to provide high reliability for specific customers.

Commercial leased lines, however, continue to be utilized in many parts of the country for various reasons. For instance, it is often not economically or physically feasible to install microwave links where the circuit requirement is small or there is no path. For a nationwide or statewide link, it may be cost prohibitive to use microwave. When many circuits are required at one location, large savings are generally realized using customer-owned microwave.

Fiber optic links are also extremely useful in numerous transport applications. The cost and practicality of routing fiber optic or copper circuits to remote public safety communications sites (e.g. mountain tops) can be prohibitive, and as mentioned before not failsafe in case of disasters. Even with high reliability of fiber optics often alternate routing is required to gain the needed reliability and this is frequently very difficult to obtain through that medium. Fiber optics costs, however, continue to drop and fiber will be utilized for many applications. Regardless of whether fiber or microwave is used in high density applications, virtually the same electronic multiplexers are required at each end of the both media. Since electronic devices do occasionally fail, increased reliability is gained through the use of alternate routing. Alternate routing of fiber can be extremely costly because of right of way restraints when feeding multiple sites.

Increasingly, with the advent of Intelligent Transportation Systems (ITS) and other services requiring Dedicated Short Range Communications (DRSC) between infrastructure and public safety vehicles, public safety applications using this technology may occur in much higher frequency ranges as well. These systems may use channels in the microwave range (5.8 GHz) that are being pursued under the ITS program.

4.1.3 Voice Requirements. Just as wireless links are used to transport communications between the roving mobile/portable units and the fixed RF base station sites, wireless infrastructure such as microwave or satellite networks is required to route (analog and/or digital) voice and control messages between the remote RF base station sites and the command/control center. In emergency operation systems, the system operator needs control over the distribution network. As an example, numerous police and fire emergency systems require the use of "multi-site simulcasting" to provide wide area coverage with a minimum of

frequency resources. Present simulcast systems require accurate control over distribution network parameters like delay, levels, and distortion. It is conceivable with future systems on-site timing mechanisms may ease the need for such stable carrier channels, but current systems require them. Private microwave systems allow the system operator precise control over all critical parameters and control over the availability and reliability of the communication paths. The use of leased copper or fiber circuits provides less control over all distribution network parameters and over network reliability. This could result in decreased coverage, distorted messages, communication outages and high maintenance. Private microwave networks are an important requirement for public safety distribution networks.

Many public safety microwave systems also must carry telephone types of traffic. Sometimes this traffic is to connect Public Switched Telephone Network (PSTN) circuits to dispersed offices through agency owned central switching. Other times completely separate systems (separate from the PSTN) are agency provided. The main reason for agency provision of these systems is to assure continued telecommunications ability internal to the agency regardless of either the condition of the PSTN or overload of a distressed PSTN. Often there is also a security (encrypted) aspect of these communications which is better maintained through a private network.

4.1.4 Data Requirements. Wireless infrastructure links are frequently also required for transporting public safety data. Some data applications include user and equipment status updates, support of mobile/portable data and computer terminals, interfaces to numerous databases, geographic position and automatic location devices, computer aided dispatch, biomedical information, remote weather reading for fire management and a myriad of justice and other local and regional data systems.

Many law enforcement agencies have access to their jurisdiction's utility data base so that they have current resident information when they pull up to a specific address. Many public safety agencies also require high security and highly reliable telemetry for supervisory control and data acquisition purposes. Public safety agencies often use hundreds of circuits in voice, data, video, and telemetry applications.

The same kind of strict requirements for voice circuits are even more imperative for data circuit transport. For instance, the tolerances for simulcasting data are even stricter than for voice. Thus, system operator control over the availability, reliability, and technical parameters of the transport network is more critical. Private microwave links are an important requirement for public safety data distribution networks.

4.1.5 Video Requirements. Wireless (microwave and satellite) infrastructure is frequently required for routing video for numerous public safety applications. There are three types of video requirements, full motion, slower limited motion (compressed) and snap shot video.

Full motion wireless systems are required for supporting critical public safety, surveillance operations, field incidents, prison riots, major fires, robotics (i.e., the disarming of a bomb by a robot) and numerous other critical public safety operations. Microwave also routes video from the incident location to the command and control center.

Public Safety also requires full motion video for many training video applications because of the fast motion of the subject material. With the current state of the art of digital compression techniques at rates lower than 1.5 Mb/s, compressed video can jerk and smear as the motion of the subject increases in speed. In many police and fire applications this picture distortion can be unacceptable and wideband, full motion video is needed. Microwave can route video from an incident location to a command and control center. Microwave video is also routed between central facilities and outlying facilities for training purposes. Because of the content, this training video is often not suitable for carriage on common carrier networks. Infrared mapping of wildfires from air to ground is another wideband (video) application.

Compressed video circuits are transported on commercial wirelines and on microwave systems, as they require less spectrum than does full motion video. Numerous applications such as fingerprints from the vehicle to the command center, video teleconferencing and court arraignment applications can be supported by these types of networks.

## 4.2 CRIMINAL JUSTICE

4.2.1 Mission. The mission of the Criminal Justice working group is to catalog operational requirements for law enforcement and corrections organizations at federal, state and local levels.

4.2.2 Introduction. Reducing crime and its impact on the health and welfare of families continues to be a top priority in the United States. In recent years, the most successful anti-crime weapon in the criminal justice arsenal has been implementation of community-based policing in many areas of the country. The heart of this program is getting officers out of cars and into the community, whether it be on foot, bicycle or horseback. Community-based policing programs put an extraordinary demand on communications systems because they require portable coverage throughout the community. Additionally, the 100,000 new officers funded through the Violent Crime Control and Law Enforcement Act of 1994 (Public Law 103-322, commonly called the "Crime Bill") must be community-policing officers. The additional load placed on already overworked communications systems by these new officers has been noticeable.

Wireless communications support is crucial to assure quality criminal justice services and create the safest possible working environment for corrections and law enforcement personnel. The following discussion is the product of discussion and correspondence with corrections and law enforcement officials from various locations in the United States. The emphasis of the working group has been on identification of present and future operational needs, dependent on wireless communication, without regard to cost or the current availability of technology. Needs are categorized first into the broad areas of law enforcement and corrections and then are further divided into the three basic categories of voice, data and video.

### 4.2.3 Law Enforcement

4.2.3.1 Voice Requirements. In general, voice communications for law enforcement must include coverage from portable to portable unit, through a system, radio to radio, or some other technology. Officers must be able to speak with each other via the portable radio if they can see each other. Likewise, officers from one end of a jurisdiction must be able to talk to officers in another part of the jurisdiction on a jurisdiction-wide path. Voice coverage from personal portable radios must include the ability to communicate from within buildings with a high degree of reliability.

4.2.3.1.1 In particular, the law enforcement voice communications system must be expandable to support a relatively unlimited number of users quickly, i.e., 1 to 3 hours. Normal day to day police radio operations may not require high capacity. However, when a man-made or natural disaster strikes, the system must have the ability to expand to meet demand.

4.2.3.1.2 Voice communications for law enforcement must feature multiple levels of encryption. Routine operational traffic will require one level of encryption. Other operations such as executive protection, high level drug and organized crime unit operations and federal security needs often will warrant a higher level of transmission security. Some routine traffic may be “unencrypted”, but devices must be able to monitor both encrypted and non-encrypted messages simultaneously.

4.2.3.1.3 Voice Dispatch. Voice communications routinely occur between officers in the field and central dispatch points. Information conveyed commonly includes both operational instructions and information. The law enforcement voice communications system must support routine dispatch communications.

4.2.3.1.4 Officer to Officer Voice Communications. Voice communications routinely occur between one officer in the field and one or more other officers in the field. Information conveyed commonly includes both operational instructions, administrative information, and general coordination. The law enforcement voice communications system must provide support for routine voice communications between officers working within a particular jurisdiction.

4.2.3.1.5 Air to Ground Voice Communications. Aviation units are a common part of most major law enforcement agencies. Aviation units perform traffic enforcement missions, routine patrol and detection, search and tracking duties, and provide airborne command and control support. Because aviation units commonly work with a separate or distinct group of ground units for a particular operation or event, the law enforcement voice communications system must provide support for routine voice communications between aviation units and officers and commanders on the ground who are working with one or more aircraft. The same path could support air to air communications between aircraft of the employing jurisdiction.

4.2.3.1.6 Special Operations Communications. Special investigations, task forces and other discrete activities are a commonplace aspect of today's law enforcement community. A voice communications capability that is separate from normal operations voice traffic is required to support each special operation. These paths must have available the ability to provide highly secure encrypted communications.

4.2.3.1.7 Nationwide calling or Travel Channels. A need exists for nationwide calling or travel channel(s) for use for dignitary protection and emergency units working out of their home area. The channels would be used daily for units traveling across the county for prisoner transport or dignitary protection. The most significant use of these channels would be at events like the National Governors' Conference or during a major disaster like the Oklahoma City bombing, where multiple units from various federal, state and local agencies detail personnel for a specific incident. The channels must be monitored nationwide and be installed in mobile and portable units nationwide. This concept has significant impact on interoperability and is further discussed in Section 7.5 of the Working Group 3 "Future Interoperability Needs Report" prepared by the Interoperability Subcommittee.

4.2.3.2 Data Requirements. The basic law enforcement requirement for data is immediate, clear transfer and display of text and graphical information for all law enforcement personnel, in support of both routine and emergency operations.

4.2.3.2.1 Expansion of wireless data systems offers many technological assets for law enforcement. One of the most significant advantages is access to data repositories containing critical law enforcement information such as image identification, fugitive information, stolen articles and criminal histories. Repository systems such as the National Crime Information Center (NCIC) 2000 system and the Integrated Automated Fingerprint Identification System (IAFIS) are preparing to provide mission critical data to law enforcement more effectively and efficiently; they will certainly prove to be a force multiplier in the war on crime. For the first time, field officers will be able to positively and rapidly confirm the identity of persons in the field by transmitting a fingerprint to state or federal processing centers. The officer will be able to obtain a photograph of any person who has been cataloged by these systems. These systems, in conjunction with the National Performance Review IT04 initiative (establishment of a national law enforcement/public safety wireless network) are preparing for wireless data transfer and will spur the growth of wireless data communications for law enforcement.

4.2.3.2.2 Future information technology requirements for state and local law enforcement will most certainly include wireless data and voice systems utilizing encryption. In order to maximize the effectiveness of personnel in the field, a mobile office environment utilizing wireless data communications must be developed. This mobile office would provide instantaneous voice, data, and video access to other criminal justice personnel, various law enforcement data repositories, personnel from other public safety disciplines and commercial networks. At some point, law enforcement may incorporate these mobile offices into a paperless environment inclusive of multimedia transfer.

4.2.3.2.3 Mobile/Personal Data Computer/Terminal Applications. A need exists for real-time support of wireless mobile and portable computer systems capable of transmitting

and receiving routine data queries and responses, electronic mail, location data and other graphics including fingerprints and mug shots, along with incident-specific data and intelligence. Based on the rapid market penetration of portable two-way radios into law enforcement patrol ranks in the 1970's, the International Association of Chiefs of Police Communications Committee has presented the possibility that over 75% of the nation's patrol force could be equipped with portable data terminals in the 2005-2010 time frame, given that affordable equipment and the required infrastructure become available.

4.2.3.2.4 Geographic Position and Automatic Location Data. Law enforcement requires the ability to transmit location data, determined by geographic position technology or other means, automatically or on demand, to other locations. Examples of this need include constant updating of vehicle positions for dispatch and officer safety purposes, constant updating of individual officer location for safety purposes when the officer is outside of her/his vehicle, and the ability to trigger position transmitting devices on lost or stolen equipment items.

4.2.3.2.5 Emergency Signals. Officers who need emergency assistance must be able to activate an alarm that sends an automatic distress notice to a central monitoring point and other officers in the field.

4.2.3.2.6 Transmission of Reports. This system should accommodate transmission of forms and reports to central sites from mobile and remote locations. This capability will be used to transmit accident, arrest and incident reports, citation information and investigative reports to central locations in long data streams of up to several seconds. This capability will reduce paper transactions, increase officer field time, and speed transmission of vital information to command and administrative staff.

4.2.3.2.7 Electronic Messaging. Personnel require the ability to input messages into a data transmission device for transmission to single or multiple agencies, including other officers and other public safety providers.

4.2.3.2.8 Remote Device Monitoring. Law enforcement requires the ability to monitor remote device indicators via data transmission. For example, the real-time ability to monitor air quality standards at chemical and nuclear incidents is needed to help establish evacuation plans. Data transmission capabilities must support transmission of wind speed and direction, temperature, and a time and date stamp. The data bank of remote device transmissions must be accessible by remote computer or terminal for incident tracking and decision-support by field personnel.

4.2.3.2.9 Emergency Vehicle Signal Priority. Emergency units when activating lights or siren should emit a signal that is received by traffic control devices along the route of travel to change signal lights and accord the emergency vehicle the right of way. The emergency unit's signal should also be transmitted and received by school buses, mass transit and rail carriers indicating that an emergency vehicle is in the area using emergency equipment. Ultimately, a mapping device should be available that allows rail and mass transit units to see a graphical portrayal of the location and route of emergency vehicles.

4.2.3.3 Video Requirements. Multiple agencies may need to be able to monitor another agency's video transmissions, but the ability to access public safety video must be based on a "need to know" or incident management basis.

4.2.3.3.1 Incident Video. Some incidents like high risk surveillance, prison riots, high risk drug transactions, and emergencies require real-time video. While these incidents may be infrequent in some areas, others will have a more frequent demand for real-time video. The capability must exist for both point-to-point and broadcast use of the video. For example, full motion video must be transportable from the incident scene to an incident command post, and also to a remotely located emergency operations center. Prison riots, chemical/nuclear incidents, etc., may require monitoring of the incident from more than one location.

4.2.3.3.2 Aerial Surveillance Video. Many law enforcement agencies operate routine surveillance of traffic, crime in progress situations and other events from airborne platforms. Full motion video transmissions from airborne platforms to command and control locations and supervisors on the ground is required.

4.2.3.3.3 Robotics Video. Hazardous material and explosive disposal response frequently benefits from use of robotic devices. Full motion, generally short distance (up to 1000 meters), video transmissions from the robotic device to a locally-located control site is required to support such robotics activities.

4.2.3.3.4 Surveillance and Monitoring. Law enforcement requires the ability to transmit video snap shots at the rate of one frame each 5 seconds for surveillance and monitoring purposes. For example, person and building surveillance, low risk drug transactions, and building security would be adequately served by this quality of video transmission.

4.2.3.3.5 Officer Safety and Operational Video Transmission (Two Way). Many patrol cars used by law enforcement agencies now are equipped with mobile video cameras. Video recorded by these cameras provides evidence usable in criminal trials, and documents officer actions in the event professional standards concerns are voiced. The ability to transmit full motion video from mobile video cameras directly to dispatch and other command and control installations is required on demand. Although constant transmission of this data from each individual officer or mobile unit is not required, the ability to monitor video from a unit is needed on an episodic basis in the event of officer assistance situations and other high risk events, or operations of high command interest. In addition, the system must support retransmission of full motion video to mobile and remote locations, where command and control personnel and other mobile officers can monitor, perform decision-making and provide assistance based on the video transmission.

4.2.3.3.6 Still-Photographs. Law enforcement requires the ability to transmit still photographs on demand to other locations. For example, an officer in the field should be able to transmit a digital image of the violator in custody to a remote location upon demand.

#### 4.2.4 Corrections

4.2.4.1 Wireless communications support is crucial to assure quality correctional services and create the safest possible working environment for correctional personnel. These needs are into two sub-categories of correctional services: 1) Jails and prisons for facilities based operations; and 2) Parole and probation for community based operations.

4.2.4.1.1 Correctional organizations across the country are a mix of both sworn and non-sworn personnel and have a unique and varied public safety mission. The operational public safety radio communications needs of correctional organizations will mirror one or more of those of all of the other commonly recognized public safety and public service organizations. Correctional organizations provide public safety in the forms of law enforcement, fire services, emergency medical services, emergency management and disaster services. They also provide public service in the forms of highway maintenance, fire prevention, conservation, the reintegration of offenders back into society and community public works.

4.2.4.1.2 Prisons and jails can be viewed as small but fully autonomous communities. In addition to the custody staff, a variety of support staff are needed. Cooks, laundry workers, firefighters, doctors, dentists, educators and maintenance people are needed to ensure inmates are housed, clothed, and fed accordingly. Activities, tasks and communications that may appear mundane, routine or administrative in normal circumstances take on significant public safety and security implications in the correctional environment.

4.2.4.2 Voice Requirements - Prisons and Jails. In general, voice communications for correctional personnel must include coverage from portable to portable unit, with or without use of infrastructure. Prisons and jails pose formidable challenges to intra- and interbuilding communications due to their labyrinth design and heavy reliance on concrete and steel construction. Voice coverage from portable radios must include the ability to communicate from within these secure structures with a high degree of reliability. Correctional personnel must be able to speak with each other via a personal portable radio when they cannot see each other, whether between adjacent housing units or floors, or from one end of a secure campus style multi-unit facility to the other.

4.2.4.2.1 The majority of prison and jail operations result in a high concentration of users in a relatively small, confined geographic setting. When traveling away from correctional facilities, voice communications requirements for correctional personnel mirror that of other law enforcement wide area coverage needs.

4.2.4.2.2 The prison and jail voice communications system must be expandable to support a relatively unlimited number of users quickly, i.e., 1 to 3 hours. Normal day-to-day correctional operations may not require high capacity. However, when an inmate disturbance or some form of man-made or natural disaster impacts facility safety and security, the system must have the ability to expand to meet demand. The correctional environment requires the ability to remotely, across the air, selectively inhibit lost or stolen radios. A functional radio in the hands of an inmate significantly compromises the safety and security of an institution and

the staff and inmates assigned therein. The ability to remotely “hot-key” a radio microphone aids in equipment recovery and/or intelligence gathering if equipped staff are taken hostage.

4.2.4.2.3 Voice communications for most routine prison and jail operations do not require encryption. However, other operations such as disturbance control, staff investigations, and prison gang task forces often will warrant a higher level of transmission security. Devices must be able to monitor both encrypted and non-encrypted messages simultaneously.

4.2.4.2.4 Staff to Staff Voice Communications. Voice communications routinely occur in an “advise and assist” format one a one-to-one, or one-to-many basis between correctional staff in a facility. Information conveyed commonly includes general coordination, operational instructions, administrative information, as well as tactical and emergency communications. The correctional voice communications system must provide support for routine voice communications between staff working throughout a facility.

4.2.4.2.5 Voice Dispatch. The need for voice dispatch in a “command and control” format varies depending on facility size and design. In some facilities, voice communications may routinely occur between correctional staff dispersed throughout a facility and central dispatch points. In others it only occurs during the response to an incident. Information conveyed commonly includes both operational instructions and information. The correctional voice communications system must support routine dispatch communications.

4.2.4.2.6 Special Operations Communications. Disturbance control response team operations and special investigations are a commonplace aspect of today’s larger correctional facilities. A voice communications capability that is separate from normal operations voice traffic is required to support each special operation. These paths must have security (encryption) available.

4.2.4.2.7 Nationwide Calling or Travel Channels. A need exists for nationwide calling or travel channel(s) for use for prisoner transportation. The channels must be monitored nationwide and in mobile and portable units nationwide. Hundreds of thousands of convicted, often dangerous felons are transported within and between federal, state and local jurisdictions. Often times as these ground transports move through communities today, they are without any form of routine or emergency communications. Direct access to the nearest public safety agency with the ability to provide emergency response is crucial as these ground transports are often hundreds of miles removed from their home jurisdiction. This concept has significant impact on interoperability and is further discussed in Section 7.5 of the Working Group 3 “Future Interoperability Needs Report” prepared by the Interoperability Subcommittee.

4.2.4.2.8 Interoperability. Mutual aid considerations are essential to correctional organizations. Large scale inmate disturbances or the pursuit of escapees requires multi-agency coordination. Correctional organizations often provide and supervise large inmate labor forces to assist in multi-agency recovery efforts in response to man-made and/or natural disasters.

4.2.4.2.9 Voice Messaging Alarms. Operating safe and secure prisons and jails is very staff intensive and personnel costs are the largest share of operating budgets. To reduce the ongoing operational costs of incarceration, correctional organizations are searching for improved strategies. The incorporation of various electronic deterrence and detection systems have proliferated to reduce the need for staff resources. Many of these systems incorporate roving alarm notification systems to provide rapid voice based alarm information to responding correctional personnel, thus allowing less staff to patrol a larger area.

4.2.4.3 Voice Requirements - Probation and Paroles. In general, voice communications for probation and parole personnel mirrors that of law enforcement. Probation and parole officers must be able to speak with each other or with other law enforcement officers. Probation and parole personnel often cover more than one law enforcement jurisdiction. Voice coverage from portable radios must include the ability to communicate from within buildings with a high degree of reliability.

4.2.4.3.1 Voice communications for most routine probation and parole operations does not require encryption. However, joint operations such as parolee-at-large sweeps; narcotic eradication sweeps, etc. will often warrant a higher level of transmission security. Devices must be able to monitor both encrypted and non-encrypted messages simultaneously.

4.2.4.3.2 Voice Dispatch. Voice communications routinely occur between probation and parole personnel the field and central dispatch points. Information conveyed commonly includes both operational instructions and information. The probation and parole voice communications system must support routine dispatch communications.

4.2.4.3.3 Officer to Officer Voice Communications. Voice communications routinely occur between one probation or parole officer in the field and one or more other officers in the field. Information conveyed commonly includes both operational instructions, administrative information, and general coordination. The probation and parole voice communications system must provide support for routine voice communications between probation and parole officers working throughout a particular jurisdiction.

4.2.4.3.4 Special Operations Communications. Probation and parole officers routinely participate in special investigations, task forces and other discrete activities that are a commonplace aspect of today's criminal justice community. A voice communications capability that is separate from normal operations voice traffic is required to support each special operation. These paths must have security (encryption) available.

4.2.4.4 Data Requirements - Prisons and Jails. The basic prison and jail requirement for data is immediate, clear transfer and display of text and graphical information for all correctional personnel, in support of both routine and emergency operations.

4.2.4.4.1 Mobile Data Computer/Terminal Applications. A need exists for real-time communications support of wireless mobile and portable computer systems capable of transmitting and receiving routine data queries and responses, electronic mail, location data and other graphics including fingerprints and mug shots, along with incident-specific data and

intelligence. Within a facility this may take the form of secure wireless LAN connectivity, or short hop microwave connections. Portable, wireless access to facility floor plan layouts for fire suppression or the development of tactical assault plan for special teams is essential to save lives. When traveling away from correctional facilities, wide area mobile data applications are required to manage transportation routing and scheduling.

4.2.4.4.2 Geographic Position and Automatic Location Data. Correctional organizations require the ability to transmit location data, determined by geographic position technology or other means, automatically or on demand to other locations. As correctional organizations must monitor larger and larger inmate populations with less and less staff, prisons and jails have identified a need to monitor individual inmate movement and location within large facilities. Such systems may also provide for early detection of escapes between physical counts. Outside of facilities, there is the need for constant updating of vehicle positions for transportation dispatch and transportation officer safety purposes.

4.2.4.4.3 Emergency Signals. Correctional personnel in prisons and jails who need emergency assistance must be able to activate an alarm that sends an automatic distress notice to a central monitoring point and other staff in the facility. The sophistication of such systems varies from simple "panic buttons" that will activate a general alarm, to more complex systems that incorporate multiple features such as unique unit identification, automatic unit registration, mercury activated person-down switches and automatic unit location. Often times these systems are stand-alone from other communications systems such as voice radio in order to provide staff security to those who would otherwise not require a portable communication device.

4.2.4.4.4 Remote Device Monitoring. Prisons and jails require the ability to monitor remote device indicators via data transmission in order to maintain safe facility operations and secure perimeters. For example, the ability to monitor plant operations systems such as electrical power generation, water or sewer processing, and perimeter detection systems for any sign of failure. While loss of such services in the community for short periods can be inconvenient, in the correctional environment they can produce disastrous consequences. Additionally, the ability to remotely control or disable various plant or security operations is essential to isolating and containing an inmate disturbance from spreading to adjacent facilities.

4.2.4.5 Data Requirements - Probation and Parole. The basic probation and parole requirement for data is immediate, clear transfer and display of text and graphical information for all probation and parole personnel, in support of both routine and emergency operations. Probation and parole require the same law enforcement network access described in Section 4.2.3.2.1 above.

4.2.4.5.1 Mobile Data Computer/Terminal Applications. A need exists for real-time communications support of wireless mobile and portable computer systems capable of transmitting and receiving routine data queries and responses, electronic mail, location data and other graphics including fingerprints and mug shots, along with incident-specific data and intelligence.

4.2.4.5.2 Geographic Position, Automatic Location Data, Remote Device Monitoring. Probation and parole organizations require the ability to transmit location data, determined by geographic position technology or other means, automatically or on demand to other locations. A major role in incarceration is now being played out in the community by probation and parole organizations, where their charges are sequestered in their homes by remote electronic monitoring. This use of "house arrest" has risen tremendously. Additionally, there is a mounting movement to develop systems and process to continually monitor and know the whereabouts of probationers, parolees and early release inmates on a continuous basis. Proposed requirements have included a location accuracy of a few meters and a minimum five minute interval report time.

4.2.4.5.3 Emergency Signals. Probation and parole personnel who need emergency assistance must be able to activate an alarm that sends an automatic distress notice to a central monitoring point and other staff in the field.

4.2.4.5.4 Transmission of Reports. This system should accommodate transmission of forms and reports to central sites from mobile and remote locations. This capability will be used by probation and parole personnel to transmit arrest reports, report violations, request warrants and to update case records files to central locations in long data streams of up to several seconds. This capability will reduce paper transactions, increase probation and parole officer field time, and speed transmission of vital information to command and administrative staff as well as other law enforcement agencies.

4.2.4.5.5 Electronic Messaging. Probation and parole officers require the ability to input messages into a data transmission device for transmission to single or multiple agencies, including other officers and other public safety providers. Due to their constant contact with the offender population, these staff often can provide substantive information to other law enforcement agencies.

4.2.4.6 Video Requirements - Prisons and Jails. The basic prison and jail requirement for video is immediate, clear wireless transfer of video for routine and emergency operations.

4.2.4.6.1 Incident Video. Some incidents like major inmate disturbances or hostage situations require real-time video. The capability must exist for both point-to-point and broadcast use of the video. For example, full motion video must be transportable from the incident scene to an incident command post, and also to a remotely located emergency operations center.

4.2.4.6.2 Surveillance and Monitoring. As correctional organizations must monitor larger and larger inmate populations with less and less staff, prisons and jails have identified the need to use real-time video to monitor multiple secure areas from remote locations. Additionally, remotely operated video cameras are a great assets in reducing the introduction of contraband into facilities via visiting room settings. There are some prison locations where wired video systems are not practical or where portable video systems requiring wireless links are required.

4.2.4.7 Video Requirements - Probation and Parole. The basic probation and parole video requirement is for immediate, clear wireless transfer of video for routine and emergency operations.

4.2.4.7.1 Surveillance and Monitoring. Probation and parole require the ability to transmit video snapshots at the rate of one frame each five seconds, for surveillance and monitoring purposes. For example individual, gang, building and low risk drug transaction surveillance would be adequately served by this quality of video transmission.

4.2.4.7.2 Still-Photographs. Probation and parole operations require the ability to transmit still photographs on demand to other locations. For example, a probation or parole officer in the field should be able to transmit and/or receive a digital image of probationers or parolees to and/or from other officers and central dispatch points.

### 4.3 FIRE, EMERGENCY MEDICAL AND RELATED LIFE AND PROPERTY PROTECTION SERVICES

4.3.1 Mission. The mission of the Fire, Emergency Medical and Related Life and Property Protection Services working group is to catalog operational requirements for those public entities that provide services to the public, encompassing emergency life saving and the critical care of the sick and injured, as well as emergency property protection.

Historically these services have been categorized as Fire Service and Emergency Medical Service (EMS), and in many jurisdictions all or part of the functions contained herein are managed exclusively by Fire and EMS providers. For example, the County of Los Angeles Fire Department provides a broad scope of services including fire suppression and prevention, emergency medical paramedic, hazardous materials, urban search and rescue, technical and mountain search and rescue, swift water rescue, and ocean lifeguard services.

This broadening scope of service displays significant growth from the historic perspective of fire suppression and first aid. Due in part to this increased responsibility placed upon the public protectors of life and property, we now find many of these services provided by a variety of public safety provider agencies, both as combined service and single service providers.

To reasonably represent all of these providers without regard to umbrella agency categorization, this working group includes a description of the common and unique operational requirements for each of the following life and property protection services:

- Fire Suppression and Prevention
- Emergency Medical Services
- Hazardous Materials
- Urban Search and Rescue/ Technical Search and Rescue
- Swift Water Rescue
- Ocean Lifeguards/ Blue Water Rescue

## Other Property Protection and Preservation

4.3.2 Introduction. Wireless command, control and communications support is crucial to assure quality life and property protection and to create the safest possible working environment for Fire, Emergency Medical and related Life and Property Protection services personnel. Wireless technologies are the emerging backbone of command, control, communications, and computerized synthesis of intelligence gathering and distribution (C4I.)

The following material is the product of discussion and correspondence with Fire, Emergency Medical and related Life and Property Protection officials from various locations throughout the United States. The emphasis of the working group has been on identification of present and future operational needs, dependent on wireless communication, without regard to cost or the current availability of technology. Needs are categorized into three basic areas of wireless communication: voice, data, and video.

### 4.3.3 Fire Suppression and Prevention.

4.3.3.1 Voice Requirements. The basic requirement for voice is immediate, clear voice communications for all fire suppression and prevention personnel upon all demands, major and minor, created by fire-related emergencies. Adequate voice communication paths must be provided for safe, efficient, and effective operations at all incidents. It is not unusual for major incidents to require in excess of 150 separate and distinct voice communication paths to ensure positive, effective incident operations. This large requirement for communication paths is incumbent upon many factors such as, the wide variety of tactical assignments that must be performed simultaneously for rapid containment and control, the need to coordinate between multiple layers of the command structure, the need to coordinate between the incident command structure sections, i.e. operations, logistics, planning, and finance, the need to coordinate with those cooperating agencies that provide support services to the incident, and the need to coordinate with those automatic and mutual aid agencies assisting in fire suppression and prevention activities. These communication paths must be immediately available and expandable to accommodate the rapid change from day-to-day operations to major disaster requirements.

4.3.3.1.1 Tactical Voice. Tactical voice communication requirements exist at the actual situation or suppression level of an incident. Tactical assignments vary significantly by location and function. Separate tactical voice paths are required for each strike team, task force, or functional group. The total number of tactical voice paths will vary in accordance with the size and nature of the incident, as well as the number of units required for containment and control. Incidents of magnitude similar to the Old Topanga Incident (1993 Malibu wildland urban interface fire), the 1991 Oakland Hills Fire, or the 1992 Los Angeles civil disturbance fires created tactical voice path demands in excess of 80 distinct tactical paths.

4.3.3.1.2 Command Voice. Command and Control voice communication requirements exist at each successive level of command above the tactical levels. Generally, separate command voice paths will be required for each leader in the chain of command upon which all

leaders immediately subordinate will operate. The total number of command voice paths will vary in accordance with the size and nature of the incident. Standard operating procedures for the Incident Command System dictate that a five to one ratio of subordinates to commander is ideal. Large incidents may require in excess of 30 command voice paths.

4.3.3.1.3 Interoperability Voice. The Interoperability subcommittee report examines the need for interoperability voice in detail; however, this communication need must be stressed and catalogued as an operational requirement. Large fire incidents require the aid of a multitude of public safety and public service agencies to effectively save lives and protect property. The Old Topanga Incident (1993 Malibu wildland urban interface fire) called upon the services of 458 assisting agencies from twelve states and in excess of twenty cooperating agencies for containment and control. It is impossible to effect efficient command and control without the ability to communicate with assisting and cooperating agencies on major incidents.

4.3.3.2 Data Requirements. The basic need for data is immediate, clear multiplex wireless transfer and display of data (text and graphics) for all fire personnel upon all demands, major and minor, created by fire-related emergencies. The ability to transmit, receive, and display intelligent data will greatly enhance and support the overall mission of fire command and control. The advantage of digital text and graphic data in conjunction with voice is accuracy and storage for future recall. Text can be recalled unlimited times to assure correct interpretation of the information. In addition, digital information can be stored and integrated into other data for the purposes of incident reporting and documentation. Data transmission requires less air time than voice, allowing increased availability of voice communication paths.

4.3.3.2.1 Mobile Data Computer/Terminal applications. A need exists for communications support of wireless mobile and portable computer systems capable of transceiving incident specific data and intelligence. Support for these systems should accommodate transmission of text, such as electronic mail secure and unsecure individual and group messaging, multilayered geographic information data (GIS) as well as real time data, such as automatic vehicle and personnel location, weather and atmospheric conditions, hazardous material conditions and incident intelligence received from remote sensors or directly keyed.

4.3.3.2.2 Automatic Location Information. A need exists for automatic communication of location information generated to report accurate location of vehicles and personnel into a synthesized computer command and control system. This system should also accommodate associated data, such as emergency situation alert function, personnel vitals and equipment status and needs such as fuel and water. Automatic location information will accomplish several goals in the mission of life and property protection; emergency responders dispatched with regard to actual incident proximity will trim precious life and property saving response times; incident commanders will accurately assign and monitor units/personnel to accomplish strategic efficiency; and fire fighters will report emergency situation location by the push of a button, speeding help their way and reducing the likelihood of injury or death.

4.3.3.2.3 Robotics support. In extremely hazardous situations, fire suppression may only be accomplished with remote suppression equipment supported by robotics. The operation of this equipment will be heavily dependent upon wireless data connectivity.

4.3.3.2.4 Interoperability Data. The Interoperability subcommittee report examines the need for data interoperability in detail; however, this communication need must be stressed and catalogued as an operational requirement. Large fire incidents require the aid of a multitude of public safety and public service agencies to effectively save lives and protect property. Incident intelligence is greatly enhanced by the ability to send and display information formatted as text and graphics. It is impossible to effect efficient command and control without the ability to communicate with assisting and cooperating agencies on major incidents.

4.3.3.3 Video/Imagery Requirements. The basic requirement for video/ imagery is immediate, clear wireless transfer of video/ imagery for all fire personnel upon all demands, major and minor, created by fire-related emergencies. Video/imagery capture and display systems must be capable of transceiving incident specific replications and should accommodate video and imagery from all available sources including privately owned and agency controlled. For example, automatic aid agreements with commercial broadcast agencies would often provide quality video/ imagery of incident scenes for command personnel, either directly or through retransmission.

4.3.3.3.1 Incident Video/Imagery. A need exists for real time transmission of fire incident scenes from the scene location to the incident command post and also to remotely located emergency operations centers.

4.3.3.3.2 Aerial Observation Video/Imagery. A need exists for the transmission of video/imagery from airborne platforms to the incident command post.

4.3.3.3.3 Robotics Video/Imagery. In extremely hazardous situations, fire suppression may only be accomplished with remote suppression equipment supported by robotics. The operation of this equipment will be heavily dependent upon wireless connectivity and the ability to guide these devices via video support.

4.3.3.3.4 Interoperability Video/Imagery. Video/imagery interoperability need must be stressed and catalogued as an operational requirement. Large fire incidents require the aid of a multitude of public safety and public service agencies to effectively save lives and protect property. Additionally, video and imagery is gathered from multiple sources, both public and private, during major incidents. The ability to utilize video and imagery from multiple sources, as well as the ability to share this information among assisting and cooperating agencies, will greatly enhance incident operations.

#### 4.3.4 Emergency Medical Services (EMS)

4.3.4.1 Voice Requirements. The basic requirement for voice is immediate, clear voice communications for all EMS personnel upon all demands, major and minor, created by

situations requiring the intervention of EMS personnel. EMS personnel require the ability to communicate by voice with like personnel and units, base station hospitals and doctors, regional transportation coordination centers, airborne medical evacuation resources, fire service and law enforcement resources, infectious disease centers, poison control centers, and many more. Adequate voice communication paths must be provided for safe, efficient, and effective operations at all emergency medical incidents. These communication paths must be immediately available and expandable to accommodate the rapid change from day-to-day operations to multi-casualty disaster requirements.

4.3.4.1.1 Patient Care Voice. This voice communication requirement exists at the actual patient care level of an incident. This vital link provides interface between doctors and EMS personnel and fosters proper and efficient treatment for the sick and injured. Separate patient care voice paths are required for each EMS/hospital team. It is common for multiple EMS units to require immediate interface with the same or multiple base hospitals simultaneously. Seconds, not minutes, make the difference between full recovery, debilitating injury, or death. Rapid, efficient intervention supported by EMS personnel/base hospital interface plays a critical role in determining the outcome. Numbers of required patient care voice paths will vary in accordance with civilian population and EMS provider area call volume; however, our mobile society transports large numbers of potential victims via highway, rail, and air into sparsely populated areas on a routine basis.

4.3.4.1.2 Scene Control Voice. Scene control voice communication requirements exist at every EMS incident regardless of size or complexity. These voice paths are required to ensure safe working environments, the timely and accurate placement of transportation units, the immediate request for assistance and additional equipment, and overall scene coordination. The required number of scene control voice paths vary with the size and complexity of the incident. A typical multi-casualty incident will require distinct scene control voice paths to support incident command, triage, treatment, and transportation.

4.3.4.1.3 Interoperability Voice. The Interoperability subcommittee report examines the need for interoperability voice in detail; however, this communication need must be stressed and catalogued as an operational requirement. EMS personnel require the ability to communicate by voice with base station hospitals and doctors, regional transportation coordination centers, airborne medical evacuation resources, fire service and law enforcement resources, infectious disease centers, poison control centers, and many more. Adequate voice communication paths must be provided for safe, efficient, and effective operations at all emergency medical incidents.

4.3.4.2 Data Requirements. The basic need for data is immediate, clear multiplex wireless transfer and display of data (text and graphics) for all EMS personnel upon all demands, major and minor, created by EMS-related emergencies. The ability to transmit, receive, and display data will greatly enhance and support the overall mission of EMS. The advantage of digital text and graphic data in conjunction with voice is accuracy and storage for future recall. Text can be recalled unlimited times to assure correct interpretation of the information. In addition, digital information can be stored and integrated into other data for the purposes of incident

reporting and documentation. Data transmission requires less air time than voice, allowing increased availability of voice communication paths.

4.3.4.2.1 Mobile Data Computer/Terminal applications. A need exists for communications support of wireless mobile and portable computer systems capable of transceiving incident and patient specific data and intelligence. Support for these systems should accommodate transmission of text such as secure and unsecure individual and group messaging, multilayered geographic information data (GIS), as well as real time data such as automatic vehicle and personnel location.

4.3.4.2.2 Patient Care Data. A need exists for the wireless transfer of patient vitals and diagnostic data. Advanced diagnostic tools such as twelve lead EKG, EEG, ultra-sound, and MRI will transfer life saving information between field units and base hospitals.

4.3.4.2.3 Automatic Location Information. A need exists for automatic communication of location information generated to report accurate location of vehicles and personnel into a synthesized computer command and control system. This system should also accommodate associated data such as emergency situation alert function, personnel vitals, and equipment status and needs.

4.3.4.2.4 Interoperability Data. The Interoperability subcommittee report examines the need for data interoperability in detail; however, this communication need must be stressed and catalogued as an operational requirement. EMS incidents require the aid of a multitude of public safety and public service agencies. Data must be shared to effectively care for the sick and injured.

4.3.4.3 Video/Imagery Requirements. The basic requirement for video/imagery is immediate, clear wireless transfer of video/imagery for all EMS/hospital personnel upon all demands, major and minor, created by EMS-related emergencies. Video/imagery capture and display systems must be capable of transferring patient specific replications from units in the field to diagnostic patient care centers. The ability for doctors to view the actual patient in conjunction with voice and data assessment information will greatly enhance patient care and survivability.

4.3.4.3.1 Patient Care Video/Imagery. Video/imagery capture and display systems must be capable of transferring patient specific replications from units in the field to diagnostic patient care centers. The ability for doctors to view the actual patient in conjunction with voice and data assessment information will greatly enhance patient care and survivability.

4.3.4.3.2 Interoperability Video/Imagery. The Interoperability subcommittee report examines the need for data interoperability in detail; however, this communication need must be stressed and catalogued as an operational requirement. EMS incidents require the aid of a multitude of public safety and public service agencies. Video/Imagery must be shared to effectively care for the sick and injured.

#### 4.3.5 Hazardous Material Teams (Haz Mat)

4.3.5.1 Voice Requirements. The basic requirement for voice is immediate, clear voice communications for all hazardous materials team personnel upon all demands, major and minor, created by situations requiring the intervention of Haz Mat personnel. Haz Mat personnel require the ability to communicate by voice with a large variety of public safety and public service organizations to effectively contain and safely control hazardous material incidents. Adequate voice communication paths must be provided for safe, efficient, and effective operations at all hazardous materials incidents. These communication paths must be immediately available and expandable to accommodate the rapid changes that occur on incidents of this nature.

4.3.5.1.1 Tactical Voice. Tactical voice communication requirements exist at the actual situation or containment level of an incident. Tactical assignments and functional groups vary significantly on hazardous materials incidents. Haz Mat incidents may be static or dynamic. They may involve fire and explosions. Oceans, lakes, and waterways may be affected; and toxic gas clouds many times complicate the task of containment and civilian safety. Each of these concerns must be addressed and attacked by specialized task groups. Separate tactical voice paths are required for each strike team, task force, or functional group. The total number of tactical voice paths will vary in accordance with the size and nature of the incident, as well as the number and variety of units required for containment and control.

4.3.5.1.2 Command Voice. Command and Control voice communication requirements exist at each successive level of command above the tactical levels. The location and anticipated dynamic consequence of hazardous material incidents dictate command responsibility. This command responsibility may be placed upon officials from fire agencies, law enforcement, the Coast Guard, Fish and Game, AQMD, etc. Generally, separate command voice paths will be required for each leader in the chain of command upon which all leaders immediately subordinate will operate. The total number of command voice paths will vary in accordance with the size and nature of the incident. Standard operating procedures for the Incident Command System dictate that a five to one ratio of subordinates to commander is ideal. Large incidents require multiple command voice paths. The potential for disaster implied by these incidents dictates that the voice communication conduit from command to subordinate to tactical levels of operation be solid, reliable, and secure.

4.3.5.1.3 Interoperability Voice. The Interoperability subcommittee report examines the need for interoperability voice in detail; however, this communication need must be stressed and catalogued as an operational requirement. Haz Mat personnel require the ability to communicate by voice with a wide variety of assisting and cooperating agencies such as fire, law enforcement, health departments, the Coast Guard, Department of Defense state and federal forestry, fish and game, flood control, AQMD, highways and transportation, toxic substance and poison control centers, agriculture, railroads, Chem. Trek, EMS, utility providers, and state and federal disaster warning centers. Adequate voice communication paths must be provided for safe, efficient, and effective operations at all hazardous material incidents.

4.3.5.2 Data Requirements. The basic need for data is immediate, clear multiplex wireless transfer and display of data (text and graphics) for all Haz Mat personnel upon all demands, major and minor, created by Haz Mat-related emergencies. The ability to transmit, receive, and display intelligent data will greatly enhance and support the overall mission of Haz Mat teams. The advantage of digital text and graphic data in conjunction with voice is accuracy and storage for future recall. Text can be recalled unlimited times to assure correct interpretation of the information. In addition, digital information can be stored and integrated into other data for the purposes of incident reporting and documentation. Data transmission requires less air time than voice, allowing increased availability of voice communication paths.

4.3.5.2.1 Mobile Data Computer / Terminal applications. A need exists for communications support of wireless mobile and portable computer systems capable of transceiving incident-specific data and intelligence. Support for these systems should accommodate transmission of text, such as secure and unsecure individual and group messaging, multilayered geographic information data (GIS), as well as real time data, such as automatic vehicle and personnel location, as well as weather and atmospheric conditions.

4.3.5.2.2 Automatic Location Information. A need exists for automatic communication of location information generated to report accurate location of vehicles and personnel into a synthesized computer command and control system. This system should also accommodate associated data such as emergency situation alert function, personnel vitals, and equipment status and needs. Automatic location information will accomplish several goals in the mission of life and property protection: Emergency responders dispatched with regard to actual incident proximity will trim precious life and property saving response times; incident commanders will accurately assign and monitor units/ personnel to accomplish strategic efficiency; and Haz Mat personnel will report emergency situation location by the push of a button, speeding help their way and reducing the likelihood of injury or death.

4.3.5.2.3 Robotics support. In extremely hazardous situations, hazardous material containment may only be accomplished with remote equipment supported by robotics. The operation of this equipment will be heavily dependent upon wireless data connectivity.

4.3.5.2.4 Interoperability Data. The Interoperability subcommittee report examines the need for data interoperability in detail; however, this communication need must be stressed and catalogued as an operational requirement. Hazardous material incidents require the aid of a multitude of public safety and public service agencies to effectively save lives and protect property. Incident intelligence is greatly enhanced by the ability to send and display information formatted as text and graphics. It is impossible to effect efficient command and control without the ability to communicate with assisting and cooperating agencies on Haz Mat incidents.

4.3.5.3 Video/Imagery Requirements. The basic requirement for video/imagery is immediate, clear wireless transfer of video/imagery for all Haz Mat personnel upon all demands, major and minor, created by Haz Mat-related emergencies. Video/imagery capture and display systems must be capable of transceiving incident specific replications and should accommodate video and imagery from all available sources including privately owned and

agency controlled. For example, automatic aid agreements with commercial broadcast agencies would often provide quality video/ imagery of incident scenes for command personnel, either directly or through retransmission.

4.3.5.3.1 Incident Video/Imagery. A need exists for the real time transmission of Haz Mat incident scenes from the scene location to the incident command post and also to remotely located emergency operations centers.

4.3.5.3.2 Aerial Observation Video/Imagery. A need exists for the transmission of video/imagery and multi-spectral toxic cloud replication from airborne platforms to the incident command post.

4.3.5.3.3 Robotics Video/Imagery. In extremely hazardous situations, hazardous material containment may only be accomplished with remote equipment supported by robotics. The operation of this equipment will be heavily dependent upon wireless connectivity and the ability to guide these devices via video support.

4.3.5.3.4 Interoperability Video/Imagery. The Interoperability subcommittee report examines the need for video/imagery interoperability in detail; however, this communication need must be stressed and catalogued as an operational requirement. Hazardous material incidents require the aid of a multitude of public safety and public service agencies to effectively save lives and protect property. Additionally, video and imagery is gathered from multiple sources, both public and private, during major incidents. The ability to utilize video and imagery from multiple sources, as well as the ability to share this information among assisting and cooperating agencies, will greatly enhance incident operations.

#### 4.3.6 Urban Search and Rescue/Technical Search and Rescue (USAR/TSAR)

4.3.6.1 Voice Requirements. The basic requirement for voice is immediate, clear voice communications for all USAR/TSAR team personnel upon all demands, major and minor, created by situations requiring the intervention of USAR/TSAR personnel. USAR/TSAR personnel require the ability to communicate by voice in specialized environments, such as confined spaces created by collapsed structures or trenches, and difficult terrain dictated by steep and broken topography found in mountain and canyon rescues. To effectively conduct operations under these demanding situations, adequate voice communication paths must be provided to foster safety and efficiency. These communication paths must be immediately available and expandable to accommodate the precise coordination required by incidents of this nature.

4.3.6.1.1 Tactical Voice. Tactical voice communication requirements exist at the actual situation or rescue level of an incident. Tactical assignments and functional groups vary significantly on USAR/TSAR incidents. USAR/TSAR incidents present rescuers with a variety of exacting operational concerns. Each of these concerns must be addressed and attacked by specialized task groups. Separate tactical voice paths are required for each strike team, task force, or functional group. The total number of tactical voice paths will vary in

accordance with the size and nature of the incident, as well as the number and variety of units required to safely effect the rescue.

4.3.6.1.2 Command Voice. Command and Control voice communication requirements exist at each successive level of command above the tactical levels. Generally, separate command voice paths will be required for each leader in the chain of command upon which all leaders immediately subordinate will operate. The total number of command voice paths will vary in accordance with the size and nature of the incident. Standard operating procedures for the Incident Command System dictate that a five to one ratio of subordinates to commander is ideal. Large incidents require multiple command voice paths. Rapid intervention is the key to success on incidents of this nature. Successful operations depend upon immediate voice communications from command to subordinate to tactical levels of operation. This conduit must be solid, reliable, secure and immediately available.

4.3.6.1.3 Interoperability Voice. The Interoperability subcommittee report examines the need for interoperability voice in detail; however, this communication need must be stressed and catalogued as an operational requirement. USAR/TSAR personnel require the ability to communicate by voice with a wide variety of assisting and cooperating agencies, such as fire, law enforcement, building departments, Haz Mat, public works, flood control, highways and transportation, EMS, utility providers, and engineering entities, etc. Adequate voice communication paths must be provided for safe, efficient, and effective operations at all USAR/TSAR incidents.

4.3.6.2 Data Requirements. The basic need for data is immediate, clear multiplex wireless transfer and display of data (text and graphics) for all USAR/TSAR personnel upon all demands, major and minor, created by USAR/TSAR related emergencies. The ability to transmit, receive and display intelligent data will greatly enhance and support the overall mission of USAR/TSAR teams. The advantage of digital text and graphic data in conjunction with voice is accuracy and storage for future recall. Text can be recalled unlimited times to assure correct interpretation of the information. In addition, digital information can be stored and integrated into other data for the purposes of incident reporting and documentation. Data transmission requires less air time than voice, allowing increased availability of voice communication paths.

4.3.6.2.1 Mobile Data Computer/Terminal applications. A need exists for communications support of wireless mobile and portable computer systems capable of transceiving incident specific data and intelligence. Support for these systems should accommodate transmission of text, such as secure and unsecure individual and group messaging, multilayered geographic information data (GIS), as well as real time data, such as automatic vehicle and personnel location, as well as weather, atmospheric, and seismic conditions.

4.3.6.2.2 Automatic Location Information. A need exists for automatic communication of location information generated to report accurate location of vehicles and personnel into a synthesized computer command and control system. This system should also accommodate associated data, such as emergency situation alert function, personnel vitals, and equipment

status and needs. Automatic location information will accomplish several goals in the mission of life and property protection: Emergency responders dispatched with regard to actual incident proximity will trim precious life and property saving response times; incident commanders will accurately assign and monitor units/personnel to accomplish strategic efficiency; and USAR/TSAR personnel will report emergency situation location by the push of a button, speeding help their way and reducing the likelihood of injury or death.

4.3.6.2.3 Robotics support. In extremely hazardous situations, such as confined space rescues, many tasks may only be accomplished with remote equipment supported by robotics. The operation of this equipment will be heavily dependent upon wireless data connectivity.

4.3.6.2.4 Interoperability Data. The Interoperability subcommittee report examines the need for data interoperability in detail; however, this communication need must be stressed and catalogued as an operational requirement. USAR/TSAR incidents require the aid of a multitude of public safety and public service agencies to effectively save lives and protect property. Incident intelligence is greatly enhanced by the ability to send and display information, such as building floor plans formatted as text and graphics. It is impossible to effect efficient command and control without the ability to communicate with assisting and cooperating agencies on USAR/TSAR incidents.

4.3.6.3 Video/Imagery Requirements. The basic requirement for video/imagery is immediate, clear wireless transfer of video/imagery for all USAR/TSAR personnel upon all demands, major and minor, created by USAR/TSAR related emergencies. Video/imagery capture and display systems must be capable of transceiving incident specific replications and should accommodate video and imagery from all available sources including privately owned and agency controlled. For example, automatic aid agreements with commercial broadcast agencies would often provide quality video/imagery of incident scenes for command personnel, either directly or through retransmission.

4.3.6.3.1 Incident Video/Imagery. A need exists for the real time transmission of USAR/TSAR incident scenes from the scene location to the incident command post and also to remotely located emergency operations centers.

4.3.6.3.2 Aerial Observation Video/Imagery. A need exists for the transmission of video/imagery, and multi-spectral intelligence from airborne platforms to the incident command post.

4.3.6.3.3 Robotics Video/Imagery. In extremely hazardous situations, rescues may only be accomplished with remote equipment supported by robotics. The operation of this equipment will be heavily dependent upon wireless connectivity and the ability to guide these devices via video support.

4.3.6.3.4 Interoperability Video/Imagery. The Interoperability subcommittee report examines the need for video/imagery interoperability in detail, but this communication need must be stressed and catalogued as an operational requirement. USAR/TSAR incidents require the aid of a multitude of public safety agencies and pure communication requirements

exist at the actual situation or rescue level of an incident. Tactical assignments and functional groups vary significantly on Swift Water Rescue incidents. Swift Water Rescue incidents present rescuers with a variety of exacting operational concerns over a vast geographic area. Each of these concerns must be addressed and attacked by specialized task groups. Task groups consist of land based resources, watercraft resources, airborne resources, and swimmer insertion teams. Separate tactical voice paths are required for each functional group. The total number of tactical voice paths will vary in accordance with the size and nature of the incident as well as the number and variety of units required to safely effect the rescue.

#### 4.3.7 Swift Water Rescue

4.3.7.1 Voice Requirements. The basic requirement for voice is immediate, clear voice communications for all Swift Water Rescue personnel upon all demands, major and minor, created by situations requiring the intervention of water rescue personnel. Swift Water Rescue personnel require the ability to communicate by voice in specialized dynamic environments, as well as in routine patrol and rescue situations. To effectively conduct operations under these demanding situations, adequate voice communication paths must be provided to foster safety and efficiency. Paths are required to support water course surveillance, recreational user observation and other routine duties, as well as dynamic demands required in expanded incident situations. These communication paths must be immediately available and expandable.

4.3.7.1.1 Tactical Voice. Tactical Voice. Tactical voice communication requirements exist at the actual situation or rescue level of an incident. Tactical assignments and functional groups vary significantly on incidents requiring intervention by Swift Water Rescue personnel. Swift Water Rescue personnel task groups consist of land-based resources, watercraft resources, airborne resources, and swimmers. Each of these functional groups and tactical assignments must be addressed and supported by voice communication paths. Clear and distinct tactical voice communication paths must be immediately available for assignment to specific water emergency incidents. Swift Water Rescue personnel handle a multitude of incidents ranging from routine single victim water rescues to multi-casualty incidents, vessel grounding, and downed aircraft. Adequate tactical voice communication paths are required to support multiple incidents simultaneously.

4.3.7.1.2 Command Voice. Command and Control voice communication requirements exist at each successive level of command above the tactical levels. Generally, separate command voice paths will be required for each leader in the chain of command upon which all leaders immediately subordinate will operate. The total number of command voice paths will vary in accordance with the size and nature of the incident. Standard operating procedures for the Incident Command System dictate that a five to one ratio of subordinates to commander is ideal. Large incidents require multiple command voice paths. Rapid intervention is the key to success on incidents of this nature. Successful operations depend upon immediate voice communications from command to subordinate to tactical levels of operation. This conduit must be solid, reliable, secure and immediately available.

4.3.7.1.3 Interoperability Voice. The Interoperability subcommittee report examines the need for interoperability voice in detail, but this communication need must be stressed and catalogued as an operational requirement. Swift Water Rescues, as a rule, involve multiple jurisdictions due to the dynamic nature and paths of the involved waterways. Swift Water Rescue personnel require the ability to communicate by voice with a wide variety of assisting and cooperating agencies, such as fire, law enforcement, lifeguards, Coast Guard, public works, flood control, highways and transportation, EMS, etc. Adequate voice communication paths must be provided for safe, efficient, and effective operations at all Swift Water Rescue incidents.

4.3.7.2 Data Requirements. The basic need for data is immediate, clear multiplex wireless transfer and display of data (text and graphics) for all Swift Water Rescue personnel upon all demands, major and minor, created by Swift Water related emergencies. The ability to transmit, receive, and display intelligent data will greatly enhance and support the overall mission of Swift Water Rescue teams. The advantage of digital text and graphic data in conjunction with voice is accuracy and storage for future recall. Text can be recalled unlimited times to assure correct interpretation of the information. In addition, digital information can be stored and integrated into other data for the purposes of incident reporting and documentation. Data transmission requires less air time than voice, allowing increased availability of voice communication paths.

4.3.7.2.1 Mobile Data Computer/Terminal applications. A need exists for communications support of wireless mobile and portable computer systems capable of transceiving incident specific data and intelligence. Support for these systems should accommodate transmission of text such as secure and unsecure individual and group messaging, multilayered geographic information data (GIS), as well as real time data such as automatic vehicle and personnel location, as well as weather and atmospheric conditions.

4.3.7.2.2 Automatic Location Information. A need exists for automatic communication of location information generated to report accurate location of vehicles, personnel, and victims into a synthesized computer command and control system. This system should also accommodate associated data such as emergency situation alert function, personnel vitals, and equipment status and needs. Automatic location information will accomplish several goals in the mission of life and property protection: Emergency responders dispatched with regard to actual incident proximity will trim precious life and property saving response times; incident commanders will accurately assign and monitor units/ personnel to accomplish strategic efficiency; victim location may be accurately tracked to support proper placement of resources; and Swift Water Rescue personnel will report emergency situation location by the push of a button, speeding help their way and reducing the likelihood of injury or death.

4.3.7.2.3 Interoperability Data. The Interoperability subcommittee report examines the need for data interoperability in detail, but this communication need must be stressed and catalogued as an operational requirement. Swift Water Rescue incidents require the aid of a multitude of public safety and public service agencies over a multi-jurisdictional operational area. It is impossible to effect efficient command and control without the ability to communicate with assisting and cooperating agencies on Swift Water Rescue incidents.

4.3.7.3 Video/Imagery Requirements. The basic requirement for video/imagery is immediate, clear wireless transfer of video/imagery for all Swift Water Rescue personnel upon all demands, major and minor, created by Swift Water Rescue-related emergencies. Video/imagery capture and display systems must be capable of transceiving incident specific replications and should accommodate video and imagery from all available sources including privately owned and agency controlled. For example, automatic aid agreements with commercial broadcast agencies would often provide quality video/imagery of incident scenes for command personnel, either directly or through retransmission.

4.3.7.3.1 Incident Video/Imagery. A need exists for the real time transmission of Swift Water Rescue incident scenes from the scene location to the incident command post and also to remotely located emergency operations centers.

4.3.7.3.2 Aerial Observation Video/Imagery. A need exists for the transmission of video/imagery and multi-spectral intelligence from airborne platforms to the incident command post.

4.3.7.3.3 Interoperability Video/Imagery. The Interoperability subcommittee report examines the need for video/imagery interoperability in detail, but this communication need must be stressed and catalogued as an operational requirement. Swift Water Rescue incidents require the aid of a multitude of public safety and public service agencies to effectively save lives. Additionally, video and imagery is gathered from multiple sources, both public and private, during Swift Water Rescue incidents. The ability to utilize video and imagery from multiple sources as well as the ability to share this information among assisting and cooperating agencies will greatly enhance incident operations.

#### 4.3.8 Lifeguards/Water Safety Personnel.

4.3.8.1 Voice Requirements. The basic requirement for voice is immediate, clear voice communications for all Lifeguards/Water Safety personnel upon all demands, major and minor, created by situations requiring the intervention of Lifeguards/ Water Safety personnel. Lifeguards/Water Safety personnel require the ability to communicate by voice in specialized dynamic environments, as well as in routine patrol and rescue situations. To effectively conduct operations under these demanding situations, adequate voice communication paths must be provided to foster safety and efficiency. Paths are required to support beach management, swimmer surveillance, and other routine duties, as well as dynamic demands required in expanded incident situations. These communication paths must be immediately available and expandable.

4.3.8.1.1 Tactical Voice. Tactical voice communication requirements exist at the actual situation or rescue level of an incident. Tactical assignments and functional groups vary significantly on incidents requiring intervention by Lifeguard/Water Safety personnel. Lifeguard/Water Safety personnel task groups consist of land-based resources, watercraft resources, airborne resources, and swimmers. Each of these functional groups and tactical assignments must be addressed and supported by voice communication paths. Clear and distinct tactical voice communication paths must be immediately available for assignment to

specific water emergency incidents. Lifeguards/Water Safety personnel handle a multitude of incidents ranging from routine single victim water rescues to multi-casualty incidents, vessel grounding, and downed aircraft. Adequate tactical voice communication paths are required to support multiple incidents simultaneously.

4.3.8.1.2 Command Voice. Command and Control voice communication requirements exist at each successive level of command above the tactical levels. Clear and distinct command voice communication paths must be immediately available and assigned with regard to geographic beach/ water use locations. The quantity of command voice communication paths must be sufficient to support multiple incidents occurring at separate geographic beach/ water use locations simultaneously. This need can be illustrated by examining the jurisdictional area of the County of Los Angeles Fire Department Lifeguards. The County manages 76 miles of coastline on the mainland and the entire coastline of Catalina Island, 28 miles off shore. The mainland shoreline alone is subdivided into 31 separate public beaches. Each beach location requires a clear and distinct command voice path to support rescue operations in that area.

4.3.8.1.3 Interoperability Voice. The Interoperability subcommittee report examines the need for interoperability voice in detail, but this communication need must be stressed and catalogued as an operational requirement. Lifeguard and water rescue operations often involve multiple jurisdictions and public safety agencies. This shared service posture requires the ability to communicate by voice with a wide variety of assisting and cooperating agencies such as, fire, law enforcement, swift water, Coast Guard, public works, flood control, highways and transportation and EMS. Adequate voice communication paths must be provided for safe, efficient, and effective operations at all Lifeguard/Water Safety incidents.

4.3.8.2 Data Requirements. The basic need for data is immediate, clear multiplex wireless transfer and display of data (text and graphics) for all Lifeguard/Water Safety personnel upon all demands, major and minor, created by Water-related emergencies. The ability to transmit, receive, and display intelligent data will greatly enhance and support the overall mission of Lifeguard/Water Safety personnel. The advantage of digital text and graphic data in conjunction with voice is accuracy and storage for future recall. Text can be recalled unlimited times to assure correct interpretation of the information. In addition, digital information can be stored and integrated into other data for the purposes of incident reporting and documentation. Data transmission requires less air time than voice, allowing increased availability of voice communication paths.

4.3.8.2.1 Mobile Data Computer/Terminal applications. A need exists for communications support of wireless mobile and portable computer systems capable of transceiving incident specific data and intelligence. Support for these systems should accommodate transmission of text such as secure and unsecure individual and group messaging, multilayered geographic information data (GIS), as well as real time data such as automatic vehicle and personnel location, as well as weather and atmospheric conditions.

4.3.8.2.2 Automatic Location Information. A need exists for automatic communication of location information generated to report accurate location of vehicles, personnel, and

victims into a synthesized computer command and control system. This system should also accommodate associated data, such as emergency situation alert function, personnel vitals, and equipment status and needs. Automatic location information will accomplish several goals in the mission of life and property protection: Emergency responders dispatched with regard to actual incident proximity will trim precious life and property saving response times; incident commanders will accurately assign and monitor units/ personnel to accomplish strategic efficiency; victim location may be accurately tracked to support proper placement of resources; and Lifeguard/ Water Safety personnel will report emergency situation location by the push of a button, speeding help their way and reducing the likelihood of injury or death. Additionally, search and rescue represents a major responsibility for Lifeguard/ Water Safety personnel. Watercraft in distress or aircraft lost can quickly turn into tragedy if passengers are not rapidly located and rescued. Automatic Location Information can be utilized to establish grid search patterns that will efficiently streamline search and rescue operations.

4.3.8.2.3 Robotics support. Lifeguards/Water Safety personnel will utilize the support of robotics devices in underwater search and rescue operations when persons, planes, and ships are submerged in water depths greater than 200 feet. At these depths robotics equipment becomes the preferred method of retrieval. Use of human divers at these depths requires considerable decompression time. The utilization of remote control recovery vehicles eliminates the need to further risk human life to recover a dead body or salvage from ships or planes.

4.3.8.2.4 Interoperability Data. The Interoperability subcommittee report examines the need for data interoperability in detail, but this communication need must be stressed and catalogued as an operational requirement. Lifeguard/ Water Safety personnel incidents require the aid of a multitude of public safety and public service agencies including the Coast Guard, Harbor Police, local Law enforcement, Fire and EMS agencies. It is impossible to effect efficient command and control without the ability to communicate with assisting and cooperating agencies on water rescue incidents.

4.3.8.3 Video/Imagery Requirements. The basic requirement for video/imagery is immediate, clear wireless transfer of video/ imagery for all Lifeguard/Water Safety personnel upon all demands, major and minor, created by water rescue-related emergencies. Video/imagery capture and display systems must be capable of transceiving incident specific replications and should accommodate video and imagery from all available sources including privately owned and agency controlled. For example, automatic aid agreements with commercial broadcast agencies would often provide quality video/imagery of incident scenes for command personnel, either directly or through retransmission. Remote surveillance of little frequented beaches, underwater inspections of submerged aircraft or vessels, aerial observation of oil spills or major off shore incidents are just a few applications of video/ imagery utilization.

4.3.8.3.1 Incident Video/ Imagery. The ability to transmit clear video/ imagery to the incident commander provides invaluable information for incident management. Large offshore incidents such as cruise ship disasters, aircraft disasters, or oil spills will be greatly enhanced by video/imagery transmission.

4.3.8.3.2 Aerial Observation Video/ Imagery. A need exists for the transmission of video/imagery and multi-spectral interrogation from airborne platforms to the incident command post. This information will greatly assist efforts related to operations such as oil spill management and multiple victim searches created by disasters caused by cruise line or aircraft incidents.

4.3.8.3.3 Robotics Video/ Imagery. Remote and lightly-used beaches are not staffed with daily water safety and lifeguard personnel due to fiscal restraints. Staffing of these water use areas is determined daily by on-site Lifeguard/ Water Safety personnel inspection. Robotics Video/Imagery will allow continuous staffing decisions based on actual real time water use area populations.

4.3.8.3.4 Interoperability Video/Imagery. The Interoperability subcommittee report examines the need for video/ imagery interoperability in detail; however, this communication need must be stressed and catalogued as an operational requirement. Lifeguard/Water Safety personnel incidents require the aid of a multitude of public safety and public service agencies to effectively save lives. Additionally, video and imagery is gathered from multiple sources, both public and private, during Water Rescue incidents. The ability to utilize video and imagery from multiple sources, as well as the ability to share this information among assisting and cooperating agencies, will greatly enhance incident operations.

#### 4.4 EMERGENCY MANAGEMENT AND DISASTER SERVICES

4.4.1 Mission. The mission of the Emergency Management and Disaster Services (EMD) working group is to catalog operational requirements for emergency management and disaster services at the federal, state and local levels.

4.4.2 Introduction. Communications system requirements for emergency management and disaster services are characterized by very low usage patterns during routine operations and extremely high usage patterns during a major event. Thus, radio systems designed and used by emergency management agencies appear to be virtually unused on a day-to-day basis, yet when a major event occurs, these same systems are inadequate for meeting the need to communicate. Although individual communications systems performed properly, incident needs still were not met due to interoperability issues in New York at the World Trade Center, in Miami following Hurricane Andrew, in Oklahoma City, in Los Angeles during the Rodney King riots and following the Northridge Earthquake, in San Francisco following the Loma Prieta Earthquake, and countless other times.

We should not look at large-scale events as being an anomaly. True, major earthquakes do not occur that often. Nor do hurricanes or floods. Taken all together though, they occur more often than we would like to think. Furthermore, few years pass without a major forest or wildland fire such as those in Yellowstone National Park and in Malibu, California being battled by one thousand or more firefighters from hundreds of fire agencies. Special events such as the Olympics, political conventions, and the "Million Man March" occur each year. The reality is, large-scale events happen every year at unpredictable locations and at

unpredictable times. Public safety agencies must be prepared to respond to these events when they occur and they need effective communications to aid in their response. While the unpredictability of these events makes it impractical to have adequate wireless communications facilities in place, we can identify and protect a block of frequencies from which such facilities can be rapidly developed. Portable repeaters and programmable multi-channel radios have provided the needed technology. It is time for frequency planners to provide the spectrum.

#### 4.4.3 Voice Requirements.

**Routine Operations.** Emergency management agencies require at least one voice communications path (encryption capable) and one data communications path for command and control of their own personnel during routine operations. These same links would be used for a similar function during a disaster or major emergency. Agencies having this need include the Federal Emergency Management Agency (FEMA), state disaster control agencies and county disaster control agencies.

**Mutual Aid.** Large-scale emergencies and disasters place a particular burden upon the operation of public safety communications systems. Many of these events exceed the capability of local agencies and they turn to outside agencies to provide mutual aid. While the outside agencies provide the personnel and equipment needed to handle the situation, they also produce an increased demand for communications. A major forest fire, for instance, may involve over one thousand firefighters from over 100 different agencies.

Currently, one channel has been designated nationwide for law enforcement use (155.475 MHz), four channels have been designated nationwide for fire use (45.88 MHz, 154.265 MHz, 154.280 MHz, and 154.295 MHz), and five channels have been designated nationwide for public safety use (866.0125 MHz, 866.5125 MHz, 867.0125 MHz, 867.5125 MHz, and 868.0125 MHz). The Boise Inter-agency Fire Cache (BIFC) provides a resource of equipment which operates on Federal channels which are reserved nationwide for deployment of the BIFC equipment. Some state and local agencies have set aside additional channels to improve the situation, but there remains a dearth of channels to handle a large-scale event. This becomes a particular problem in the major metropolitan areas where all other public safety are already in use for normal operations. Specific recommendations regarding the number of communications paths needed for mutual aid purposes is a subject of the Interoperability Subcommittee report. While those links are desperately needed for mutual aid functions during a disaster or major emergency, to have all of those links remain unused at other times is a misuse of the limited spectrum. Therefore, the Operational Requirements Subcommittee recommends that the mutual aid links be available for use based upon a system of priorities such as the following:

- |            |  |
|------------|--|
| Priority 1 | Disaster and extreme emergency operations for mutual aid and interagency communications    |
| Priority 2 | Emergency or urgent operations involving imminent danger to the safety of life or property |

- Priority 3 Special event control activities, generally of a preplanned nature, and generally involving joint participation of two or more agencies
- Priority 4 Single agency secondary communications

It may be desirable to restrict Priority 3 and 4 communications to a particular sub-set of the set aside mutual aid channels, with different channels available for police, fire, EMS, and other public safety users. While Priority 4 communications do not seem to satisfy the mutual aid requirement, they provide an incentive to public safety agencies to implement the mutual aid capability in their mobile/portable radios.

**Inter-Agency Communications.** Many public safety emergencies, particularly large-scale emergencies and disasters, require a response from multiple agencies. The response from these agencies needs to be coordinated and controlled. Currently, much of this coordination occurs over the public switched telephone network (PSTN). History has shown, however, that the PSTN network is disrupted during a large-scale emergency or disaster due to damage or overload. During a major event, at least one voice and one data communications path are needed between each of the following points:

Federal Emergency Management Agency (FEMA) and State Disaster Services Agency

State Disaster Services Agency and Event Command Center

Event Command Center and County Government Command Center (provide 10 sets of links (both voice and data) to allow for multiple counties to be involved in the event. The Loma Prieta Earthquake, for example, affected eight counties).

County Government Command Center and Major City Command Center (provide 10 sets of links (both voice and data) to allow for multiple counties and cities to establish communications)

The voice links should be capable of encryption.

Some of these voice and data communications requirements may be satisfied by the long-range communications systems discussed below.

**Long-Range Communications.** Public safety response to large-scale emergencies and disasters usually requires the assistance of agencies from outside the "event area." One characteristic of such events, however, is disruption of the normal long-range communication networks through which such assistance might be requested. The public telephone network, for instance, may be unusable due to actual damage resulting from the event or due to system overload. Thus, there is a requirement for long-range communications which either are sufficiently robust as to withstand the initial event or are rapidly deployable.

High-frequency single-sideband (HF-SSB) communications systems are one method by which public safety agencies currently satisfy this requirement. These systems have been established under Section 90.264 of the Federal Communications Commission Rules and Regulations. They operate in the 2-10 MHz portion of the radio spectrum and offer communications over distances of several hundred miles.

**RECOMMENDATION:** Maintain the current frequency allocations but eliminate the inter-state restrictions on the points of communications. Federal Communications Commission licensing practices on these paths currently restrict use of certain channels to “inter-state use only” and, in some cases, to communications with specified other states. These restrictions fail to recognize the usefulness of HF systems for communications within a large state. The distance between Los Angeles and Sacramento, CA, for instance, is nearly 400 miles. Also eliminate “day/night” restrictions on the use of certain frequencies. The choice of frequency is dependent on many different factors, including not only the time-of-day but also the distance between communication points and the propagation conditions. The determination of which frequency is used should be based upon that frequency which provides the needed communications, not the position of the sun.

Satellite based communications are another method by which public safety agencies currently satisfy the requirement. Systems utilizing very-small aperture (VSAT) technology are capable of providing both voice and data services over virtually any distance.

Urban Search & Rescue. Several Urban Search and Rescue (USART) teams have been established across the country. These teams have proven their value during the Northridge Earthquake and the Oklahoma City bombing through their ability to conduct difficult rescue operations in downed buildings. By their very nature, USART operations are high-risk events where effective communications may affect personnel safety. Currently, the communications for these teams is based upon radio equipment and frequencies used in their home area and are subject to causing/receiving interference with other public safety agencies within the area of the event.

**RECOMMENDATION:** Set aside communications paths on a nation-wide basis for use by USART personnel. As a minimum, the following is needed:

- |                    |  |
|--------------------|--|
| 1 ea repeater pair | National USART command channel for communications between the USART team leaders and the event command center.   |
| 3 ea repeater pair | Team command channel for communications between USART team leaders and members of their team. This is based upon three teams being “on-duty” at any given time. Specific channels would be assigned to each team on a “per-event” basis. |
| 10 ea simplex      | On-scene tactical communications for USART team members. This is based upon different groups working different parts of a building in close proximity, each needing a “clear” channel for safety reasons.                                |

- 2 ea simplex            Robotics control channels. This is based upon two different robotics operations in close proximity.
- 2 ea simplex            Robotics video/audio channels. This is based upon two different robotics operations in close proximity.

The National USART Command channel should be maintained as a clear channel nationwide. The three repeater capable team command channels should be available for local search and rescue operations on the proviso that USART teams have priority access to those channels. Similarly, the simplex tactical and robotics channels should be available for local search and rescue, ski patrol, lifeguard and related activities with the same proviso that USART teams have priority access to those channels in the event of a disaster.

Disaster Medical Assistance. Similar to the USART teams formed by FEMA, the U.S. Public Health Service has formed Disaster Medical Assistance Teams. These DMAT teams provide medical personnel and equipment to handle mass casualties which might result from a major disaster. DMAT teams need to exchange information regarding the numbers and types of casualties, the availability of resources, and requests for additional resources.

**RECOMMENDATION:**     Set aside communications paths on a nationwide basis for use by DMAT teams. As a minimum, the following is needed:

- 1 ea repeater pair        National DMAT command channel for communications between the DMAT team leaders and the event command center.
- 1 ea data channel        National DMAT data channel for communications between DMAT teams and the event command center.

Damage Assessment and Infrastructure Repair. Immediately following a major disaster such as an earthquake, flood or hurricane, the amount of damage needs to be inventoried. From this inventory, damage to critical infrastructure such as roads, water works and utilities can be identified, prioritize and repaired.

**RECOMMENDATION:**     Establish one voice and data communications path nationwide for each of the following infrastructure services. In each case, private utility and governmental disaster services agencies should be eligible to use the link for purposes of exchanging information regarding damage/repair.

- Electric power providers
- Natural gas distributors
- Water providers
- Road agencies

The Operational Requirements Subcommittee recognizes that each of these infrastructure services have requirements for radio spectrum to support their disaster response. Although

the committee supports these requirements, discussion of the requirements and the spectrum requirements are not within the scope of the PSWAC report.

**Non-Public Safety Agency Communications.** Many non-public safety agencies provide valuable services during a disaster or major emergency. These agencies include the American Red Cross, the Salvation Army, the Civil Air Patrol and the National Guard. Public officials managing the disaster or event need voice and data communications with these agencies to exchange information regarding the care and feeding of victims.

**RECOMMENDATION:** Establish 5 nationwide voice/data channels in each band for communications between event command centers and these agencies. Eligibility for use of these channels should include the American Red Cross, the Salvation Army, Civil Air Patrol and National Guard and other non-public safety agencies providing similar disaster relief functions.

These agencies also have a need for communications internal to their operations during the disaster. Although these needs are not a subject of this report, the Operational Requirements Subcommittee recognizes these needs and supports providing radio spectrum for these functions. Communications requirements include internal operation of a shelter to provide security, food, water, clothing, bedding and other supplies.

**News Media & Emergency Broadcast.** Public officials managing any event have an obligation to inform the public about the emergency. The Emergency Broadcast System and the news media provide a valuable means by which information can be distributed to the public. A weak link in the system, however, is the link between the public official and the media. Currently, these messages are passed to the media either at a news conference or via telephone calls.

The State of California has implemented a system called the Emergency Digital Information System (EDIS) which utilizes land-mobile radio channels to pass digital messages directly to commercial broadcasters. These messages are formatted such that radio/TV announcers can “rip and read” as if the message were a teletype message and TV broadcasters can scroll the message across the screen. Messages can be generated by any public official

**RECOMMENDATION:** Establish a nationwide communications path for EDIS-type messages from appropriate public officials to broadcasters.

**RACES.** Radio Amateur Civil Emergency Service (RACES) operates on radio amateur frequencies by authority of the Federal Communications Commission in support of public safety. RACES can augment existing systems, substitute for damaged and inoperable systems, and establish communications links with otherwise inaccessible areas. RACES uses HF, VHF, and UHF equipment operating on packet (data), voice, CW Morse code, radio-teletype, and television (ATV). While not a public safety spectrum requirement, the services provided through RACES should be continued and protected.

#### 4.4.5 Data Requirements.

Global Positioning. Access to the Global Positioning System (GPS) is a valuable tool in a disaster. Following an earthquake, flood, hurricane, or other disaster it is not uncommon for normal landmarks to have disappeared. Buildings are destroyed, streets are covered, and road signs are missing. Emergency management personnel need a means by which they can map the event so that they can better understand where the problems lie and dispatch personnel to deal with situations appropriately. Although access to the GPS signal itself does not create a path or channel requirement, use of location data at any other location will create a path or channel requirement for transport of GPS-generated data, as described in paragraph 4.2.4 and similar paragraphs included in other portions of section 4.

### 4.5 HIGHWAY MAINTENANCE

4.5.1 Mission. The mission of the Highway Maintenance working group is to catalog operational requirements for highway maintenance at the state and local levels.

4.5.2 Introduction. Organizations at federal, state and local levels are charged with specific highway maintenance activities. Activities of these organizations include maintenance and construction of roads, highways, tunnels, bridges required to allow safe thoroughfare of the general public. Highway maintenance organizations also respond to events such as snow storms, mud slides, flooding, and hazardous material spills in order to allow safe passage on transportation infrastructures. Communications needs are based on official duties.

The Highway Maintenance mission is to serve the public by establishing, operating and maintaining a high quality cost effective transportation system that emphasizes safety, vehicle throughput and environmental preservation.

#### 4.5.3 Voice Requirements

Two-Way Voice Communications. Dispatch requirements usually fall into the categories of emergency response, maintenance and construction activities. These require dispatch operation to insure timely response and to control and manage activities. Wireless voice dispatch is critical to controlling costs, coordinating projects, and promoting safe, efficient traffic flow.

Voice communications are necessary from dispatcher control points to field units; field units to multiple field units; or individual to individual through either mobile mounted, hand held portable or desktop radios.

Telephone System Access. Interconnect capabilities are required for management level to interface with the public and provide semi-private contact at a management level. Mobile mounted or hand held portable radios which have system access to the public switched telephone network would be necessary.

Interoperability. Mutual aid considerations are vital to highway operations. Highway maintenance crews are often the first to arrive on the scene of accidents and require a method of contacting appropriate emergency response entities. Incidents occurring on or adjacent to highway right of way also require response by highway maintenance units to provide primary traffic control, vehicle relocation, emergency repair, detours along with providing general assistance to other public safety responders. Highway maintenance organizations are equipped with heavy equipment which is necessary to respond to public safety incidents involving multiple public safety disciplines. A primary consideration is weather associated operations such as snow removal which is very critical to public safety entities being able to perform their function. The ability to interface with other aspects of public safety are essential.

Connections to remote traveler information systems such as localized broadcast transmitters providing the public with timely road condition information.

#### 4.5.4 Data Requirements

Two-Way Mobile and Portable Data Terminals. Field computers capable of remotely accessing information systems and files may be used for dispatch or field support to perform real time changes to system data. Equipment may be vehicle mounted or a hand held portable unit.

Mobile unit status and control provide essential cost and time saving abilities to day to day operations. Unit status as well as road condition status can be transmitted by data exchange increasing the timeliness and accuracy of information.

Administrative data transfer allows for overhead information exchange for a work force that is remote and mobile.

Telemetry Systems. Monitoring of infrastructure integrity such as pavement temperature, salt content, water flow and height at bridges, mud flow areas, high wind areas provide instant information and warning freeing up personnel and equipment to perform their functions more efficiently.

Monitoring of equipment and fleet productivity increase effectiveness of operations.

Supervisory Control and Data Acquisition (SCADA). Monitoring systems and providing control functions to lighting, traffic control, pumping and specialized equipment such as toll collection and lane access control equipment.

Infrastructure inventory and control can be transmitted as data allowing better control of required maintenance of structures such as bridges and signs.

Remote Public Information Systems. Changeable signs and traveler information radio systems. Weather and road condition data transfer from remote sites.

Vehicle and Device Location Tracking. Vehicle location information allows more efficient use of equipment utilization, equipment management inventory and location control. The amount and location of material such as sand and asphalt both in storage and application. Road maintenance management including bridge, buildings and signs. Road surface condition and repair needs inventory data acquisition. Road construction survey information requires differential Global Positioning System (DGPS) accuracy. Accuracy for all of these requirements depend on the availability of DGPS. DGPS is provided by many means including transmission over dedicated public safety frequencies.

#### 4.5.5 Video Requirements

One-Way Video. Ability to view specific locations or interests through either snapshot, real time or close to real time accuracy to monitor traffic flow, facilitate incident response, and manage traffic control gates from remote sites.

4.5.6 ITS - Intelligent Transportation Systems. Many of the ITS requirements fall to the highway programs. These range from public information dissemination to monitoring transport vehicles regarding weight/height/fuel permits. Section 4.6 provides a detailed description of services that fall into this range of applications.

### 4.6 INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

4.6.1 Purpose. Innovative applications planned within this services may be unfamiliar to many in the public safety community especially those designed to aid in emergency vehicle response. ITS represents a broad range of applications that, because of their ability to enhance performance of different public safety communities' transportation and operations, apply horizontally across many other public safety communities' requirements. As a result, ITS-related operational requirements appear in some of the other sections of this report. It should be noted that the operational requirements for ITS defined in this section of the report are derived from the ITS National Architecture and the user services on which the architecture is based.

Many of the applications will enhance the safety of the individual traveler, and will be available to both personally owned vehicles as well as vehicles owned and operated by traditional public safety agencies. This creates an environment where spectrum use may be shared between public safety-related, public service and non-safety related functions.

4.6.2 Introduction. The Intermodal Surface Transportation Efficiency Act was passed by Congress and approved by the President in December 1991. It formally established the Intelligent Transportation Systems (ITS) program, which seeks to apply advanced communications and computer technologies to surface transportation systems in order to decrease traffic congestion, improve safety, reduce transportation related environmental impacts, and increase productivity. Public safety goals of the Intermodal Surface Transportation Efficiency Act (ISTEA) legislation being addressed by ITS are reducing the frequency of accidents, reducing the severity of accidents, reducing congestion due to incidents and enhancing traveler security.

In order to reduce the time and cost of implementing such a system, existing communications services will be used to the extent possible, provided they can meet ITS requirements. Some systems will require wireless data communications technologies such as dedicated short range communications (DSRC using roadside readers and vehicular mounted transponders) or may require the use of collision avoidance radar. There are likely to be ITS-specific systems or applications requiring new spectrum. Intelligent Transportation Systems may also require dedicated and shared use of frequencies currently allocated to public safety and other services.

The relationship between ITS and public safety has several aspects including: the safety of the traveler and the safety of public safety personnel performing mission related functions.

4.6.3 Operational Needs. Channels will be required for point to point and point to multi-point control of subsystems. Public safety features of the Intelligent Transportation Systems network include:

- .. Emergency vehicle location tracking
- .. Emergency vehicle route guidance
- .. Emergency vehicle signal priority
- .. Driver and personal security
- .. Automatic collision notification
- .. En-route driver information
- .. In-vehicle signing
- .. Incident detection and management
- .. Probe data for traffic control
- .. Transit management
- .. Priority treatment for transit
- .. Public travel security
- .. Automated roadside inspections
- .. Weight in motion
- .. Automated vehicle classification
- .. International border crossings
- .. Electronic clearance
- .. On-board safety monitoring
- .. Hazardous materials incident response
- .. Collision avoidance
- .. Intersection collision avoidance
- .. Safety readiness
- .. Pre-crash restraint deployment
- .. Automated highway system check-in
- .. Highway-rail intersection safety

#### 4.6.4 Descriptions of each Typical Operational Requirement

Emergency vehicle location tracking: Wireless data communications will be used to collect position or location information and data from emergency vehicles to improve the monitoring and display of emergency vehicle locations and help dispatchers efficiently task the

units that can most quickly reach an incident site. Direct field access to vehicle position-location information will help field forces to coordinate incident response.

**Emergency vehicle route guidance:** Route guidance information is sent via wireless data communications to direct emergency vehicles equipped with guidance and navigation displays to an incident location. Directions are provided based on real-time information collected concerning traffic conditions and road closures in developing the best route.

**Emergency vehicle signal priority:** Signal priority uses wireless data communications to clear traffic signals in an emergency vehicle's route. In order to facilitate speedy movement for emergency vehicles, the vehicle can (with the help of an "onboard transceiver") alter the timing of traffic signals in the immediate vicinity (via the "fixed reader" mounted beside the traffic lights) to generate a "green wave" (a series of green signal lights in the desired direction of travel).

**Driver and personal security:** Wireless communications will be used for user initiated distress signals for incidents ranging from mechanical breakdowns to car jackings.

**Automated collision notification:** Sensor technology is used to identify when a vehicle has had a collision and information is automatically sent via wireless data communications regarding location, nature, and incident severity to emergency personnel.

**Enroute driver information:** Wireless data communications are used to provide driver advisories conveying information about traffic conditions, incidents, construction, and weather conditions to drivers of personal, commercial, emergency, and public transit vehicles. The information may be provided by state and local authorities, transit authorities, and emergency management centers.

**In-vehicle signing:** Transmitters installed at critical points of a roadway are used to transmit data containing driver safety advisories and warnings on road hazards which could be displayed, enunciated or both to travelers in vehicles.

**Incident detection and management:** Sensor technology, digitized video and wireless data communications are used to help public officials quickly and accurately identify a variety of transportation system incidents, and to implement a response which minimizes the effects of these incidents on the movement of people and goods.

**Probe data for traffic control:** Continuous collection and transmission of vehicle counts, flow data, and travel times by wireless data communications incorporating position-location data provides information needed for traffic management, emergency fleet management and route guidance. This also provides state and local traffic management centers with real-time detection of obstructions due to traffic incidents and road hazards (this is a special case of the surveillance capability needed to effectively manage the transportation system).

**Transit management:** Wireless data communications are used to maintain position location information on transit vehicles and to transfer data between transit management centers and transit vehicles. Transit vehicles can be instructed to adjust their schedule or route to allow for incidents or bad road conditions. Within the transit vehicle, this information can also be utilized to provide automatic signage and annunciation of the next stop.

**Priority treatment for transit:** Identification of transit vehicles at access points of HOV lanes or at intersections can be used to provide priority treatment for these vehicles via appropriate adaptation of signal timing. This is accomplished by wireless data communications between the transit vehicle and the control signal or a transit vehicle and a traffic/transit management center that can exercise signal control.

**Public Travel Security:** Wireless video and data communications can be used for systems monitoring the environment in transit stations, parking lots, bus stops, and transit vehicles and generate alarms either automatically or manually as necessary. This improves security for both transit riders and operators.

**Automated roadside inspections:** Inspections are performed on commercial vehicles using wireless data communications allowing “real-time” access at the roadside to the safety performance records of carriers, vehicles, and drivers. This enables safety inspectors to access these records from the roadside.

**Weight-In-Motion (WIM):** Weight measuring equipment (fixed sensors embedded in the pavement or portable and temporarily deployable equipment) can ascertain the weight of a commercial vehicle at highway speeds to ensure the vehicle is operating within the rated safety limits. Wireless data communications systems are used to match the weight data obtained with the relevant credentials in the official database while the vehicle is in motion.

**Automatic Vehicle Classification (AVC):** In-pavement sensors, in conjunction with the roadside wireless data transceivers (and, perhaps, an inspection facility computer), are used to count the number of axles of a commercial vehicle for classification, and match the data with the vehicle.

**International border crossing:** Using automated vehicle identification (AVI), commercial vehicles are identified via wireless data transmission to a roadside reader and matched to its Pre-cleared credentials, allowing the vehicle to proceed without stopping. This service enables the carriers to Pre-clear vehicles at international border crossings. Automating this process implies cooperation of registration, fuel tax, immigration, safety enforcement, and customs agencies, as well as the state transportation agencies.

**Electronic clearance:** A wireless data communications system would be used to identify a commercial vehicle and its electronic credentials would be verified automatically while the vehicle is traveling past the roadside reader at highway speeds. This would allow commercial vehicles to travel across state borders without being stopped for verification of paperwork and permits regarding fuel usage and tax, registration, safety clearance, etc. Combined with the networking infrastructure, which would connect roadside readers to

central databases and administration centers, this service will facilitate state tax report preparation, auditing, and insurance requirements.

**On-board safety monitoring:** Safety data is provided to enforcement personnel, carriers, transit authorities, and drivers to review the safety status of a commercial vehicle, its cargo, and its operator, over a wireless data communications link as the vehicle passes the roadside reader while traveling at highway speeds. Safety conditions of the vehicle and the driver including the condition of critical vehicle components such as brakes, tires, and lights, and sensing unsafe conditions such as shifts in cargo while the vehicle is in operation would be stored as data on the vehicle, and interrogated using wireless data communications from the roadside.

**Hazardous materials incident response:** The safety of shipments of hazardous materials is enhanced by providing enforcement and response teams information from the vehicle via wireless data communications on the nature and location of any incident, and the type of material involved in order to enable safe and efficient response.

**Collision avoidance:** Radar is used to provide crash warnings and some degree of vehicle control for lane changes, road departures, and potential or impending collisions. It will help reduce the number of longitudinal and lateral collisions involving two or more vehicles, and crashes involving a single vehicle leaving the roadway.

**Intersection Collision Avoidance:** Drivers are warned of imminent collisions when approaching or crossing an intersection that has traffic control (e.g., stop signs or traffic signals). This application uses wireless data communications at the various arms of an intersection to sense the speed and direction of passing vehicles, which in turn, is coordinated by a roadside processor (or master reader for that intersection). Appropriate messages are dynamically transmitted to vehicles warning them of a potential collision.

**Safety readiness:** Radar equipment onboard the vehicle will be used to detect unsafe road conditions, such as bridge icing and standing water on a roadway, and provide warnings to the driver.

**Pre-crash restraint deployment:** Radar identifies the velocity and direction of vehicles and objects involved in a potential crash. Responses include tightening lap-shoulder belts, arming and deploying air bags at an optimal pressure, and deploying roll bars.

**Automated highway system (AHS) check-in:** Automated check-in using wireless data communications between the roadside and the vehicle at the entrance of (AHS) lanes will be used to examine lane-worthiness of a vehicle by verifying qualifying credentials for the vehicle, driver and carrier on their safety ratings and status. This ensures that both the driver and vehicle have passed the necessary safety checks to travel on automated highways.

**Highway-rail intersection safety:** Vehicle Proximity Alerting Systems (VPAS) will use wireless communications to provide warning messages to vehicles concerning the approach

of trains at highway-rail intersections.

## 4.7 FORESTRY

4.7.1 Mission. The mission of the Forestry working group is to catalog operational requirements for forestry operations at federal, state and local levels.

4.7.2. Introduction. Organizations at federal, state and local levels are charged with the specific oversight of our nation's environmental and agricultural resources. Activities of these organizations include management of forests, riparian environments, parks and various other environmental and agricultural resources for the common good of the general public.

The Forestry/Conservation mission is to serve the public through its activities directed to conserve, improve, and protect natural resources and environment. Communications needs are based on the performance of official duties.

Major activities in the management of the fragile and limited public resources associated with forest, wildlife, fish, recreation and other renewable resources include enforcement of environmental conservation laws; maintenance of air & water quality; hazardous, toxic, and solid waste management; mined land reclamation; wetland protection; environmental impact analysis; pesticide use regulation; fish & wildlife management; stream protection; park & primitive area management; and forestry.

The Forestry/Conservation mission emphasizes safety, environmental preservation, cost-effectiveness and quality. A specific component of Forestry/Conservation activity includes public safety response in such areas as law enforcement, rural and rural/urban interface fire protection, first response medical assistance, search and rescue, and boating safety.

Varied and wide area response including air support require dynamic frequency assignments for all operational categories through well coordinated procedures. Forestry/Conservation Communications systems require areas of operation covering entire states or regions.

### 4.7.3 Voice Requirements

Two-Way Voice Dispatch. Dispatch requirements usually fall into the categories of maintenance and management activities. Both require dispatch operation to control and manage activities. Wireless voice dispatch is critical to controlling costs and coordinating projects including mutual aid interoperability with other Public Safety Service providers. Law enforcement actions in Forestry/Conservation usually take place in remote isolated areas dealing with groups or individuals who are often difficult to deal with emphasizing the importance of a robust communications infrastructure and mutual aid interoperability requirements.

Voice communications are required from dispatcher control points to field units; field units to multiple field units; or individual to individual through either mobile mounted or hand held portable radios. In addition, voice communications in harsh terrain may require the use of vehicular communications repeaters to retransmit signals.

**Air to Ground.** Air to ground communications are necessary when aircraft perform wildfire detection and suppression, conservation law enforcement investigations and patrol, inspections of reclamation projects and contamination sites, and while tracking wildlife and transporting personnel.

**Fisheries Operations.** Voice communications are necessary to support transportation of fish, fish tracking, habitat and species studies, fish catching for species development, and fish ladder construction and operation.

**Conservation Law Enforcement.** Conservation officers in most states are full-time peace officers. Voice communications are required to support conservation law enforcement operations, marine safety enforcement and patrol, hunter safety training, poaching investigations, citizen evacuations, traffic control, and search and rescue missions. Conservation officers also must have the ability to contact other law enforcement officers to request and provide mutual aid.

**Wildlife Management:** Voice communications are required by conservation officers and staff to support transportation of animals, along with tracking and general management of various species of wildlife.

**Wildfire Detection and Suppression.** Voice communications are required for mutual aid with other states agencies, foreign governments, Department of Defense, federal agencies, and local municipal fire suppression agencies. Forestry or conservation agencies provide the first response in many states because of the heavy equipment resources of such agencies, the availability of a reliable state-wide radio communications system and the availability of caches of handheld communications devices for on-scene activities.

**Park and Recreation Area Management.** Voice communications are required to support operation of state parks and mooring facilities by forestry and conservation agencies. Activities involved in this requirement include construction of facilities, traffic control, facilities maintenance, fire suppression, boating safety, beach patrol and life guard services, basic first aid and emergency medical response. The essential nature of these services often is magnified by the geographically remote nature of park.

**Environmental and Waste Management Operations.** Voice communications are required to support contamination investigations and site management during cleanup and restoration.

**Telephone Interconnect.** Interconnect capabilities are required for management level to interface with the public and provide semi-private contact at a management level.

Telephone System Access would be accomplished through mobile mounted or hand held portable radios which have system access to the public switched telephone network.

Interoperability. Mutual aid considerations are vital to Forestry/Conservation operations. Forestry/Conservation crews are often the first to arrive on the scene of accidents in remote areas and require a method of contacting and coordinating with appropriate emergency response entities. The ability to interface with other aspects of public safety during ongoing natural disaster incidents are essential.

Wireless Public Announcement System. Public announcement broadcast information systems such as localized broadcast transmitters providing the public with timely area specific resource and safety information.

#### 4.7.4 Data Requirements

Portable & Mobile Data Terminals. Mobile unit status and control provide essential cost and time saving abilities to day to day operations. Unit status as well as resource condition status can be transmitted by data exchange increasing the timeliness and accuracy of information. Routine administrative data transfer allows for overhead information exchange for a work force that is remote and mobile. Resource management and condition reporting are an essential component of large scale incidents such as wildland fires.

Data collection and monitoring of public environmental resources such as water flow and quality provide instant information and warning freeing up personnel and equipment to perform their functions more efficiently. Infrastructure inventory and control can be transmitted as data allowing better control of required maintenance of resource support facilities.

Public Information Systems. Remote public information systems such as changeable signs and public information radio systems. Weather and resource condition data transfer from remote sites linked to administrative sites.

One Way Data Transmission/Telemetry. Data monitoring of fish and wildlife to allow better resource management.

Vehicle, Device, and Wildlife Location Tracking. Location information allows more efficient use of equipment utilization, equipment management inventory and location control. The location and control of limited resources during routine and extended emergency incidents is crucial to safe and quick mitigation of such incidents.

Facilities management. Facilities management includes oversight of bridges, buildings and signs. Data transmission support assists infrastructure and repair through maintenance of inventory and status information. Also, resource identification requires survey information utilizing differential Global Positioning System (DGPS) accuracy. Accuracy for all of these requirements depend on the availability of DGPS. DGPS is provided by many means including transmission over dedicated public safety frequencies.

Wildfire Detection and Suppression. Data transport is required to support transmission of weather-related data and area vegetation and combustible materials inventory data.

Environmental and Waste Management Operations. Data transport is required to support transmission of data regarding water quality, well contamination and other data from remote monitoring or control systems.

4.7.5 Video Requirements. Real time and close to real time incident monitoring from remote sites (including airborne) provide up to date information on such incidents as wildland fires as well as crowd control in routine parks environments. Infrared real time mapping of fire via airborne resources.

## 4.8 GENERAL GOVERNMENT

4.8.1. Mission. The mission of the General Government working group is to catalog operational requirements for general government operations at federal, state and local levels.

4.8.2. Introduction. The general governmental group's needs are diverse in nature since they perform a myriad of tasks to carry out their respective mission. This group includes any United States territory, possession, state, county, city, town, village or similar governmental entity, including a district and an authority. The need is for essential communications necessary to fulfill official governmental responsibilities.

A major portion of this section is based on the needs of large urban regions since there are a broad range of uses in densely populated areas. In addition, the needs of surrounding suburban and rural areas were also taken into account for these regions. General Governmental services focus on legislative, community and general matters all of which are a function of government.

4.8.3 Voice Requirements. Voice communications is the most widely used method of communications for the general governmental agency. Dispatch requirements are necessary for day to day operations to accomplish specific agency missions in a timely and cost effective manner.

Communications are directed towards management of field personnel, control of workload distribution, and coordination of services affecting public safety. Agencies in the general governmental category are most likely the "public safety support" service providers who provide the tools necessary for emergency responders to fulfill their tasks.

Another aspect of the general governmental service is direct public safety. Many times a general government service is called upon to act on a routine matter of public interest such as a housing, heating, or community assistance matter only to be faced with a potentially volatile situation requiring immediate attention from specific governmental groups. Immediate action

on these matters from the general government groups calms the tension of the public and involved parties reducing the risk of major public safety incidents such as riots.

Typical voice communications would be from dispatcher control points to field units; field units to multiple field units; or individual to individual through either mobile mounted or hand held portable radios.

Telephone System Access: Interconnect capabilities are required for certain management levels to interface with the public and provide semi-private contacts at with other public services. Telephone System Access would be accomplished through mobile mounted or hand held portable radios which have system access to the public switched telephone network through dedicated links or through commercially available services. A necessary consideration is that the device utilized for voice communications be a singular piece of equipment capable of all voice features. Mobile mounted or hand held portable radios would be necessary in order to facilitate the field office workers' needs.

Interoperability. Mutual aid considerations are vital to General Government. Governmental services require interaction among other regional public safety services and public service entities for both routine and emergency situations.

#### 4.8.4 Data Requirements

Two-Way Mobile and Portable Data Terminals. General Government uses field computers capable of remotely accessing information systems and files. Field Computers may be used for dispatch or field support to perform real time changes to system data. Equipment may be vehicle mounted or a hand held portable unit.

Mobile unit status and control provide essential cost and time saving abilities to day to day operations. Administrative data transfer allows for information exchange for a work force that is remote and mobile.

One-way Data Transmission & Telemetry Systems. General Government requires real time information transfer from field locations (fixed, mobile, or portable) to fixed control points. Transmission is used to monitor the functions of a system, site, or device. This may also incorporate a type of personal paging device used to alert personnel with limited alphanumeric messages.

Remote Public Information Systems. Changeable signs and public information systems with the ability of the authorized entity are used to dynamically change visible street signs/bulletin boards and alert the public to potential hazards or delays.

Vehicle, Personal, and Device Location Tracking. Location information allows more efficient use of equipment and personnel utilization, equipment management inventory and location control. The ability of dispatch control point or other vehicles to monitor apparatus locations within the geographical service area would improve efficiency of services provided by the governmental agency.

Since many general governmental field personnel are not assigned to a vehicular mandated task, there is a need for a personal location device to track the location of an assigned individual in the event of an emergency. This tracking device may be incorporated within the voice communications equipment or be a separate personal device.

As stated within previous sections, the accuracy for all of these requirements depend on the availability of DGPS. DGPS is provided by many means including transmission over dedicated public safety frequencies.

#### 4.8.5 Video Requirements

**Two-Way Portable Video.** Two-way portable video capabilities enhance the voice communications need for general government since field units and dispatch control points would be able to communicate using real time video with voice from mobile or hand held portable radios.

**One-Way Video.** One way video gives the ability to remotely view specific locations or interests through either snapshot or real time video as necessary throughout the jurisdiction.

### 4.9 PUBLIC MASS TRANSIT

4.9.1. **Mission.** The mission of the Public Mass Transit working group is to catalog operational requirements for public mass transit operations at regional, state and local levels.

4.9.2. **Introduction.** Governmental Public Mass Transit organizations operate transportation systems (i.e. trains and buses) which on a regular basis transport passengers. These organizations have direct responsibility for the safety and general welfare of the passengers during transportation.

Emergency mass transportation incidents can arise as a result of human error, equipment failure, and environmental factors such as weather conditions. Operational needs to address these issues are incorporated within this report and represent operational concerns, system safety concerns, and the protection and maintenance of facilities and equipment. The need for communications is based on these safety and operational concerns and the need to provide the appropriate response to conditions as they arise.

The majority of the operational requirements are based on the needs of major metropolitan areas where government is charged with providing these services, where massive numbers of people are transported daily, and services are essential to the general public.

#### 4.9.3 Voice Requirements

**Two-Way Voice Communications.** Dispatch requirements are in the categories of passenger operations, system safety, train location, passenger and property protection, and

maintenance and coordination of internal and external emergency response activities. All require prompt and reliable communications to control and manage activities. Immediate access to a dedicated wireless voice dispatch system is critical to safety and coordination of operations.

Incidents occurring on or adjacent to roadways or train track right of ways require immediate action by public mass transportation providers. Public transportation personnel are often the first to report, respond, and arrive on the scene of emergencies (for example fires, collisions, derailments, crime incidents, medical emergencies affecting passengers) occurring within their systems. Field crews work to rectify the underlying problem and must provide necessary updates to responding personnel.

The central communications command center must notify and coordinate emergency personnel, must re-direct other trains around the danger zone, must coordinate activities, such as the removal and restoration of power, to protect passengers and response personnel while directing field personnel assisting passengers.

If, for example, a train is stranded in an underground river tunnel without power due to a mechanical failure, its passengers are subjected to extreme conditions. In this instance, personnel on scene as well as response personnel are posed with a major problem due to the lack of emergency exits. The absence of emergency exits in such locations makes it critical for the situation to be satisfactorily addressed promptly. Climate control systems and main lighting in this disabled train may be inoperable. Other trains may be within the same tunnel behind the incapacitated train, forcibly trapped by the first. The cramped passengers of these trains become increasingly apprehensive of the situation and a rapid response from crews and emergency personnel is essential. The condition may grow to a multiple casualty incident due to passengers exposure to extreme conditions of temperature and confinement. Immediate communications to appropriate emergency response maintenance personnel is imperative to avoiding a major public safety incident with potentially disastrous results.

Voice communications are necessary from dispatcher control points to field units; field units to multiple field units; or individual to individual through either mobile mounted or hand held portable radios. The area of operation for Public Mass Transportation Providers communications may be in harsh locations such as below ground or waterway tunnels in addition to outdoor areas ranging from dense urban areas through mountainous rural areas.

Telephone System Access. Interconnect capabilities are required for limited management levels to interface with the public and provide semi-private contact at a management level. Telephone system access would be accomplished through mobile mounted or hand held portable radios which have system access to the public switched telephone network through dedicated links or through commercially available services.

A necessary consideration is that the device utilized for voice communications be a singular piece of equipment capable of all voice features. Mobile mounted or hand held portable radios would be necessary in order to facilitate the transportation personnel's needs.

Interoperability. Mutual aid considerations are essential to public transportation operations. Public Transportation agencies require a method of contacting and being contacted by emergency response entities.

Public mass transportation is a dynamic tool for the emergency management services. Buses and rail cars are routinely used to transport police, fire, and other personnel, including military personnel, to the scenes of incidents. In addition, public transportation entities in large urban areas are used to evacuate large number of people when necessary.

Wireless Public Address/Announcements. The ability of dispatchers or controllers to issue announcements to passengers on board buses or trains and those in the vicinity of stations regarding emergency conditions and other aspects of service enhances public safety. Passengers need to be advised of conditions on a real time basis, both to reduce panic and to facilitate emergency evacuation, when needed.

Passenger Emergency Notification. A voice communications system primarily utilized to alert train crews of an emergency situation involving passenger safety such as medical emergencies or criminal activity is the passenger's only way of reaching out for assistance. This system would not only notify the on-board crew but also be capable of accessing a distress channel linked to public safety answering points.

4.9.4 Data Requirements. The data requirements of the Public Mass Transit entity are also directed toward improving safe operations and overall system safety, as well as general functions. In this connection, vehicle and train locator systems can be used to ensure that trains carrying hundreds of passengers are not permitted to enter the zone of danger when emergencies ensue.

Two-Way Mobile and Portable Data Terminals. Field computers capable of remotely accessing information systems and files are increasingly used in all transportation methods. Data systems may be used for dispatch or field support to perform real time changes to system data. Equipment may be vehicle mounted or be in the form of a rugged hand held portable unit.

One-Way Data Transmission. Telemetry or real time information transfer from field locations (fixed, mobile, or portable) to fixed control points is key in maintaining the integrity of equipment, track, signal system and other safety features. Transmission is used to monitor the functions of a system, site, or device can alert transportation vehicles, maintenance, and emergency workers to potential hazards. One way signaling devices can be used to alert these vehicles or persons and transmit limited alphanumeric messages.

Train Signal Data. A combination of on-board train data with information provided through an Intelligent Transportation System (ITS) suited to railroad operations is paramount in the avoidance of train collisions and improvement of system safety.

Variable Information Distribution. The ability of an authorized entity to dynamically change signs/bulletin boards etc., to alert the public of potential hazards or delays

on-board transportation vehicles and at stations is necessary for the transportation provider. This improves efficiencies and gives up to date information to the public on any conditions affecting transportation.

A number of Intelligent Transportation System (ITS) features listed in the ITS portion of the report are also suited for the Public Mass Transportation provider. They are noted below:

- Vehicle route guidance
- Driver and personal security
- Automated collision notification
- Enroute driver information
- In-vehicle signing
- Transit management
- Priority treatment for transit
- Public Travel Security
- Hazardous materials incident response
- Collision avoidance
- Safety readiness
- Pre-crash safety system deployment
- Automated highway system (AHS) check-in
- Highway-rail intersection safety

4.9.5 Video Requirements. Video requirements are classified regarding local operations, system safety and property protection aspects of transit.

One-Way Video gives the ability to remotely view specific locations or interests through either snapshot or real time video as necessary. For example, this feature allows railroad crews to monitor safety within train cars in response to incidents or activation of passenger emergency alarms plus view upcoming stations and track for safety risks.

Two-Way Portable Video would be necessary on a limited basis when system or passenger safety is necessary when responding to a remote station. Field units and dispatch

control points could communicate using real time video with voice from mobile radios, hand held portables, or fixed sites.

#### 4.10 PUBLIC SERVICE

4.10.1 Mission. The mission of the Public Service working group is to catalog operational requirements for public service entities at the federal, state and local levels.

4.10.2 Introduction. One classification of public safety wireless communication users are those entities that rely on wireless systems to prevent catastrophes which endanger life and property. Entities such as transportation companies and public utilities operate communications networks that interface with local, state, Department of Defense and federal public safety entities on a daily basis. One primary purpose of these networks is to minimize risk to the public. These networks also aid other public safety providers in performing their missions when a catastrophe does occur. This section of the report briefly identifies many of the current communications requirements of this class of wireless communication users. A more detailed description of these requirements can be found in Appendix C.

##### 4.10.3 Voice Requirements.

Dispatcher to Crews. This is a typical communications path between dispatchers and field personnel. The call types are typically business oriented with emphasis on operating the business in a safe and efficient manner.

Crew to Crew. This function relates to the typical communications between field users. These communications are used for the coordination of daily activities to maximize the safety and efficiency of operations.

Emergency Call. This function is typically initiated from a field user to a dispatcher. As the name implies, the call type is that of an emergency where loss of life or property is imminent or has already taken place.

“Talk Around”. In many operations between field users, routing a call through the network or a repeater is not feasible for reasons such as access delay or being out of range of the system. A talk around mode is necessary so that the field users can communicate with each other, within the range of their mobiles and portables, without the assistance of a network or repeater.

Interconnect. In nearly all field activities, users have a need to communicate with people by way of land line telephones. Telephone interconnect is a necessary option for many of the present day radio systems.

4.10.4 Data Requirements. The Public Services entities have a substantial need for data communications which is typically very specific for each type of entity. As an example, the railroad industry relies on data communication links to assist the engineer in safe train

handling as well as providing early notification of track or equipment malfunctions. The railroads also utilize data communication links to assist in the prevention of collisions between two trains as well as between trains and other types of vehicles.

The Utility industry relies on data communication systems for the purposes of controlling electrical distribution systems and pipelines which include gas, steam, and water. Electrical distribution systems utilize these data links to trip circuit breakers in the event of a power fault or short circuit. They also utilize these systems to control the amount of load which the generation facilities have to serve during peak demands. The pipe line systems utilize similar techniques for the purposes of controlling valves to reroute or inhibit the flow of materials in the event of a failure of section in a pipe line network.

Data needs which are common to most Public Services entities are security system monitoring, location systems, and inventory access systems. As with many other entities, security systems are essential to help protect lives and property from destruction or tampering by individuals. Location systems provide a means to track crews and equipment for the purposes of effective response to disruption of service as well as train collision avoidance. When a catastrophic event does occur, the Public Service entities rely on access to data bases which contain information concerning the availability of repair and restoration materials and equipment.

4.10.5 Video Requirements. As an extension of the security system monitoring item above, video surveillance provides much more information in specific situations than typical alarms can provide. Video systems are very valuable tools when Public Service entities respond to catastrophic events such as train derailments, tornadoes, hurricanes, as well as earthquakes. In many cases, the video surveillance would be most effective if made available through a wireless means.

4.10.6 Special Agents. Another application for communications in Public Services are those communications which occur between railroad police, also known as Special Agents, and local, state, as well as federal agents. The Special Agents have arrest authority if a crime occurs on the railroad right of way. They are often the first responders when dealing with murder, rape, robbery, drug enforcement, and vandalism to name a few. During derailments, the Special agents work with a variety of Public Safety entities to coordinate activities with the railroads in an effort to contain the disaster as quickly as possible. Most of the communications are voice, however, there is a significant need for data communications for the purposes of having access to the same information which is shared between the Police, Fire, and Rescue entities.

## 5.0 FEDERAL GOVERNMENT & DEPARTMENT OF DEFENSE OPERATIONAL REQUIREMENTS

This section identifies operational requirements unique to Department of Defense, and federal government public safety/public services agencies. The diversity and complexity of federal agency missions compel the use of a wide variety of telecommunications capabilities.

Effective and reliable radio communications are required for federal agencies and the Department of Defense to perform Congressionally mandated functions dealing with safety-of-life, security and protection of federal property and military bases, protection of the President and other government dignitaries, enforcement of federal laws, protection of Native Americans, provide for immigration and border patrol, to operate federal prisons, protection of natural resources, security of our coasts and harbors, protection of natural resources, maintain and protect streams and inland waterways, distribution of water and natural resources, and many other essential missions.

To support these missions and responsibilities, federal and Department of Defense agencies frequently use wireless platforms, such as, land mobile radio (LMR), HF, satellite, paging, cellular communications for clear and encrypted voice communications, audio and video monitoring, alarm systems, electronic tags and tracers, and limited data collection and transfer. These platforms are used both nationally and internationally, over diverse geographic conditions, often requiring subscriber unit interoperability and the ability to communicate on a priority basis 24 hours per day, 7 days per week.

From a LMR perspective, there are many similarities between federal uses of LMR systems and that of our state and local counterparts. However, national security implications, extensive geographical communications coverage requirements, privacy and security concerns are significant differences that require comment.

The Federal Government uses land mobile radio systems in support of the following: Law Enforcement, Transportation, Natural Resources, Emergency and Disaster Services, Utilities, Medical, and Administration functions.

## 5.1 TRANSPORT MECHANISMS

Federal and Department of Defense Land Mobile Radio systems planning and operations must include implementing features that ensure services continue to be available even in the most adverse conditions. Dependency on Land Mobile Radio systems requires those capabilities be available in times of emergencies when some key element of the transport mechanism (infrastructure) may be damaged or destroyed. Land-line based systems may not be available following earthquakes. Hurricane or other windstorms almost always damage wireless systems by bringing down towers and antennas. Some portions of the transport mechanism (infrastructure) are more likely to survive disaster than others.

Federal and Department of Defense agencies rely on a mix of federally developed or owned linking mediums and commercial wireline and fiber networks to connect systems throughout the nation. When commercial services are used, federal and Department of Defense agencies often configure the system for diverse circuit routing or apply National Security and Emergency Preparedness (NSEP) circuit restoration priorities

In those areas where commercial service are not available, federal and Department of Defense agencies use traditional point-to point and point-to-multi-point RF systems as outlined in section 4.1.

The experience of the federal, state and local community has shown that during times of natural disasters, especially earthquakes, the agency owned point to point radio systems are better able to withstand damage than commercial leased lines. It is also the experience of this community that during situations similar to the Oklahoma City bombing, the commercial systems quickly become overloaded preventing access and use by the law enforcement and public safety community causing further reliance on agency owned systems.

## 5.2 LAW ENFORCEMENT

The patrolman on the city beat has a very different view of public safety from the Federal agent working an international terrorism conspiracy. Drug smuggling from outside the country is connected to drug violence in low-income city housing projects, but the people who combat drug smuggling work for different levels of government, have varying duties, and use different tools and techniques.

Effective and reliable radio communications are required for, but are not limited to: safety-of-life, security of federal and Department of Defense building complexes, federal lands, military bases and other installations; protection of the President, First Family, Vice President & Family, Former Presidents, senior federal officials, visiting foreign heads of states; counterintelligence; investigations involving organized crimes, drug interdiction, fugitives, hostage situations, terrorism, smuggling, gun and explosives, counterfeiting, fraud, forgery, tax evasions; protection of the money supply; prisoner transport and operations of the federal prison system; customs; postal operations and immigration and naturalization.

Current federal and Department of Defense law enforcement land mobile radio systems were designed and installed based on specific missions of the various federal entities, the number of radio frequencies allocated and the availability of funding and support personnel. Over time, these systems were gradually expanded as mission requirements increased. These systems provide radio coverage in urban, suburban and rural areas, for both mobile and portable use, and must operate in a wide variety of terrain conditions.

Federal and Department of Defense radio systems are often designed to provide coverage to a field, military base or district office whose law enforcement jurisdictions might include more than one metropolitan area and which may also cross state boundaries. The number of federal users in any particular field or district office or at a military installation varies with mission requirements. Field and district offices are frequently complemented with additional personnel to support special operations, such as organized crime task forces, drug interdiction case, protective operations, etc. In many cases, the fixed land mobile radio system is augmented with transportable equipment to provide the required coverage.

Spectral requirements are imposed to support the U.S. Coast Guard mission to provide maritime law enforcement, including drug and illegal immigrant interdiction, in ocean areas, coastal areas and inland navigable waterways. These duties are accomplished through a complex organization of people, ships, aircraft, boats and shore stations, each with unique and challenging communications needs.

Federal law enforcement will require spectrum for technologies that support voice and data communications, paging, video and imaging, electronic agents, sensors, surveillance systems, position location, parole monitoring, covert communications, multi-media applications; and a comprehensive infrastructure which may consist of wireline, microwave, satellite, and HF/VHF/UHF frequencies.

Interoperability with other public safety/public service agencies at all levels of government is a paramount concern. Military bases will require spectrum for technologies that support voice and data communications, paging, video and imaging, electronic agents, sensors, surveillance systems, position location, parole monitoring, covert communications, multi-media applications; and a comprehensive infrastructure which may consist of wireline, microwave, satellite, and HF/VHF/UHF frequencies.

#### 5.2.1 Voice Requirements

Federal and Department of Defense law enforcement will continue to depend on voice as the primary method of tactical communication. Voice is the best communication method in a rolling surveillance, quickly developing operations, crisis situations, close-in tactical operations, and in situations where split-second command and control decisions must be made and acted on. Federal and Department of Defense personnel must have reliable and secure communications in either peer-to-peer, wide-area, or dispatch-based environments. Other requirements are: air-to-ground, air-to-air, special operations, surveillance (covert) and for national and international travel.

#### 5.2.2 Data Requirements

The use of mobile data technology is becoming more and more important in law enforcement operations. The potential speed and efficiencies available with this technology provides for quicker identification of suspects and dangerous situations which improves agent or officer safety as well as causing faster responses to protect life and property.

Federal and Department of Defense agencies envision greater use of commercial off-the-shelf lap-top or notebook computers in lieu of specifically designed mobile data terminals (MDT). This approach is cost effective since it provides the greatest flexibility in meeting ever changing mission requirements.

Border sensors/monitors, electronic agents, parolee monitoring and other remote sensing technologies will continue to evolve and will require wireless communication paths.

Currently, wireless data use within the Federal and Department of Defense Law enforcement agencies is minimal. In general, the data requirements are limited to such uses as mobile data terminal applications, geographic position and automatic location data, emergency signals, transmission of reports, electronic messaging, home incarceration monitoring, and perimeter and vehicle alarms. Remotely controlled radio devices are routinely used for turning off and on surveillance microphones, effecting kill switches in vehicles, arming and disarming alarm and monitoring systems, and aiming video cameras. This control can be a one-time data burst or can be a continuous data stream.

Expansion of wireless data systems offers many technological assets to law enforcement. One of the most significant advantages is access to data repositories containing critical law enforcement information such as image identification, fugitive information, stolen articles, and criminal histories. Data repository systems such as the National Crime Information Center (NCIC) 2000 system and the Integrated Automated Fingerprint Identification System (IAFIS) are preparing to provide mission critical data to law enforcement more effectively and efficiently. These systems, in conjunction with the National Performance Review (NPR)/IT04 initiative (establishment of a national law enforcement/ Public safety wireless network) are preparing for wireless data transfer and will spur the growth of wireless data communications for law enforcement.

Future information technology requirements for Federal and Department of Defense law enforcement will most certainly include wireless data and voice systems utilizing encryption. In order to maximize the effectiveness of agents in the field, a mobile office environment utilizing wireless data communications must be developed. This mobile office would provide instantaneous voice, data, and video access to other agents/law enforcement personnel, various law enforcement data repositories, and commercial networks. At some point, law enforcement may incorporate these mobile offices into a paperless environment inclusive of multimedia transfer.

### 5.2.3 Video Requirements

Generally, video requirements within Federal and Department of Defense law enforcement fall within these categories: incident video, aerial surveillance video, robotics video, surveillance and monitoring, officer safety and operational video transmission, and still photographs.

## 5.3 INFORMATION SYSTEM SECURITY

Voice communications for law enforcement must feature multiple levels of encryption. Routine operational traffic will require one level of encryption. Other operations such as executive protection, high level drug and organized crime unit operations and federal and security needs often will warrant a higher level of transmission security. Some routine traffic may be "unencrypted", but devices must be able to monitor both encrypted and non-encrypted messages simultaneously.

Preservation of the confidentiality of the information passed and the integrity of a communications system is of paramount importance to the overall federal and Department of Defense mission. Similar requirements exist today and are rapidly expanding for the state and local levels. Threats may exist anywhere along a communications path. Federal and Department of Defense agencies are extremely concerned with threats to the wireless component of the communications network, both the active threats: masquerading, information modification, denial of service, sabotage and the passive threats: monitoring/eavesdropping, traffic flow analysis.

In light of these communications security requirements, federal, Department of Defense, state and local agencies must have the technical means at their disposal to counter both today's threat and that of the future. Such techniques are covered under the information systems security umbrella.

Federal and Department of Defense agencies have a requirement for cryptographically protected wireless communications systems. State and local agency requirements for secure communications are also rapidly emerging. Suitable cryptographic algorithms or techniques are available to provide the necessary levels of privacy/security commensurate with the federal and Department of Defense mission. Federal government cryptographic processes are categorized by "type" with Type-I being the highest and Type-IV the lowest. Information that is classified pursuant to federal statute or executive order must be protected by use of an National Security Agency (NSA) approved Type-I cryptographic algorithm and implementation. Type-II algorithms are used by federal and Department of Defense agencies for the protection of defense related sensitive-but-unclassified information. Type-III algorithms are used by federal and Department of Defense agencies for the protection of all other sensitive-but-unclassified information. The National Institute for Standards and Technology provide for the endorsement of Type III algorithms and their implementation.

In addition, where cryptographic protection is employed, federal, Department of Defense, state and local agencies require user friendly electronic key variable dissemination and management. Terms such as Over-The-Air-Rekey (OTAR) are often used to describe this process, often in conjunction with multi-key, which refers to the use of multiple cryptographic keys to facilitate interoperability. State and local agencies also require flexible systems for key management and distribution, to accommodate the formation of ad-hoc forces from groups of agencies with overlapping jurisdictions.

Extremely sensitive information may require the application of multi-dimensional techniques providing for low probability of detection or low probability of interception, and are often referred to as covert communications. The accommodation of covert communications poses unique spectrum requirements.

Lastly, there must be adequate trust in the operating systems and software used in the network components, as well as the continuous use of access control and authentications services to prevent authorized users from being denied the use of their mission critical communications services or networks.

## 5.4 NATURAL RESOURCES, PUBLIC SERVICE AND FIRE EMERGENCY SERVICES

The Federal Government manages its natural resource programs using radio communications to accomplish Congressionally-mandated missions. Congressionally-mandated services include the mission of the U.S. Postal Service. Fixed stations, mobiles, hand-held portables, and transportable repeaters and base stations make up these radio systems. These operations are spread throughout the United States and its Possessions, in suburban, urban and rural, sometimes remote and almost inaccessible areas. Some systems encompass only a few buildings in a city or a small wildlife refuge, while others encompass large geographic areas, such as the national forests, Indian reservations, and national parks; multiple counties or states such as the Tennessee Valley Authority; or are nationwide in nature. These systems provide for the safety of the public and government personnel which includes over 300,000 postal vehicles and the security of 180 billion pieces of mail per year, monitoring and distribution of water, management of timber growth and harvest, protection, operation, and management of our national parks, national forests, range and grass lands, wildlife refuges, protection of Native Americans and protection and management of their lands; forestry and range management; and assessment of mineral deposits. In addition, wildlife monitoring and tracking to protect endangered and threatened species and to control animal damage are performed with transmitters as small as dimes or as large as softballs. The gathering of wildlife data is crucial to track and catalogue the motions of specific species under study by multiple parties. The emphasis is on the identification of present and future migratory patterns which will influence the environmental habitats and future survival of these species. This telemetry is solely dependent on wireless technology.

Natural emergency situations such as fires, hurricanes, earthquakes, and volcanic eruptions place great demands on existing communications systems and sometimes require a tenfold expansion of communications facilities in a matter of hours. The U.S. Departments of Agriculture and Interior are responsible for maintaining a large inventory of radio systems available for rapid deployment in support of fighting wildfires or natural disasters. The agencies and bureaus of both departments maintain installed communications systems supporting the day to day administrative and tactical operations on almost 500 million acres of public land. These systems also support numerous search and rescue situations. In the event of fire or disaster, the installed systems are capable of being expanded through communications resources available from the National Interagency Fire Center in Boise, ID. This unique shared-agency facility maintains a cache of approximately 7000 radios that are preboxed into fully operational groupings called "systems" or "kits"; each containing one or more repeater stations and a number of portables. The majority of these radios operate in the VHF, 162-174 MHz band with approximately 1500 operating in the UHF, 406-420 MHz band. Additional equipment available from the Center includes 10 transportable INMARSAT satellite ground stations and several transportable microwave stations. Since aircraft can taxi directly up to the Center's front door for loading, this equipment can easily be shipped back and forth between most locations in the United States, Canada, and Mexico and be distributed to local authorities, allowing for cooperative, interoperable communications between Federal, state, and local agencies when necessary.

Federal and Department of Defense Fire-fighting services, when their mission is to serve a specific base or installation, in general, function in the same manner as State and local government fire fighting services. Where Federal fire management missions diverge is in the responsibility for fire protection and fire fighting over wide-ranging federal lands such as National Parks, federal reservations and National Forests. The National Interagency Fire Center is responsible for management of this function within the Federal Government. It includes the Bureau of Land Management, National Park Service, Bureau of Indian Affairs, U.S. Fish and Wildlife Service, U.S. Forest Service, the National Weather Service and Interior's Office of Aircraft Services. These bureaus and agencies form an interagency partnership aimed at providing efficiency and economy in the field of fire management to include presuppression, suppression and fire use.

The Federal Maritime Environmental protection mission, performed by the U.S. Coast Guard, serves to minimize damage from pollutants released into the ocean, inland waterways, and coastal zones. In addition, they help to develop national and international pollution response plans and operate the National Strike Force. These operations frequently involve close coordination by Federal, State, and local agencies in addition to private and commercial organizations.

#### 5.4.1 Voice Requirements

In general, voice requirements for Natural Resources management include coverage from portable to portable unit, through a system, radio to radio. Personnel must be able to speak with each other via a portable radio if within line of sight. Likewise personnel must be able to communicate from distant locations where geographic responsibility for a natural resource crosses all political boundaries.

#### 5.4.2 Data Requirements

The data requirements of Federal Natural Resources and Fire Emergency Services is not unique to the Federal agencies. State and local public safety agencies have similar requirements. In general, the data collected, analyzed, and disseminated in these services originates and terminates among Federal, State, and local agencies alike.

Wireless data transmission is mission critical to the Postal Service. In order to provide continued low cost mail service to over 95 million addresses, spectrum must be available.

The gathering of Hydrological data is crucial to assure the latest weather patterns, snow and precipitation levels, temperature and water quality are monitored in order to minimize a natural disaster due to these conditions. The emphasis is on the collection of data from remote sensors and prediction of flooding conditions based on that data. The Federal Hydrologic program involves a large number of Federal agencies as well as State and local agencies. The network, data, and frequency assets are shared among these agencies.

The gathering of seismic data is crucial to assure that earth movements and motions are cataloged and patterns detected to reduce potential earthquake damage, and potential loss of life and property.

For wildlife telemetry, the basic need for data is immediate, clear transfer of information concerning the mobility of wildlife.

#### 5.4.3 Video Requirements

Requirements encompass a wide variety of scenarios ranging from provision of full-motion real-time video from on-site personnel or robotic sensors to remote command center, to slow-scan images for damage assessment. These video data should be accessible by a number of users under strict, need-to-know management procedures. Often a video image of current conditions is necessary to make critical decisions, like the release of water from a reservoir, in the management of natural resources.

Hydrologic management requires the ability to transmit still photographs on demand to various locations to facilitate decisions concerning the adjustment of water releases or the evacuation of population downstream from a flood stage river.

### 5.5 EMERGENCY MANAGEMENT AND DISASTER SERVICES

The Federal Government provides an array of emergency and disaster response communications capabilities to protect the public and resources from natural and technological hazards. This involves a wide range of missions including prevention, mitigation, preparedness, response, and recovery. These services involve virtually every department and agency of the government. Where safety of life and property is at risk, communications systems that can operate reliably when normal systems are disrupted are essential. A significant number of the Federal Government emergency and disaster response communications systems interface (but are not necessarily interoperable) with State and local governments as well as with national volunteer organizations such as the Red Cross, amateur radio operators, and similar groups.

Many specialized emergency requirements have unique spectrum-dependent needs that must also be satisfied by the nationwide dedication of radio spectrum for that purpose. As an example, Federal and Department of Defense, State, and local government search and rescue teams deploying to the site of a national emergency or disaster need reliable communications to locate victims in collapsed buildings, administer medical and lifesaving treatment and relocate them to safety or medical facilities.

The U.S. Coast Guard, in cooperation with other Federal and Department of Defense, State, and local public safety agencies, monitors distress and safety radio channels 24 hours/day, and serves as maritime Search and Rescue (SAR) coordinator within the National SAR Plan. The Cospas-Sarsat Search and Rescue satellite system is an example of dedicated emergency response communications system. This multi-national safety-of-life system uses

earth orbiting satellites and ground stations to locate emergency distress beacons. These beacons signal that a life-threatening maritime, aviation, or land-based emergency has occurred. Current spectral requirements include 406-406.1 MHz, 121.5 MHz, 243 MHz, and 1544-1545 MHz. Future expansion of the system may add the use of geostationary satellites and beacons using GPS locations.

Providing the communications needed during major natural and technological emergencies requires a significant quantity of readily deployable land mobile radio communications assets. Major disasters have required the deployment of thousands of radios. These have traditionally been Federal Government owned land mobile radios (e.g. the fire cache discussed above) used to effectively coordinate and provide emergency management during the readiness, response, and recovery phases of major disasters.

#### 5.5.1 Voice Requirements

Emergency Management and Disaster Services within the Federal Government have a need for a large number of interoperable radio assets able to be deployed anywhere in the nation on a moment's notice. These requirements are generally the same as with State and local government and disaster relief organizations. Primarily, they include numbers of radio and frequency assets that far and away exceed normal operating requirements. Lack of interoperability, in the technical and spectrum senses, represents the greatest impediment to the effective solution of these needs.

#### 5.5.2 Data Requirements

In general the data requirements of Federal emergency management and disaster services are similar to those of their state and local counterparts. Often the data collected, analyzed and disseminated in these services originates and terminates among Federal, state and local agencies alike. A current example of Federal emergency service data usage is in the broadcast and response to Cospas-Sarsat distress alerts.

#### 5.5.3 Video Requirements

Like the data requirements, Federal emergency management and disaster service video requirements are similar to those of their state and local counterparts. As an example, on-scene video is often utilized to assist in developing appropriate level of response.

### 5.6 TRANSPORTATION

Federal activities in aviation, maritime, highways, and railroads have a tremendous investment in both fixed and mobile operations. Aviation-sector land mobile applications include maintenance, safety, and inspection using portable and mobile radios, and repeater and base station facilities; remote maintenance monitoring equipment; airport runway light control systems and wind shear alert systems. These systems are installed in airports and airway facilities for management and coordination activities. The systems use both voice and data to:

automate equipment monitoring; perform safety-of-life, anti-terrorist, and air security functions; integrate air traffic control communications within the centers and control towers; and conduct various airport and airfield communications.

Federal and Department of Defense surface transportation operations provide a variety of management and oversight support to coordinate activities at various highway and rail sites. The Intermodal Surface Transportation Efficiency Act (ISTEA) was passed by Congress and approved by the President in December 1991. It enabled the establishment of the Intelligent Transportation Systems (ITS) program. Several goals of the ISTEA are addressed in the ITS program, including: (1) the enhancement of the capacity, efficiency, and safety of the highway system, serving as an alternative to additional physical capacity; (2) the enhancement of efforts to attain air quality goals established by the clean air act; and (3) the reduction of societal, economic, and environmental costs associated with traffic congestion. The relationship between ITS and public safety encompasses several aspects concerning not only the safety of the traveler, but the array of new technologies and services that will be available to both personally owned vehicles as well as vehicles owned and operated by emergency service providers and traditional public safety agencies.

Public safety goals of the ISTEA legislation being addressed by ITS are reducing the frequency of accidents, reducing the severity of accidents, reducing congestion due to incidents and enhancing traveler security. Technology being deployed by ITS will enable these goals to be met by performing the following safety-related functions described in the ITS National Program Plan: improving on-board system monitoring, reducing the number of impaired drivers, enhancing driver performance, enhancing vehicle control capability, improving traffic safety law enforcement, smoothing traffic flows, improving emergency and roadway services responsiveness, improving passenger protection, improving response to hazardous materials (HAZMAT) incidents, improving incident management, improving incident information to drivers, improving the availability of communications devices, reducing vehicle theft, and increased monitoring of transportation facilities.

Maritime safety and waterway management agencies within the Federal Government provide for the safe operation of the Nation's navigable water resources. It requires coordination of many diverse, yet interrelated disciplines. From inspection of user vessels and offshore facilities, to provision of icebreaking capabilities to keep shipping routes open year-round, to ensuring port security, many tasks must be performed to ensure seamless utilization of coastal and inland waterways. In addition, safe passage is promoted through waterway management involving the interrelationship between vessels, waterway authorities, and facilities including docks, bridges, and piers. Finally, a key link in ensuring maritime safety results from continuous monitoring of maritime radio emergency channels, and the broadcast of maritime safety information.

#### 5.6.1 Voice Requirements

In general, voice requirements for Federal Transportation services are similar to other Federal agencies. Immediate or near-immediate voice communications is an absolute necessity, especially when dealing with safety-of-life/property response.

Voice communications for maritime safety and waterway management must provide connectivity for command, control, and communications of operational U.S. Coast Guard forces; ensure connectivity, compatibility and interoperability with the maritime industry, the boating public, and other Federal, state and local agencies. Supported services must include: (1) Damage and degraded service/outage reports to/from mariners, (2) notification of marine casualties, (3) dissemination of Notice to Mariners, and (4) reports of pollution incidents and coordination of responding assets.

### 5.6.2 Data Requirements

Basic data requirements for Maritime Safety and Waterway management include clear, immediate transfer of information in support of both routine and emergency operations. Examples of required services include: (1) short range aids to navigation, (2) acquisition of vessel position, identification, and sailing intentions, and (3) data dissemination with respect to ice conditions and/or port status.

ITS by its very nature, is totally dependent on mobile communications in order to provide most of the user services. ITS frequencies must fit several criteria, among which are good propagation characteristics for the function being performed, adequate bandwidth, freedom from harmful interference, availability of low-cost components, and minimal regulatory restrictions.

There are three basic ways to provide the connectivity that is needed for ITS: (1) through the use of existing communications facilities (e.g. cellular radio, enhanced specialized mobile radio (ESMR), existing dispatch systems); (2) through new services within current spectrum allocations (e.g. high-speed data subcarriers on broadcast FM radio); or, (3) through dedicated facilities with new spectrum, which includes cases where current allocations are inadequate and where new spectrum is required to meet growth demands (e.g. electronic toll and traffic management (ETTM)).

To the maximum possible extent, the Federal Highway Administration (FHWA) has emphasized appropriate use of the first two alternatives.

### 5.6.3 Video Requirements

Video requirements for Transportation management may include real-time situation updates from on-scene units to command centers. Multiple agencies may need to have the capability of monitoring another agency's video transmissions, however this capability must be controlled through a need to know or incident management process.

## 6.0 CURRENT SHORTFALLS

The mission of the Subcommittee included identifying operational requirements that currently are unmet or suffer from reliability, quality or coverage deficiencies. Shortfalls of

this nature were identified by virtually every working group, but in general they can be categorized as indicated in the following discussion.

**Foreign Frequency Interference.** Public safety entities operating along United States borders with Mexico are experiencing interference from communications devices and services located outside the United States. For example, business communications from Mexico are occurring on VHF and UHF public safety frequencies. Coordination with Mexico or other decisive action is necessary to ensure that whatever frequencies are allocated for public safety use in the United States remain free from foreign frequency interference.

**Insufficient Paths or Channels.** A general observation of virtually all participants in the Subcommittee's work was that the existing allocation scheme does not provide sufficient paths or channels to support existing operations, let alone the future needs identified by the various working groups. Some public safety entities already have been forced to lease voice communications support due to channel shortages. Shortages exist in some parts of the country in microwave channels for infrastructure support. Existing allocations do not and will not support implementation of mobile data or NCIC 2000 terminal needs, or transmission of video. The rapid growth of the field of corrections, for example, has placed and will continue to place unprecedented demands on the need for communications paths or channels.

Although these shortfalls are universally understood and a major portion of the rationale for formation of the Advisory Committee, the Subcommittee deemed it appropriate to highlight the urgency created by the spectrum shortfalls that already exist.

**Coverage Inside Buildings.** Present standards in the 800 MHZ spectrum limit signal strength to 40 dBu at service area boundaries. This strength may not be sufficient to support building penetration near service area boundaries. Optional design changes, such as installation of inside antennas, RF amplifiers or additional sites with directional antennas should first be considered. As a final resort, exception to limiting standards should be considered, consistent with protection to adjacent service areas.

**Multi-Path Interference.** Voice and data communication problems created by multi-path interference in some frequencies must be resolved to provide clear voice and data communications in areas affected by multi-path interference.

## 7.0 INTEROPERABILITY REQUIREMENTS

Interagency communications between federal and Department of Defense, state, county, township and local police, fire, and EMS units is necessary. Coordination at natural and man-made disasters requires close communication for deployment of scarce resources during incident management by the police, fire and EMS units responding to the event.

The ability to communicate among and between the various public safety units must also be broken out by geographic area yet respecting the ability to "look-back" or monitor the chain of command of the several organizations. In other words, at the site of a wide area

incident various police and fire units responding should be able to monitor selected channels or talk groups within their organizational structure, but also have the ability to speak across organizational lines (police to fire, fire to EMS, etc.) to coordinate activities at a given geographic location up to several miles wide.

Interoperability must exist across organizational groups by rank or responsibility. The officer in charge of comparable responsibility from each of the respective jurisdictions should have the ability to speak directly with each other in a secure or uninterrupted channel or talk group over the portable radio to deploy the necessary resources where they are most needed.

Interoperability is not just an issue for response to unique or large scale public safety incidents. Interoperability is requisite on a routine basis as a preventive measure. For example, sharing information in the form of voice and data between correctional and law enforcement agencies can lead to the quick identification of criminal behavior patterns and expedited apprehension. Crime prevention requires more resources, not just more laws.

## 8.0 CONSOLIDATION OF SERVICES AND SYSTEMS

The issue of consolidation of services and systems has been discussed in this and other subcommittees. Considerable difference of opinion exists, as many services and agencies vigorously defend their right to remain independent. Modern technology does make it relatively simple to share certain systems in a way that is virtually transparent to other users. This is particularly true in trunked systems and in systems which carry data only.

The only impact on these systems, provided they cover identical service areas, is channel loading. Systems designed for data only, for example, can support a large number of users due to the short duration of any individual transmission. Trunking can provide either discrete or combined talk groups which result in privacy or interoperability as desired.

The stated operational requirements of many users noted in this document, particularly the services of Police, Fire and emergency medical, are similar if not identical. Because these services generally are provided under the authority of a single political agency, such as a county or city, sharing of a common infrastructure is both spectrum efficient and economically effective.

This sharing technique can be applied to data, vehicle location and trunked systems, and should be given strong consideration when the necessary parameters are present.

ANNEXES

A - OPERATIONAL REQUIREMENTS FOR COMMUNICATIONS QUALITY

B - OPERATIONAL REQUIREMENTS INPUTS TO QUANTITY MODELING

C - ADDITIONAL PUBLIC SERVICE OPERATIONAL REQUIREMENTS

**ANNEX A - OPERATIONAL REQUIREMENTS FOR COMMUNICATIONS QUALITY**

SECTION I: Audio and Data Transmission

Audio Quality

A method of quantifying audio quality has been developed by the Telecommunications Industry Association (TIA) in conjunction with the Institute of Electrical and Electronics Engineers (IEEE), and published in a TIA report entitled “A REPORT ON TECHNOLOGY INDEPENDENT METHODOLOGY FOR THE MODELING, SIMULATION AND EMPIRICAL VERIFICATION OF WIRELESS COMMUNICATIONS SYSTEM PERFORMANCE IN NOISE AND INTERFERENCE LIMITED SYSTEMS OPERATING ON FREQUENCIES BETWEEN 30 AND 1500 MHZ”, April 29, 1996.

The principal metric involves recipient understanding and whether or not repetition is required. The metric is called Delivered Audio Quality and consists of a 5 point scale. The lowest value is one, referring to the worst case where the message is unreadable and therefore unusable. The highest is five, where speech is easily understood, no repetition is necessary and noise or distortion components are not introduced in the communications channel. The intermediate values range in the ease of understanding and the frequency of repetition required as well as the nuisance contribution of noise and distortion components introduced along the way.

The basis of understanding uses the equivalent intelligibility of a TIA test value for static receiver sensitivity called SINAD. This refers to a ratio of signal to noise and distortion. These values are subjective and will have variability amongst individuals as well as configurations of equipment and distractions such as background noise. They are intended to represent the mean opinion scores of a group of individuals, thus providing a target for evaluation.

The following table from the report sets out the target equivalency between DAQ (Delivered Audio Quality) and TIA SINAD measurements.

Delivered Audio Quality	Subjective Performance Description	SINAD Equiv. Intelligibility
1	Unusable, Speech present but unreadable	<8dB
2	Understandable with considerable effort. Frequent repetition due to Noise/Distortion	12 dB

Delivered Audio Quality	Subjective Performance Description	SINAD Equiv. Intelligibility
3	Speech understandable with slight effort. Occasional repetition required due to Noise/Distortion	17 dB
3.4	Speech understandable without repetition. Some Noise/Distortion	20 dB
4	Speech easily understood. Occasional Noise/Distortion	25 dB
4.5	Speech easily understood. Infrequent Noise/Distortion	30 dB
5	Speech easily understood.	>33 dB

Values less than three (3) transition quickly so no intermediate definitions exist. Values greater than three (3) contain intermediate steps. The specific value of 3.4 was derived from a specific Federal Government design criterion. Different radio bandwidths and modulations require different ratios of signal versus the combined disruptive effect of noise and interference. Additional details are available in the report. In paragraph 3.4.1 of the TIA TR8.8 report referenced above, it states:

The goal of DAQ is to determine what mean  $C/(I+N)$  is required to produce a subjective audio quality metric under Raleigh multipath fading. The reference is to FM analog radio SINAD equivalent intelligibility. That is a static analog measurement so the Table 1 description (see the table above) has been provided to provide a cross reference.

... (Channel Performance Criterion) CPC requirements would normally specify either a 3 or 3.4 DAC at the boundary of a protected service area.

Radio systems for public safety should be designed to provide the users with a DAQ of 3.4 so that over the vast majority of the coverage area speech is easily understood.

An equivalent to DAC can be derived for digital systems. It is related to the Bit Error Rate (BER). However, the DAC - BER relationship depends on the specifics of the error correction algorithm, vocoder and related performance of the particular digital platform.

The report also includes methodologies to allow system design, specification, and verification of desired audio quality levels for a given reliability percent of the coverage area. Procurement specifications should detail the desired DAQ and the percentage of the service area that must achieve the required DAQ as well as the acceptance testing methodology to be used.

#### Data Performance

Additional studies are required in this area, including video. Data performance impacts system loading due to retries (repetition). The length of the data file and whether or not acknowledgments are utilized effect the overall system loading. We encourage TIA to continue its efforts to include data and video in this or a similar report.

### SECTION II: Other Quality Considerations

In addition to the quality in technical performance related to voice clarity, other areas of quality may be considered by the public safety users and manufacturers. An integral part of the design and production of public safety radio products and services is the implementation of traditional quality control and quality assurance activities. While each public safety entity has unique user requirements related to quality, the following list gives examples of areas where quality may be an operational requirement. This list is in no way exhaustive, and no effort has been made to establish or suggest numerical recommendations, but gives suggestions of areas in which public safety entities may require a specific quality measurement when designing their systems.

#### Delay:

For terrestrial systems, the maximum amount of system delay should be limited to the following criteria as is stated in the APCO Project 25 Statement of Requirements:

Throughput delay shall be as follows:

- a. Less than 250 msec in direct radio-to-radio communications.
- b. Less than 350 msec in radio-to-radio communications through a single conventional repeater.
- c. Less than 500 msec in radio-to-radio communications within an RF subsystem.

For satellite systems, an additional system delay should be limited to 250 msec.

**Reliability:**

System Failures: What is the mean time between system failures?

System Repair: What is the mean time for system repair?

System Redundancy: If the system fails is there system redundancy?

System Durability: What are the durability test results? (e.g. driven rain or drop test?)

Diagnostics: What methods are in place to monitor and report on degradations prior to failure modes?

**Ergonomics:**

Legibility of Display: Is the display readily readable?

Lighting: Are displays readable in varying ambient light?

Radio Design: Is the radio comfortable to wear and user?

Keypad: Are the buttons big enough? Can the radio be used with gloves?

**After Market Services:**

Repair: Are repair parts and service supported?

Training: Is there training associated with maintenance, repair and use?

**Software Releases:**

Are software upgrades user friendly?

**Field Programmable:**

Program Radio in Field: Can the radio be programmed in the field?

**Throughput:**

Throughput rate: How long does it take to get the communication?

Retry rate: How long does it take to get the retried communication?

**Environmental**

Recycling: Is there a method of recycling batteries?

Is there a method for recycling packaging materials?

Radio Coverage:

In paragraph 3.6.2.2 of TIA TR8.8 it states:

For law enforcement and/or other public safety agencies, it is recommended that the CPC (Channel Performance Criterion) be applied to 97% of the prescribed area of operation in the presence of noise and interference. Law enforcement and public safety systems should be designed to support the lowest effective radiated power subscriber set intended for primary usage. In most instances this will necessitate systems be designed to support handheld/portable operation.

This subcommittee accepts the recommendation of TIA TR8.8. Using Figure 1 of that document, 97% area coverage translates to approximately 90% coverage at the contour representing the fringe of coverage.

**DISCUSSION**

Coverage Area

When describing land mobile performance, two numbers are frequently quoted in percent. The first is the percent area coverage at the fringe contour of the coverage area. In the referenced TR-8.8 document, Figure 1, pp. 7 the relationship between total area coverage and that coverage at the fringe is presented. 95 percent area coverage translates into about 82 percent coverage at the fringe. I do not believe this was the intent of the subcommittee but 95 percent fringe coverage translates to 99 percent area coverage. From TR-8.8, paragraph 5.8, the margin in the design required for each of these is 10.2dB and >14dB respectively. It is my understanding that it was the intent of ORS that the coverage at the total area coverage should be 97 percent. This translates to a fringe coverage of 90% with a total margin of 11.5 dB required to obtain this level of coverage. These numbers are summarized below. In fact, the recommendations of TR-8.8 for public safety in section 3.6.2.2 is for the 97% area coverage as shown above.

% COVERAGE CONTOUR	AREA	MARGIN dB
82	95	10.2
90	97	11.5 < Recommendation
95	99	> 14

Coverage Time and DAC

From TR-8.8, it says “The goal of DAC is to determine what mean C/(I+N) is required to produce a subjective audio quality metric under Raleigh multipath fading .... (Channel Performance Criterion) CPC requirements would normally specify either a 3 or 3.4 DAC at

the boundary of a protected service area.” Percent time availability is usually associated with Raleigh fading. So, by specifying the percentage time parameter and DAC, the ORS was being redundant. Further, it appeared that the members of the subcommittee were applying DAC over the total area of coverage, not at the coverage boundary.

### Safety

Channel Access Time: How long does it take to get an open channel?

### Speaker Identification:

Ability to identify speaker: Can you identify who is speaking?

### Batteries

Battery Life: Do the batteries meet the needs of your organization? (e.g. can they last for an entire shift without recharging?)

### Value

Consistent value: What is the quality per unit dollar?

Alternatively, some public safety entities may view Quality in a more defined structure. In general, all equipment may need to conform to industry standards to be of the highest quality and reliability. All materials should be the best of their respective kinds, free of corrosion, scratches, indentations, or other such defects. The design and construction of the communications equipment should be performed in a neat and craftsman like manner and should be consistent with good engineering practices.

## **ANNEX B - SPECTRUM CALCULATION INPUT DATA BASED UPON USER NEEDS**

The purpose of this section is to describe the method used to develop the public safety input data projections for the year 2010 to be used in the calculation of spectrum need. These parameters are:

- 1) Population - the number of people in the various agencies, listed by general category of Police, Fire, EMS and General Government. It should be noted that in some jurisdictions, Fire and EMS have become merged into a single agency function. In the equation for calculating spectrum need, this parameter is abbreviated as POP. The material describing population is found in section B-1.
- 2) Penetration - the percentage of the identified population that will use a particular type of radio communication. In the equation for calculating spectrum need, this parameter is abbreviated as PEN. The material describing penetration is found in section B-2.

The following sections will provide information for the New York and Los Angeles Metropolitan Areas as follows:

- B-1-A Population Data for state and local Governmental entities in the 31 county, New York Metropolitan Area - FCC Public Safety Region 8.
- B-1-B Population Data for federal government agencies in the 31 county, New York Metropolitan Area - FCC Public Safety Region 8.
- B-1-C Population Data for state and local governmental entities in the 5 county, Los Angeles Metropolitan Area.
- B-1-D Population Data for federal government agencies in the 5 county, Los Angeles Metropolitan Area.
- B-2-A Penetration Data for state and local governmental entities in the 31 county, New York Metropolitan Area - FCC Public Safety Region 8.
- B-2-B Penetration Data for federal government agencies in the 31 county, New York Metropolitan Area - FCC Public Safety Region 8.
- B-2-C Penetration Data for state and local governmental entities in the 5 county, Los Angeles Metropolitan Area.
- B-2-D Penetration Data for federal government agencies in the 5 county, Los Angeles Metropolitan Area.

B-2-E Aggregate Penetration Data, derived for each category of communication service offering from the sum of the preceding four spreadsheet penetrated population sums divided by the sum of the two area total populations.

The data from these sections are summarized as follows:

1. New York Metropolitan Area - State and Local Government:

SUMMARY PENETRATION AND POPULATION DATA:

AREA	VOICE DISPATCH	VOICE INTERCON	TRANSACT PROCES'G	FACSIMILE	SNAP SHOT	REM FILE ACCESS	SLO SCN VIDEO	FULL MO VIDEO	2010 POPULATION BY CATEGORY	% USER CATEGORY POPULATION OF TOTAL REGION 8 POPULATION
POLICE	53.12%	11.58%	31.25%	6.71%	28.79%	23.34%	1.87%	12.24%	83,229	0.39%
FIRE	39.62%	11.29%	31.48%	10.53%	16.83%	28.12%	1.04%	19.54%	153,321	0.73%
EMS	35.67%	11.34%	34.20%	14.13%	30.99%	30.99%	13.60%	3.52%	51,909	0.25%
GENERAL GOV'T SERVICES	20.69%	1.29%	16.16%		0.71%	0.91%	2.54%	0.59%	251,138	1.19%
TOTAL REGION 8 AREA POPULATION =									21,099,700	

2. New York Metropolitan Area - Federal Government:

SUMMARY PENETRATION AND POPULATION DATA:

AREA	VOICE DISPATCH	VOICE INTERCON	TRANSACT PROCES'G	FACSIMILE	SNAP SHOT	REM FILE ACCESS	SLO SCN VIDEO	FULL MO VIDEO	2010 POPULATION BY CATEGORY	% USER CATEGORY POPULATION OF TOTAL REGION 8 POPULATION
POLICE										
FIRE										
EMS										
GENERAL GOV'T SERVICES										
TOTAL REGION 8 AREA POPULATION =									21,099,700	

3. Los Angeles Metropolitan Area - State and Local Government:

SUMMARY PENETRATION AND POPULATION DATA:

AREA	VOICE DISPATCH	VOICE INTERCON	TRANSACT PROCES'G	FACSIMILE	SNAP SHOT	REM FILE ACCESS	SLO SCN VIDEO	FULL MO VIDEO	2010 POPULATION BY CATEGORY	% USER CATEGORY POPULATION OF TOTAL LOS ANGELES POPULATION
POLICE										
FIRE										
EMS										
GENERAL GOV'T SERVICES										
TOTAL LOS ANGELES AREA POPULATION =										

4. Los Angeles Metropolitan Area - Federal Government:

SUMMARY PENETRATION AND POPULATION DATA:

AREA	VOICE DISPATCH	VOICE INTERCON	TRANSACT PROCES'G	FACSIMILE	SNAP SHOT	REM FILE ACCESS	SLO SCN VIDEO	FULL MO VIDEO	2010 POPULATION BY CATEGORY	% USER CATEGORY POPULATION OF TOTAL LOS ANGELES POPULATION
POLICE										
FIRE										
EMS										
GENERAL GOV'T SERVICES										
TOTAL LOS ANGELES AREA POPULATION =										

5. Aggregate Penetration:

ALL SERVICES	VOICE DISPATCH	VOICE INTERCON	TRANSACT PROCES'G	FACSIMILE	SNAP SHOT	REM FILE ACCESS	SLO SCN VIDEO	FULL MO VIDEO

## PSWAC Operational Requirements - Appendix B-1-A

### New York Metropolitan Area Operational Needs Report On Population (POP)

The purpose of this section is to describe the method used to develop the state and local public safety population projection for the year 2010. This parameter, population, is a required input to the future needs equation being solved by the overall PSWAC process. Population has been given the abbreviation POP.

The population determined in this section **does NOT include any values for the federal government** needs within the boundaries of the New York Metropolitan Area, or the needs for interoperability in the region. These needs, must be added to the population determined in this document in order to arrive at the total population for the New York Metropolitan Area.

#### I. DEFINITION OF NEW YORK METRO AREA

The New York Metropolitan Area is defined as the 31 counties of Connecticut, New York, and New Jersey which make up NPSPAC Region 8. NPSPAC Region 8 is the New York Metropolitan Area per FCC Docket PR 87-112 which allocated six MHz of spectrum, 821-824 and 866-869 MHz, for public safety use. It is appropriate to use that same area here to define the New York Metropolitan Area. Table 1 lists the 31 counties of NPSPAC Region 8 with the 1990 population of each county.

State	County	Population, 1990 <sup>1</sup>
CT	Fairfield	827,645
CT	Litchfield	174,092
CT	Middlesex	143,196
CT	New Haven	804,219
NJ	Bergen	825,380
NJ	Essex	778,206
NJ	Hudson	553,099
NJ	Hunterdon	107,776
NJ	Mercer	325,824
NJ	Middlesex	671,780
NJ	Monmouth	553,124
NJ	Morris	421,353
NJ	Passaic	453,060

<b>State</b>	<b>County</b>	<b>Population, 1990<sup>1</sup></b>
NJ	Somerset	240,279
NJ	Sussex	130,943
NJ	Union	493,819
NJ	Warren	91,607
NY	Dutchess	259,462
NY	Nassau	1,287,348
NY	Orange	307,647
NY	Putnam	83,941
NY	Rockland	265,475
NY	Suffolk	1,321,864
NY	Sullivan	69,277
NY	Ulster	165,304
NY	Westchester	874,866
NYC	Bronx	1,203,789
NYC	Kings	2,300,664
NYC	New York	1,487,536
NYC	Queens	1,951,598
NYC	Richmond	348,977
<b>Total =</b>		<b>19,523,150</b>

**TABLE 1 - NPSPAC Region 8**

The metro region was studied in two distinctly different ways. First, the 26 counties outside of New York City proper were studied by interviewing key people and collecting data regarding population, population density, personnel reports and the like. New York City, on the other hand, was broken down into the various agencies within city government and their populations. The sum of the two parts was the overall population, POP, for the New York Metropolitan Area.

**II. OVERALL POPULATION**

The first item to be determined was a forecast of the overall population of the region in the year 2010. A chart<sup>2</sup> was found which listed 30 of the 31 counties with population projections, by county, every five years out to the year 2020. The missing county was Middlesex county in Connecticut.

The values for the year 2010 were used in the following work. A projection for Middlesex county, CT was calculated using a growth similar to the other counties of Connecticut. The overall population of the region was forecast at 21,099,700 for the year 2010.

The next task was to search for a relationship between the total population and the number of public safety personnel. The following sections describe the findings.

### III. POLICE OFFICER POPULATION

Each of the states annually publishes a crime report. Copies of the 1993 reports were obtained for New York<sup>3</sup> and New Jersey<sup>4</sup>. Contained within these reports are tables listing the number of police employees by town, county, etc. By using the number of sworn municipal and county police officers in each county and dividing by the population, a rate of police officers as a percent of overall population was determined.

Reference 1 contained population and land area statistics for each county. From these data the population density was calculated in population per square mile.

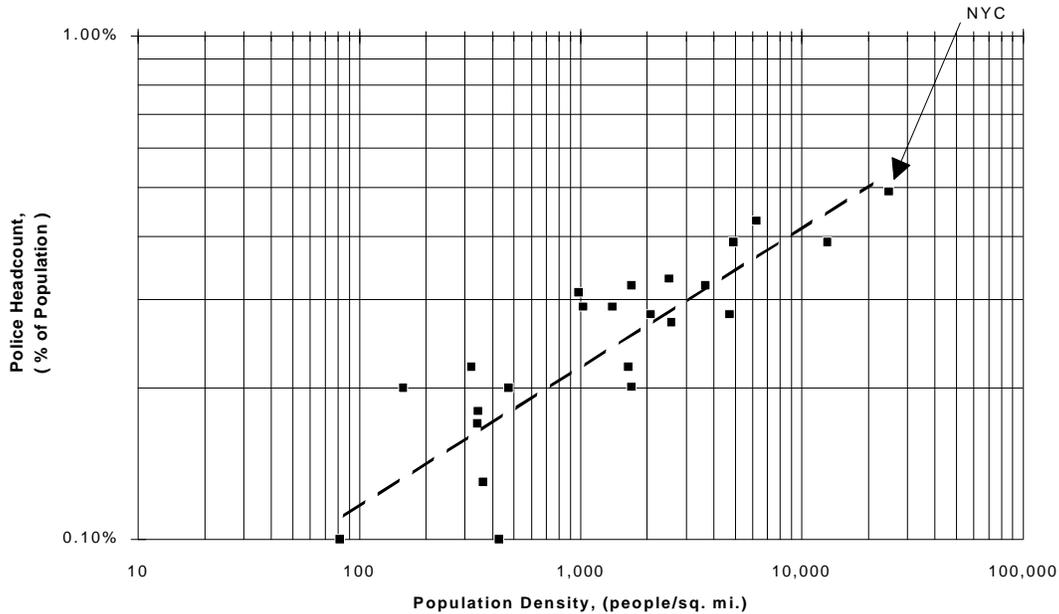


Figure 1 - Sworn Police Officer Rate vs. Population Density

Figure 1 shows that the rate of sworn police officers for a given area is directly proportional to the population density. New York City has 0.49% police at a population density of over 24,000 people/sq. mi, while Sullivan county has 0.1% police at a population density of 81 people/sq. mi. Values were then selected for the four counties of Connecticut by drawing a line through the data. The resulting values for Connecticut were in very close agreement with those received from the police frequency coordinator for the state.

Since the data above for New York and New Jersey did not include State Police functions of various kinds, a portion of the overall state police headcount was added, for New Jersey - based upon the percentage of the state geography included within NPSPAC Region 8 or 50.7% of the state, and for New York - based upon the distribution of personnel assigned within those NYS counties in Region 8.

The sworn police officer population projections for NPSPAC Region 8 are shown in exhibit 2 attached in column I. The grand total of sworn police officers is about 83,000.

**IV. FIRE FIGHTER POPULATION**

Outside of the City of New York the fire fighting community is made up largely of volunteer fire companies. The population values for fire fighters was determined in three ways. First, interviews were conducted in Bergen, Rockland, Westchester and Suffolk counties during which the number of volunteers and paid personnel were estimated for the entire county. Second, for Nassau county the county *Fire and EMS Data Book*<sup>5</sup> was used to sum the personnel for the entire county. Third, for the city of New York the *1994-95 Green Book*<sup>6</sup> listed the Fire Department at 12,421 personnel. In each of these six instances the current headcount was calculated as a percent of the current population. Then, this percentage was applied to the projected 2010 overall population in order to arrive at the projected population in 2010. Figure 2 is a plot of the data for these six instances.

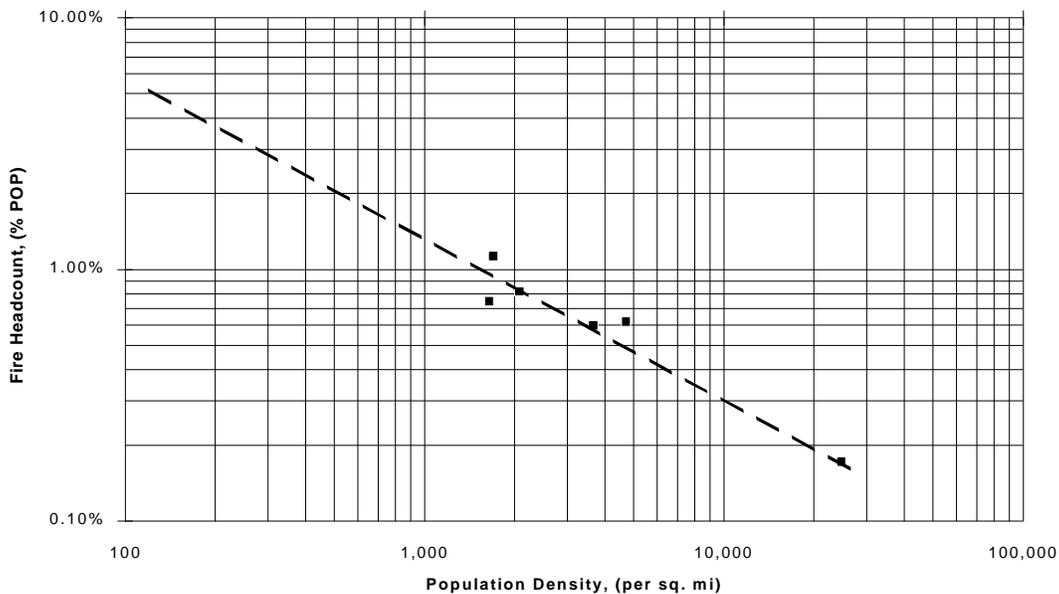


Figure 2 - Fire Fighter Rate vs. Population Density

Note that the slope of the line through these data is the opposite of the data for police. This is because in the case of fire fighters the more rural an area is, the more volunteer fire fighters there are (as a % of population). New York City, with 24,000 people per square mile has a fire fighter rate of 0.17% of population, while Rockland county has 1,700 people per square mile and 1.13% of population as fire fighters. A line was drawn through these six data points, and fire rates were determined for the other counties in that matter. Once the fire rate was established, it was applied to the 2010 population projection in order to determine the number of fire fighters in the year 2010.

The number of fire fighters projected in the year 2010 is shown in exhibit 2 attached at column K. The total for NPSPAC Region 8 is about 153,000.

**V. EMERGENCY MEDICAL POPULATION**

Emergency medical population was determined in the same manner as fire fighters. That is, through a process of interviews with key people in each of several counties and the City of New York. The Nassau County *Fire and EMS Data Book*, reference 5, was a valuable source of data which was used to check the sanity of the values determined through the interviews. Figure 3 is the plot of the data for the six samples.

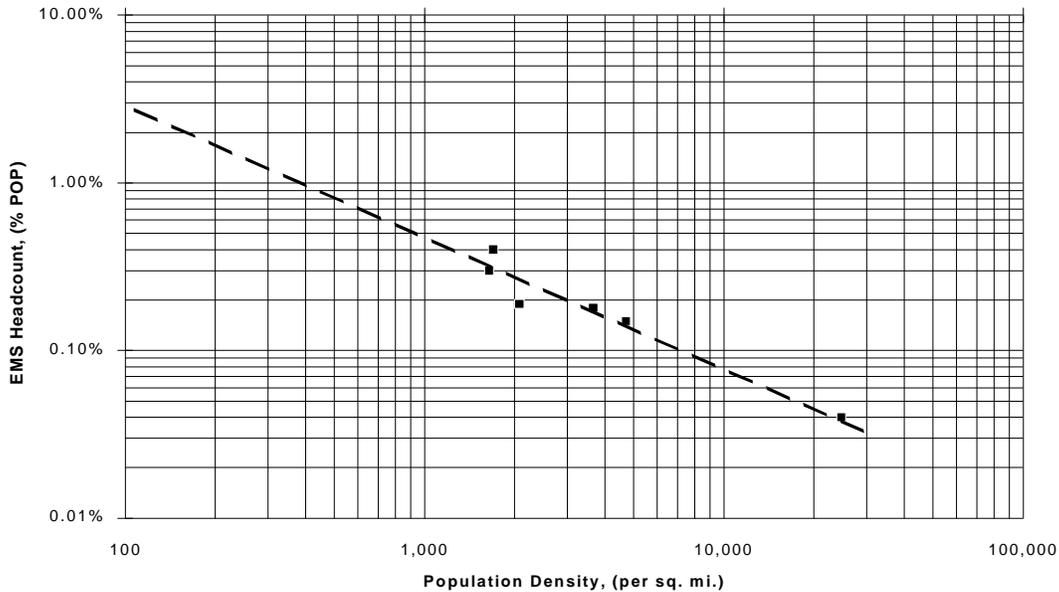


Figure 3 - EMS Headcount vs. Overall Population Density

The number of EMS personnel projected in the year 2010 is shown in exhibit 2 attached at column M. The total for NPSPAC Region 8 is about 52,000.

## VI. GOVERNMENTAL SERVICES POPULATION

The police, fire, and emergency medical services populations within this report generally are considered the “first response” personnel within NPSPAC Region 8 and data on these services is more readily available than those of general (local) government, highway maintenance, forestry/conservation, public mass transportation, and correctional services.

These other governmental services have been combined for purposes of this report. The data presented for these services have been combined to simplify the presentation of the region’s requirements and not to diminish their respective importance.

The governmental service population values for 1995 for the counties **within the City of New York** are taken from the *1994-1995 Green Book*, reference 6. The various agencies of city government are listed with their staffing. The listing was studied and those agencies which are candidates for wireless communications were added to the attached exhibit 2 in column N. These 1995 values were summed and a growth rate applied to project the POP for the year 2010. The number of New York City governmental service employees (less the “first responders”) who are candidates for wireless communications is shown in attached exhibit 2 in column P at row 72. The total is about 149,000.

The governmental service population values for counties **outside of the City of New York** are calculated based on the following regional observations and relationships:

- The wireless needs of the general governmental users represents roughly half of the full-time employed “first response” personnel.
- Greater than 90% of the fire and emergency medical services are community based volunteer services.
- Regional Fire/EMS coordinators estimate that four volunteers in each of the respective services are equivalent to one full-time employee in that service.

Based on the above, the governmental services population rate for areas outside of the City of New York can be expressed as:

$$\text{government population rate} = 0.5 [\text{police rate} + 0.25(\text{fire rate} + \text{EMS rate})]$$

This empirical formula is applied for all counties within NPSPAC Region 8 outside of the City of New York. The margin of error of this formula may not be significant when compared to the number of employees of the City of New York.

The staffing levels for several of the other large government run agencies such as, NYC Transit Authority<sup>7</sup>, Metro North RR, Long Island RR, New Jersey Transit, and the Port Authority of NY and NJ, were added to exhibit 2 at rows 75 through 79.

The number of local government employees who are candidates for wireless communications are shown in attached exhibit 2 in column P. The grand total for Governmental Services is about 251,000.

**VII. GRAND TOTAL**

The grand total state and local public safety population for the New York Metropolitan Area was determined to be forecast in the year 2010 at 539,222.

For comparison purposes, the following attributes identify the New York Metropolitan Area.

- Includes portions of three (3) states
- Estimated area population in the year 2010 = 21,099,700
- Total land area = 12,369 square miles
- Average population density of the total area = 1,706 persons / square mile.

**EXHIBIT 1 - POPULATION PROJECTIONS BY COUNTY (000)**

NEW YORK METROPOLITAN TRANSPORTATION COUNCIL - 9/20/95

(PREPARED BY URBANOMICS - LAST REVISION 9/18/95 )

	1970	1980	1990	1994	1995	2000	2005	2010	2015	2020
BRONX	1,471.7	1,169.0	1,203.8	1,191.3	1,192.6	1,203.8	1,223.4	1,240.3	1,260.0	1,289.8
KINGS	2,602.0	2,231.0	2,300.7	2,271.0	2,275.7	2,285.5	2,300.8	2,333.7	2,370.0	2,412.4
NEW YORK	1,539.2	1,428.3	1,487.5	1,506.4	1,510.0	1,520.4	1,540.8	1,556.7	1,565.2	1,575.0
QUEENS	1,986.5	1,891.3	1,951.6	1,964.3	1,970.3	1,999.0	2,029.4	2,062.4	2,124.0	2,189.2
RICHMOND	295.4	352.0	379.0	397.7	400.0	413.7	428.4	441.5	455.0	475.0
NEW YORK CITY	7,894.8	7,071.6	7,322.6	7,330.7	7,348.6	7,422.4	7,522.8	7,634.6	7,774.2	7,941.4
NASSAU	1,428.1	1,321.6	1,287.3	1,302.3	1,302.3	1,318.8	1,329.6	1,349.8	1,379.9	1,433.6
SUFFOLK	1,125.0	1,284.2	1,321.9	1,349.2	1,347.1	1,367.3	1,423.3	1,495.2	1,571.0	1,658.1
LONG ISLAND	2,553.0	2,605.8	2,609.2	2,651.5	2,549.4	2,686.1	2,752.9	2,845.0	2,950.9	3,091.7
DUTCHESS	222.3	245.1	259.5	261.5	259.8	263.6	278.4	289.9	301.1	315.6
ORANGE	221.7	259.6	307.6	320.5	319.5	336.9	361.5	384.7	407.1	431.5
PUTNAM	56.7	77.2	83.9	89.2	89.2	91.8	95.2	98.8	102.3	106.3
ROCKLAND	229.9	259.5	265.5	274.8	274.8	280.0	286.9	295.5	305.3	315.0
SULLIVAN	52.6	65.2	69.3	70.6	70.0	71.0	74.9	79.0	83.2	87.7
ULSTER	141.2	158.2	165.3	168.9	165.9	169.2	173.1	177.1	186.6	200.1
WESTCHESTER	894.1	866.6	874.9	888.8	885.6	891.0	892.9	897.7	900.0	905.0
MID-HUDSON	1,818.5	1,931.3	2,026.0	2,074.3	2,064.6	2,103.5	2,162.9	2,222.7	2,285.6	2,361.2
NEW YORK SUBURBS	4,371.5	4,537.1	4,635.2	4,725.8	4,714.2	4,789.6	4,915.8	5,067.7	5,236.5	5,452.9
NEW YORK METRO	12,266.3	11,608.7	11,957.8	12,056.5	12,062.8	12,212.0	12,438.6	12,702.3	13,010.7	13,394.3
BERGEN	898.0	845.4	825.4	842.4	846.9	847.6	851.2	857.3	858.9	859.2
ESSEX	930.0	851.3	778.2	765.4	770.1	777.8	782.2	782.4	779.9	779.7
HUDSON	609.3	557.0	553.1	552.4	556.0	567.9	588.1	612.5	638.4	652.1
HUNTERDON	69.7	87.4	107.8	115.2	117.9	127.3	136.8	146.4	158.0	165.6
MERCER	304.0	307.9	325.8	329.4	330.8	343.5	361.3	383.1	400.4	411.7
MIDDLESEX	583.3	595.9	671.8	692.9	701.5	729.6	763.9	797.5	838.8	889.6
MONMOUTH	459.4	503.2	553.1	578.5	586.6	601.6	633.1	656.6	680.1	703.6
MORRIS	383.5	407.6	421.4	438.5	445.5	460.4	460.4	460.5	465.2	475.2
OCEAN	208.5	346.0	433.2	456.5	466.5	508.5	559.9	606.9	653.9	703.5
PASSAIC	460.8	447.6	453.1	461.8	463.8	463.6	463.5	463.4	463.3	453.2
SOMERSET	198.4	203.1	240.3	260.7	267.7	288.7	292.0	312.3	348.6	371.1
SUSSEX	77.5	116.1	130.9	138.3	140.6	149.7	157.6	167.2	178.1	185.2
UNION	543.1	504.1	493.8	496.2	499.0	502.0	502.5	503.8	515.5	523.1
WARREN	73.9	84.4	91.6	95.4	96.7	106.3	115.0	122.9	131.2	140.8
NEW JERSEY	5,799.7	5,857.0	6,079.5	6,223.6	6,289.6	6,474.5	6,667.5	6,872.8	7,108.3	7,323.6
FAIRFIELD	792.8	807.1	827.6	829.8	838.4	846.6	877.8	906.3	945.5	978.1
LITCHFIELD	144.1	156.8	174.1	178.5	181.0	190.6	200.4	211.6	223.2	241.0
NEW HAVEN	744.9	761.3	804.2	796.5	807.6	823.3	839.2	857.5	876.3	903.7
CONNECTICUT	1,681.9	1,725.2	1,806.0	1,804.8	1,827.0	1,860.5	1,917.4	1,975.4	2,045.0	2,122.8
REGION	19,747.9	19,190.9	19,843.2	20,084.9	20,179.4	20,547.0	21,023.5	21,550.5	22,164.0	22,840.7

**EXHIBIT 2 DEMOGRAPHIC DATA**

I/A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
2	State	County	1990 POP	2010 POP	Area, s.m.	2010 p/s/m	Police Rate	2010 POL	Fire Rate	2010 FIRE	EMS Rate	2010 EMS	1995 NYC	Rate	2010 GOV	
3	CT	Fairfield	827,645	906,300	626	1,448	0.30%	2,719	1.00%	9,063	0.35%	3,172		0.32%	2,889	
4	CT	Litchfield	174,092	211,600										0.32%	230	
											0.17%	360	3.30%	6,983	1.50%	
											3,174		0.69%	1,449		
5	CT	Middlesex	143,196	156,100	369	423	0.20%	312	2.20%	3,434	0.90%	1,405		0.49%	761	
6	CT	New Haven	804,219	857,500	606	1,415	0.30%	2,573	1.00%	8,575	0.32%	2,744		0.32%	2,701	
7																
8	NJ	Bergen	825,380	857,300	234	3,664	0.32%	2,743	0.58%	4,972	0.18%	1,543		0.26%	2,186	
9	NJ	Essex	778,206	782,400	126	6,210	0.43%	3,364	0.40%	3,130	0.11%	861		0.28%	2,181	
10	NJ	Hudson	553,099	612,500	47	13,032	0.39%	2,389	0.23%	1,409	0.06%	367		0.23%	1,416	
11	NJ	Hunterdon	107,776	146,400	430	340	0.17%	249	2.50%	3,660	1.10%	1,610		0.54%	783	
12	NJ	Mercer	325,824	383,100	226	1,695	0.32%	1,226	0.90%	3,448	0.30%	1,149		0.31%	1,188	
13	NJ	Middlesex	671,780	797,500	311	2,564	0.27%	2,153	0.70%	5,583	0.23%	1,834		0.25%	2,004	
14	NJ	Monmouth	553,124	656,600	472	1,391	0.29%	1,904	1.00%	6,566	0.25%	1,642		0.30%	1,978	
15	NJ	Morris	421,353	460,500	469	982	0.31%	1,428	1.30%	5,987	0.48%	2,210		0.38%	1,738	
16	NJ	Passaic	453,060	463,400	185	2,505	0.33%	1,529	0.70%	3,244	0.22%	1,019		0.28%	1,298	
17	NJ	Somerset	240,279	312,300	305	1,024	0.29%	906	1.30%	4,060	0.45%	1,405		0.36%	1,136	
18	NJ	Sussex	130,943	167,200	521	321	0.22%	368	2.70%	4,514	1.10%	1,839		0.59%	978	
19	NJ	Union	493,819	503,800	103	4,891	0.39%	1,965	0.47%	2,368	0.13%	655		0.27%	1,360	
20	NJ	Warren	91,607	122,900	358	343	0.18%	221	2.50%	3,073	1.00%	1,229		0.53%	648	
21	NJ	New Jersey State Police (50.7%)						1,467								
22	NJ	Dept of Corrections (50.7%)						3,147								
23	NJ	Other Police (50.7%)						363								
24																
25	NY	Dutchess	259,462	289,900	802	361	0.13%	377	2.50%	7,248	1.00%	2,899		0.50%	1,457	
26	NY	Nassau	1,287,348	1,349,800	287	4,703	0.28%	3,779	0.50%	6,749	0.13%	1,755		0.22%	2,953	
27	NY	Orange	307,647	384,700	816	471	0.20%	769	2.10%	8,079	0.85%	3,270		0.47%	1,803	
28	NY	Putnam	83,941	98,800	232	426	0.10%	99	2.20%	2,174	0.90%	889		0.44%	432	
29	NY	Rockland	265,475	295,500	174	1,698	0.20%	594	0.90%	2,660	0.30%	887		0.25%	740	
30	NY	Suffolk	1,321,864	1,495,200	911	1,641	0.22%	3,289	0.95%	14,204	0.30%	4,486		0.27%	3,981	
31	NY	Sullivan	69,277	79,000	970	81	0.10%	79	6.00%	4,740	3.00%	2,370		1.18%	928	
32	NY	Ulster	165,304	177,100	1,127	157	0.20%	354	4.00%	7,084	2.00%	3,542		0.85%	1,505	
33	NY	Westchester	874,866	897,700	433	2,073	0.28%	2,514	0.80%	7,182	0.10%	898		0.25%	2,267	
34	NY	NY State Police						877								
35	NY	Other PD's (Campus, Parks, etc)						250								
36																
37																
38																
39	NYC	Bronx	1,203,789	1,240,300	42	29,531										
40	NYC	Kings	2,300,664	2,333,700	71	32,869										
41	NYC	New York	1,487,536	1,556,700	28	55,596										
42	NYC	Queens	1,951,598	2,062,400	109	18,921										
43	NYC	Richmond	348,977	441,500	59	7,483										
44		AGENCY														
45		Aging, Dept for the												288		
46		Borough President (5 boros)												506		
47		Buildings, Dept of												605		
48	NYC	City Sheriff												452		
49		City University												3,587		
50		Consumer Affairs, Dept of												252		
51	NYC	Dept. of Corrections												12,342		
52	NYC	Bronx District Attorney												706		
53	NYC	Kings District Attorney												1,106		
54	NYC	New York DA												1,140		
55	NYC	Queens DA												561		
56	NYC	Richmond DA												96		
57	NYC	Board of Education												87,346		
58	NYC	DEP												6,029		
59	NYC	Dept of Health												2,600		
60		Housing, Pres & Dev, Dept of												3,557		
61	NYC	DOITT												318		
62		Investigation, Dept of												345		
63	NYC	Mayoralty												1,182		
64	NYC	Mental Health Svcs												268		
65	NYC	Prosecution-Special Narcotics												233		
66	NYC	Parks & Recreation												2,548		
67	NYC	Office of Probation												1,636		
68	NYC	Dept of Sanitation												8,832		
69	NYC	Taxi & Limousine Commission												463		
70	NYC	Dept of Transportation												6,125		
71	NYC	Youth Services, Dept of												145		
72	NYC	Total City	7,292,564	7,634,600	309	24,707	0.49%	37,562	0.17%	13,132	0.04%	3,054	141,869	1.95%	148,523	
73																
74																
75	NYC	NYCTransit Authority												46,000	0.64%	48,861
76		Metro North						200						5,300	0.07%	5,344
77		Port Authority of NY & NJ						700								
78		Long Island Railroad						250						1,950	?	1,950
79		New Jersey Transit						150						3,700	?	3,700
80		TOTAL	19,523,150	21,099,700	12,369	1,706		83,229		153,317		51,909			251,140	
81																
82																

GRAND TOTAL P.S. POP. IN 2010 595

**PSWAC Operational Requirements - Appendix B-2-A**  
**New York Metro Region Operational Needs**  
**Report On Penetration (PEN)**

This section is a companion to the section, Appendix B-1-A, state and local public safety population (POP) for the 31 county, New York Metropolitan Area - FCC Public Safety Region 8. In that section on population, the New York Metro Region was defined and population values were determined for each county in the region, the various agencies of New York City and certain state agencies.

Certain key agencies were interviewed to determine the percentage of the user category population (penetration) that would require a particular category of communication service offering. In order to complete this task in the time available, the other governmental entities in the study area were compared to the interviewed agencies for similar operational attributes and penetration data assigned accordingly.

This section on penetration, Appendix B-2-A, uses the population data projected for the year 2010 from Appendix B-1-A. Eight spreadsheet pages each list the data for one of the eight categories of communication service offerings. For each row in a worksheet, the four user categories of Police, Fire, EMS and General Government are listed. For each user category, the population is listed along with its penetration. The penetrated population (population x penetration) is then summed for each user category. This sum, divided by total population, yields the weighted penetration for that user category and communication service offering.

The eight categories of communication service offerings are:

1. Voice Dispatch
2. Voice Interconnect
3. Transaction Processing
4. Facsimile
5. Snapshot (visual image)
6. Remote File Access/Decision Processing
7. Slow Scan Video
8. Full Motion Video

These eight categories of communication service offerings agree with those defined in the PSWAC model for prediction of spectrum need.

The four categories of users are:

1. Police
2. Fire
3. Emergency Medical Service
4. General Government

The results are shown on the attached spreadsheets.

**PENETRATION DATA - VOICE DISPATCH**

	County/ Agency	POLICE 2010	VX DISP PEN %	PERSNL PEN	FIRE 2010	VX DISP PEN %	PERSNL PEN	EMS 2010	VX DISP PEN %	PERSNL PEN	GOV. SVCS 2010	VX DISP PEN %	PERSNL PEN %
CT	FAIRFIELD	2,719	50.00%	1,360	9,063	15.00%	1,359	3,172	20.00%	634	2,889		0
CT	LITCHFIELD	360	50.00%	180	6,983	50.00%	3,492	3,174	40.00%	1,270	1,449		0
CT	MIDDLESEX	312	50.00%	156	3,434	50.00%	1,717	1,405	40.00%	562	761		0
CT	NEW HAVEN	2,573	50.00%	1,287	8,575	15.00%	1,286	2,744	20.00%	549	2,701		0
NJ	BERGEN	2,743	40.00%	1,097	4,972	50.00%	2,486	1,543	40.00%	617	2,186	50.00%	1,093
NJ	ESSEX	3,364	50.00%	1,682	3,130	50.00%	1,565	861	50.00%	431	2,181		0
NJ	HUDSON	2,389	50.00%	1,195	1,409	50.00%	705	368	50.00%	184	1,416		0
NJ	HUNTERDON	249	50.00%	125	3,660	50.00%	1,830	1,610	40.00%	644	783		0
NJ	MERCER	1,226	50.00%	613	3,448	15.00%	517	1,149	20.00%	230	1,188		0
NJ	MIDDLESEX	2,153	40.00%	861	5,583	50.00%	2,792	1,834	40.00%	734	2,004	50.00%	1,002
NJ	MONMOUTH	1,904	40.00%	762	6,566	50.00%	3,283	1,642	40.00%	657	1,978	50.00%	989
NJ	MORRIS	1,428	40.00%	571	5,987	50.00%	2,994	2,210	40.00%	884	1,738	50.00%	869
NJ	PASSAIC	1,529	50.00%	765	3,244	50.00%	1,622	1,019	50.00%	510	1,298		0
NJ	SOMERSET	906	50.00%	453	4,060	50.00%	2,030	1,405	40.00%	562	1,136		0
NJ	SUSSEX	368	50.00%	184	4,514	50.00%	2,257	1,839	40.00%	736	978		0
NJ	UNION	1,965	50.00%	983	2,368	50.00%	1,184	655	50.00%	328	1,360		0
NJ	WARREN	221	50.00%	111	3,073	50.00%	1,537	1,229	40.00%	492	648		0
NJ	NJ STATE POLICE	1,467	50.00%	734									
NJ	NJ DEPT. CORRECT.	3,147	50.00%	1,574									
NJ	NJ OTHER POLICE	363	50.00%	182									
NY	DUTCHESS	377	50.00%	189	7,248	50.00%	3,624	2,899	40.00%	1,160	1,457		0
NY	NASSAU	3,779	50.00%	1,890	6,749	15.00%	1,012	1,755	20.00%	351	2,953		0
NY	ORANGE	769	50.00%	385	8,079	50.00%	4,040	3,270	40.00%	1,308	1,803		0
NY	PUTNAM	99	50.00%	50	2,174	50.00%	1,087	889	40.00%	356	432		0
NY	ROCKLAND	594	50.00%	297	2,660	50.00%	1,330	887	40.00%	355	740		0

	County/ Agency	POLICE 2010	VX DISP PEN %	PERSNL PEN	FIRE 2010	VX DISP PEN %	PERSNL PEN	EMS 2010	VX DISP PEN %	PERSNL PEN	GOV. SVCS 2010	VX DISP PEN %	PERSNL PEN %
NY	SUFFOLK	3,289	36.00%	1,184	14,204	15.00%	2,131	4,486	20.00%	897	3,981		0
NY	SULLIVAN	79	50.00%	40	4,740	50.00%	2,370	2,370	40.00%	948	928		0
NY	ULSTER	354	50.00%	177	7,084	50.00%	3,542	3,542	40.00%	1,417	1,505		0
NY	WESTCHESTER	2,514	50.00%	1,257	7,182	15.00%	1,077	898	20.00%	180	2,267		0
NY	NY STATE POLICE	877	40.00%	351									
NY	NY OTHER POLICE	250	50.00%	125									
NY	NEW YORK CITY	37,562	60.00%	22,537	13,132	60.00%	7,879	3,054	50.00%	1,527	148,523	15.00%	22,278
	BRONX												
	KINGS												
	NEW YORK												
	QUEENS												
	RICHMOND												
NY	METRO TRANSIT AUTH										48,861	43.00%	21,010
	METRO NORTH RR	200	50.00%	100							5,344	43.00%	2,298
	PORT AUTH NY NJ	700	80.00%	560									
	LONG ISLAND RR	250	50.00%	125							1,950	43.00%	839
	NJ TRANSIT	150	50.00%	75							3,700	43.00%	1,591
	<b>TOTALS</b>	<b>83,229</b>		<b>44,210</b>	<b>153,321</b>		<b>60,746</b>	<b>51,909</b>		<b>18,519</b>	<b>251,138</b>		<b>51,969</b>
	<b>PENETR.BY CATEGORY</b>	<b>53.12%</b>			<b>39.62%</b>			<b>35.67%</b>			<b>20.69%</b>		

**PENETRATION DATE - VOICE INTERCONNECT**

	County / Agency	POLICE 2010	VX INTRC PEN %	PERSNL PEN	FIRE 2010	VX INTRC PEN %	PERSNL PEN	EMS 2010	VX INTRC PEN %	PERSNL PEN	GOV SVCS 2010	VX INTRC PEN %	PERSNL PEN
CT	FAIRFIELD	2,719	20.00%	544	9,063	7.00%	634	3,172	20.00%	634	2,889		0
CT	LITCHFIELD	360	20.00%	72	6,983	20.00%	1,397	3,174	10.00%	317	1,449		0
CT	MIDDLESEX	312	20.00%	62	3,434	20.00%	687	1,405	10.00%	141	761		0
CT	NEW HAVEN	2,573	20.00%	515	8,575	7.00%	600	2,744	20.00%	549	2,701		0
NJ	BERGEN	2,743	0.00%	0	4,972	0.00%	0	1,543	0.00%	0	2,186		0
NJ	ESSEX	3,364	10.00%	336	3,130	10.00%	313	861	10.00%	86	2,181		0
NJ	HUDSON	2,389	10.00%	239	1,409	10.00%	141	368	10.00%	37	1,416		0
NJ	HUNTERDON	249	20.00%	50	3,660	20.00%	732	1,610	10.00%	161	783		0
NJ	MERCER	1,226	20.00%	245	3,448	7.00%	241	1,149	20.00%	230	1,188		0
NJ	MIDDLESEX	2,153	0.00%	0	5,583	0.00%	0	1,834	0.00%	0	2,004		0
NJ	MONMOUTH	1,904	0.00%	0	6,566	0.00%	0	1,642	0.00%	0	1,978		0
NJ	MORRIS	1,428	0.00%	0	5,987	0.00%	0	2,210	0.00%	0	1,738		0
NJ	PASSAIC	1,529	10.00%	153	3,244	10.00%	324	1,019	10.00%	102	1,298		0
NJ	SOMERSET	906	20.00%	181	4,060	20.00%	812	1,405	10.00%	141	1,136		0
NJ	SUSSEX	368	20.00%	74	4,514	20.00%	903	1,839	10.00%	184	978		0
NJ	UNION	1,965	10.00%	197	2,368	10.00%	237	655	10.00%	66	1,360		0
NJ	WARREN	221	20.00%	44	3,073	20.00%	615	1,229	10.00%	123	648		0
NJ	NJ STATE POLICE	1,467	20.00%	293			0			0			0
NJ	NJ DEPT. CORRECT.	3,147	20.00%	629			0			0			0
NJ	NJ OTHER POLICE	363	20.00%	73			0			0			0
NY	DUTCHESS	377	20.00%	75	7,248	20.00%	1,450	2,899	10.00%	290	1,457		0
NY	NASSAU	3,779	20.00%	756	6,749	7.00%	472	1,755	20.00%	351	2,953		0
NY	ORANGE	769	20.00%	154	8,079	20.00%	1,616	3,270	10.00%	327	1,803		0
NY	PUTNAM	99	20.00%	20	2,174	20.00%	435	889	10.00%	89	432		0
NY	ROCKLAND	594	20.00%	119	2,660	20.00%	532	887	10.00%	89	740		0
NY	SUFFOLK	3,289	5.00%	164	14,204	7.00%	994	4,486	20.00%	897	3,981		0

	County / Agency	POLICE 2010	VX INTRC PEN %	PERSNL PEN	FIRE 2010	VX INTRC PEN %	PERSNL PEN	EMS 2010	VX INTRC PEN %	PERSNL PEN	GOV SVCS 2010	VX INTRC PEN %	PERSNL PEN
NY	SULLIVAN	79	20.00%	16	4,740	20.00%	948	2,370	10.00%	237	928		0
NY	ULSTER	354	20.00%	71	7,084	20.00%	1,417	3,542	10.00%	354	1,505		0
NY	WEST-CHESTER	2,514	20.00%	503	7,182	7.00%	503	898	20.00%	180	2,267		0
NY	NY STATE POLICE	877	20.00%	175			0			0			0
NY	NY OTHER POLICE	250	20.00%	50			0			0			0
NY	NEW YORK CITY	37,562	10.00%	3,756	13,132	10.00%	1,313	3,054	10.00%	305	148,523	2.00%	2,970
	BRONX			0			0			0			0
	KINGS			0			0			0			0
	NEW YORK			0			0			0			0
	QUEENS			0			0			0			0
	RICHMOND			0			0			0			0
NY	METRO TRANSIT AUTH			0			0			0	48,861	0.43%	210
	METRO NORTH RR	200	0.43%	1			0			0	5,344	0.43%	23
	PORT AUTH NY NJ	700	10.00%	70			0			0			0
	LONG ISLAND RR	250	0.43%	1			0			0	1,950	0.43%	8
	NJ TRANSIT	150	0.43%	1			0			0	3,700	0.43%	16
	<b>TOTALS</b>	<b>83,229</b>		<b>9,639</b>	<b>153,321</b>		<b>17,316</b>	<b>51,909</b>		<b>5,888</b>	<b>251,138</b>		<b>3,228</b>
	<b>PENETR. BY CATEGORY</b>	<b>11.58%</b>			<b>11.29%</b>			<b>11.34%</b>			<b>1.29%</b>		

**PENETRATION DATA - TRANSACTION PROCESSING**

	County / Agency	POLICE 2010	TRNS/ PRC PEN %	PERSNL PEN	FIRE 2010	TRNS/ PRC PEN %	PERSNL PEN	EMS 2010	TRNS/ PRC PEN %	PERSNL PEN	GOV SVCS 2010	TRNS/ PRC PEN %	PERSNL PEN
CT	FAIRFIELD	2,719	50.00%	1,360	9,063	7.00%	634	3,172	20.00%	634	2,889		0
CT	LITCHFIELD	360	50.00%	180	6,983	50.00%	3,492	3,174	40.00%	1,270	1,449		0
CT	MIDDLESEX	312	50.00%	156	3,434	50.00%	1,717	1,405	40.00%	562	761		0
CT	NEW HAVEN	2,573	50.00%	1,287	8,575	7.00%	600	2,744	20.00%	549	2,701		0
NJ	BERGEN	2,743	40.00%	1,097	4,972	40.00%	1,989	1,543	40.00%	617	2,186	low	0
NJ	ESSEX	3,364	50.00%	1,682	3,130	50.00%	1,565	861	50.00%	431	2,181		0
NJ	HUDSON	2,389	50.00%	1,195	1,409	50.00%	705	368	50.00%	184	1,416		0
NJ	HUNTERDON	249	50.00%	125	3,660	50.00%	1,830	1,610	40.00%	644	783		0
NJ	MERCER	1,226	50.00%	613	3,448	7.00%	241	1,149	20.00%	230	1,188		0
NJ	MIDDLESEX	2,153	40.00%	861	5,583	40.00%	2,233	1,834	40.00%	734	2,004	low	0
NJ	MONMOUTH	1,904	40.00%	762	6,566	40.00%	2,626	1,642	40.00%	657	1,978	low	0
NJ	MORRIS	1,428	40.00%	571	5,987	40.00%	2,395	2,210	40.00%	884	1,738	low	0
NJ	PASSAIC	1,529	50.00%	765	3,244	50.00%	1,622	1,019	50.00%	510	1,298		0
NJ	SOMERSET	906	50.00%	453	4,060	50.00%	2,030	1,405	40.00%	562	1,136		0
NJ	SUSSEX	368	50.00%	184	4,514	50.00%	2,257	1,839	40.00%	736	978		0
NJ	UNION	1,965	50.00%	983	2,368	50.00%	1,184	655	50.00%	328	1,360		0
NJ	WARREN	221	50.00%	111	3,073	50.00%	1,537	1,229	40.00%	492	648		0
NJ	NJ STATE POLICE	1,467	50.00%	734			0			0			0
NJ	NJ DEPT. CORRECT.	3,147	50.00%	1,574			0			0			0
NJ	NJ OTHER POLICE	363	50.00%	182			0			0			0
NY	DUTCHESS	377	50.00%	189	7,248	50.00%	3,624	2,899	40.00%	1,160	1,457		0
NY	NASSAU	3,779	50.00%	1,890	6,749	7.00%	472	1,755	20.00%	351	2,953		0
NY	ORANGE	769	50.00%	385	8,079	50.00%	4,040	3,270	40.00%	1,308	1,803		0
NY	PUTNAM	99	50.00%	50	2,174	50.00%	1,087	889	40.00%	356	432		0
NY	ROCKLAND	594	50.00%	297	2,660	50.00%	1,330	887	40.00%	355	740		0
NY	SUFFOLK	3,289	30.00%	987	14,204	7.00%	994	4,486	20.00%	897	3,981		0

	County / Agency	POLICE 2010	TRNS/ PRC PEN %	PERSNL PEN	FIRE 2010	TRNS/ PRC PEN %	PERSNL PEN	EMS 2010	TRNS/ PRC PEN %	PERSNL PEN	GOV SVCS 2010	TRNS/ PRC PEN %	PERSNL PEN
NY	SULLIVAN	79	50.00%	40	4,740	50.00%	2,370	2,370	40.00%	948	928		0
NY	ULSTER	354	50.00%	177	7,084	50.00%	3,542	3,542	40.00%	1,417	1,505		0
NY	WESTCHESTER	2,514	50.00%	1,257	7,182	7.00%	503	898	20.00%	180	2,267		0
NY	NY STATE POLICE	877	50.00%	439			0			0			0
NY	NY OTHER POLICE	250	50.00%	125			0			0			0
NY	NEW YORK CITY	37,562	12.50%	4,695	13,132	12.50%	1,642	3,054	25.00%	764	148,523	10.00%	14,852
	BRONX			0			0			0			0
	KINGS			0			0			0			0
	NEW YORK			0			0			0			0
	QUEENS			0			0			0			0
	RICHMOND			0			0			0			0
NY	METRO TRANSIT AUTH			0			0			0	48,861	43.00%	21,010
	METRO NORTH RR	200	43.00%	86			0			0	5,344	43.00%	2,298
	PORT AUTH NY NJ	700	50.00%	350			0			0			0
	LONG ISLAND RR	250	43.00%	108			0			0	1,950	43.00%	839
	NJ TRANSIT	150	43.00%	65			0			0	3,700	43.00%	1,591
	<b>TOTALS</b>	<b>83,229</b>		<b>26,006</b>	<b>153,321</b>		<b>48,260</b>	<b>51,909</b>		<b>17,755</b>	<b>251,138</b>		<b>40,590</b>
	<b>PENETR. BY CATEGORY</b>	<b>31.25%</b>			<b>31.48%</b>			<b>34.20%</b>			<b>16.16%</b>		

**PENETRATION DATA - FACSIMILE**

	County / Agency	POLICE 2010	FAX PEN %	PERSNL PEN	FIRE 2010	FAX PEN %	PERSNL PEN	EMS 2010	FAX PEN %	PERSNL PEN	GOV SVCS 2010	FAX PEN %	PERSNL PEN
CT	FAIRFIELD	2,719	10.00%	272	9,063	7.00%	634	3,172	20.00%	634	2,889		0
CT	LITCHFIELD	360	1.00%	4	6,983	20.00%	1,397	3,174	10.00%	317	1,449		0
CT	MIDDLESEX	312	1.00%	3	3,434	20.00%	687	1,405	10.00%	141	761		0
CT	NEW HAVEN	2,573	10.00%	257	8,575	7.00%	600	2,744	20.00%	549	2,701		0
NJ	BERGEN	2,743	20.00%	549	4,972	low	0	1,543	20.00%	309	2,186	low	0
NJ	ESSEX	3,364	5.00%	168	3,130	5.00%	157	861	10.00%	86	2,181		0
NJ	HUDSON	2,389	5.00%	119	1,409	5.00%	70	368	10.00%	37	1,416		0
NJ	HUNTERDON	249	1.00%	2	3,660	20.00%	732	1,610	10.00%	161	783		0
NJ	MERCER	1,226	10.00%	123	3,448	7.00%	241	1,149	20.00%	230	1,188		0
NJ	MIDDLESEX	2,153	20.00%	431	5,583	low	0	1,834	20.00%	367	2,004	low	0
NJ	MONMOUTH	1,904	20.00%	381	6,566	low	0	1,642	20.00%	328	1,978	low	0
NJ	MORRIS	1,428	20.00%	286	5,987	low	0	2,210	20.00%	442	1,738	low	0
NJ	PASSAIC	1,529	5.00%	76	3,244	5.00%	162	1,019	10.00%	102	1,298		0
NJ	SOMERSET	906	1.00%	9	4,060	20.00%	812	1,405	10.00%	141	1,136		0
NJ	SUSSEX	368	1.00%	4	4,514	20.00%	903	1,839	10.00%	184	978		0
NJ	UNION	1,965	5.00%	98	2,368	5.00%	118	655	10.00%	66	1,360		0
NJ	WARREN	221	1.00%	2	3,073	20.00%	615	1,229	10.00%	123	648		0
NJ	NJ STATE POLICE	1,467	1.00%	15			0			0			0
NJ	NJ DEPT. CORRECT.	3,147	1.00%	31			0			0			0
NJ	NJ OTHER POLICE	363	1.00%	4			0			0			0
NY	DUTCHESS	377	1.00%	4	7,248	20.00%	1,450	2,899	10.00%	290	1,457		0
NY	NASSAU	3,779	10.00%	378	6,749	7.00%	472	1,755	20.00%	351	2,953		0
NY	ORANGE	769	1.00%	8	8,079	20.00%	1,616	3,270	10.00%	327	1,803		0
NY	PUTNAM	99	1.00%	1	2,174	20.00%	435	889	10.00%	89	432		0

	County / Agency	POLICE 2010	FAX PEN %	PERSNL PEN	FIRE 2010	FAX PEN %	PERSNL PEN	EMS 2010	FAX PEN %	PERSNL PEN	GOV SVCS 2010	FAX PEN %	PERSNL PEN
NY	ROCKLAND	594	1.00%	6	2,660	20.00%	532	887	10.00%	89	740		0
NY	SUFFOLK	3,289	5.00%	164	14,204	7.00%	994	4,486	20.00%	897	3,981		0
NY	SULLIVAN	79	1.00%	1	4,740	20.00%	948	2,370	10.00%	237	928		0
NY	ULSTER	354	1.00%	4	7,084	20.00%	1,417	3,542	10.00%	354	1,505		0
NY	WEST-CHESTER	2,514	10.00%	251	7,182	7.00%	503	898	20.00%	180	2,267		0
NY	NY STATE POLICE	877	1.00%	9			0			0			0
NY	NY OTHER POLICE	250	1.00%	3			0			0			0
NY	NEW YORK CITY	37,562	5.00%	1,878	13,132	5.00%	657	3,054	10.00%	305	148,523	low	0
	BRONX			0			0			0			0
	KINGS			0			0			0			0
	NEW YORK			0			0			0			0
	QUEENS			0			0			0			0
	RICHMOND			0			0			0			0
NY	METRO TRANSIT AUTH			0			0			0	48,861	low	0
	METRO NORTH RR	200	1.00%	2			0			0	5,344	low	0
	PORT AUTH NY NJ	700	5.00%	35			0			0			0
	LONG ISLAND RR	250	1.00%	3			0			0	1,950	low	0
	NJ TRANSIT	150	1.00%	2			0			0	3,700	low	0
	<b>TOTALS</b>	<b>83,229</b>		<b>5,581</b>	<b>153,321</b>		<b>16,151</b>	<b>51,909</b>		<b>7,334</b>	<b>251,138</b>		<b>0</b>
	<b>PENETR. BY CATEGORY</b>	<b>6.71%</b>			<b>10.53%</b>			<b>14.13%</b>			<b>0.00%</b>		

**PENETRATION DATA - SNAP SHOT (VISUAL IMAGE)**

	County / Agency	POLICE 2010	SNP SHOT PEN %	PERSNL PEN	FIRE 2010	SNP SHOT PEN %	PERSNL PEN	EMS 2010	SNP SHOT PEN %	PERSNL PEN	GOV SVCS 2010	SNP SHOT PEN %	PERSNL PEN
CT	FAIRFIELD	2,719	25.00%	680	9,063	3.00%	272	3,172	10.00%	317	2,889		0
CT	LITCHFIELD	360	50.00%	180	6,983	10.00%	698	3,174	40.00%	1,270	1,449		0
CT	MIDDLESEX	312	50.00%	156	3,434	10.00%	343	1,405	40.00%	562	761		0
CT	NEW HAVEN	2,573	25.00%	643	8,575	3.00%	257	2,744	10.00%	274	2,701		0
NJ	BERGEN	2,743	40.00%	1,097	4,972	40.00%	1,989	1,543	40.00%	617	2,186	very low	0
NJ	ESSEX	3,364	25.00%	841	3,130	40.00%	1,252	861	33.00%	284	2,181		0
NJ	HUDSON	2,389	25.00%	597	1,409	40.00%	564	368	33.00%	121	1,416		0
NJ	HUNTERDON	249	50.00%	125	3,660	10.00%	366	1,610	40.00%	644	783		0
NJ	MERCER	1,226	25.00%	307	3,448	3.00%	103	1,149	10.00%	115	1,188		0
NJ	MIDDLESEX	2,153	40.00%	861	5,583	40.00%	2,233	1,834	40.00%	734	2,004	very low	0
NJ	MONMOUTH	1,904	40.00%	762	6,566	40.00%	2,626	1,642	40.00%	657	1,978	very low	0
NJ	MORRIS	1,428	40.00%	571	5,987	40.00%	2,395	2,210	40.00%	884	1,738		0
NJ	PASSAIC	1,529	25.00%	382	3,244	40.00%	1,298	1,019	33.00%	336	1,298		0
NJ	SOMERSET	906	50.00%	453	4,060	10.00%	406	1,405	40.00%	562	1,136		0
NJ	SUSSEX	368	50.00%	184	4,514	10.00%	451	1,839	40.00%	736	978		0
NJ	UNION	1,965	25.00%	491	2,368	40.00%	947	655	33.00%	216	1,360		0
NJ	WARREN	221	50.00%	111	3,073	10.00%	307	1,229	40.00%	492	648		0
NJ	NJ STATE POLICE	1,467	50.00%	734			0			0			0
NJ	NJ DEPT. CORRECT.	3,147	50.00%	1,574			0			0			0
NJ	NJ OTHER POLICE	363	50.00%	182			0			0			0
NY	DUTCHESS	377	50.00%	189	7,248	10.00%	725	2,899	40.00%	1,160	1,457		0
NY	NASSAU	3,779	25.00%	945	6,749	3.00%	202	1,755	10.00%	176	2,953		0
NY	ORANGE	769	50.00%	385	8,079	10.00%	808	3,270	40.00%	1,308	1,803		0
NY	PUTNAM	99	50.00%	50	2,174	10.00%	217	889	40.00%	356	432		0

	County / Agency	POLICE 2010	SNP SHOT PEN %	PERSNL PEN	FIRE 2010	SNP SHOT PEN %	PERSNL PEN	EMS 2010	SNP SHOT PEN %	PERSNL PEN	GOV SVCS 2010	SNP SHOT PEN %	PERSNL PEN
NY	ROCKLAND	594	50.00%	297	2,660	10.00%	266	887	40.00%	355	740		0
NY	SUFFOLK	3,289	5.00%	164	14,204	3.00%	426	4,486	10.00%	449	3,981		0
NY	SULLIVAN	79	50.00%	40	4,740	10.00%	474	2,370	40.00%	948	928		0
NY	ULSTER	354	50.00%	177	7,084	10.00%	708	3,542	40.00%	1,417	1,505		0
NY	WEST-CHESTER	2,514	25.00%	629	7,182	3.00%	215	898	10.00%	90	2,267		0
NY	NY STATE POLICE	877	50.00%	439			0			0			0
NY	NY OTHER POLICE	250	50.00%	125			0			0			0
NY	NEW YORK CITY	37,562	25.00%	9,391	13,132	40.00%	5,253	3,054	33.00%	1,008	148,523	0.50%	743
	BRONX			0			0			0			0
	KINGS			0			0			0			0
	NEW YORK			0			0			0			0
	QUEENS			0			0			0			0
	RICHMOND			0			0			0			0
NY	METRO TRANSIT AUTH			0			0			0	48,861	2.00%	977
	METRO NORTH RR	200	5.00%	10			0			0	5,344	0.50%	27
	PORT AUTH NY NJ	700	25.00%	175			0			0			0
	LONG ISLAND RR	250	5.00%	13			0			0	1,950	0.50%	10
	NJ TRANSIT	150	5.00%	8			0			0	3,700	0.50%	19
	<b>TOTALS</b>	<b>83,229</b>		<b>23,962</b>	<b>153,321</b>		<b>25,804</b>	<b>51,909</b>		<b>16,085</b>	<b>251,138</b>		<b>1,775</b>
	<b>PENETR. BY CATEGORY</b>	<b>28.79%</b>			<b>16.83%</b>			<b>30.99%</b>			<b>0.71%</b>		

**PENETRATION DATA - REMOTE FILE ACCESS/DECISION PROCESSING**

	County / Agency	POLICE 2010	RFA/ DECP PEN %	PERSNL PEN	FIRE 2010	RFA/ DECP PEN %	PERSNL PEN	EMS 2010	RFA/ DECP PEN %	PERSNL PEN	GOV SVCS 2010	RFA/ DECP PEN %	PERSNL PEN
CT	FAIRFIELD	2,719	25.00%	680	9,063	3.00%	272	3,172	10.00%	317	2,889		0
CT	LITCHFIELD	360	40.00%	144	6,983	40.00%	2,793	3,174	40.00%	1,270	1,449		0
CT	MIDDLESEX	312	40.00%	125	3,434	40.00%	1,374	1,405	40.00%	562	761		0
CT	NEW HAVEN	2,573	25.00%	643	8,575	3.00%	257	2,744	10.00%	274	2,701		0
NJ	BERGEN	2,743	very low	0	4,972	40.00%	1,989	1,543	40.00%	617	2,186	very low	0
NJ	ESSEX	3,364	25.00%	841	3,130	40.00%	1,252	861	33.00%	284	2,181		0
NJ	HUDSON	2,389	25.00%	597	1,409	40.00%	564	368	33.00%	121	1,416		0
NJ	HUNTERDON	249	40.00%	100	3,660	40.00%	1,464	1,610	40.00%	644	783		0
NJ	MERCER	1,226	25.00%	307	3,448	3.00%	103	1,149	10.00%	115	1,188		0
NJ	MIDDLESEX	2,153	very low	0	5,583	40.00%	2,233	1,834	40.00%	734	2,004	very low	0
NJ	MONMOUTH	1,904	very low	0	6,566	40.00%	2,626	1,642	40.00%	657	1,978	very low	0
NJ	MORRIS	1,428	very low	0	5,987	40.00%	2,395	2,210	40.00%	884	1,738	very low	0
NJ	PASSAIC	1,529	25.00%	382	3,244	40.00%	1,298	1,019	33.00%	336	1,298		0
NJ	SOMERSET	906	40.00%	362	4,060	40.00%	1,624	1,405	40.00%	562	1,136		0
NJ	SUSSEX	368	40.00%	147	4,514	40.00%	1,806	1,839	40.00%	736	978		0
NJ	UNION	1,965	25.00%	491	2,368	40.00%	947	655	33.00%	216	1,360		0
NJ	WARREN	221	40.00%	88	3,073	40.00%	1,229	1,229	40.00%	492	648		0
NJ	NJ STATE POLICE	1,467	40.00%	587			0			0			0
NJ	NJ DEPT. CORRECT.	3,147	40.00%	1,259			0			0			0
NJ	NJ OTHER POLICE	363	40.00%	145			0			0			0
NY	DUTCHESS	377	40.00%	151	7,248	40.00%	2,899	2,899	40.00%	1,160	1,457		0
NY	NASSAU	3,779	25.00%	945	6,749	3.00%	202	1,755	10.00%	176	2,953		0
NY	ORANGE	769	40.00%	308	8,079	40.00%	3,232	3,270	40.00%	1,308	1,803		0
NY	PUTNAM	99	40.00%	40	2,174	40.00%	870	889	40.00%	356	432		0

	County / Agency	POLICE 2010	RFA/ DECP PEN %	PERSNL PEN	FIRE 2010	RFA/ DECP PEN %	PERSNL PEN	EMS 2010	RFA/ DECP PEN %	PERSNL PEN	GOV SVCS 2010	RFA/ DECP PEN %	PERSNL PEN
NY	ROCKLAND	594	40.00%	238	2,660	40.00%	1,064	887	40.00%	355	740		0
NY	SUFFOLK	3,289	1.00%	33	14,204	3.00%	426	4,486	10.00%	449	3,981		0
NY	SULLIVAN	79	40.00%	32	4,740	40.00%	1,896	2,370	40.00%	948	928		0
NY	ULSTER	354	40.00%	142	7,084	40.00%	2,834	3,542	40.00%	1,417	1,505		0
NY	WEST-CHESTER	2,514	25.00%	629	7,182	3.00%	215	898	10.00%	90	2,267		0
NY	NY STATE POLICE	877	40.00%	351			0			0			0
NY	NY OTHER POLICE	250	40.00%	100			0			0			0
NY	NEW YORK CITY	37,562	25.00%	9,391	13,132	40.00%	5,253	3,054	33.00%	1,008	148,523	1.50%	2,228
	BRONX			0			0			0			0
	KINGS			0			0			0			0
	NEW YORK			0			0			0			0
	QUEENS			0			0			0			0
	RICHMOND			0			0			0			0
NY	METRO TRANSIT AUTH			0			0			0	48,861	0.05%	24
	METRO NORTH RR	200	very low	0			0			0	5,344	0.30%	16
	PORT AUTH NY NJ	700	25.00%	175			0			0			0
	LONG ISLAND RR	250	very low	0			0			0	1,950	0.30%	6
	NJ TRANSIT	150	very low	0			0			0	3,700	0.05%	2
	<b>TOTALS</b>	<b>83,229</b>		<b>19,430</b>	<b>153,321</b>		<b>43,117</b>	<b>51,909</b>		<b>16,085</b>	<b>251,138</b>		<b>2,276</b>
	<b>PENETR. BY CATEGORY</b>	<b>23.34%</b>			<b>28.12%</b>			<b>30.99%</b>			<b>0.91%</b>		

**PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE**

September 11, 1996

**PENETRATION DATA - SLOW SCAN VIDEO**

	County / Agency	POLICE 2010	VIDEO-SS PEN %	PERSNL PEN	FIRE 2010	VIDEO-SS PEN %	PERSNL PEN	EMS 2010	VIDEO-SS PEN %	PERSNL PEN	GOV SVCS 2010	VIDEO-SS PEN %	PERSNL PEN
CT	FAIRFIELD	2,719	10.00%	272	9,063	3.00%	272	3,172	10.00%	317	2,889		0
CT	LITCHFIELD	360		0	6,983		0	3,174	10.00%	317	1,449		0
CT	MIDDLESEX	312		0	3,434		0	1,405	10.00%	141	761		0
CT	NEW HAVEN	2,573	10.00%	257	8,575	3.00%	257	2,744	10.00%	274	2,701		0
NJ	BERGEN	2,743	low	0	4,972	low	0	1,543	40.00%	617	2,186	0.00%	0
NJ	ESSEX	3,364	0.50%	17	3,130	0.50%	16	861	5.00%	43	2,181		0
NJ	HUDSON	2,389	0.50%	12	1,409	0.50%	7	368	5.00%	18	1,416		0
NJ	HUNTERDON	249		0	3,660		0	1,610	10.00%	161	783		0
NJ	MERCER	1,226	10.00%	123	3,448	3.00%	103	1,149	10.00%	115	1,188	0.00%	0
NJ	MIDDLESEX	2,153	low	0	5,583	low	0	1,834	40.00%	734	2,004	0.00%	0
NJ	MONMOUTH	1,904	low	0	6,566	low	0	1,642	40.00%	657	1,978	0.00%	0
NJ	MORRIS	1,428	low	0	5,987	low	0	2,210	40.00%	884	1,738		0
NJ	PASSAIC	1,529	0.50%	8	3,244	0.50%	16	1,019	5.00%	51	1,298		0
NJ	SOMERSET	906		0	4,060		0	1,405	10.00%	141	1,136		0
NJ	SUSSEX	368		0	4,514		0	1,839	10.00%	184	978		0
NJ	UNION	1,965	0.50%	10	2,368	0.50%	12	655	5.00%	33	1,360		0
NJ	WARREN	221		0	3,073		0	1,229	10.00%	123	648		0
NJ	NJ STATE POLICE	1,467		0			0			0			0
NJ	NJ DEPT. CORRECT.	3,147		0			0			0			0
NJ	NJ OTHER POLICE	363		0			0			0			0
NY	DUTCHESS	377		0	7,248		0	2,899	10.00%	290	1,457		0
NY	NASSAU	3,779	10.00%	378	6,749	3.00%	202	1,755	10.00%	176	2,953		0
NY	ORANGE	769		0	8,079		0	3,270	10.00%	327	1,803		0
NY	PUTNAM	99		0	2,174		0	889	10.00%	89	432		0

	County / Agency	POLICE 2010	VIDEO-SS PEN %	PERSNL PEN	FIRE 2010	VIDEO-SS PEN %	PERSNL PEN	EMS 2010	VIDEO-SS PEN %	PERSNL PEN	GOV SVCS 2010	VIDEO-SS PEN %	PERSNL PEN
NY	ROCKLAND	594		0	2,660		0	887	10.00%	89	740		0
NY	SUFFOLK	3,289	1.00%	33	14,204	3.00%	426	4,486	10.00%	449	3,981		0
NY	SULLIVAN	79		0	4,740		0	2,370	10.00%	237	928		0
NY	ULSTER	354		0	7,084		0	3,542	10.00%	354	1,505		0
NY	WEST-CHESTER	2,514	10.00%	251	7,182	3.00%	215	898	10.00%	90	2,267		0
NY	NY STATE POLICE	877		0			0			0			0
NY	NY OTHER POLICE	250		0			0			0			0
NY	NEW YORK CITY	37,562	0.50%	188	13,132	0.50%	66	3,054	5.00%	153	148,523	4.00%	5,941
	BRONX			0			0			0			0
	KINGS			0			0			0			0
	NEW YORK			0			0			0			0
	QUEENS			0			0			0			0
	RICHMOND			0			0			0			0
NY	METRO TRANSITAUTH			0			0			0	48,861	0.75%	366
	METRO NORTH RR	200	0.75%	2			0			0	5,344	0.75%	40
	PORT AUTH NY NJ	700	0.50%	4			0			0			0
	LONG ISLAND RR	250	0.75%	2			0			0	1,950	0.75%	15
	NJ TRANSIT	150	0.75%	1			0			0	3,700	0.75%	28
	<b>TOTALS</b>	<b>83,229</b>		<b>1,556</b>	<b>153,321</b>		<b>1,593</b>	<b>51,909</b>		<b>7,062</b>	<b>251,138</b>		<b>6,390</b>
	<b>PENETR. BY CATEGORY</b>	<b>1.87%</b>			<b>1.04%</b>			<b>13.60%</b>			<b>2.54%</b>		

**PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE**

September 11, 1996

**PENETRATION DATA - FULL MOTION VIDEO**

	County / Agency	POLICE 2010	VIDO-FLM PEN %	PERSNL PEN	FIRE 2010	VIDO-FLM PEN %	PERSNL PEN	EMS 2010	VIDO-FLM PEN %	PERSNL PEN	GOV SVCS 2010	VIDO-FLM PEN %	PERSNL PEN
CT	FAIRFIELD	2,719	12.50%	340	9,063	1.00%	91	3,172	0.05%	2	2,889		0
CT	LITCHFIELD	360	5.00%	18	6,983	30.00%	2,095	3,174	5.00%	159	1,449		0
CT	MIDDLESEX	312	5.00%	16	3,434	30.00%	1,030	1,405	5.00%	70	761		0
CT	NEW HAVEN	2,573	12.50%	322	8,575	1.00%	86	2,744	0.05%	1	2,701		0
NJ	BERGEN	2,743	25.00%	686	4,972	40.00%	1,989	1,543	low	0	2,186	0.00%	0
NJ	ESSEX	3,364	12.50%	421	3,130	12.50%	391	861	10.00%	86	2,181		0
NJ	HUDSON	2,389	12.50%	299	1,409	12.50%	176	368	10.00%	37	1,416		0
NJ	HUNTERDON	249	5.00%	12	3,660	30.00%	1,098	1,610	5.00%	81	783		0
NJ	MERCER	1,226	12.50%	153	3,448	1.00%	34	1,149	0.05%	1	1,188		0
NJ	MIDDLESEX	2,153	25.00%	538	5,583	40.00%	2,233	1,834	low	0	2,004		0
NJ	MONMOUTH	1,904	25.00%	476	6,566	40.00%	2,626	1,642	low	0	1,978	0.00%	0
NJ	MORRIS	1,428	25.00%	357	5,987	40.00%	2,395	2,210	low	0	1,738	0.00%	0
NJ	PASSAIC	1,529	12.50%	191	3,244	12.50%	406	1,019	10.00%	102	1,298	0.00%	0
NJ	SOMERSET	906	5.00%	45	4,060	30.00%	1,218	1,405	5.00%	70	1,136		0
NJ	SUSSEX	368	5.00%	18	4,514	30.00%	1,354	1,839	5.00%	92	978		0
NJ	UNION	1,965	12.50%	246	2,368	12.50%	296	655	10.00%	66	1,360		0
NJ	WARREN	221	5.00%	11	3,073	30.00%	922	1,229	5.00%	61	648		0
NJ	NJ STATE POLICE	1,467	5.00%	73			0			0			0
NJ	NJ DEPT. CORRECT.	3,147	5.00%	157			0			0			0
NJ	NJ OTHER POLICE	363	5.00%	18			0			0			0
NY	DUTCHESS	377	5.00%	19	7,248	30.00%	2,174	2,899	5.00%	145	1,457		0
NY	NASSAU	3,779	12.50%	472	6,749	1.00%	67	1,755	0.05%	1	2,953		0
NY	ORANGE	769	5.00%	38	8,079	30.00%	2,424	3,270	5.00%	164	1,803		0
NY	PUTNAM	99	5.00%	5	2,174	30.00%	652	889	5.00%	44	432		0
NY	ROCKLAND	594	5.00%	30	2,660	30.00%	798	887	5.00%	44	740		0
NY	SUFFOLK	3,289	1.00%	33	14,204	1.00%	142	4,486	0.05%	2	3,981		0

	County / Agency	POLICE 2010	VIDO-FLM PEN %	PERSNL PEN	FIRE 2010	VIDO-FLM PEN %	PERSNL PEN	EMS 2010	VIDO-FLM PEN %	PERSNL PEN	GOV SVCS 2010	VIDO-FLM PEN %	PERSNL PEN
NY	SULLIVAN	79	5.00%	4	4,740	30.00%	1,422	2,370	5.00%	119	928		0
NY	ULSTER	354	5.00%	18	7,084	30.00%	2,125	3,542	5.00%	177	1,505		0
NY	WEST-CHESTER	2,514	12.50%	314	7,182	1.00%	72	898	0.05%	0	2,267		0
NY	NY STATE POLICE	877	5.00%	44			0			0			0
NY	NY OTHER POLICE	250	5.00%	13			0			0			0
NY	NEW YORK CITY	37,562	12.50%	4,695	13,132	12.50%	1,642	3,054	10.00%	305	148,523	0.60%	891
	BRONX			0			0			0			0
	KINGS			0			0			0			0
	NEW YORK			0			0			0			0
	QUEENS			0			0			0			0
	RICHMOND			0			0			0			0
NY	METRO TRANSIT AUTH			0			0			0	48,861	1.00%	489
	METRO NORTH RR	200	5.00%	10			0			0	5,344	1.00%	53
	PORT AUTH NY NJ	700	12.50%	88			0			0			0
	LONG ISLAND RR	250	4.00%	10			0			0	1,950	1.00%	20
	NJ TRANSIT	150	1.00%	2			0			0	3,700	1.00%	37
	<b>TOTALS</b>	<b>83,229</b>		<b>10,191</b>	<b>153,321</b>		<b>29,958</b>	<b>51,909</b>		<b>1,829</b>	<b>251,138</b>		<b>1,490</b>
	<b>PENETR. BY CATEGORY</b>	<b>12.24%</b>			<b>19.54%</b>			<b>3.52%</b>			<b>0.59%</b>		

1. U.S. Bureau of the Census. *County and City Data Book: 1994*.
2. Prepared by Urbanomics, a consulting firm, for the New York Metropolitan Transportation Council, a planning organization of New York State government. The chart was last revised on 9/18/95.
3. New York State, Division of Criminal Justice Services, *1993 Crime and Justice Annual Report*.
4. State of New Jersey, Division of State Police, *Uniform Crime Reports, State of New Jersey, 1993*.
5. *Fire and EMS Data Book* is a compilation of detailed information on the resources available in the county of Nassau. The data included information on the number of personnel in each category.
6. *The 1994-95 Green Book* is an official directory of the City of New York.
7. Taken from *New York City Transit's Facts & Figures: 1995* booklet. Commodity Number 22-30-0202, Log Number 1095038, Printed 5/95.

## **ANNEX C - ADDITIONAL PUBLIC SERVICE OPERATIONAL REQUIREMENTS**

### 1.0 Voice Requirements.

1.1 Dispatcher to Crews. This is a typical communications path between dispatchers and field personnel. The call types are typically business oriented with emphasis on operating the business in a safe and efficient manner.

1.2 Crew to Crew. This function relates to the typical communications between field users. These communications are used for the coordination of daily activities to maximize the safety and efficiency of operations.

1.3 Emergency Call. This function is typically initiated from a field user to a dispatcher. As the name implies, the call type is that of an emergency where loss of life or property is imminent or has already taken place.

1.4 "Talk Around". In many operations between field users, routing a call through the network or a repeater is not feasible for reasons such as access delay or being out of range of the system. A talk around mode is necessary so that the field users can communicate with each other, within the range of their mobiles and portables, without the assistance of a network or repeater.

1.5 Interconnect. In nearly all field activities, users have a need to communicate with people by way of land line telephones. Telephone interconnect is a necessary option for many of the present day radio systems.

### 2.0 Data Requirements.

2.1 End of Train Control. This is a system which provides a data communications link between the end of the train and the train crew. With this link, the engineer of the train can determine if the end of the train is in motion, what the brake line pressure is and whether the end of train flashing marker is illuminated. The engineer can also apply the brakes from the end of the train by remotely releasing the brake pipe pressure. All functions associated with this device relate to safer handling of the train.

2.2 Positive Train Control. This is a data system which utilizes a computer on board the locomotive to minimize collisions between trains. The locomotive computer obtains movement authorities from a host computer and calculates when it needs to stop the train based on the speed and weight of the train. If the limits of authority are going to be violated, the computer will stop the train automatically.

2.3 Track Warrants. Track warrants are the movement authorities which are used by the train engineer. Track warrants are typically read to the engineer over the radio system by the

dispatcher. There are plans in place to provide a data link between the dispatcher and the train engineer to reduce errors in copying the track warrant.

2.4 Crossing Safety. Crossing accidents are of great concern to the railroad industry. Systems are being investigated which will provide a notification to public safety vehicles and school busses that a train is approaching a specific crossing which may affect them. This will provide added warning of approaching trains.

In addition to the warning systems, data links are being investigated which will be used to report any malfunctions with the railroad crossing. Defects such as inoperative or broken crossing arms, vandalism, as well as power failures can be reported to maintenance personnel.

2.5 Cab Signals. Cab signals provide a visual warning to the train crew as to the status of the track immediately ahead of them. As an example, if the track is occupied, the signals to the train crew will show red. If the track is clear, the signals will show green. This form of alerting the crew is very helpful in train control and collision avoidance.

2.6 Train Line. The current form of braking for trains is through a pressurized brake line. If the air pressure is reduced, the brakes of the cars as well as the locomotives are applied. Often the air pressure does not respond as quickly or as fully as needed by the train engineer, creating a problem with train handling.

A train line is being developed which will provide a communications path thorough the train. One of the functions of the train line will be to provide electronic braking information to each car, eliminating the need for the air line.

2.7 Consist Telemetry. An extension of the train line function listed above is a communications system which handles information for all items being transported. Typical information includes the condition of the cargo in terms of over temperature or rough riding which would be helpful when transporting hazardous materials. Other uses would be to provide additional alarming to the train crew for purposes of theft and vandalism control.

2.8 Facilities and System Protection Telemetry. The power utilities rely on communication links to assist in monitoring and control of power distribution systems. Very large and fast acting circuit breakers obtain information about short circuits and disconnect the power source in order to minimize risk of life and damage to property. These communication links are also utilized in the substations which are used to reduce the voltage of the transmission systems for distribution to households.

Pipe line companies transport a variety of materials which include water, oil , gas, and steam. Electronic monitoring and control systems are designed to assist the operators of these transport networks. If a malfunction occurs, the materials can be rerouted or their flow can be inhibited to minimize the impact to life, property, and the environment.

2.9 Load Shed Telemetry. On a smaller scale from system protection as described above, load shed telemetry is used to control the amount of power used by consumers. A data

communication system is used to remotely control air conditioners and electric water heaters in an attempt to minimize overloading of the transmission and distribution systems.

2.10 Defect Detector Communication Link. Defect detector communication is typically one way and is composed of a low power transmitter located at the detector sites. If a defect is detected, a synthesized voice radio transmission is sent. This will alert the crew of the train in the area of the detector before injury and/or damage occurs.

The following is a list of typical defect detectors:

1. Hot box/journal.
2. Dragging equipment.
3. High and wide equipment.
4. Rock slide/mud slide.
5. Flood.

2.11 Security System Monitoring. Property and equipment need to be monitored via security systems. Most of the applications require some form of wireless communications to establish the link.

2.12 Location Systems. For train control, location systems such as GPS are needed to obtain the location of the train in relation to limits of movement authority as well as other trains. Unfortunately, standard GPS does not have the required accuracy which can be accomplished by Differential Global Positioning Systems (DGPS). One of the requirements for the DGPS system is that the users must have a secondary data link which is independent of the satellite link.

2.13 Inventory Access. Both railroad and utility industries have situations where access to a store department record would facilitate derailment clean up or storm restoration respectively. To accomplish this, a data link between the field user and a host computer is necessary in order to determine and acquire needed materials.

### 3.0 Video Requirements.

Video Surveillance. As an extension of the security system monitoring item above, video surveillance provides much more information in specific situations than typical alarms can provide. In many cases, the video surveillance would be most effective if it was available through a wireless means.

### 4.0 Special Agents

Another application for communications in Public Services are those communications which occur between railroad police, also known as Special Agents, and local, state, as well as federal agents. The Special Agents have arrest authority if a crime occurs on the railroad right of way. They are often the first responders when dealing with murder, rape, robbery, drug enforcement, and vandalism just to name a few. These incidents require communications with other law enforcement agencies in order to coordinate operations.

Many of the railroads have a K-9 unit. The railroad police dogs are trained to assist the Special Agents in the same ways that Public Safety Police dogs are utilized. As an example, they are used to locate illegal drugs on railroad property. Once the suspected illegal materials are found, the Special Agents work with the local and federal and Department of Defense law enforcement agencies for further investigation and handling.

During derailments, the Special agents work with a variety of Public Safety entities to coordinate activities with the railroads in an effort to contain the disaster as quickly as possible. Most of the communications are voice, however, there is a significant need for data communications for the purposes of having access to the same information which is shared between the Police, Fire, and Rescue entities.

6.2 APPENDIX B - Technology Subcommittee Report

**FINAL REPORT  
of the  
TECHNOLOGY SUBCOMMITTEE  
  
PUBLIC SAFETY WIRELESS ADVISORY  
COMMITTEE**

**Sponsored by**

**FEDERAL COMMUNICATIONS COMMISSION  
and  
NATIONAL TELECOMMUNICATIONS AND INFORMATION  
ADMINISTRATION**

**July 12, 1996**

*Technology Subcommittee Chairman: Alfred Mello*  
*Alternate Chairman: Richard DeMello*

*Chair of TEC WG-1 (Matrix Preparation): Jeff Pegram*  
*Chair of TEC WG-2 (Report Preparation): Steven Crowley*  
*Technology Inventory: David Buchanan*  
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THIS REPORT IS FOR DISCUSSION PURPOSES ONLY.

IT REPRESENTS THE VIEWS OF THE TECHNOLOGY SUBCOMMITTEE ONLY.

THE CONCLUSIONS AND RECOMMENDATIONS CONTAINED HEREWITHIN  
SHALL NOT BE USED IN WHOLE OR IN PART UNTIL FINAL ADOPTION BY THE  
FULL COMMITTEE OF THE PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE.

THE FINAL REPORT OF THE TECHNOLOGY SUBCOMMITTEE  
MAY BE CHANGED BASED ON FURTHER DISCUSSIONS OF THE  
PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE.

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**FINAL REPORT  
TECHNOLOGY SUBCOMMITTEE  
PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE**

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**FINAL REPORT  
TECHNOLOGY SUBCOMMITTEE  
PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE**

**1.0 EXECUTIVE SUMMARY**

**1.1 Background**

- 1.1.1 Wireless communications, mobile and portable, provide an essential resource for public safety operations. This paper describes the technology used today in public safety radio and the technology reasonably expected to be available by the year 2010 to support public safety mobile communications. This information is to be used to support forecasts of spectrum demand.
- 1.1.2 The revolution in microelectronics and computers has brought and will continue to bring enormous improvements in the performance of these systems. Improved electronic systems also change the ways public safety agencies can use wireless communications systems. There was no need for wireless access to digital messaging systems until digital messaging systems came into being. While voice communications has been, and remains today, by far the most important public safety application of wireless technology, it appears highly likely that non-voice communications, most importantly data and image communications, will become increasingly important and will account for a major fraction of all public safety wireless communications by the year 2010.
- 1.1.3 The Technology Subcommittee is tasked with the responsibility of reviewing present technologies used by public safety. It is also to identify spectrally-efficient existing and emerging technologies that will impact spectrum requirements. As part of the technology deliberations, 19 organizations made presentations highlighting wireless technologies pertinent to public safety activities. The Subcommittee also undertook to compile an inventory of current, under development and future technologies.
- 1.1.4 This report provides a self-contained description of wireless technology and trends in wireless technology that appear to be most important for public safety communications. This report also gives the reader with an up-to-date (mid-1996) view of the evolving technologies that support wireless communications and with forecasts of the evolution of those technologies. The report provides the technical information necessary for predicting, in conjunction with usage forecasts, the future spectrum requirements of public safety land mobile radio.
- 1.1.5 The following table provides a simplified snapshot of the state of public safety communications technology relative to voice, data, image, and video.

	DESCRIPTION
Voice	Public safety systems are designed to maximize availability and minimize delay. Current systems are 25 kHz analog. Future is digital. Digital systems are being introduced. Digital improves security and supports data.
Data	Data today is typically sent over the voice channel or by a separate radio. Data rates range from 0.3 to 19.2 kbps in a 25 kHz channel. Mobile data terminals (MDTs) are growing rapidly.
Image	Current systems can support still images but are little used today. Outlines existing standards for facsimile and snapshots. Medical services will need high resolution imaging.
Video	Today's systems are wideband, analog and are not widely deployed due to lack of allocated spectrum (one channel, shared with television services). Digital video cameras are being introduced.

## 1.2 Public Safety Communications Applications

- 1.2.1 Increasingly, voice is transitioning to digital transmission. High quality digital speech in land mobile channel bandwidths could not be implemented in affordable technology until recently. Digital transmission provides mechanisms to combat the familiar static and pop effects that radio reception impairments traditionally caused to analog transmission. Digital signals can be encrypted to prevent interception far more easily, reliably and effectively than can analog signals. Among the attributes of voice communications systems are availability and delay.
- 1.2.2 With the growth in the use of computers and associated reductions in the cost of computing equipment has come an increased demand for data communications capabilities. Many of the early public safety data communications systems used circuitry much like telephone modems to create a voice-like signal which could both carry the data and travel over the analog voice paths of the public safety radio communication systems. Such hybrid systems are still widely used today.
- 1.2.3 More recently, manufacturers have begun to provide radio systems that are fully digital and that can carry data directly on the radio channel. Transmitting high speed data reliably on mobile radio channels is an enormous engineering challenge as compared to transmitting via wire, cable, microwave, fiber optics or other similar carriers. Key attributes of data communications systems are message/file size, reliability, error control, and encryption.
- 1.2.4 Images represent a special category of data that is a numeric representation of a picture. The rapid increase in use of "wire-line" based facsimile transmission and

similar image technologies within the public safety services has paralleled that within the broader economy.

- 1.2.5 There are several public safety imaging applications. Emergency medical providers desire the ability to transmit images of the injured from paramedic units back to trauma centers or hospitals to aid in diagnosis and pre-arrival treatment. Fire agencies desire the ability to transmit building plans and copies of permit and other data for fire prevention and protection. Law enforcement agencies need to quickly transmit fingerprints from field units back to local, state and federal databases; units need the capability to receive mugshots and drivers license photographs to aid in identifying people in the field. Key attributes of image communications systems include resolution, B/W vs color, compression, and error control.
- 1.2.6 Wireless video systems have seen limited use in state/local public safety services to date primarily due to a lack of available public safety spectrum over which to implement these systems. Key attributes of video communications systems include frame rate, resolution and color level, error control, and compression.
- 1.2.7 The fire service uses full motion video extensively in some areas, primarily to monitor wildland fire scenes from airborne platforms, providing real-time video back to emergency command centers. Law enforcement agencies, particularly at the federal level and which have spectrum available for video, have long used video for surveillance purposes. State/local agencies have only recently begun to implement similar systems for monitoring areas of high crime and drug use. State/local transportation agencies have implemented wireless video systems to monitor traffic flow and detect collisions and hazards on roadways in congested metropolitan areas.
- 1.2.8 There is a growing need for full motion video for use with robotic devices in bomb, hostage, hazard avoidance and hazardous materials situations.
- 1.2.9 Public safety agencies have struggled with the problem of identifying the location of vehicles and personnel. Today there are several ways to obtain such location information. Each alternative has its strengths and weaknesses.

### **1.3 Existing Public Safety Communications Capabilities**

- 1.3.1 Most public safety communications systems use analog FM technology operating in 25 or 30 kHz channels to carry their voice signals. Public safety communications systems normally operate using a variant of one of two basic methods: repeater and trunked.
- 1.3.2 While digital voice is a technological possibility, it is little used today in public safety communications. It is expected that digital voice systems will be offered by several manufacturers in the public safety market in the next few years.

- 1.3.3 Today data communications capabilities are used in public safety for such purposes as digital dispatch and checking computer data bases for information associated with wanted persons/property and vehicle registration license plates.
- 1.3.4 Still images include snapshots such as accidents, and crime scenes, mug shots, fingerprints, and a wide variety of other images. Today, there is relatively little use of still image transmission to and from the field in public safety. It is expected that such systems will be deployed in increasing numbers over the next decade and a half.
- 1.3.5 Video is used in public safety today primarily for surveillance of crime scenes and of highways. Transmission of such images back to central locations could be quite helpful in the management of major incidents. Today, video images are normally transmitted using analog modulation. Wideband channels (several megahertz) are normally used to carry full-motion, high-quality video. However, only very limited spectrum is available to state and local. In the future, we expect that most public safety video communications will be digital. Currently, though, compression equipment is still expensive and standards are changing rapidly. The coming of affordable digital video cameras and affordable digital compression can be expected to lead to substantial growth in the requirements for public safety video communications.

#### **1.4 System Building Blocks and Tool: Fundamental Constraints and Likely Evolution**

- 1.4.1 The fundamental technology thrust through the year 2010 will be, as it has been in the recent past, that of semiconductor technology. The improvements in semiconductor processing and materials have resulted in roughly an order of magnitude advance every five years. Rapid advancement is also observed in the progress of microprocessor technology over the last two decades.
- 1.4.2 The batteries required to operate portable communications equipment are usually heavy, provide limited hours of operation, and can be expensive. A number of developments in battery technology are alleviating this situation.
- 1.4.3 Spectrum efficiency is improved if more communication channels can be placed within a given band of spectrum. In the past, the ability to decrease the channel size has been limited by both the transmission bandwidth and frequency stability concerns. Frequency stability in land mobile radio has also benefitted from improvements in semiconductors. Improvements in frequency stability can be used to enhance spectrum efficiency even when channel spacing is not reduced because the guard bands around the occupied bandwidth of each transmission can be reduced. The information content of the transmitted signal can be increased while maintaining acceptable adjacent channel splatter. This is important because reductions in guard bandwidth are limited by adjacent channel splatter considerations.

- 1.4.4 Smart antennas is a term applied to a family of technologies that generally integrate active antenna elements with microprocessor technology. By changing the current distribution of the array, the shape of the beam can be changed electronically in real-time.
- 1.4.5 Diversity is a commonly used technique for improving the quality of both digital and analog signals. When the new technique of single sideband is employed the use of multiple antennas becomes a virtual necessity, as when the vehicle is traveling at high speed, signal will become distorted due to phase shift. The most common form of diversity is space diversity, which is implemented using two appropriately spaced antennas. Another method being researched is a one-piece diversity antenna system that uses two antenna elements that performs the signal combining function in the antenna base. Maximal ratio diversity combining is a third diversity technique which is used to combat fading. The advantages of these techniques must be weighed against the disadvantages.
- 1.4.6 Using today's systems, additional traffic demands can only be met by increases in the available spectrum. However, the demands can, at least in part, be offset by utilizing semiconductor advances to make more efficient use of the limited spectrum resources. Information compression allows reduction in the amount of information which must be transmitted on the communications channel. Digital speech encoding has received significant attention of late. This means of transmitting speech leads naturally to encryption which is one very important aspect in many public safety communications scenarios. Looking to the future, it can be expected that increasingly powerful digital signal processing IC's will facilitate the introduction of more powerful and effective methods for reducing the amount of information that must be transmitted on the communication channel.
- 1.4.7 As digital processing capability improves, higher complexity compression algorithms will become viable, increasing the compression ratios possible for these services. Thus, by the year 2010, compression schemes more than ten times as complex as those of today should be viable for public safety radio. As a result, an assumption of a 3:1 increase in source coding efficiency for fax by 2010 seems reasonable.
- 1.4.8 For full-motion video, a 2:1 improvement over today's compression ratios, or roughly 0.25 bits/pel, should be achievable by the year 2010. For slow video, a 3:1 increase in slow video coding efficiency is indicated when we it is assumed that MPEG-4 will be implemented by 2010.
- 1.4.9 Another method of improving improved spectrum efficiency is to increase the amount of information that the communication channel can support. Nonlinear constant-envelope systems have approached 1.28 bit/sec/Hz, considered to be the limit for those systems. Linear modulation, based on newer SSB-based techniques, is expected to be able to improve this efficiency to approximately 5 bit/sec/Hz by the year 2010; while such linear modulation narrowband techniques have long been

used in other applications, the engineering challenges of matching them to mobile communications channels have only recently been overcome in commercially available products.

- 1.4.10 FDMA, TDMA, CDMA, and TDD are different channel access methods. In FDMA (Frequency Division Multiple Access), different conversations are separated onto different frequencies. In TDMA (Time Division Multiple Access), different conversations are separated into different time slots. In CDMA (Code Division Multiple Access), all conversations are separated by code space. And in TDD (Time Division Duplexing multiple access), a single channel is shared in time to achieve full duplex operation. Each has specific strengths and weaknesses.
- 1.4.11 Software programmable radios, in which applications are configured under software control, makes it possible to implement multiple military, law enforcement, and commercial air interface standards in a single radio, despite different physical layers (modulation, frequency bands, forward error correction), link layers (link acquisition protocols, link maintenance, frame/slot processing), network layers (network protocols, media access protocols, network time maintenance), upper layers (source coding), timebases and bandwidths. There are many challenges, however, to producing a practical and economical software programmable radio for law enforcement applications; software radios are now much more expensive than hardware-based radios, with the market being largely confined to military applications. It has been projected that, within a few hardware generations, software radios will sufficiently leverage the economics of advancements in microelectronics, and provide seamless communications at a vest-pocket and palmtop level of affordability and miniaturization.
- 1.4.12 Most public safety mobile communications systems need a reliable backbone to carry signals to and from the base station sites to the control points. Historically, many of these links have been provided over microwave connections operated by the public safety agency. Leased lines obtained from the local telephone companies have also been used. It is expected that the future supply of backbone system elements will look much like the past but with two major exceptions. First, the lowest microwave frequencies (2 GHz) are no longer available for such backbone systems. The second exception is the supply of facilities by the local carriers; historically, only one firm, the local telephone company, provided telecommunications services for hire. However, changes in law and technology have led to the entry of new competitors in many markets and the probability of extensive further entry. Considering all these factors it is reasonable to conclude that these commercial fiber systems could provide valuable backbone alternatives for many public safety communication needs. However, the use of any ground-based carrier for public safety systems in earthquake-prone areas may be undesirable. In contrast, in areas affected by hurricanes, such as the southeastern coastal areas, an in-ground fiber network could be preferred.

1.4.13 As wireless communications systems evolve, the complexity in determining compatibility among different types of such systems increases. Geography, frequency, modulation method, antenna type, and other such factors impact compatibility. Spectrum managers, system designers and system maintainers have a common interest in utilizing the most accurate and repeatable modeling and simulation capabilities to determine likely wireless communications system performance. The Telecommunications Industries Association TR-8 WG-8.8 Technology Compatibility Committee is working under a charter and mission statement to address these technical challenges.

## **1.5 Commercial Services — Technological Capabilities and Developments**

1.5.1 Many present and future technological capabilities are (or will be) developed for large commercial service providers or government systems. Public safety agencies often utilize the existing commercial services as an adjunct to the systems which they have developed to provide their essential services. Those essential services (such as voice dispatch) may have unique operational, availability, or security needs, or may be more economically feasible and desirable. In the future, as usage of and dependence on these services increase, public safety agencies might elect to “partner” with commercial services (for customized services or features), or develop their own systems utilizing similar technologies.

1.5.2 Satellite systems support thousands of voice channels and in many spot beams are used so that some frequency reuse is possible. Satellite services can be completely digital thereby facilitating encryption systems, as well as commercial voice privacy alternatives. Public safety agencies and others may lease dedicated channel(s) for their exclusive use. Dispatch, push-to-talk, and “party line” talk group services are available. Priority designations will be lost when communications enter the Public Switched Telephone Network (PSTN) as they are currently configured unless dedicated lines are provided between gateway stations and public service agencies.

1.5.3 Current cellular telephone systems have several attributes which limit their appeal to public safety users. They are designed to provide adequate capacity during most peak periods, but they are still vulnerable to overload and abuse during large incidents or special activities. In spite of these limitations, cellular telephones are able to meet certain aspects of public safety communications needs. They are useful for communications between public safety field personnel and the public being served. Cellular telephones are also preferred by many public safety agencies as an alternative to carrying telephone interconnect traffic (and consuming large percentages of available capacity) on essential voice channels.

1.5.4 Even with the proliferation of analog cellular systems, circuit switched communications are still not popular for general data applications. Circuit switched usage fees are based on connect time, not data volume. Short interruptions during hand-offs between cell sites are often imperceptible during voice conversations, but most data communications equipment sends (and expects to receive) a continuous

carrier signal. Cellular Digital Packet Data (CDPD) systems were developed to transport data to (or between) cellular users without the need to set up a traditional call. Without some method to provide priority access, CDPD users are subject to the same delays or unavailability of service during peak periods that traditional voice users encounter.

- 1.5.5 Personal Communications Systems (PCS) are an emerging commercial technology. Due to propagation characteristics of the band, most 2 GHz systems are expected to be developed using a micro-cellular architecture, serving the most populous metropolitan areas using a network of closely spaced stations. Service in lower demand areas will be provided by systems with antenna heights, output power levels, and coverage areas which are more in line with today's cellular systems. Both are intended to provide subscribers with enhanced features and untethered access to the public switched telephone network. Personal Communications Services are under development as of this writing, but indications are that the successful licensees will select and implement differing technologies, even for similar systems in adjacent areas or bands; thus limiting not only competition, but interoperability and mobility as well. The lack of standards is likely to impede the ability of some PCS users to roam nationwide using "local subscriber equipment," or to select between carriers to the extent that current cellular telephones allow.
- 1.5.6 Specialized Mobile Radio (SMR) services were established by the FCC in the mid-1970's with the allocation of a portion of the 800 MHz band for private land mobile communications system. SMR systems are characterized by a single high-power, high-elevation base station for maximum coverage. The versatility of the SMR industry and its relationship to public safety because of the dependence of both on dispatch as a primary service will continue to be attractive as the SMR industry becomes more sophisticated and integrated.
- 1.5.7 The latest systems, based on digital technology, are known as Enhanced SMR (ESMR) or wide-area SMR systems. ESMR systems are typically characterized by a network of base stations in a cellular-type configuration. They are several times as spectrum efficient as SMR systems and offer enhancements including the consolidation of voice dispatch, telephone interconnect and data services into a single portable/mobile subscriber unit. Regardless of the type of SMR/ESMR service, the public safety agency must insure that the coverage, security, priority access and reliability factors associated with each service provider/operator will meet the requirements of the applying agency.
- 1.5.8 Today, over 27 million people use commercial paging services. Continued use, and increased dependence are expected for many public safety functions. New higher speed, multi-level paging protocols have been developed to increase the efficiency of paging networks, while maintaining backward compatibility with existing (lower speed) devices. With increased transmission speeds, higher content messages (such as facsimiles) can also be delivered to paging receivers with reasonable latency. Advanced paging systems being introduced today allow peer-to-peer

communications between pagers, by allowing the initiation of messages from pagers to the network over the reverse channel. Future two-way paging applications are likely to include services like AVL and individual-based GPS services, telemetry services, and interoperable services on dual devices with other wireless providers.

## **1.6 Conclusions and Recommendations**

- 1.6.1 In the year 2010, a great deal of available resources will be served by some technology which has not yet even emerged from the research labs. However, several aspects of future technology are fairly well agreed by examination of technical trends, regardless of whatever specific technology may emerge within the next decade.
- 1.6.2 Technology is constantly improving spectrum efficiency. Improvements in semiconductor processing and materials have resulted in roughly an order of magnitude advancement every five years. Rapid advancements in microprocessor technology has also been observed over the last two decades. Although theoretically possible to approach gains of 8:1 based on 25 kHz analog by the year 2010, it is appropriate to set the factor to 4:1 for planning purposes. A 4:1 efficiency recognizes the practical limit of advances over the intervening years; that is, doubling (2:1) in five years, doubling again in another five (4:1), then doubling again in five more years (for a 8:1 improvement in 15 years). Further, within current public safety bands, there will be an established base of equipment that will have to be amortized and withdrawn from service before full benefits of any advanced technologies can be realized. Additionally, many of the emerging public safety technologies (video and high speed data, for example) will require significantly wider bandwidths than the current 25 kHz channel for analog voice.
- 1.6.3 Digital technology will be the key technology for the future. A digital signal format is assumed by most of the bandwidth efficient methods employed today. Digital is essential to data transmission. Digital appears to be superior for secure communications technology. Nevertheless, there is a vast investment in existing analog voice communications technology which meets communications needs today and which will last for a long time. Analog equipment with 10 to 20 year lifetimes will continue to be installed for several years. Current public safety digital equipment offers approximately a 2:1 improvement in spectrum efficiency over 25 kHz analog. Consequently, the public safety community will operate with a mix of analog and digital equipment (a mix shifting towards digital) for the foreseeable future.
- 1.6.4 Trunking will become increasingly prevalent as the technology for trunking control becomes deployed and copied in what are currently known as conventional systems.
- 1.6.5 Improvement in technology unrelated to voice, such as data, will be driven by dramatic technology improvements in computers. It is quite conceivable that computer spectrum efficiency may be more important than voice spectrum

efficiency in 2010. Imaging technology will be driven by improvements in digital signal processing (DSP) technology, which should also be dramatic in a decade.

- 1.6.6 Voice interoperability will require pre-planning. This is not a prediction, but rather a direct implication of the first two conclusions.
- 1.6.7 Spectrum efficient technology includes low bit-rate speech coding. Speech coding trends have already left the concept of “waveform coding” behind, where the ability to reproduce the exact analog speech waveform is lost. This property, employed commonly in land-line telephony where wire bandwidth is less of an issue, permits voice to be converted back and forth from analog to digital at will without loss of quality. Low bit-rate speech coding also produces greater speech delay. Barring currently unexpected innovation in transcoding, this means that interoperability between systems with different speech coding technologies will likely suffer quality loss and increased speech delay, even when patched through infrastructure.
- 1.6.8 Direct interoperability over-the-air does not appear possible between systems with different speech coding technologies, bit rates, modulations, formats, access method, or any other attribute associated with the air-interface of a given RF system.
- 1.6.9 Without any significant coordination, disparate systems will achieve analog interoperability using a common base-line interoperability technology.<sup>1</sup> This can serve both analog speech or data that is converted to a speech bandwidth signal in a fashion similar to using modems over telephone. Data transmitted via analog transmission are subject to no more coordination than generally practiced today requiring compatible modems on both sides of a telephone link. Data speed is significantly less than compared to direct digital transmission.

## **2.0 INTRODUCTION AND OVERVIEW**

- 2.1 This paper describes the technology used today in public safety radio and the technology reasonably expected to be available by the year 2010 to support public safety mobile communications in order to develop technical support for forecasting spectrum demand.
- 2.2 This paper proceeds in four steps. First, we describe the communications services needed by public safety and the demands they make for communications support. Second, we describe the current state and likely evolution of the key technologies used to build communications systems. Next, we describe the rate of advance of these key technologies and offer predictions on the capabilities of future

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<sup>1</sup> We note that the PSWAC Interoperability Subcommittee has recommended such a common transmission mode (analog FM) for such interoperability. We note that current generation digital cellular telephones also support FM transmission mode.

communications systems. Finally, we review commercial technologies to refine our picture of future wireless capabilities.

- 2.3 What will be the predominant technology of the year 2010? In the year 2010, a great deal of available resources will be served by some technology which has not yet even emerged from the research labs. Remember that the first trunking systems were only deployed in the very late 70s, and the first cellular systems went commercially on-line in the early 80s. The most pervasive technology of the year 2010 may be just emerging, or may still be yet to emerge. We just don't know. For certain, the cutting edge technologies of today will still be employed for 15 years. However, several aspects of future technology are fairly well agreed by examination of technical trends, regardless of whatever specific technology may emerge within the next decade.

### **3.0 REVIEW OF TECHNOLOGY SUBCOMMITTEE PROCESS**

#### **3.1 Background**

- 3.1.1 The Omnibus Budget Reconciliation Act of 1993 required the Federal Communications Commission (FCC) to study public safety spectrum needs through the year 2010. The 1995 FCC Public Safety Report identified public safety issues needing to be defined, studied, and clarified to determine the scope of the public safety community spectrum needs. Subsequently, the FCC and the National Telecommunications and Information Administration (NTIA) established the Public Safety Wireless Advisory Committee (PSWAC) to address public safety requirements through the year 2010.
- 3.1.2 Five subcommittees were established to accomplish specified tasks. The five subcommittee are: Operational Requirements, Technology, Interoperability, Spectrum Requirements, and Transition. The Technology Subcommittee is tasked with the responsibility of reviewing present technologies used by public safety. It is also to identify spectral efficient, perspective and emerging technologies that will impact on spectrum requirements. In developing this report, the Technology Subcommittee has cataloged public safety equipment, both present and developmental, solicited input about a wide range of mobile systems including commercial providers, and reviewed several white papers.

#### **3.2 Presentations**

- 3.2.1 As part of the technology deliberations, 19 organizations made presentations highlighting wireless technologies pertinent to public safety activities.<sup>2</sup> The

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<sup>2</sup> A summary of the oral presentations are included with this report as Appendix A. Written submissions can be found in the PSWAC public inspections file WTB-1 at the FCC's Wireless Telecommunications Bureau.

presenting organizations fell into three groups: manufacturers, commercial service providers, companies engaged in research and development, and users, some of which have developed their own custom communications systems. The following gives an overview of the concepts presented.

- 3.2.2 Presentations consisted of several manufacturers of traditional land mobile radio systems denoting the latest in current technologies for public safety use. The Subcommittee also heard details of a proposed mathematical model to be used in projecting public safety spectrum requirements; this model is being considered by the Spectrum Subcommittee. The Subcommittee also heard from several commercial service providers active in cellular, satellite, paging and messaging, and communications systems integration and networking. Among their respective views is the importance of interoperability and the role that commercial systems can play in public safety communications.
- 3.2.3 Several technology advancements were described, including those related to trunking, modulation, multiple access, voice coding, and antennas; a common theme is that these advancements will continue to reduce the bandwidth necessary for sending a given quantity of information. Satellite service was presented as a form of backup in emergencies if terrestrial systems are destroyed or overloaded, as well as useful in remote areas where it is not economical to deploy terrestrial facilities. Cellular service providers said their services can be used to support emergency needs as well as to support administrative uses. One system has been employed in disaster and civilian crowd control applications to support inter-agency communications. Some of the commercial wireless services have fleet-calling capability, which can be used to efficiently communicate with a large number of users. The trend in these systems is toward increasing use of digital technology, which provides increased security over analog systems.
- 3.2.4 Public safety users made presentations not only in their user capacity, but also as developers of innovative systems that perform public safety communication functions. A full motion video surveillance system was described, which is used as an aid to a narcotics law enforcement program. The system is assembled from a variety of existing, new, and even homemade components. Despite this resourcefulness, the systems deployment is hampered because only one frequency (2.475 GHz) is available for public safety wideband video use; moreover, the frequency must be shared with many more broadcasters who use it for new gathering purposes.
- 3.2.5 A microwave system custom-made from surplus components is used in emergency situations as a wireless link in the local loop. It is deployed at a command center at a disaster scene to provide seamless interconnections with the public switch telephone network. The system is mounted on a van that can be moved as the command center relocates. Put to use in the 1991 Oakland, California fire, the system helps overcome time-to-deploy, traffic saturation, and reliability problems

that can occur with other communications systems, such as cellular telephone and hard-wired PSTN interconnections.

- 3.2.6 A satellite system was described that is used to form a network among many California public safety agencies. Another public safety user who, though not a technology expert, reviewed the barriers experienced in the use of technology, especially with regard to interoperability. Several real-world examples of communications problems in disaster situations also were presented.

### **3.3 Matrix/Inventory**

- 3.3.1 The Subcommittee also undertook to compile an inventory of current, under development and future technologies that will impact spectrum usage over the next 15 years. The subcommittee developed a matrix form to use to gather the information. Requests for inventory information were sent to 25 companies who have participated in the meetings or were known to the Subcommittee. Six companies responded with information on fifteen technologies.<sup>3</sup>

- 3.3.2 The technologies reported by the companies cover current and systems under development. No future technologies were reported by the responding companies. For current technology, Motorola and Transcrypt indicated systems are available or under development using FDMA for 12.5 kHz bandwidth. Also under development from Ericsson is a TDMA system that will use 6.25 kHz bandwidth (2 channels in 12.5 kHz). Another TDMA system was Motorola's iDEN system which is used commercially and has a 4.167 kHz bandwidth efficiency. Although these technologies appear to target primarily voice, most also support some level of data capability. There were no responses that reported data only or video systems; although one indicated that it could support video and snapshot on its TDMA system. Except as noted above, no responses were received for commercially provided technologies such as mobile satellite systems.

## **4.0 PUBLIC SAFETY COMMUNICATIONS APPLICATIONS**

### **4.1 Background**

- 4.1.1 Public safety pioneered mobile radio communications. The dramatic improvements in safety and productivity that came from putting radios in police patrol cars and fire engines led public safety agencies to deploy radio systems long before such radio systems were used in the broader economy. Public safety radio communications began with group voice dispatch as the sole radio service. This breadth of utilized radio services has grown significantly with more new services

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<sup>3</sup> See Appendix B for a summary of information received.

anticipated to come. This section will introduce and describe distinct radio services.

## 4.2 Voice

- 4.2.1 Speech is the most fundamental means of human communication and thus it is only natural that public safety radio systems provided voice communications first. While transmission of the spoken word is fundamental, radio systems often go beyond simple transmission of the words to provide other information such as inflection, emphasis, ability to recognize the speaker, and so on.
- 4.2.2 Originally, all mobile radio systems used analog transmission and the voice signal was transmitted as an analog waveform. Such transmissions were normally restricted to the frequency range of 300 to 3,000 Hz about the same as on telephone calls. This range of speech frequencies provides reasonable speech quality without using excessive spectrum. At present, the most commonly used analog transmission technology is frequency modulation (FM) in a 25 kHz bandwidth. The bandwidth expansion of FM serves to help protect the voice signal from noise and interference. Analog FM signals can be received easily on hobby-type "scanners". This has both positive and negative effects. Criminals can eavesdrop on public safety communications. But, low cost scanners are also widely used by public safety agencies to monitor the radio communications of other agencies to provide assistance. Scanners provide one of the most widely used forms of interoperability. While historically, analog transmissions were difficult to encode in a manner that provided a high degree of transmission security from monitoring by unintended and/or unauthorized listeners, modern signal processing chips allow for far stronger analog scrambling. The process of scrambling or rendering transmissions unintelligible except to authorized listeners is known as "encryption" and is very clearly defined and controlled at different levels of protection by the National Security Agency (NSA) and the National Institute of Standards and Technology (NIST).
- 4.2.3 Analog mobile radio has often been employed as a carrier for equivalent voice band signals other than voice. Its use as an analog carrier for traditional voice modems is described later in this report. Numerous other uses for voice-band analog signaling include everything from coded sequential tone squelch, to touch-tone signaling such as from a telephone keypad (known as dual-tone-multi-frequency, or DTMF).
- 4.2.4 Increasingly, voice is transitioning to digital transmission. In the digital service the speaker's analog voice waveform is converted to a numeric representation before transmission. After reception the received numeric representation is converted back into an analog waveform for presentation to listening users. The device used to convert the analog voice waveform to a numeric representation is called a vocoder, which is shorthand for VOICE CODER. Speech quality varies among different vocoders. Typically, those that transmit more digital bits generally produce better

speech quality. High quality digital speech in land mobile channel bandwidths could not be implemented in affordable technology until recently.

4.2.5 Digital transmission provides mechanisms to combat the familiar static and pop effects that radio reception impairs traditionally caused to analog transmission. The ability to mitigate the effects of errors without resulting in distracting audible effects has a significant impact on improving the perceived quality. This is usually accomplished by moderately increasing transmission overhead, although further increased overhead may result in the requirement for increased bit rate and wider bandwidths.

4.2.6 One advantage of digital voice transmission is security. Digital signals can be encrypted to prevent interception far more easily, reliably and effectively than can analog signals.

4.2.7 A few key attributes of voice communications systems include:

4.2.7.1 *Availability.* Availability of communications to public safety professionals for local to cross-jurisdictional needs is critical, with lives (of both citizens and officers) and property at stake. This manifests itself in the highest requirements for availability. Availability is generally descriptive of the percent of time that a radio channel is available for use when needed.

4.2.7.2 *Delay.* Timeliness of communications is critical, with lives and property often at stake. The classic example of latency is the fact that it takes less than a second to utter the entire phrase “don’t shoot.” Within the phrase, the first word “don’t” takes only a fraction of a second, with obvious effect on the meaning of the phrase. Delay is generally descriptive of (1) the time between when a radio channel is needed to when it is available, (2) the lag between when it is available to when it can begin serving useful communications, as well as (3) the start-up character of the service. For the purposes of this report, the following terms (which are variously interpreted today) are presented:

4.2.7.2.1 *Set-up.* The time necessary to make a channel available for service. The time waiting for a busy channel to become available is not included.

4.2.7.2.2 *Busy.* The time waiting for a busy channel to become available in trunking systems. This is typically expressed as the average waiting time for only those occurrences where a busy condition occurred.

4.2.7.2.3 *Truncation.* The amount of speech lost between when a voice service is requested to when it is set-up and conveying speech. Digital technology may trade-off truncation for latency.

4.2.7.2.4 *Latency.* In-to-out delay for an established channel. While analog was real-time, digital processing, transmission, blocking, vocoding, and other factors can produce higher latency.

4.2.7.3 *Clarity.* The ability to recognize the individual speaking.

### **4.3 Data**

4.3.1 Distinguished from voice service described above, data is fundamentally all non-voice communication of anything representable in alphanumeric form. This service is newer than voice, and has grown along with advances in computer technology.

4.3.2 With the growth in the use of computers and associated reductions in the cost of computing equipment has come an increased demand for data communications capabilities. Many of us are familiar with this in our everyday lives. Computer modems and facsimile machines are now commonplace in the office. Similar data communications needs exist in the public safety radio services. Indeed, most public safety systems are using data radio systems based on technologies of at least two decades ago.

4.3.3 Many of the early public safety data communications systems used circuitry much like telephone modems to create a voice-like signal which could both carry the data and travel over the analog voice paths of the public safety radio communication systems. Such hybrid systems are still widely used today.

4.3.4 More recently, manufacturers have begun to provide radio systems that are fully digital and that can carry data directly on the radio channel. Transmitting high speed data reliably on mobile radio channels is an enormous engineering challenge as compared to transmitting via wire, cable, microwave, fiber optics or other similar carriers.

4.3.5 Key attributes of data communications systems include:

4.3.5.1 *Message / file size.* The quantity of data to be transmitted via data communication is the first order differentiation of the type of data. At one time, *short data or messages* was generally descriptive of anything that could be conveyed by an equivalent voice short-hand. Short data has grown in recent years to also include the quantity of data text or alphanumeric information typically containing 500 characters or less. *Files* are in excess of 500 characters in length and may include images or file attachments to shorter messages.

4.3.5.2 *Reliability.* Data is significantly different from voice services in many respects. The contrast is significant in terms of reliability. Voice is generally thought of as a real-time event while the speaker is talking. The service goal of speech is to convey the best reliability achievable in real-time. Data however, according to its non-voice definition, generally lacks the real-time constraint of

voice. As such, the reliability goal for data is not to deliver as reliable a signal as possible in real time, but instead to deliver 100% error free data in as little time as possible. To this extent, data reliability generally refers to two separate attributes: (1) the percent of data that is not deliverable, and (2) the percent of data that is delivered with undiscovered error. The former may often be referred to as reliability while the later is often referred to as falsing.

4.3.5.3 *Error Control (ARQ)*. Error control refers to the same numerical techniques of error correction and error detection as described for voice. Data networks often provide return receipts back to the originator when the data is successfully delivered, coupled with repeated transmissions from the originator as needed. These are generally referred to as Automatic repeat ReQuest, or ARQ.

4.3.5.4 *Encryption*. Encryption is applicable for data transmissions in the same manner as for voice. Although the numeric representation of data is not intended to be converted into meaningful speech, the goal of data encryption is to prevent the unintended reception from being converted back into the data's original form.

4.3.6 *Examples*. The public safety services have used data to varying extents for several decades, starting first with short data and more recently with file data. The increasing availability and falling costs of mobile data terminals (MDTs) and portable data terminals (PDTs) in recent years has resulted in a dramatic increase in their use in public safety wireless applications.

4.3.6.1 Short data often conveys voice short-hand such as the common 10 codes. A traditional application conveys officer status such as available, enroute, at-scene, or out-of-vehicle. Emergency medical, fire, and law enforcement agencies extensively use these officer/vehicle status systems, particularly for first responders.

4.3.6.2 File-type data includes what is commonly known as data dispatch in which information on assignments are directly conveyed between a dispatch computer and a data terminal in the vehicle; these terminals typically include the short data message capabilities as a subset. Again, emergency medical, fire, and law enforcement agencies all use such terminals to varying degrees, particularly in large metropolitan areas.

4.3.6.3 Other traditional file applications from data-terminal equipped users include direct access of motor vehicle and driver information from state motor vehicle departments and wanted persons/property checks to state justice departments or to the FBI's National Crime Information Center (NCIC) by law enforcement agencies and the transmission of building plans and permit information to fire agencies.

## 4.4 Image

4.4.1 Images represent a special category of data that is a numeric representation of a picture. While voice has the natural duration of the speaker, and other data has the natural length of the message or file, an image has no such natural definition.

4.4.2 The rapid increase in use of "wire-line" based facsimile transmission and similar image technologies within the public safety services has paralleled that within the broader economy. Recent developments such as the inexpensive digital storage camera will lead to a rapid expansion in the use of image services.

4.4.3 Key attributes of image communications systems include:

4.4.3.1 *Resolution.* An image must first be converted into a numeric format before a length or quantity of data attribute exists. The attribute of the conversion which determines this is referred to as the resolution. It is expressed as image dimensions in terms of pixels, which each represent one PIXture cELI or dot. Any given image can variably be represented in higher resolution by using more pixels, resulting in a larger digital representation. Conversely lower resolution using fewer pixels results in a smaller digital representation. When the image is captured by a camera, the resolution is typically expressed as the number of pixels across and down. When the image is captured from a printed image, the resolution is often expressed as the dots-per-inch or dpi of the scanning device, which coupled with the image dimensions can equivalently define the number of total pixels across and down.

4.4.3.2 *B/W vs color level.* A picture of a given resolution defines the number of pixels. Along with the resolution there is a second dimension of the quantity of data in a digital representation of an image. It is based upon how much data is used to represent each pixel. Simple black and white images use minimally 1 bit per pixel, while gray scale imaging may utilize multiple bits to define the intensity of each pixel. In color imaging each pixel may be further represented by multiple data words defining the intensity of each primary color component of each pixel (red, green, and blue). The total data size of a given resolution image varies by over an order of magnitude from 1 bit per pixel (normally referred to as line-art) to 24 bits per pixel (normally for digital representation of broadcast quality color).

4.4.3.3 *Compression.* Compression can be applied to any service, whether it is voice, data, or image. Because of the ease with which an image may be converted into large digital representations, there has been a special focus on image compression techniques. Pioneered by technology to speed FAX transmission, areas of like pixels are represented by short-hand representation. The more uniform an image area the smaller the resulting compressed image. Conversely the more complex an image the larger the resulting compressed image will be. Popular standard image formats have emerged from the computer industry for compressed images such as Graphic Image Format or GIF, or newer negotiated standards such as JPEG. Many other standard image formats exist. However, they were not designed for efficiency of representation and are thus less suited for transmission.

4.4.3.4 *Error Control.* Error control can be applied to image transmissions identically to other non-voice data. However (unlike textual or numeric data), the graphical nature of images may lend itself to less than 100% reliability. FAX transmission normally is useful even in the presence of a limited transmission corruption as each line is individually only a piece of the total image. In a similar fashion, error control on image transmission may usefully provide an optional lesser reliability service.

4.4.4 *Examples.* The typical passport photo of 2 inch square black and white results in only 1 or 2 kilobytes, while a full-color still from a video camera may exceed a few hundred kilobytes, and a high-definition (several hundred dpi) scan of a color photo can easily reach several megabytes. Image translation can convert higher resolution into a smaller form for transmission, although the reverse is not generally achievable. A notable exception is the emerging technology known as fractal image coding. It promises highly compressed image formats which are rescalable without loss of quality by the destination.

4.4.4.1 Emergency medical providers desire the ability to transmit images of the injured from paramedic units back to trauma centers or hospitals to aid in diagnosis and pre-arrival treatment.

4.4.4.2 Fire agencies desire the ability to transmit building plans and copies of permit and other data for fire prevention and protection.

4.4.4.3 Law enforcement agencies need to quickly transmit fingerprints from field units back to local, state and federal databases; units need the capability to receive mugshots and drivers license photographs to aid in identifying people in the field. Indeed, millions of dollars have been spent by the Federal government to update the FBI's automated system to support fingerprints and mugshots for NCIC-2000.

## 4.5 Video

4.5.1 Video has a real-time length attribute based on how long a scene is viewed.

4.5.2 Wireless video systems have seen limited use in state/local public safety services to date primarily due to a lack of available public safety spectrum over which to implement these systems. In fact, only a single video channel is currently available for public safety use and it is shared with other radio services.

4.5.3 Key attributes of video communications systems include:

4.5.3.1 *Frame rate.* In addition to the duration, the next attribute defining the size of the video transmission is the frame rate, the number of frames represented in each second of video. Television typically refreshes half of the picture lines at a 60 times per second rate, which results in the whole picture being refreshed at 30

frames per second. Reduction of the frame rate to half this rate (15 frames per second) loses the continuity or smoothness of motion, resulting in a jerky, old-time movie effect. Low frame rate video is commonly employed today in software or CD playback of video on computers due to its obvious impact of reducing storage requirements in half, compared to more fluid 30 frames per second.

4.5.3.2 *Resolution and Color level.* Within each video frame, resolution and color level define the transmission size. Because of the transient nature of each frame or the fact that the focus of the viewer is on the motion between frames, lower resolutions and color levels are viable. This is typically done to limit data storage in software or CD playback on computers, as well as in minimizing transmission times for picture telephone. A great deal of public safety video imaging is done under low light level conditions in which color information is generally unavailable.

4.5.3.3 *Error control.* Unlike still images where the viewer can study the image, transient noise in a video transmission can detract from the viewer's perception. User's tolerance to noisy or distorted video is different than for still images. Current ARQ techniques are not usable in real-time applications. The role of error control within video is to minimize viewer distractions.

4.5.3.4 *Compression.* Image compression takes account of like pixels within a picture. Likewise standards for two-dimensional compression take into account 'likeness' between successive frames. In this area, standards such as MPEG have emerged.

4.5.4 *Examples.* Motion video images, like still images, can be ranked on an image quality continuum. Limited black and white slow scan surveillance is accomplished today in analog on a standard voice bandwidth channel. Animating a black & white image the size of a passport photo at 15 frames per second can be accomplished with as little as 10 kilobytes per second with good signal quality (where minimal error control is needed). At the other extreme, broadcast quality color requires several megabits per second bandwidth. High definition TV requirements are even greater. Public safety agencies have expressed varied operational requirements for video systems.

4.5.4.1 The fire service uses full motion video extensively in some areas, primarily to monitor wildland fire scenes from airborne platforms, providing real-time video back to emergency command centers. The lack of public safety spectrum has often required state/local fire agencies to enlist Amateur Radio Service licensees to provide this service on amateur frequencies.

4.5.4.2 Law enforcement agencies, particularly at the federal level which have spectrum available for video, have long used video for surveillance purposes. State/local agencies have only recently begun to implement similar systems for monitoring areas of high crime and drug use.

4.5.4.3 State/local transportation agencies have implemented wireless video systems to monitor traffic flow and detect collisions and hazards on roadways in congested metropolitan areas.

#### **4.6 Location information/GIS/APL/AVL<sup>4</sup>**

4.6.1 Public safety agencies have struggled with the problem of identifying the location of vehicles and personnel. A variety of techniques have been tried over the years. The federal government funded substantial research into such systems in the late 1960s and early 1970s. Today there are several ways to obtain such location information. Each alternative has its strengths and weaknesses. The systems are:

- satellite navigation systems,
- the LORAN C terrestrial navigation system,
- the FCC licensed LMS service,
- dead reckoning systems,
- signpost systems,
- inertial navigation systems, and
- systems deriving location information from commercial mobile radio services (CMRS).

4.6.2 *Satellite navigation systems.* The most widely known and most widely available of these location systems are the satellite navigation systems. The two best know satellite navigation systems are the Global Positioning Service (GPS), and the Global Navigation Satellite System (GLONASS). GPS is operated by the U.S. Department of Defense; the somewhat similar GLONASS system is operated by Russia. The discussion below focuses on GPS, but similar comments would apply to GLONASS in many instances.

4.6.3 The heart of the GPS system is a constellation of 24 satellites in medium earth orbit that continuously broadcast time and satellite location information. A system that receives a signal from four of these satellites can calculate its location to within about 100 meters. GPS receivers are now offered in the consumer market for less than \$200. Differential GPS can provide location estimates that are accurate to within ten meters. GPS can provide a signal to a ship or to an airplane. It was not designed to provide a signal capable of penetrating a building, nor to operate optimally in urban canyons or heavily forested areas. There may be some applications where better reliability or better accuracy can be obtained by a terrestrial system that processes signals from both the GPS and GLONASS satellites.

Reference:

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<sup>4</sup> GIS=Geographic information system, APL=Automatic Personnel Location, and AVL=Automatic Vehicle Location.

For more details on GPS, see the excellent and comprehensive volumes (1,400 pages) *Global Positioning System: Theory and Applications*, Volumes I and II, Edited by B. W. Parkinson and J. J. Spilker Jr, AIAA, 1996.

- 4.6.4 *Loran C.* Loran C is a older radio navigation system. Its future maintenance is not certain.
- 4.6.5 *Location Monitoring Service.* In the 1970s, the FCC allocated spectrum for the automatic vehicle monitoring service (AVM), now known as the location and monitoring service (LMS). One firm, Teletrac, is providing commercial LMS service in several larger cities. The Teletrac system uses multiple sites to measure the time of arrival of wideband pulses from vehicles and then solves for the vehicle's location. The Teletrac technology provides better coverage in urban areas than does GPS. It does not require augmentation by dead reckoning or inertial navigation systems.
- 4.6.6 *Dead reckoning systems.* Dead reckoning systems provide another approach to deriving location information. A computer system in a vehicle can count the number of rotations of the tires and thus estimate how far it has gone. Vehicle turns can be detected by differences in the rotation of the left and right side wheels. Anti-lock braking systems already require wheel rotation sensors. Combining this information with compass headings and a map database will allow for reliable calculation of the vehicle location even if the vehicle has traveled a substantial distance. Ultimately, after a sufficiently long interval, dead reckoning systems do tend to lose track of the vehicle's location. Either the user can manually update the location (a user-unfriendly system element if ever there was one) or another technology can be used to update the system's location estimate. GPS is an excellent candidate for such updating. Dead reckoning can be used for a few blocks, then the vehicle drives into the open, reacquires the satellites, and updates its location. Lacking an odometer equivalent, there is no application to portable units.
- 4.6.7 *Signpost systems.* Signpost systems involve the use of low-power, short-range transmitters that transmit messages describing their own location. Vehicles passing these signposts receive updates of their location as they pass the signpost. This technology requires a substantial investment in infrastructure. Signpost systems can be used to complement dead reckoning technology.
- 4.6.8 *Inertial navigation systems.* Inertial navigation systems process data from acceleration sensors to estimate the path of the vehicle. Such systems are still expensive today and work like dead reckoning systems in that their location estimates must be reinitialized from time to time.
- 4.6.9 *Commercial mobile radio services.* Commercial mobile radio services (cellular, PCS, and SMRS) have the potential for providing location information of varying resolution. For example, cellular systems know which cell is serving the mobile or

portable unit. Some PCS systems also calculate fairly accurate range estimates and can combine the information from range estimates and cell locations to give more precise location estimates. Technologies exist for using the CMRS transmissions to generate more accurate location information.

- 4.6.10 Most of the systems discussed above, with the exception of the FCC's LMS service and location services provided by CMRS, provide location information at the vehicle or portable. For such information to be used with computer-aided dispatch (CAD), it must be transmitted from the mobile unit to the control point. This requires a data communications capability in the mobile unit.
- 4.6.11 Location information may serve the mobile user as well as fixed dispatch facilities. Where location information is used by the fixed dispatch, the information must be available. Technologies which natively generate the location fix at the mobile user (including GPS, Loran, dead-reckoning, and signposts) can place a burden on the capacity of the public safety communication system to transport the location back to the fixed dispatch facilities.
- 4.6.12 To conclude. Location technology is changing rapidly. Satellite systems, most notably GPS, are affordable and will provide near-universal coverage. Integration of GPS with other systems offers near universal coverage in urban areas. It appears likely that public safety agencies will be able to choose from several different technologies for identifying the location of vehicles and personnel. Depending upon the systems used and the design, this may require a substantial amount of air time, and possibly a dedicated channel.

Reference:

Robert L. French, "Land Vehicle Navigation and Tracking," Chapter 10 of Global Positioning System: Theory and Applications, Volume II, Edited by B. W. Parkinson and J. J. Spilker Jr., AIAA, 1996. p. 275-301.

## **5.0 EXISTING PUBLIC SAFETY COMMUNICATIONS CAPABILITIES<sup>5</sup>**

### **5.1 Background**

- 5.1.1 This section briefly describes public safety communications capabilities as they exist today. It tries to give the reader perspective on both the systems currently operating today and on the system solutions that are on the market. We consider the various technologies in the same order as they were historically introduced.

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<sup>5</sup> While we use the broad term "existing public safety communications capabilities," our focus in this chapter is primarily on mobile communications capabilities as they are used and implemented today. We also discuss briefly some of the backbone communications needed to support mobile communications. We do not consider other important issues in public safety communications such as administrative support, 911 and E-911, etc.

## 5.2 Voice

- 5.2.1 Most public safety communications systems use analog FM technology operating in 25 or 30 kHz channels to carry their voice signals. This technology has the advantage of being both robust and affordable. Almost all public service officers use voice radio communications to communicate from the field with their dispatchers and to communicate with their co-workers in the field. Vehicles are equipped with radios and most staff are also equipped with portable units. Radio voice communications has an enormous payoff in improved responsiveness and effectiveness of public safety operations and in improved safety for officers in the field.
- 5.2.2 Public safety communications systems normally operate using a variant of one of two basic methods. The first method, found primarily in bands above 406.1 MHz where frequencies are commonly paired, is repeater operation. A typical repeatered system uses two frequencies — one for communications from the mobile units to the base station and another frequency for transmissions from the base station to the mobile units. Communications from a mobile unit are transmitted to the dispatcher on one frequency and then are repeated on another frequency for reception by other mobile units. Some systems do not repeat all mobile transmissions and only send communications from the dispatcher out on the base-to-mobile frequency. Repeatered operation is normally used for day to day operations, for dispatcher control of mobile units, and for communications over a wide area. The second method is simplex or half-duplex which is repeaterless and relies upon direct unit-to-unit communications. This method is most common on bands below 406 MHz where frequencies are not paired. While most commonly used by operations or tactical groups working in a small area and needing to coordinate one with another, there are a number of wide area and statewide systems which still use this method. Typical examples include units needing to coordinate their actions at a fire, hostage situation or hazardous materials release.
- 5.2.3 Larger public safety organizations often use trunked radio systems. These systems operate using a pool of frequencies and assign these frequencies to conversations one call at a time. While use of trunking technology is more complex and adds expense, these systems are generally significantly more efficient in their use of spectrum and of radio transmitter infrastructure.
- 5.2.4 While digital voice is a technological possibility, it is little used today in public safety communications. We expect that digital voice systems will be offered by several manufacturers in the public safety market in the next few years. These systems will offer improved voice security, combined support of data and voice communications needs in a single unit, and may offer improved spectrum efficiency.
- 5.2.5 Another approach to improved spectrum efficiency is the use of narrowband analog modulation. While such narrowband techniques have long been used in other applications, the engineering challenges of matching them to mobile

communications channels have only recently been overcome in commercially available products.

### **5.3 Data**

5.3.1 Today data communications capabilities are used in public safety for such purposes as digital dispatch and checking computer data bases for information associated with wanted persons/property and vehicle registration . The flow of information is asymmetric, with more data flowing to the patrol unit than is originated at the patrol unit. Typically, such communications are done today either with an analog modem which transmits data signals over the voice communications radio link or with a with separate radio in the vehicle. Patrol officers do not normally carry portable data terminals when they are outside the vehicle. Typical data transmission efficiencies lie in the range of 0.3 to 19.2 kbps (error protected) per second in a 25 kHz channel.

### **5.4 Image**

5.4.1 Still images include snapshots such as accidents, and crime scenes, mug shots, fingerprints, and a wide variety of other images. Modern digital cameras can take a picture and generate a data file containing a digital description of the scene photographed. This file can then be transferred over existing communications pathways and displayed on computer monitors or printed out. Thus, public safety service providers have the option today of putting in place still image transfer capabilities.

5.4.2 Today, there is relatively little use of still image transmission to and from the field in public safety. Image transmission is a case where the description of existing capabilities is difficult. Public safety communications systems support the necessary communications and all the building blocks for still image transmission are available in the marketplace. But, such systems are not yet widely used. However, this situation is expected to change markedly in the next decade. Still image transmission to the field will allow the dispatcher to send pictures of missing children or of suspects to patrolling police officers or to send high-resolution diagrams of buildings and charts showing storage of hazardous materials to fire trucks as they approach the scene of an incident. Still image transmission from the field will allow police officers to transmit photographs and fingerprints of suspects back to the office for processing, inspection by other officers, and comparison with materials in data bases.

5.4.3 The essential improvements in imaging and display technology required for such technologies to become user friendly and affordable appear to have been made. We expect that such systems will be deployed in increasing numbers over the next decade and a half.

5.4.4 We expect that still images will usually be transmitted as data files using file transfer protocols similar to those used to transmit other types of files over data networks. In most situations one would expect that image communications could tolerate some delay as long as that delay did not affect the minute-to-minute operations of the officer on patrol.

## 5.5 Video

5.5.1 Video is the fancy name for television or for the electronic communications of moving images. Video is used in public safety today primarily for surveillance of crime scenes and of highways. Video cameras are also used to record some arrests and activities at crime scenes. However, it is expected that the use of video will grow greatly as video camera technology continues to improve. One can foresee hand held portable mobile radio units with built in video cameras. Transmission of such images back to central locations could be quite helpful in the management of major incidents.

5.5.2 Today, video images are normally transmitted using analog modulation. Wideband channels (several megahertz) are normally used to carry full-motion, high-quality video. However, only very limited spectrum is available to state and local agencies. Slow-scan video technology permits television pictures to be sent over a narrow-band channel by sending a picture every few seconds. Slow-scan technology is not appropriate for situations involving rapid movement, but can be quite useful for monitoring traffic, weather, secured areas, etc.

5.5.3 In the future, we expect that most public safety video communications will be digital. Digital video permits the use of compression technology, so that the resulting compressed signal requires only about 1/4 to 1/10 of the bandwidth or channel capacity required by uncompressed video. Currently though, compression equipment is still expensive and standards are changing rapidly. Video compression technologies are have already become consumer products (e.g., DirectTV's digital satellite television service uses digital compressed video) and are used in many personal computer systems. Hence, the market availability of digital video options will continue to expand.

5.5.4 The coming of affordable digital video cameras and affordable digital compression can be expected to lead to substantial growth in the requirements for public safety video communications. While many video communication needs will be satisfied by the use of recorded video, the need for real time communication of video will expand, and with it the need for public safety access to radio spectrum.

Reference:

White Paper "Wireless Video Transmission in Public Safety Applications," March 1, 1996,  
Thomas W. Christ, Chairman, HDS, Inc.

## **6.0 SYSTEM BUILDING BLOCKS AND TOOLS: FUNDAMENTAL CONSTRAINTS AND LIKELY EVOLUTION.**

### **6.1 Background**

6.1.1 In this section, the advances in technology and some of the ramifications of those advances will be presented as they relate to the demand for wireless communications and the ability to fulfill those demands. Trend curves will be presented showing the history of these trends, and from them their future directions will be projected.

### **6.2 Digital Integrated Circuits**

6.2.1 The fundamental technology thrust through the year 2010 will be, as it has been in the recent past, that of semiconductor technology. The impact that this has had on computer and communications needs and capabilities has created the demand for increased radio spectrum through the wireless demand for these services. The increase in semiconductor capability will permit the partial offset of the spectrum demand by improved information compression techniques as well as increasing the capability of communication channels. Communication system architecture and the associated spectrum management policies are also affected by semiconductor technology. In this section, we examine the impact of semiconductor technology on future public safety communications system requirements.

6.2.2 The improvements in semiconductor processing and materials have resulted in roughly an order of magnitude advance every five years. This trend is demonstrated in the histories of memory devices, microprocessors, and computer systems.

Figure 1 presents the chip density of Dynamic Random Access Memory (DRAM) in bits versus the year of original market introduction.<sup>6</sup> The clear trend, indicated here, shows that chip densities have increased by a factor of ten every four years. Although Figure 1 addresses only DRAM devices, similar trends with almost identical slopes are observed for other types of memory devices.

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<sup>6</sup> Four Japanese microchip makers develop 256 M-bit DRAMs, Journal of Electronic Engineering, Vol. 30 , Issue 323, Nov. 1993, pp. 30-31.

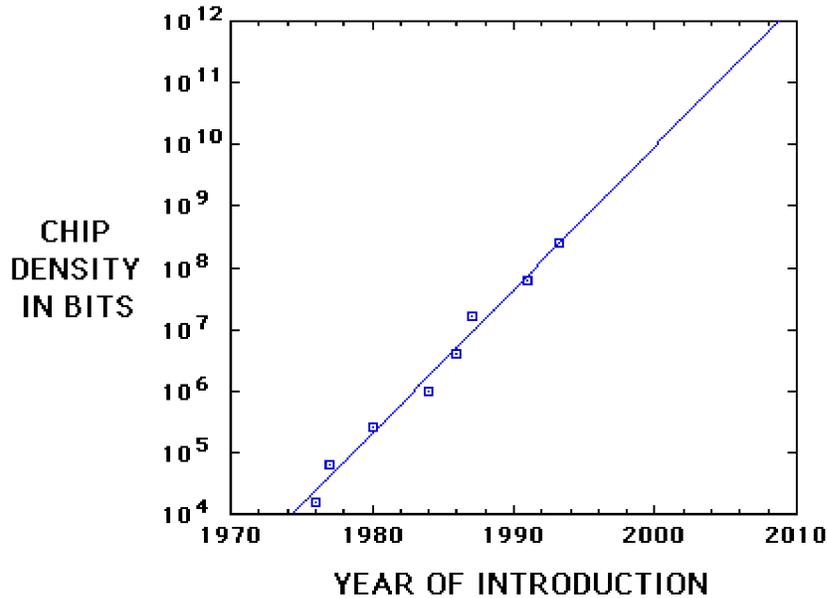


Figure 1 DRAM density trend over time

- 6.2.3 Rapid advancement is also observed in the progress of microprocessor technology over the last two decades. The increase in number of transistors per chip is displayed in Figure 2<sup>7</sup>. In this chart, each data point represents a new microprocessor plotted at its year of introduction, and it can be seen that the technology accomplishes an order of magnitude improvement about every 6 years.
- 6.2.4 The speed of microprocessors is also continuing to increase. The Semiconductor Industry Association predicts that on chip clocks will run at 1,100 MHz by the year 2010.<sup>8</sup> Their projection of the clock speed that will be resident on Microprocessors from the years 1995 through the year 2010 is shown in Figure 3.

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<sup>7</sup> N. Ikumi et. al., A 300 MIPS, 300 MFLOPS four-issue CMOS superscalar microprocessor, 1994 IEE E International Solid-State Circuits Conference Digest, Feb. 16-18, 1994, pp. 204-205. See also footnote 2 in the body of this paper.

<sup>8</sup> Solid State Technology 1996, IEEE Spectrum, January 1996, pp.51-55.

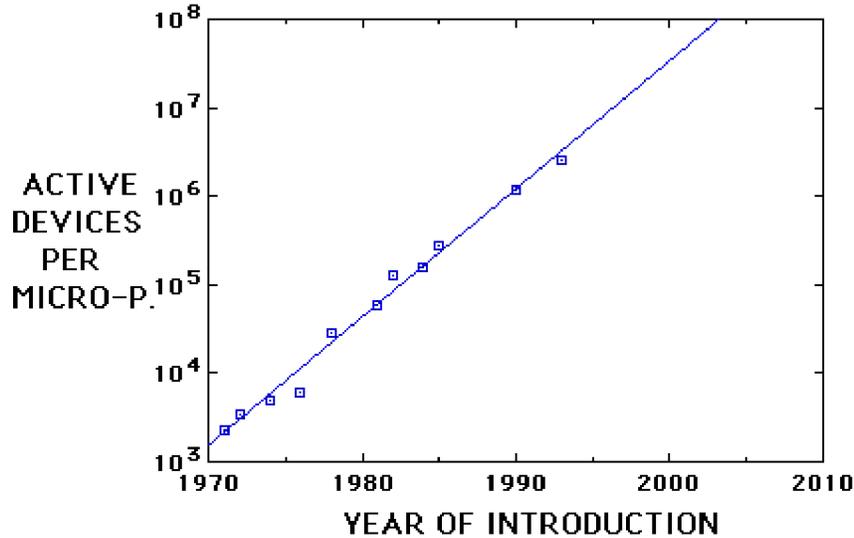


Figure 2 Microprocessor density trend over time.

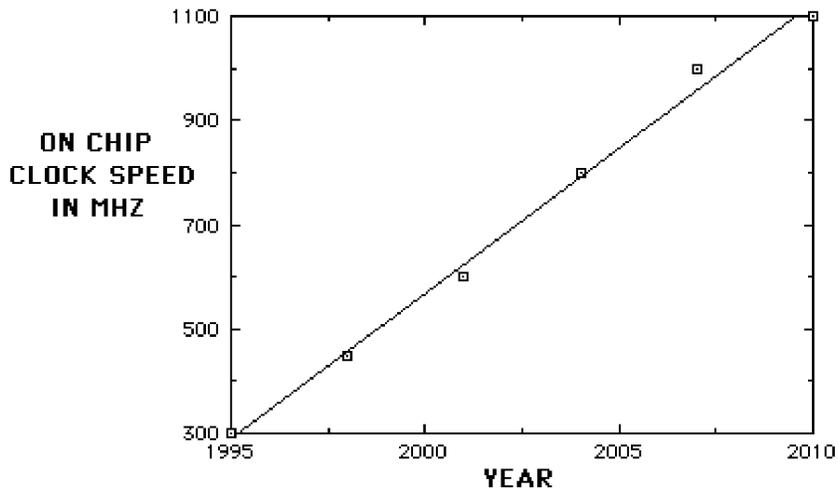


Figure 3 On chip clock speed projected to the year 2010

6.2.5 The result of these component level improvements has been that computer systems have advanced along similar trend lines. It has been observed that the performance of computer systems has advanced at approximately 35% per year.<sup>9</sup> Thus an order of magnitude improvement is seen every five years. In the case of computer systems, this is equivalent to a step of one platform tier. For example, the trend would predict that the current performance of a minicomputer will be available in a

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<sup>9</sup> D. L. Nelson and C. G. Bell, "The Evolution of Workstations," IEEE Circuits and Devices Magazine, Vol. 2, pp. 12-16, July 1986.

workstation platform after seven years, and in a portable laptop computer by the year 2010.

### **6.3 RF Generation Devices**

#### **6.3.1 Batteries.**

6.3.1.1 The batteries required to operate portable communications equipment are usually heavy, provide limited hours of operation, and can be expensive. A number of developments in battery technology are alleviating this situation. Some involve new technologies, such as nickel-metal-hydride and lithium-ion batteries. Another development is a zinc-air battery that draws oxygen from the atmosphere to extend its life. Power saving solutions that make more efficient use of battery power by communications equipment hold promise for extending battery life further; more power efficient amplifiers and more efficient sleep modes are examples of ways in which battery life may be increased.

Reference:  
Office of Technology Assessment, "Wireless Technologies and the National Information Infrastructure," August 1995, page 16.

#### **6.3.2 Oscillators.**

6.3.2.1 Spectrum efficiency is improved if more communication channels can be placed within a given band of spectrum. In the past, the ability to decrease the channel size has been limited by both the transmission bandwidth and frequency stability concerns. Frequency stability in land mobile radio has also benefitted from improvements in semiconductors.

6.3.2.2 Figure 4 shows the trend of requirements on land mobile frequency stability. The trends for both base stations and mobiles track together until the mid-60's. Thereafter, the base station trend has continued toward tighter tolerances at a steeper slope than that of the mobile radio trend line. In both cases, the stability improvements were met via two primary developments. These were the practical implementation of frequency synthesizers and the integration of temperature compensated oscillators.

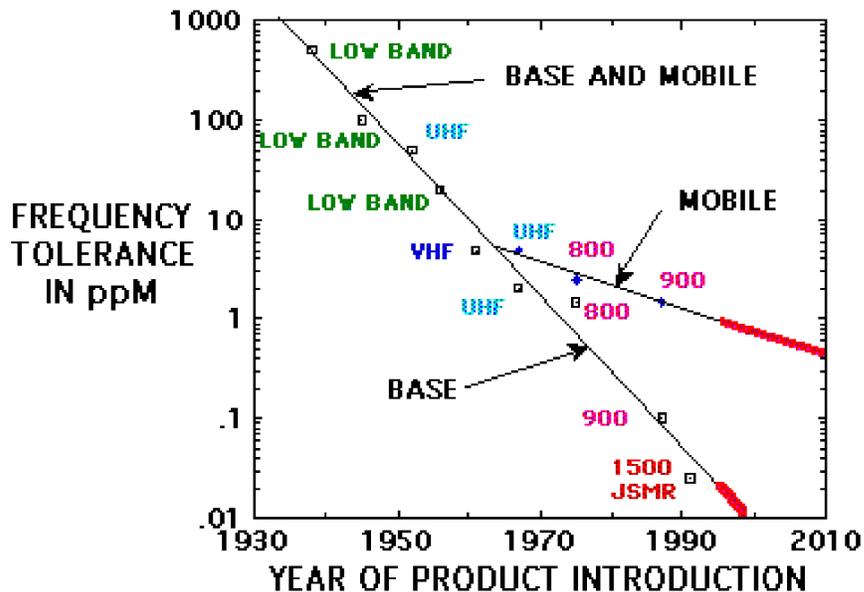


Figure 4 Trend of frequency stability over time.

6.3.2.3 Advances in semiconductors allowed the development of integrated temperature compensation circuits which could be packaged with the crystal. These compensation circuits dramatically reduce the variation in output frequency over the wide range of temperatures experienced, thus directly improving the frequency stability of the associated radio equipment.

6.3.2.4 The implementation of synthesized radio equipment was made practical by the integration of many complex functions into integrated circuits; among these are loop filters, phase detectors, and frequency dividers. The contribution of synthesizers to frequency stability was the standardization of the frequency source from which the signals were synthesized. This allowed effort to be focused on a small set of oscillator devices which drove the learning curve faster so the tolerance could be improved more rapidly.

6.3.2.5 Improvements in frequency stability can be used to enhance spectrum efficiency even when channel spacing is not reduced because the guard bands around the occupied bandwidth of each transmission can be reduced. The information content of the transmitted signal can be increased while maintaining acceptable adjacent channel splatter. This is important because reductions in guard bandwidth are limited by adjacent channel splatter considerations.

6.3.2.6 With the refarming report and order, the FCC has required that 6.25 kHz equivalent spectrum efficient technology be implemented for newly type accepted

equipment after the year 2005.<sup>10</sup> The required frequency stability has also been improved to 0.1 ppm for the mobile units. However, system considerations, such as not assigning adjacent channels in the same geographic area can make it unnecessary to provide close in splatter protection. In crowded urban areas where cellular type of coverage is required (such as for different precincts in a city) this does not impact spectral efficiency and can reduce the cost of equipment. The refarming Report and Order is the subject of several petitions for reconsideration, and it is not clear what the result will be at this time.

### 6.3.3 Antennas

6.3.3.1 *Smart antennas.* Smart antennas is a term applied to a family of technologies that generally integrate active antenna elements with microprocessor technology. One of these technologies, planar arrays, spreads the power over a large number of radiating elements in a flat plane in order to achieve, typically, a narrow beamwidth. By changing the current distribution of the array, the shape of the beam can be changed electronically in real-time. This can be used to increase gain and narrow beamwidth as necessary. The same techniques can be used to place a pattern null in the direction of an interfering signal, whether a strong multipath reflection, unintentional interference, an intentional jammer. The ability of the array to be flat allows for an installation that mechanically conforms to the antenna support.

6.3.3.2 In a transmitting situation, such antennas must split the input power several times in order to feed it to the multiple radiating elements. This multiple power splitting results in inevitable power losses which, in turn, limit the achievable antenna gain. (Similar concerns obtain in the reciprocal receiving situation.)

6.3.3.3 These techniques have been used for some time in military applications, but are not widely used in commercial applications. This is likely to change with the attendant improvements in digital signal processing technology, which is necessary for economical implementation.

6.3.3.4 *Space diversity.* With land mobile radio communication, there is rarely a line-of-sight propagation path between the base and mobile station, and multiple signal paths exist. The signals from those paths combine both constructively and destructively at the receiver to produce multipath fading. For narrowband transmissions, the propagation delays associated with the various paths are extremely small compared to the inverse of the signal bandwidth. The channel can be considered as a Rayleigh fading channel with frequency flat fading. This fading results in both signal strength variation characterized by a Rayleigh distribution, and phase variation characterized by random FM noise.

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<sup>10</sup> FCC Report and Order and Further Notice of Proposed Rule Making, commonly called the Refarming Notice, FCC 95-255, Adopted June 15, 1995, Released June 23, 1995.

6.3.3.5 Diversity is a commonly used technique for improving the quality of both digital and analog signals. When the new technique of single sideband is employed the use of multiple antennas becomes a virtual necessity, as when the vehicle is traveling at high speed, signal will become distorted due to phase shift. The most common form is space diversity, which is implemented using two appropriately spaced antennas. The advantages of this technique must be weighed against the disadvantages. There is some added cost for installation of the second antenna in a mobile vehicle, and a further cost for repairing or patching the hole when the vehicle is traded. Another concern is the difficulty in disguising the second antenna on unmarked or undercover vehicles.

6.3.3.6 For portable units, use of two antennas becomes even more of a problem, due to the limited space available. This concern for portables becomes even greater as agencies install infrastructures which provide portable coverage throughout the system and as portable units are used in vehicles in lieu of mobile units. There are at least two approaches to overcome this problem. One is the use of vehicle mounted adapter/chargers into which a portable unit can be inserted, which in turn connects to two space-diversity antennas on the vehicle. It should be noted that past use of such vehicular mounted devices has not been totally satisfactory due to the high incidence of wear and resultant equipment failure. Improved designs may overcome these former problems. Another method being researched is a one-piece diversity antenna system that uses two antenna elements, but performs the signal combining function in the antenna base and thus requires only one hole and one cable for mounting for either a mobile or a portable installation. In all instances, the difficulty of using two antennas is directly related to the frequency band used, with implementation becoming easier as the frequency increases.

6.3.3.7 Maximal ratio diversity combining is a third diversity technique which is used to combat fading. It is designed, as the name implies, to maximize the signal-to-noise ratio of the received signal. The performance of maximal ratio combining is theoretically the best of the three. In the past, the difficulties of practical implementation often rendered its performance relatively poor compared to the other two methods. However, with the advances in semiconductor technology, the implementations being made today reach the theoretical promise of this method.

## **6.4 Source Coding**

6.4.1 Using today's systems, the additional traffic demands described above can only be met by increases in the available spectrum. However, the demands can, at least in part, be offset by utilizing semiconductor advances to make more efficient use of the limited spectrum resources. Information compression allows reduction in the amount of information which must be transmitted on the communications channel. Typically, this is done by removing redundant information, thereby reducing the overall information bandwidth. These improvements in voice coding technology must be counterbalanced with other factors. For example, it appears quite likely that

public safety users (like other users of communications systems) will demand higher quality speech as that option becomes available. We note that some cellular equipment suppliers have moved from 8 kbps vocoders to 13 kbps vocoders in order to improve speech quality.

## 6.4.2 Voice

6.4.2.1 Digital speech encoding has received significant attention of late. This means of transmitting speech leads naturally to encryption which is one very important aspect in many public safety communications scenarios.

6.4.2.2 Figure 5 shows trends in digital voice compression technology. The top line represents the speech bit rate reduction experienced for high or "toll" quality speech as used over telephone networks. The lower line shows rates necessary for "communications" quality coders. These coders produce slightly degraded but demonstrably useful speech for public safety applications. Since the mid-1970s, the federal government has had a digital voice standard operating at 2.4 kbps. However, this standard, valuable though it is, provides limited speech quality and does not always operate well in noisy environments. It did provide an early technology for digital secure voice.

Reference:

T.E. Tremain, "The government standard linear predictive coding algorithm: LPC-10,"  
Speech Techno., vol 1, no. 2, pp. 40-49, Apr. 1982

6.4.2.3 In the past, these speech encoding systems have actually increased the occupied bandwidth due to relatively unsophisticated coding schemes, while noticeably degrading the audio quality. The 12 kb/s CVSD in Figure 5 is one example. More recently, advanced digital signal processors, made practical by improved IC technology, have contributed to the development of improved speech coding algorithms. For example, the 8.0 kbps VSELP shown in Figure 5 is used in Japan and US digital cellular and provides near toll quality audio with an information bandwidth comparable to analog speech.

6.4.2.4 Looking to the future, we can expect that increasingly powerful digital signal processing IC's will facilitate the introduction of more powerful and effective methods for reducing the amount of information that must be transmitted on the communication channel. Speech and image (facsimile) communications are two areas that should benefit greatly by these techniques. In 1995, the ITU started the process of producing a standard for a 4 kb/s speech coder for toll quality applications.<sup>11</sup> A closely related approach to improving spectrum efficiency is to use variable rate vocoders -- that is voice coding technology that outputs data at a variable rate reflecting the changes in speech patterns. Such vocoders are used

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<sup>11</sup> ITU Study Group 15 Question Q.7/15 titled Subjective Qualification Test Plan for the ITU-T 4 kbit/s Speech coding Algorithm, November 9, 1995.

today in some land mobile radio systems and related technologies have long been used in telecommunications. Such techniques can improve spectrum efficiency by roughly a factor of two. Variable rate vocoders also offer another potential advantage to public safety systems. They allow capacity and quality to be traded off. For example, a public safety communications system shared with highway maintenance might could, in a time of emergency, borrow capacity from the highway maintenance radio communications capabilities by reducing the bit rate used to encode their calls. Such a reduction would free up capacity for public safety communications, but would allow the highway maintenance staff to maintain communications connectivity - albeit at reduced quality.

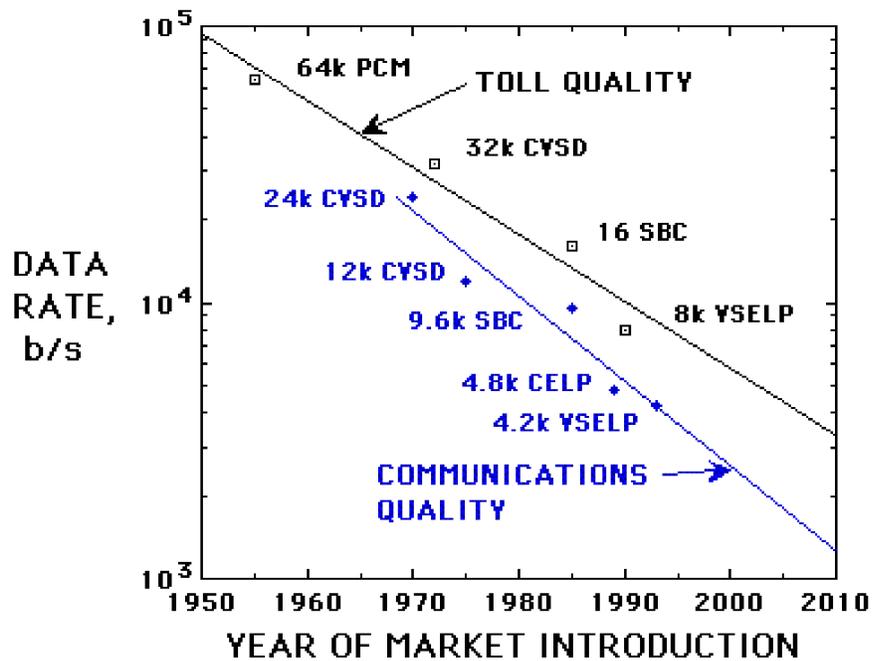


Figure 5 Trend of digital voice compression technology over time.

6.4.2.5 Of course, the mobile radio channel is subject to severe signal degradation due to shadowing and multipath fading. This degradation is more harmful to digital speech than analog, which tends to degrade gracefully in the presence of impairments. The recovery and regeneration of the source information from the compressed digital information is difficult due to the lack of redundancy. Thus, only with complex fading mitigation techniques such as error correction coding (which further increases the required bandwidth) and diversity can the compressed information be used effectively. Here again the digital signal processor IC will allow the implementation of the complex recovery techniques needed to realize usable communications in the mobile radio environment.

### 6.4.3 Image

6.4.3.1 *Facsimile.* Transmission of facsimile today is governed by two widely accepted international standards, ITU-T's Group 3 and 4. These standards specify both horizontal and vertical resolution, which governs the "information" content, in bits, for a typical 8.5 "x 11" page.<sup>12</sup> The Group 4 standard specifies a nominal resolution of 200 pixels per inch horizontally (300 and 400 pels per inch are also allowed) , and 100 lines per inch vertically (200, 300 and 400 lines per inch optional). Since the facsimile is a bitonal image, the nominal source content in bits, is:

$$\begin{aligned} 8.5 \text{ in.} \times 200 \text{ pels/in.} \times 11 \text{ in.} \times 100 \text{ lines/in.} \times 1 \text{ bit/pel} &= 1.87 \text{ megabits (Mbits)} \\ &= 234 \text{ kilobytes (kbytes)} \end{aligned}$$

6.4.3.2 The ITU-T Group 3 and 4 standards also specify compression algorithms to reduce the number of bits, and hence the bandwidth, needed to represent a typical page. These compression algorithms are content dependent, i.e. the amount of compression is dependent on the source material. The ITU-T defines eight reference source pages to measure the effectiveness of the compression algorithms. The Group 4 compression scheme averages a compression ratio of roughly 10:1 over the eight reference source documents. Thus, one page of fax, transmitted at nominal resolution, can be represented in approximately 23 kbytes.

6.4.3.3 *Snapshot.* Unlike fax, snapshot images may contain full color or grayscale information, which greatly increases the amount of source data needed to represent an image. As stated earlier, the snapshot service may supply various resolutions and image sizes, according to the particular imaging application. As examples, two public safety applications which have received considerable interest may be represented by the snapshot application: wireless transmission of criminal fingerprint and mug shot descriptions.

6.4.3.4 The NCIC 2000 system will provide nationwide wireline and wireless access for criminal justice agencies to the FBI's considerable data repositories. Current data repositories contain information fields on such things as stolen vehicles, stolen articles, stolen guns, stolen license plates, wanted persons, stolen securities, stolen boats, missing persons, unidentified persons, foreign fugitives, and violent felons. In addition, the NCIC 2000 system will provide information regarding probation/parole status, fingerprint searches, mugshot information, generic image information, on-line ad hoc inquiries, and on-line manuals. Use of mobile data terminals, laptops and other wireless technologies by criminal justice agencies have spurred an interest and necessity in immediate, responsive information transfer. Mobile units will be capable of capturing a fingerprint image

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<sup>12</sup> "Information" as used here refers to the uncompressed bit content, not the source entropy, as in a strict theoretical sense.

and transmitting it over wireless communications systems. Likewise, data retrieved from the national level will contain mugshot images which will require relay through the wireless medium to mobile units. As use of these capabilities increases, the demand on law enforcement spectrum allocations will increase.

6.4.3.5 The NCIC requirement is that a 24 kb (or 3 Kbyte) file be provided for fingerprint identification purposes. If a record is on file (based on a fingerprint or demographic identifier search), a copy of the mugshot (from chin to top of head) will also be returned to the requesting officer. These files will be 20 kb (2.5 kbytes). These file sizes have been purposely limited to a size that will create the least impact on the wireless channels. However, due to the current loading on these channels, it is anticipated that many systems will require expanded bandwidth and additional spectrum.

6.4.3.6 Other snapshot applications may be envisioned which require much higher resolutions, such as medical imaging. As an illustration of such an application, a 1024 x 800 pixel image will be assumed. For a full color image, three component colors must be coded per pixel, typically at 8 bits each for adequate color quantization. As a result, one 1024 by 800 pixel color snapshot image contains:

$$\begin{aligned} 1024 \text{ pels} \times 800 \text{ pels} \times 8 \text{ bits/color} \times 3 \text{ colors} &= 19.66 \text{ Mbits} \\ &= 2.5 \text{ Mbytes} \end{aligned}$$

6.4.3.7 As with facsimile, a fairly well established standard compression algorithm exists. The JPEG (Joint Photographic Expert Group) standard, developed jointly by ISO/CCITT, has been developed to support a wide range of compression ratios for still color and grayscale images. The JPEG algorithm operates in two modes: a lossy and a lossless mode. The lossless mode provides modest amounts of compression with no degradation in image quality, while the lossy modes provide varying amounts of compression, which trades off directly for reconstructed image fidelity. It is generally accepted that the JPEG algorithm provides good quality image reconstruction at about 1 bit per pixel, or a 24:1 compression ratio, although this ratio is, like fax, source dependent. As a result of this compression technology, a snapshot image can be represented with good quality at about 820 kbits, or 102.5 kbytes. Of course, higher quality reconstruction may be obtained at the expense of added bits with the lossless mode, but this is a good estimate for high resolution and good image quality.

6.4.3.8 It should be noted that a specific timeline for the implementation of the NCIC 2000 technology requirements has not yet been finalized. However, these technology requirements need to be considered for the purposes of this report.

#### 6.4.4 Video

6.4.4.1 *Slow Video.* This is envisioned as a high resolution video service with very modest frame rates, approximately 1 per second. There are two audio/video

compression standard suites which have seen widespread use: MPEG and H-Series. The ISO's MPEG-2 (Motion Picture Expert Group) standard is designed as a single direction protocol providing audio/video compression, using various spatial and temporal resolutions, targeted at CD-ROM applications, using a compressed rate of roughly 1.5 Mbps for 352 by 240 pixel frame at 30 frames per second with associated audio. The ITU-T's H-Series standard includes a two way protocol and is designed specifically for video communication services like teleconferencing, at a default resolution of 352 x 288 pixels per frame, and varying spatial resolutions from 1-30 fps. The H.261 standard is optimized for coded bit rates of 384 kbps. Both of these algorithms are designed to take advantage of temporal as well as spatial redundancies in the source material to achieve compression. For current planning purposes, it can be assumed that the current implemented art uses H.261 at roughly 384 kbps for the video and associated audio channel.

6.4.4.2 *Full Motion Video*. For the full motion video application, it can be assumed that the same spatial resolution as the slow video application obtains, but that the frame rate is increased to 30 frames per second. For this type of application, the current state of the art is represented by MPEG-2, which as stated above requires roughly 1.5 Mbps for 352 by 240 pixels by 30 frames per second audio/video.

#### 6.4.5 Source Coding Advances 1996-2000

6.4.5.1 As digital processing capability improves, higher complexity compression algorithms will become viable, increasing the compression ratios possible for these services. Semiconductor technology trends show that microprocessor computing speed increases by roughly an order of magnitude every 10 years see Figure 3 and <sup>13</sup>. Special purpose DSP processors, which are more popular for the multiply-accumulate operations prevalent in compression, have demonstrated a similar trend. Thus, by the year 2010, compression schemes more than ten times as complex as those of today should be viable for public safety radio.

6.4.5.2 New directions in compression are already under development to take advantage of this increased processing capability. In the fax arena, a more general standard, called JBIG, has recently been formalized.<sup>14</sup> Although JBIG is not yet widely used, as time progresses, it is likely that the higher compression ratios associated with JBIG will become increasingly attractive to wireless applications. Computed over the same corpus of eight typical fax documents, JBIG provides roughly a 2:1 increase in compression relative to the currently popular Group 3 and

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<sup>13</sup> Patrick P. Gelsinger, Paolo A. Gargini, Gherhard H. Parker, and Albert Y.C. Yin, "Microprocessors circa 2000", IEEE Spectrum, pp. 43-47, October 1989.

<sup>14</sup> ITU-T Recommendation T.82, "Coded representation of picture and audio information: progressive bi-level image compression," 1994.

Group 4 methods. As a result, our assumption of a 3:1 increase in source coding efficiency for fax by 2010 seems reasonable.

6.4.5.3 Haskell and Netravali<sup>15</sup> have quantified the compression efficiency versus complexity issue, by examining compression ratio in bits per Nyquist sample (pixel) in terms of relative complexity for video signals. Drawing from them, with the expected increase of roughly a factor of ten in complexity capability due to advances in microprocessor speed, improved compression ratios on the order of 5:1 should result in compressed data of 0.2 bits per pixel. While this level of compression is exciting, a more conservative estimate is used here: a 2:1 improvement over today's compression ratios, or roughly 0.25 bits/pel, should be achievable by the year 2010.

6.4.5.4 For slow video, MPEG-4 is in its early stages of development.<sup>16</sup> MPEG-4 should provide improved quality over H.263 with additional features, at a coded bit rate of 128 kbps. Importantly, MPEG-4 is the first video coding scheme to explicitly address wireless concerns; the requirements include constant bit rate and error resiliency. A 3:1 increase in slow video coding efficiency is indicated when we assume that MPEG-4 will be implemented by 2010.

6.4.5.5 The source content and compression capabilities of present day technology and expected gains in compression due to algorithmic advances and/or semiconductor technology gains are summarized in Appendix C of this report. These processing advances will allow more complicated, more efficient compression algorithms.

## **6.5 Modulation**

- 6.5.1 Another method of improving improved spectrum efficiency is to increase the amount of information that the communication channel can support. A communication unit moving through an urban environment encounters severe multipath fading. As a result, there are serious limitations to the data rates that are achievable when compared to those in stationary point-to-point communications.
- 6.5.2 Figure 6 shows the modulation efficiency of some representative digital systems that have been marketed for land mobile communications.

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<sup>15</sup> A. Netravali, and B. Haskell, Digital Pictures: Representation and Compression, Plenum Press, New York, 1988.

<sup>16</sup> "MPEG-4 Call for Proposals," ISO/IEC JTC1/SC29/WG11 submission N0997, 28 July 1995.

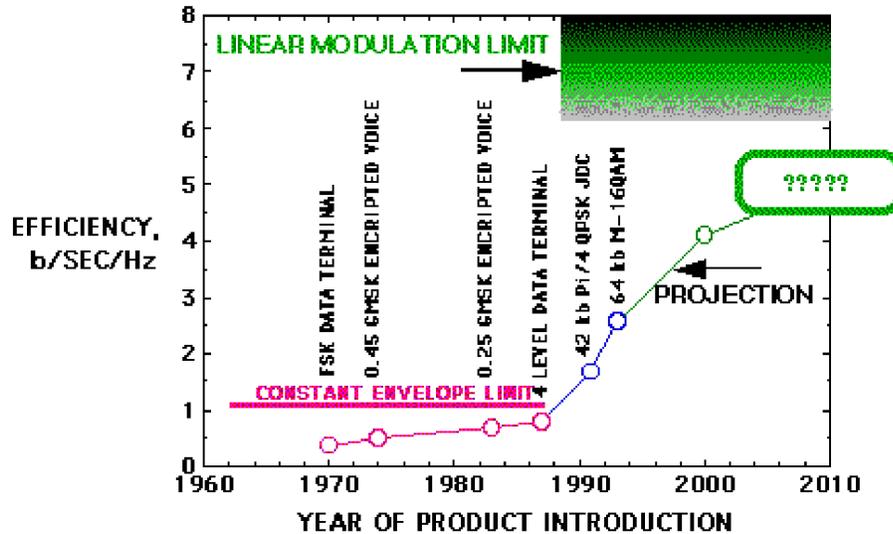


Figure 6 Modulation efficiency

### 6.5.3 Linear

6.5.3.1 Single sideband (SSB) modulation forms a basis for newer linear modulation techniques due to SSB's narrow-bandwidth properties; with standard SSB, the RF occupied bandwidth is identical to that of the information bandwidth. In addition to its spectrum efficient properties, SSB is a waveform preserving system, with the information waveform simply translated to an RF frequency, without the requirement for information source digitization and source coding. This makes SSB suitable for a wide range of information signals.

6.5.3.2 One common challenge of using SSB is its susceptibility to fading encountered in land mobile radio environments. Newly developed techniques are variations on traditional SSB that provide resistance to this fading. Many of these methods have been known for some time, but have only recently become economical to implement because of declining costs in digital signal processing technology.

6.5.3.3 Among the techniques used by current manufacturers of linear modulation technologies is Transparent Tone In Band (TTIB), which applies corrections to the received signal as necessary to produce known pilot tone characteristics, and thus correct the accompanying information signal. Fast Forward Signal Regeneration (FFSR) is also used for improving the performance of TTIB. A new TTIB linear modulation product now undergoing FCC type acceptance can send 14.4 kbps in a single 5 kHz channel, for a spectrum efficiency of 2.88 bits/sec/Hz. Tone Above Band (TAB) performs similarly, but with the pilot tone placed above the information signal instead of at its center.

6.5.3.4 A newly developed SSB technology is Real Zero Single Sideband (RZ SSB), which obtains information from zero crossings of the received signal, making

detected signal quality independent of input RF signal amplitude. Equal-gain combining of RF signals can be used to improve performance by using pilot assisted cophasing circuits. RZ SSB equipment in prototype form can send and receive 19.2 kbps in a single 5 kHz channel, for a spectrum efficiency of 3.84 bits/sec/Hz.

#### 6.5.4 Nonlinear

6.5.4.1 Constant envelope systems have approached 1.28 bit/sec/Hz, considered to be the limit for those systems. However, this advancement has been achieved largely through the use of more complex multi-level, partial response, and channel coding techniques, made possible by the improved performance of digital signal processing hardware.

### 6.6 Multiple Access Techniques

6.6.1 FDMA, TDMA, CDMA, and TDD are different channel access methods. Each has specific strengths and weaknesses. Because of these differences they are each best suited for various applications. FDMA is employed in narrowest-bandwidth, multi-licensed channel operation. TDMA is employed in exclusive license use, moderate bandwidth applications. CDMA is employed for widest-bandwidth in both single system applications such as cellular as well as distributed uncoordinated applications such as the Industrial, Medical, and Scientific band (ISM). TDD is employed to achieve full duplex operation in a single radio channel.

6.6.2 FDMA is the acronym for Frequency Division Multiple Access. In FDMA different conversations are separated onto different frequencies.

- Advantages: Maximizes licensable channels, simplest talkaround, simplest configurations, maximizes range
- Disadvantages: Limits maximum bit rate, duplexer required for full duplex, more stations for multi-channel sites, increases guardbands required.

6.6.3 TDMA is the acronym for Time Division Multiple Access. In TDMA different conversations are separated into different time slots.

- Advantages: Bandwidth on demand, minimizes stations for multi-channels, additional channel(s) for single licensee.
- Disadvantages: Range limited, exclusivity needed, talkaround complex, doesn't increase licensable channels.

- 6.6.4 CDMA is the acronym for Code Division Multiple Access.<sup>17</sup> In CDMA all conversations are separated by code space.
- Advantages: Possible increased capacity and reuse.
  - Disadvantages: Significant bandwidth required, power control complexity.
- 6.6.5 TDD is the acronym for Time Division Duplexing Multiple Access. In TDD, a single radio channel is shared in time to achieve full duplex operation.
- Advantages: Full duplex without duplexer, maximizes licenseable channels.
  - Disadvantages: Range limited, sensitive to timing.

## **6.7 Error correction coding**

- 6.7.1 In radio systems the primary goal is to reliably deliver communications. In digital communications systems this equates to maximizing the ability to successfully receive digitally coded messages. In radio systems this is influenced by a variety of factors such as modulation sensitivity, receiver sensitivity, antenna gain, antenna height, transmitter power, etc. These measures may be impractical or prohibited by rules restricting effective radiated power.
- 6.7.2 Another method of improving signal reception that is specific to digital communications is to employ error control. A simplistic method to improve reliability is to send messages more than once. This has the serious disadvantage of increasing transmission time by the number of times the message is repeated. More efficient methods use error control techniques that add bits to the data stream in a precise fashion. The extra bits, however, are placed in a precise mathematically-prescribed pattern at the transmitter such that complementary circuitry in the receiver can tell when an error has occurred, and determine what the correct bit value should be.
- 6.7.3 Two types of error control techniques are Forward Error Correction (FEC), which provides the ability to receive a correct message even in the presence of transmission errors, and error detection which provides the ability to detect the presence of errors within a transmission. Error detection is often employed in concert with Automatic Repeat reQuest (ARQ), which uses a return channel to request retransmission of corrupted data. FEC is more commonly used in voice communications or one-way data communications, while error detection and ARQ are more commonly used in two-way data communications.

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<sup>17</sup> CDMA is often referred to as spread spectrum, although spread spectrum generally includes CDMA as well as other techniques such as fast frequency hopping.

- 6.7.4 Adding extra bits (redundancy) to the transmitted data stream may at first seem unusual, as increasing transmission rates tends to REDUCE modulation sensitivity. However, as long as the improved success reliability more than compensates for the reduced modulation sensitivity a net gain in communications reliability can result.
- 6.7.5 Often, the added error correction information may amount to 50% or higher of the raw data rate, and significantly reduce the throughput. On the other hand, error detection typically requires only a modest increase in transmission overhead.
- 6.7.6 As described in the earlier section on specific services used in public safety land mobile radio systems, different methods of error control are traditionally applied to different services. Further, errors that escape the error control process vary in their effect based upon the nature of the communications. Voice or video decoders in the receiver can sometimes interpolate what a few missing bits should have been, while error induced text or numeric translation might have serious consequences. However as voice and video coders advance, each transmitted bit generally becomes more important, increasing the importance of error control techniques.
- 6.7.7 In addition to inadequate signal strength or excessive interference, the timing of the received bit energy also affects the bit error rate. In hilly and mountainous areas, and in urban settings, reflections cause multiple signal echoes to arrive at the receiver some time after the signal is received directly from the transmitter. If the directly-received signal is weak due to shadowing, the reflections can be stronger than the direct signal. The reflected propagation path lengths are longer than the direct path, and are often many in number. Such multipath effects are commonly recognized as “ghosting” in broadcast television. Much as ghosting can impair picture quality, multipath distortion can impair the ability of the receiver to determine if a received bit has the value of 0 or 1. Adaptive equalization, while not categorized as a form of error correction, can be used within constraints to alleviate the multipath problem, by determining what the multipath profile of the received signal is, and then adjust the timing of the received signal in the receiver such that the received signal is processed with the inverse of the multipath delay profile, canceling out the multipath effects.

Reference:

Roger Freeman, “Telecommunications Transmission Handbook,” New York, John Wiley & Sons, Inc., 1991, p. 772-778.

## **6.8 Constraints on using various bands**

### **6.8.1 Propagation issues (including air-to-ground).**

6.8.1.1 Radio waves are blocked and reflected by mountains and buildings. These impairments greatly affect the working of mobile radio communications systems. The mobile radio channel presents one of the most difficult engineering challenges

seen in communications engineering. Providing reliable service to mobiles and portables throughout an agency's service area is extremely hard.

## 6.8.2 Multiband/Software radios

6.8.2.1 A software programmable radio is a radio in which the applications are configured under software control and in which the application, in whole or in part, is implemented by software resident in the radio. A software radio requires that the information is presented in a digital format for processing.

6.8.2.2 The software radio is seen by proponents as having several advantages. A number of applications can be hosted on the same hardware platform, which reduces the total amount of equipment required. The radio can be upgraded without changing the hardware for increased effectiveness and cost savings. New multimode/multiband capabilities can be achieved efficiently through dynamic allocation of radio assets in a multimode installation, including bridging among different air interfaces, which can facilitate interoperability in fixed and mobile applications.

6.8.2.3 Functional integration is used in the software radio to reduce the number of radio types into a single general-purpose programmable waveform processor. It is possible for multiple military, law enforcement, and commercial air interface standards to be implemented in a single radio, despite different physical layers (modulation, frequency bands, forward error correction), link layers (link acquisition protocols, link maintenance, frame/slot processing), network layers (network protocols, media access protocols, network time maintenance), upper layers (source coding), timebases and bandwidths.

6.8.2.4 The software radio can be compared with the personal computer (PC), with the PC's operating system functioning similarly to the software radio run time system, which runs applications under a high order language. The radio operating system is a set of utilities and interfaces that control the flow of information within the radio, and can be computed with the basic input output system (BIOS) of the PC. Unlike the personal computer, the software radio requires real-time processing to process a continuous signal, and requires low-latency processing for real-time acquisition responses.

6.8.2.5 The military is placing an increasing emphasis on digital radio technology because of its potential for lower cost, reconfigurability for multimode/interoperable communications. A current military project developing a software radio is the Speakeasy multiband multimode radio program. Hazeltine is the prime contractor, with TRW, Rockwell, Motorola, Martin Marietta, and Texas Instruments as major subcontractors. The goal of the program is to develop an open system architecture for radio service and demonstrate interoperability of multiple and simultaneous waveforms across a frequency range of 2-2,000 MHz.

6.8.2.6 Aspects of the program include study of a 2-2,000 MHz front end, implementation of a 2-2000 MHz (contiguous) RF subsystem, assessment of alternate processor technologies, multi-chip module integration, and wideband HF, VHF, and UHF antennas. Emphasized in the Speakeasy program is open bus standards to foster competition, third-party participation, evolutionary technology insertion, and reduced life-cycle costs. Also being studied is an open application programmer's interface, which eases design and integration, eases software maintenance, and encourages new applications and third-party participation.

6.8.2.7 There are many challenges to producing a practical and economical software programmable radio. Antenna systems must operate across a wide frequency range; a single multiband antenna systems is preferable to many antennas for different frequency bands. These antenna systems may be augmented with "smart" antenna technology to increase range and node density. Other enabling technologies under study include multiband power amplifiers, tunable preselectors, interference cancellers, low-noise synthesizers, wideband low noise amplifiers, wideband linear mixers, high- throughput digital signal processors, and smaller chip packaging.

6.8.2.8 Software radios are now much more expensive than hardware-based radios, with the market being confined to military, big business, and government applications. Over time, the cost of software radio enabling technologies will decrease as does the cost of digital signal processing chips, analog/digital and digital/analog converters, and memory and interconnection hardware. It has been projected that, within a few hardware generations, software radios will sufficiently leverage the economics of advancements in microelectronics, and provide seamless communications at a vest-pocket and palmtop level of affordability and miniaturization.

6.8.2.9 To summarize, as radio protocols and air interfaces become more complex, software-based technology solutions will play an increasing role. Software radios can be effective for facilitating interpretability by providing for multiple wireless standards at a single cell site, and for accommodating roaming mobiles crossing system boundaries.

References:

Patrick B. Tilley, Hazeltine Corporation, "Software Programmable Radios," Presentation to the Federal Communications Commission, November 2, 1995.

Joe Mitola, "The Software Radio Architecture," IEEE Communications Magazine, May 1995, p. 26.

## **6.9 Backbone System Elements**

6.9.1 Most public safety mobile communications systems need a reliable backbone to carry signals to and from the base station sites to the control points. Historically, many of these links have been provided over microwave connections operated by

the public safety agency. Leased lines obtained from the local telephone companies have also been used.

- 6.9.2 We expect the future supply of backbone system elements to look much like the past but with two major exceptions. First, the lowest microwave frequencies (2 GHz) are no longer available for such backbone systems. Rather, such systems will have to be established at higher frequencies where rainfall attenuation may pose a greater problem. Such propagation problems may restrict the length of microwave hops and raise the cost of new systems.
- 6.9.3 We also expect fixed microwave systems to continue to improve and additional digital capabilities are built into the radios. Modern microwave radios already allow for integration of their systems into current technology operations and management systems (OMS). We expect such trends to continue. Similarly, we expect that microwave radios will evolve to support the latest signal formats (e.g. ATM).
- 6.9.4 The second exception is the supply of facilities by the local carriers. Historically, only one firm, the local telephone company, provided telecommunications services for hire. However, changes in law and technology have led to the entry of new competitors in many markets and the probability of extensive further entry. We expect that most urban areas will have several firms offering ground-based fiber connectivity. Firms offering such services are now known as competitive local exchange carriers (CLECs). Such firms include MFS, Teleport, local cable companies, and even AT&T and MCI. Many of these fiber systems will use a ring architecture, allowing service to continue even if the fiber is cut at one point. Such backup capabilities give modern fiber rings substantially higher reliability than traditional copper wire telephone services. It is reasonable to expect that fiber rings will provide connectivity to many public safety communications centers and to many of the major antenna sites. Modern (1996 state-of-the-art) fiber system provide the most capacity of any widely used communications technology. Operational fiber systems carry gigabits per second of capacity on a single fiber. The theoretical capacity is far higher. Considering all these factors it is reasonable to conclude that these commercial fiber systems could provide valuable backbone alternatives for many public safety communication needs. However, the use of any ground-based carrier for public safety systems in earthquake-prone areas may be undesirable. In contrast, in areas affected by hurricanes, such as the southeastern coastal areas, an in-ground fiber network could be preferred.
- 6.9.5 Fiber is another option for high-density ground-based systems. The long distance carriers abandoned microwave for fiber not only because fiber had greater capacity and a lower error rate but because it was a less costly technology. In most fiber systems the largest cost is for the installation of the fiber itself. If municipalities have access to utility rights-of-way or utility poles, this cost can be markedly lowered. Self provision of fiber systems by public safety agencies will remain a valuable alternative in the years to come.

## 6.10 Performance Modeling and Verification

- 6.10.1 As wireless communications systems evolve, the complexity in determining compatibility among different types of such systems increases. Geography, frequency, modulation method, antenna type, and other such factors impact compatibility.
- 6.10.2 Spectrum managers, system designers and system maintainers have a common interest in utilizing the most accurate and repeatable modeling and simulation capabilities to determine likely wireless communications system performance. With increasing market competition in wireless communications systems, in terms of both technical approaches offered and the number of entities involved, a standardized approach and methodology is desirable for the modeling and simulation of wireless communications system performance. Such an approach should be technology neutral, and consider a variety of technical practices at all frequency bands of interest.
- 6.10.3 In addition, subsequent to wireless communications system implementation, validity or acceptance testing is often an issue subject to much debate and uncertainty. Furthermore, long after a system is in place and optimized, future interference dispute resolution demands application of a unified quantitative methodology for assessing system performance and interference.
- 6.10.4 The Telecommunications Industries Association (TIA) Land Mobile Radio Section TR-8 WG-8.8 Technology Compatibility Committee is working under a charter and mission statement to address the following technical challenges:
- Accommodating narrowband/bandwidth-efficient technologies likely to be deployed as a result of the Commissions “Spectrum Refarming” efforts;
  - Assessing and quantifying the impact to existing analog and digital technologies from new narrowband/bandwidth- efficient digital and analog technologies;
  - Assessing and quantifying the impact to new narrowband/bandwidth efficient digital and analog technologies from existing analog and digital technologies; and
  - Addressing migration and spectrum management issues involved in the transition to narrowband/bandwidth-efficient digital and analog technologies. This includes developing solutions to the spectrum management and frequency coordination issues resulting from channel splitting from 25 kHz to 12.5 kHz, and from 25 kHz or 12.5 kHz to 7.5, 6.25 kHz or 5 kHz channel

spacing, as well as increases in capacity of existing channels to provide equivalent narrowband spectrum efficiency.

- 6.10.5 To accomplish these objectives, the WG-8.8 Committee is working with the Institute of Electrical and Electronic Engineers (IEEE) Vehicular Technology Society's (VTS) Propagation Committee. The IEEE Propagation Committee's contribution to this technology compatibility effort is in the area of supporting development and adoption of standard two-dimensional (2D) and three-dimensional (3D) electromagnetic wave propagation models, a diffraction model, and standards pertaining to the selection of terrain and land use data bases. The propagation related effort shall be generalizable to the electromagnetic wave propagation modeling and simulation of both current and future land mobile wireless systems.
- 6.10.6 WG-8.8 has noted a TIA commitment to the spectrum refarming effort, a request from APCO Automated Frequency Coordination, Inc. for post refarming technical support, and a request for expansion of the Committee's work by the Land Mobile Communications Council (LMCC). The WG-8.8 effort has focused on the following:
- Establishment of standardized methodology for modeling and simulating narrowband/bandwidth efficient systems operating in a post "Refarming" environment;
  - Establishment of a standardized methodology for empirically confirming the performance of narrowband/bandwidth efficient systems operating in a post "Refarming" environment; and
  - Aggregating the modeling, simulation and empirical performance verification standards into a unified "Spectrum Management Tool Kit" that may be employed by frequency coordinators, system engineers and system operators.
- 6.10.7 The Committee's draft document, entitled "On the Standardization of a Methodology for the Modeling, Simulation and Empirical Verification of Wireless Communications System Performance in Noise and Interference Limited Systems Operating On Frequencies Between 30 And 1500 MHz," is near completion, and is intended to ultimately serve as a standard to define the compatibility criteria of the various different modulation types using terms consistent with overall TIA and IEEE land mobile efforts.
- 6.10.8 The expressed purpose of the document is to define and advance a scientifically sound standardized methodology for addressing technology compatibility. This document provides a formal structure and quantitative technical parameters from which automated design and spectrum management tools can be developed based on proposed configurations that may temporarily exist during a migration process or for longer term solutions for systems that have different technologies.

- 6.10.9 The document puts forth a standardized definition and methodology for a process for determining when various wireless communication configurations are compatible. The document contains performance recommendations for public safety and non-public safety type systems that should be used in the modeling and simulation of these systems. The document also attempts to satisfy the requirement for a standardized empirical measurement methodology that may be useful for routine proof-of-performance and acceptance testing and in dispute resolution of interference cases that are likely to emerge in the future.
- 6.10.10 To provide this utility requires that various performance criteria be defined for the different modulations and their specific implementations by specific manufacturers. Furthermore, sufficient reference information is to be provided so that software applications can be developed and employed to determine if the desired system performance can be realized.
- 6.10.11 Wireless system performance will be modeled and simulated with the effects of single or multiple potential distortion sources taken into account. These sources include:
- Co-channel users
  - Adjacent channel users
  - Internal noise sources
  - External noise sources
  - Equipment non-linearities
  - Transmission path geometry
  - Delay spread and differential signal phase
- 6.10.12 Predictions of system performance will be based on the desired RF carrier versus the combined effects of single or multiple performance-degrading sources. Performance will be based on a faded environment to more accurately simulate actual usage and will consider both signal magnitude and phase attributes.
- 6.10.13 It is anticipated that the document will serve as the standard reference for developers and suppliers of wireless communications system design, modeling, simulation and spectrum management software and automated tools.
- 6.10.14 It is envisioned by WG-8.8 that future wireless systems that employ the WG-8.8 standard in the design, modeling, simulation, and implementation processes will benefit from consistent performance as designed. Furthermore, the Committee expects that spectrum management based upon the same precepts and standard will not only be “consistent” with the designs submitted, but will be more accurate and more flexible accommodating each unique set of conditions rather than relying upon generalized tables and “rules-of-thumb.”
- 6.10.15 Since the migration from the analog world of today to the digital future will be gradual, it is anticipated that there will be additions to the collective knowledge

base. Therefore, on a regular basis, initially on an annual basis, the WG-8.8 document will be revised based upon the receipt of relevant additions and/or corrections. Updates will also be issued that reflect refinements as requested by the body of systems designers, and spectrum managers who will ultimately be the users of this standard.

## **7.0 COMMERCIAL SERVICES — TECHNOLOGICAL CAPABILITIES AND DEVELOPMENTS**

### **7.1 Background**

- 7.1.1 Many present and future technological capabilities are (or will be) developed for large commercial service providers or government systems. Commercial services presently complement those which are developed by public safety agencies, where any combination of user density, offered load, geographic area, or other similar factors do not justify development of dedicated systems or expansion of existing networks.
- 7.1.2 Commercial services are motivated to derive the maximum utilization and efficiency from large systems and limited spectrum. As market penetration increases, carriers are more inclined to improve coverage, expand capacity, and provide additional features to allow (encourage) higher utilization and increased income.
- 7.1.3 Public safety agencies often utilize the existing commercial services as an adjunct to the systems which they have developed to provide their essential services. Those essential services (such as voice dispatch) may have unique operational, availability, or security needs, or may be more economically feasible and desirable. In the future, as usage of and dependence on these services increase, public safety agencies might elect to “partner” with commercial services (for customized services or features), or develop their own systems utilizing similar technologies. Their decision will depend on many factors, including cost comparisons, security, reliability, priority availability and access, and restorial, service area and feature requirements, and system administration.
- 7.1.4 Likewise, as regulatory and technological changes are made, commercial systems will likely evolve to provide universal services such as voice dispatch, data services, and electronic messaging. These services may also address the other issues above to meet the demands of their subscriber base.

### **7.2 Mobile Satellite Systems**

- 7.2.1 Commercial Mobile Satellite Systems started in the 1970's when COMSAT offered service in the Atlantic for shipboard communications through its MARISAT system. This was subsumed into the International Maritime Satellite Organization (INMARSAT) when it was formed. In the early days, INMARSAT installations

cost about \$50,000 each, and tariffs were \$10 per minute. Both have been reduced significantly in recent years. INMARSAT became global and ultimately changed its name to International Mobile Satellite Organization (INMARSAT was retained). It now offers worldwide aeronautical, land and maritime mobile telecommunications. Some interim operations have been allowed in the U.S., but with commencement of mobile satellite operations by the American Mobile Satellite Corporation (AMSC), INMARSAT will not be allowed to provide land mobile communications in the U.S. because there is a domestic alternative with an exclusive license.

7.2.2 Recently, INMARSAT created another organization, ICO Global Communications to provide non geostationary mobile satellite communications from an Intermediate Circular Orbit (ICO). ICO has received substantial investments and awarded satellite construction contracts to Hughes Space and Communications International. The system will include two orbits of five operational satellites in two different 40 degree planes with one in orbit spare satellite for each plane. Satellites will orbit at 10,355 kilometers. Licensing issues for service in the U. S. are not resolved.

7.2.3 In the U. S., three “Big LEOs” have been licensed by the FCC. Big LEO means satellites in low or medium earth orbit operating above 1 GHz and providing both voice and data. “Little LEOs” operate below 1 GHz and provide data service only. The three big LEO licensees are: Motorola’s Iridium, Loral/Qualcomm’s Globalstar, and Odyssey Telecommunications International, Inc.’s Odyssey where TRW Inc. and Teleglobe Inc. are the founding shareholders. Mobile Communications Holding, Inc.’s Ellipso has a pending application before the FCC to join the other three.

7.2.4 It is expected that all the Big LEOs plan to offer service late in this century or early in the next with dual mode satellite\cellular telephones. Currently, ORBCOMM is the only Little LEO in operation. It has two satellites in orbit, and beta testing is in progress. To provide continuous coverage over the U.S., 26 satellites are necessary. This constellation is planned for full deployment by the end of 1997. As these systems are placed in operation and their user terminals tested in quantity, much more will be learned about their ability to support emergency communications.

7.2.5 While Mobile Satellite Systems may be able to provide some public safety-related communications capability, concerns have also been expressed that both Big LEOs and Little LEOs may infringe on current public safety spectrum. Some Big LEOs are seeking radio frequencies in the 2 GHz bands now used for public safety microwave operations, and Little LEOs have advocated sharing UHF, VHF, and 800 MHz land mobile spectrum.

7.2.6 Constellations/coverage

7.2.6.1 Satellite systems support thousands of voice channels and in many spot beams are used so that some frequency reuse is possible. Satellite services are

completely digital thereby facilitating National Security Agency encryption systems, as well as, commercial voice privacy alternatives. Public safety agencies and others may lease dedicated channel(s) for their exclusive use. Dispatch, push-to-talk, and "party line" talk group services are available. Voice, data, fax, and location services are possible through automatic connections to the public networks. Dual mode satellite/cellular, satellite only, transportable and fixed site systems are available. In some cases, duplicate coverage will be supplied. Capacity sharing and backup support agreements are provided so there will be no single point of failure in the space segment.

7.2.6.2 The public safety community would not require dedicated satellites costing billions of dollars. Dedicated satellite systems are unnecessary. Future public safety systems can rely on the public switched and data networks and commercial mobile satellite systems to avoid costly infrastructure investments. Even DOD is moving in this direction. Public safety organizations cannot create the management structure, obtain regulatory approval and raise money for dedicated satellite systems. A better approach is to follow and influence developments of these systems, use them, and factor requirements into existing and future systems.

7.2.6.3 Dual mode satellite/cellular radios cost about \$2500 per unit; the per minute charges are \$1.49 or less including terrestrial long distance charges. Talk groups can be established for \$100 per month, and practically unlimited users may join them for \$70 per month. The \$70 per month allows dispatch and unlimited talk time for users. An organization could buy 1000 radios for \$2.5 million and operate them in 100 talk groups for about \$80,000 per month. Up to 35 users per circuit can be accommodated -- so 100 talk groups per 1000 users is conservative. On the AMSC system, a user may belong to 16 different talk groups. A state with such a system could deploy units gathered throughout the nation to respond with units to an Oklahoma City type disaster. Arriving units would be ready to communicate anywhere, anytime, provided there is a clear view to the south. Talk groups could be rearranged over the air in minutes without touching the installed equipment. The GPS interface could provide position locally or to transmit it to distant control stations for automatic tracking of responders. Differential GPS corrections are available via the AMSC system to provide accuracies better than 10 meters.

## 7.2.7 Priority Access

7.2.7.1 Priority access to the mobile satellite system may be assured in several ways. Channel priorities may be implemented by techniques ranging from access to the next available channel to preempting existing users; however, preemption is fraught with practical and public relations difficulties. In the early years of operation where capacity limit problems are not expected, setting aside a few channels for emergencies may be the desired approach. With these as an initial cushion, the highly dynamic nature of calls on and off the systems will allow timely access to channels as needed.

7.2.7.2 Priority designations will be lost when communications enter the Public Switched Telephone Networks as they are currently configured unless dedicated lines are provided between gateway stations and public service agencies. Overloaded telephone systems during an emergency are common. Priority access via the PSTN or dedicated lines will be required for an effective emergency system. One such method is "GETS", the Government Emergency Telecommunications System.<sup>18</sup>

Reference:

White Paper "Mobile Satellite Systems," February 27, 1996, prepared by M. Edward Gilbert, RADM, USCG (Ret.), President, Gilbert & Associates, on behalf of American Mobile Satellite Corporation (AMSC).

### 7.3 Cellular Telephone Systems

7.3.1 Cellular telephone systems are an outgrowth of, and improvement on early mobile telephone systems. Those early systems relied on a small number<sup>19</sup> of channels, each served by a single base station covering the widest possible geographic area. Even though the communications were between two parties (usually, only one of which was mobile), "blanket coverage" was provided to the entire area. Obviously, this type of system had serious capacity limitations, and was not spectrum efficient because it limited channel reuse.

7.3.2 The concept of cellular systems is to utilize a number of fixed sites, arranged and connected as a network of "cells." Lower antenna heights are used; and transmit power is limited and controlled dynamically to the lowest possible level, while ensuring quality communications. All sites are connected to the public switched network and controlled from a central location, typically referred to as the mobile switching center (MSC) or mobile telephone switching office (MTSO). As power and antenna heights decrease, the smaller coverage area of each cell allows greater channel reuse. The lower power and closer proximity to subscribers also makes portable operations more feasible.

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<sup>18</sup> The Government Emergency Telecommunications Service (GETS) supports national security and emergency preparedness (NS/EP) requirements for use of the public telephone network by Government departments, agencies, and other authorized users. Developed in response to White House tasking, GETS provide s authenticated access, enhanced routing, and priority treatment in local and long-distance telephone networks. GETS access is through a simple dialing plan and personal identification number (PIN) and provides switched telephone service that can be used for secure or unsecure voice and voice-band data services. It s implementation consists primarily of software enhancements to the signaling networks and switching systems of the major communications carriers, both local and long distance. As such, the program is leveraged t o provide maximum capability at a minimum investment, to exploit technology improvements in the installed systems, and to provide NS/EP support with an inexpensive "service", rather than an expensive, dedicated "system."

<sup>19</sup> Thirty-four (34) channels were available to telephone companies, among three services in three bands, with a maximum of 12 channels available in any system. The largest systems typically had no more than si x channels, owing to overlapping systems which covered adjacent geographic areas.

- 7.3.3 Smaller coverage areas mean that traveling subscribers might lose service during a call. To counter that problem, each cell in the system continuously monitors call quality, and when necessary, hands ongoing conversations off to a site which can provide better service at the mobile subscriber's present location. These hand-offs typically require less than 0.3 seconds, and are barely noticeable to either party.
- 7.3.4 In rural areas, cells may be designed with much larger coverage areas, and initially equipped with relatively few channels to serve the small number of users. Doing so allows the initial investment in infrastructure to be scaled, making initial market penetration easier to accomplish. As the number of subscribers and demand for service increase, additional channels and cells may be added, and the coverage area of existing cells can be reduced. As traffic density increases in high use areas, cells may be subdivided further into sectors, but served from the same site using directional antenna systems (commonly referred to as cell splitting).
- 7.3.5 Several years of delay were experienced as cellular technology and the regulatory framework for its implementation were developed. As a result of the regulatory framework, cellular carriers were prohibited from providing other services such as voice dispatch and one-way paging; mostly because of concerns over unfair competition and market advantage. Even though many services could have been implemented technically, the equipment, systems, and software developed under initial regulatory constraints is still not capable of providing many needed services.
- 7.3.6 Initially, 40 MHz was allocated for cellular services from spectrum which had previously been allocated as UHF television channels.<sup>20</sup> This spectrum was organized into 30 KHz duplex channels, with all 666 initially envisioned for assignment to a single service provider in each geographic area. Final regulations divided the spectrum into two blocks of 333 channels each, to encourage competition through a duopoly of services. Over 700 cellular geographic service areas (CGSAs) were defined, with 305 metropolitan statistical areas (MSAs) containing the most populous cities. The remaining areas are considered rural service areas (RSAs). One of the blocks (designated B) was set aside in each "market" area for the wireline common carrier (telephone company). The other block (designated A) was assigned<sup>21</sup> to interested common carriers which did not provide wireline services to that same market. In 1986, an additional allocation of 5 MHz (166 channels) was divided equally between the two existing blocks.
- 7.3.7 Service requests, call supervision, and mobile "paging" calls are accomplished on 21 setup channels in each block (313-333 and 334-354). The A and B band setup channel blocks are contiguous so that synthesizers can scan quickly between

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<sup>20</sup> Parts of television channels 73-77, and 80-83.

<sup>21</sup> Initial assignments were made by comparative hearings, but the large number of speculators delayed the licensing process and deployment of systems. Later assignments were made by lottery drawing, from a pool of qualified applicants in each market.

systems in either band. Mobile subscribers use a self locating scheme, where inbound requests are made on the setup channel having the strongest received signal (hence probably the best, if not closest server). Because of this approach, a broadcast “paging” message must be sent from each cell’s setup channel for each outbound call. The called mobile responds through the best serving cell (which it is already monitoring), making its approximate location in the system known. Because a large majority of calls are initiated from mobile subscribers, the inefficiency of this paging method does not negatively impact system performance.

- 7.3.8 Current cellular systems have several attributes which limit their appeal to public safety users. As mentioned earlier, cellular systems were not developed to provide dispatch services. Subscribers must be registered in the system, and the unique identification of the desired unit(s) must be known to the system and calling party. Broadcast type communications are not supported, so it isn’t possible to make an “all call” to any unit available to respond. Because of the full duplex nature of subscriber equipment (and lack of a push-to-talk button), a conversation between mobile subscribers requires one “bearer” channel for each unit involved. Talk group calls between multiple units could easily consume all available channels in a cell. One of the greatest concerns to public safety agencies is the lack of priority access and availability to their units. A subscriber’s service options may also be limited if the available carriers adopt incompatible technologies to improve spectrum efficiency or increase capacity. Direct system monitoring and unit access control is not available to managers, making administration and cost control difficult.
- 7.3.9 Cellular systems are designed to provide adequate capacity during most peak periods, but they are still vulnerable to overload and abuse<sup>22</sup> during large incidents or special activities. Cellular systems have also suffered significant loss of service or capacity (due to hardware failure) during the initial hours of major natural disasters. With the proposed cellular priority access scheme, state and local government users would be limited to no more than level three (of five) access. Most proposed priority access schemes will not preempt calls in progress. To do so presents a risk, but as long as preemption is prohibited, callers may continue to abuse the system once access is gained. Mobile systems are also available and marketed to television broadcasters, which utilize six simultaneous cellular connections to send “video feeds” back to their studios from the field. One minute of full motion broadcast quality video is provided for each eight minutes of connect time. The presence of such anonymous users at a public safety incident can severely impact the grade of service provided by any cellular system.

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<sup>22</sup> During disasters, “non-public safety” cellular subscribers have been known to access a channel, make a call to their “home base,” and keep the connection open continuously (placing the handset in the seat of a vehicle), so that it would be available when needed. Even when accumulating usage fees over several hours, some deem it a small price to pay to ensure availability in a competitive environment.

- 7.3.10 In spite of the limitations mentioned here, cellular telephones are able to meet certain aspects of public safety communications needs. For instance, they are useful for communications between public safety field personnel and the public being served. Cellular telephones can also provide communications with other adjunct members of the public safety system (regional or specialty service facilities, off-duty specialists, security personnel, etc.). Contact with these adjunct members might be difficult or impossible otherwise. The need rarely justifies the associated fixed equipment, or the compromises in security necessary to provide access. Personnel can use cellular telephones when they are out of their normal service (coverage) area, or when in areas that cannot be economically served by the primary system.
- 7.3.11 Cellular telephones are also preferred by many public safety agencies as an alternative to carrying telephone interconnect traffic (and consuming large percentages of available capacity) on essential voice channels. Some public safety agencies use cellular phones to backup wireline telephone trunks, or to provide dial tone on demand at itinerant locations where little notice is given. These uses are likely to be effective only during localized hardware or trunk failures or isolated needs; not during widespread outages of the public switched telephone network.

#### **7.4 Cellular Digital Packet Data (CDPD)**

- 7.4.1 Even with the proliferation of analog cellular systems, circuit switched communications are still not popular for general data applications. Circuit switched usage fees are based on connect time, not data volume. Short interruptions during handoffs between cell sites are often imperceptible during voice conversations, but most data communications equipment sends (and expects to receive) a continuous carrier signal. Special precautions must be taken to prevent loss of established connections, and to retransmit information lost or impaired during brief interruptions or fades. Often, digital message traffic is short and sporadic, but frequent. It is not cost effective (or efficient) to maintain an established connection for sporadic data bursts with a low average utilization. Alternatively, the time to establish a connection may exceed by magnitudes, the duration of the messages to be sent.
- 7.4.2 A standard method was devised to allow analog advanced mobile phone system (AMPS) cellular voice channels to carry high speed packet switched data communications during otherwise idle times. Cellular Digital Packet Data (CDPD) systems were developed to transport data to (or between) cellular users without the need to set up a traditional call. Since communications are "connectionless," usage is determined by traffic volume instead of session duration. The bursty nature of many data systems allows messages to be packetized and transported during those idle times, with little or no perceptible impact on response times.
- 7.4.3 CDPD systems can be implemented with no additional spectrum for control or traffic channels, and relatively little additional infrastructure. Since systems can be overlaid on existing cellular networks, work to increase utilization, and generate

additional revenue, they are very attractive to carriers. They are also attractive to users, since wireless data communications can be obtained over a well defined coverage area, with much lower (or no) capital costs for infrastructure. A group of CDPD users may also share fixed end interface equipment (where necessary), with limited connection to the cellular network. This could make the service affordable for smaller users who would not otherwise be able to justify the fixed equipment cost.

- 7.4.4 CDPD systems support a “raw” data rate of 19.2 kbps. The systems monitor the control channel in their own cell, and “sniff” voice channel activity in adjacent cells, utilizing only idle channels. If the CDPD system detects assignment of, or activity on a voice channel that it is using, it interrupts its own data stream on the channel immediately, and the next packet is passed over another idle channel. The systems are built on an Internet Protocol (IP) foundation, and applications may use either the Transmission Control Protocol (TCP) or the User Datagram Protocol (UDP). Transmission of data is transparent, allowing encryption of user information, if desired.
- 7.4.5 System developers are able to easily adapt most TCP/IP based software applications for CDPD transport. Care must be taken, however, since some TCP/IP based software applications are verbose, and developed considering a relatively usage insensitive cost model. As messages get smaller, they become a smaller percentage of the total transmission. Characters associated with session control, acknowledgment, flow control, and packet retransmission are passed through on CDPD systems, along with the actual message, and the customer may be charged for those additional characters. Pricing packages vary greatly among providers, and should be analyzed carefully when considering the use of CDPD. It is important for users to understand the impact of different pricing structures in deciding which transport method to use. Users who are planning to purchase or develop software applications should make sure that TCP is used only where appropriate.
- 7.4.6 The alternative (UDP), provides an “unreliable” delivery mechanism. Reliability in this sense relates to the fact that data packets may be lost; errored; duplicated, or improperly sequenced (by arriving through different traffic pathways); or dropped by message overruns and the lack of flow control at the receiving end. When using UDP, reliability is the responsibility of the application program.
- 7.4.7 Some economies can be gained for “chatty” applications (such as automatic vehicle location) by using UDP, but additional care must be taken by the application software to ensure “reliability.” For instance, if vehicle location packets are serialized before transmission (and the sequence number sent as part of the user’s location information message), the receiver may still detect missed packets. If location information is being sent every 30 seconds, an occasional missed packet can be detected, but will probably not affect long term reliability, and need not be retransmitted. If location information is received out of sequence, the problem can

be detected and handled by the application program. If location information from a vehicle is interrupted unexpectedly for an extended period of time, that too can be easily detected and reported by the application program. These methods allow one-way inbound messaging, with outbound messages necessary only for exception handling.

7.4.8 Because UDP and TCP both rely on IP, they can both be used (concurrently) for different applications. TCP can support mobile data applications, while UDP serves other less critical needs, possibly with higher information content. Applications may also switch between TCP and UDP, depending on the current status of the user, or whether the messages are routine or urgent.

7.4.9 Some “traditionally wired” networks also poll all users on a frequent basis to enquire whether they have traffic, and to ensure connection. “Spoofing” can be provided by the wireline interface to handle actual traffic on the wireless side, and act as an agent for the wireless equipment. It will “answer” enquiries from the wireline network without generating additional unnecessary traffic on (or costs for/delays in) the wireless network.

7.4.10 Hybrid systems are also under development which can operate in a packet switched mode (CDPD) for small bursty transactions, or in a circuit switched packet mode (still IP based, but with an established and guaranteed connection) for larger volumes or more time sensitive information.

7.4.11 Even though CDPD equipment does not rely on a connection, it does rely on the availability of an idle channel for brief periods. As channel utilization approaches unity, the availability of idle channel time diminishes. Without some method to provide priority access, CDPD users are subject to the same delays or unavailability of service during peak periods that traditional voice users encounter. Delays may also result in increased CDPD traffic, since packets may be properly received, but not acknowledged within the timeout window. If public safety providers are to rely on this technology, some method of priority access (or dedicated capacity) must be provided.

## **7.5 Personal Communications Services (PCS)**

7.5.1 Action taken at the World Administrative Radio Conference (WARC) of 1992 upgraded to primary status, future public land mobile telecommunications systems (FPLMTS) between 1.7 and 2.6 GHz. As a result, the FCC made approximately 140 MHz of spectrum available for Wideband Personal Communications Services near 2 GHz, with more held in reserve, possibly for future mobile satellite service. Additional channels were reallocated in the 900 MHz band, referred to as narrowband PCS.

7.5.2 The Federal Communications Commission devised a plan to auction the available spectrum to interested parties, who could then provide personal communications

services (PCS) for public benefit at a profit. By auctioning the spectrum, the FCC avoided the problems of earlier assignment schemes, curbed speculation, generated government revenue, and motivated auction winners to develop systems quickly and maximize spectrum efficiency. No standard technology was mandated for these services, because the FCC felt that service providers should be free to employ the technologies that are most appropriate for their service, market and investment goals.

- 7.5.3 The FCC designated four different levels of “marketing” areas. The first level is a nationwide assignment. The remaining areas of operation, or “markets” are derived from the 123rd edition of the Rand-McNally Commercial Atlas and Marketing Guide and adopted for use with few exceptions and changes. The United States is divided into 51 Major Trading Areas (MTAs) and 493 Basic Trading Areas (BTAs). BTAs are not distinct from MTAs, they just represent a finer detail of local market areas. The FCC then created five regional markets, defined by the MTAs that they encompass.
- 7.5.4 In the 900 MHz band, the FCC reallocated 26 “narrowband” channels for PCS. The channels are divided into four distinct groups. The first group includes 11 channels, which are allocated on a nationwide basis. The second group of six channels will be licensed in each of the five designated regions. Seven channels will be licensed in each of the MTAs as described earlier. The two remaining channels will be licensed in each of the BTAs. No single licensee will be allowed to aggregate more than three channels.
- 7.5.5 Three types of channels were developed. The first type is a two-way, paired 50 KHz channel with 39 MHz transmit-receive spacing, which can support full two-way voice or data messaging. Asymmetric paired channels are allocated with a 50 KHz “forward frequency” and 12.5 KHz low speed “return frequency” for limited responses from subscriber units. Those channels have approximately 29 MHz transmit-receive spacing. The final type of channel is a 50 KHz unpaired channel intended for one way-paging or messaging.
- 7.5.6 The FCC created seven blocks from 140 MHz in the 2 GHz band. Six of the blocks contain upper and lower allocation sub-blocks, separated by 80 MHz. The A and B bands were each allocated 30 MHz, to be assigned in each of the MTAs. The C band was allocated 30 MHz, for assignment in each of the BTAs to designated entities (minority and small business entrepreneurs). The D, E, and F blocks were also allocated 10 MHz in each of the BTAs. The D and E blocks are available for assignment to any eligible bidder, but available to the incumbent cellular carriers (whose participation is otherwise limited).<sup>23</sup> The F block is intended for assignment

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<sup>23</sup> A cellular carrier may be licensed to provide PCS in an area, if there is less than 10% overlap between their cellular market area, and the BTA or MTA license that they would hold. In the case of an overlap of more than 10%, cellular licensees are limited to one 10 MHz license in that same area.

to designated entities as described above. Finally, the unlicensed UTAM block is one contiguous 20 MHz block of spectrum between the two sub-bands. UTAM systems are likely to be private wireless PBX systems, wireless local area network devices, etc.

- 7.5.7 Due to propagation characteristics of the band, most 2 GHz systems are expected to be developed using a micro-cellular architecture, serving the most populous metropolitan areas using a network of closely spaced stations. Service in lower demand areas will be provided by systems with antenna heights, output power levels, and coverage areas which are more in line with today's cellular systems. Both are intended to provide subscribers with enhanced features and untethered access to the public switched telephone network.
- 7.5.8 Services provided by PCS licensees will vary, but can range from consolidating what are now separate services (cellular, paging, wireline telephone, mobile data), to the provision of very specialized services. For instance, vending machines have been equipped with wireless devices to provide information on remaining inventory, total receipts, empty change bins, mechanical problems, or burglary. The device could be supported by a wireline circuit, but the mobility of the vending machines — which are often moved regularly from one location to another — is limited as a result. The “wireless solution” allows flexibility, freeing the device from the limitations of wireline networks (physical connections and identification constraints). A PCS device can thus reduce the need for unnecessary trips to vending machines on a route, while improving the level of service; a highly specialized service.
- 7.5.9 Personal Communications Services are under development as of this writing, but indications are that the successful licensees will select and implement differing technologies, even for similar systems in adjacent areas or bands; thus limiting not only competition, but interoperability and mobility as well. Different systems may utilize different access schemes (TDMA, CDMA, FDMA as described elsewhere) and system architectures, limiting service options for owners of subscriber equipment. For instance, the sub-bands of licensed blocks are intended to allow frequency division duplex, but they could be implemented using time division duplex schemes. Inexpensive subscriber equipment will likely have limited interoperability. Units providing service option selections may be more expensive, because of the need to support multiple technologies.
- 7.5.10 The lack of standards is likely to impede the ability of some PCS users to roam nationwide using “local subscriber equipment,” or to select between carriers to the extent that current cellular telephones allow. PCS systems will be able to provide enhanced local access without the provisioning delays, costs, or maintenance required by outside cable plants. PCS providers will probably enter the competitive access provider (CAP) market, but likely target similar services (cellular) in urbanized areas; initially concentrating on the CAP market only in underserved areas where they can be more competitive.

## 7.6 Special Mobile Radio/Enhanced Special Mobile Radio (SMR/ESMR)

### 7.6.1 Specialized Mobile Radio (SMR)

7.6.1.1 Specialized Mobile Radio (SMR) services were established by the FCC in the mid-1970's with the allocation of a portion of the 800 MHz band for private land mobile communications system. SMR services succeeded the "community repeater" shared service prevalent on other bands with more advanced offerings usually associated with a minimally-featured trunked radio system, sometimes with telephone interconnect service. SMR systems are characterized by a single high-power, high-elevation base station for maximum coverage. Today's SMR market is dominated by a quasi- open platform based on the format designed by one manufacturer. Current trends reveal large operators who have acquired many 800 MHz SMR operations.

7.6.1.2 Public safety has used SMR as a primary dispatch service with varying degrees of success. The versatility of the SMR industry and its relationship to public safety because of the dependence of both on dispatch as a primary service will continue to be attractive as the SMR industry becomes more sophisticated and integrated. These attributes may provide an alternative for public services when the specifications for this industry are more consistent and interoperable

### 7.6.2 Enhanced Specialized Mobile Radio (ESMR)

7.6.2.1 The latest systems, based on digital technology, are known as Enhanced SMR (ESMR), or "wide area," SMR systems. ESMR systems are typically characterized by a network of base stations in a cellular-type configuration. They are several times as spectrum efficient as SMR systems and offer enhancements including the consolidation of voice dispatch, telephone interconnect and data services into a single portable/mobile subscriber unit. ESMR services are most prevalent in metropolitan areas of the country. Additional ESMR systems are being built in allocations in the 900 MHz band. The 220 MHz band of 5,000 (and likely 10,000) channels are or will be available to construct ESMR-type systems that could compete for the ESMR market.

7.6.2.2 The ESMR industry is currently in the midst of change, converting to networked digital end-to-end technology. The user base is predicted to reach 4.2 million by 1999 including all of the various platforms. ESMR network operators are choosing technology which differs and is largely proprietary. Interoperable standards between ESMR providers are not necessarily being considered. There is currently no unit-to-unit interoperability between most ESMR systems and 800 MHz public safety systems. The ESMR feature set, with a strong emphasis on hand held radio operation, appears to have desirable public safety attributes. A single hand-held device operating over a wide integrated networked coverage area with data port, voice, fax and paging seems to align with public safety wireless needs. There are, however, major drawbacks with some of today's ESMR systems as they

relate to public safety use, particularly with respect to key voice attributes discussed previously.

7.6.2.3 Today's ESMR does not meet APCO's Project 16B<sup>24</sup> defacto functional trunking standard, a standard supported by all current public safety trunking system manufacturers. It does not support: (1) wireline control,<sup>25</sup> (2) simplex talk-around (direct unit-unit communications) at full power, (3) encryption, (4) dynamic regrouping, and (5) priority channel scan, all of which have been deemed essential for public safety systems. One need only examine the very basic requirements established by the public safety community to see the dichotomy between public safety systems and today's ESMR technology. Those requirements include graceful migration and interoperability: (1) there is no migration path between most ESMR technology and today's public safety technology, nor to any digital public safety systems currently proposed for tomorrow, (2) there is only a very limited interoperability potential between ESMR and public safety systems, and then only on 800 MHz General Category pool frequencies, not on 800 MHz public safety NPSPAC frequencies. An additional user concern is competitive procurement due to the limited number of ESMR manufacturers.

7.6.2.4 Regardless of the type of SMR/ESMR service, the public safety agency must insure that the coverage, security, priority access and reliability factors associated with each service provider/operator will meet the requirements of the applying agency. The degree of dependence on commercial access services by public safety wireless user will vary in accord with the commercial service providers specifications. The ESMR industry will advance to meet the demands of the mobile user and is intent on competing with cellular and the emerging PCS industry.

Reference:

"Public Safety Land Mobile vs. Enhanced SMR Systems" by John S. Powell, APCO Bulletin, pp 41-44, May 1995.

### 7.6.3 Dedicated Wireless Data Networks

7.6.3.1 Dedicated wireless data networks currently only offer data services (voice is excluded) in a wide cellular-like configuration serving subscribers with an air-time or flat-rate-based billing program for the transmission of information at rates varying between 8 kbps and 19.2 kbps. These services provide public safety an opportunity to access a dedicated wireless data network as a transport for mobile data systems.

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<sup>24</sup> The Associated Public Safety Communications Officer's (APCO) Project 16 was funded by the Law Enforcement Assistance Administration to develop a functional trunked radio standard for public safety use. This standard is met today by all manufacturers of public safety trunked radio systems.

<sup>25</sup> Wireline control is essential because it allows a control point dispatching higher priority talkgroup(s) to instantly interrupt an in-progress transmission of a lower priority talkgroup when all voice channels are busy so that a transmission can be made without delay to the higher priority talkgroup(s).

## 7.7 Paging

- 7.7.1 Today, over 27 million people use commercial paging services. Continued use, and increased dependence are expected for many public safety functions. One benefit to public safety agencies is the ability to quickly alert and accurately deliver messages and instructions to specialized response teams from diverse groups or areas (SWAT, HazMat, SAR, etc.)
- 7.7.2 Early paging systems were limited primarily because of their one-way capability. Confirmation of delivery, acknowledgment, and message latency were all concerns that often precluded the use of commercial systems which could otherwise provide adequate service. Delays of several minutes are possible during busy periods. Missed messages are uncommon, but possible. Responses are not immediate, and these uncertainties exacerbate critical situations.
- 7.7.3 New higher speed, multi-level paging protocols have been developed to increase the efficiency of paging networks, while maintaining backward compatibility with existing (lower speed) devices. These protocols also improve pager battery life by synchronizing idle (pager sleep) times, and use message serialization to provide automatic detection and indication of lost messages. Finally, the protocols allow for acknowledgment of, and limited response to messages.
- 7.7.4 Systems have recently been introduced that utilize a high speed "forward" channel for the delivery of messages to paging receivers, and a lower speed, lower power "reverse" channel to send responses. The outbound channel has the ability to send fairly lengthy messages. In the commercial marketplace, typical outbound messages are limited to 500 characters. Host computer-based messages sent on a broadcast basis may range up to 1,000 characters in length. Although the reverse channel operates at lower speeds and at a lower power level in order to allow subscriber to carry very low power devices, delivery times on return messages are still measured in seconds. The return channel is utilized for several purposes. Two-way pagers provide for automatic acknowledgment that messages have been received by the device itself. In addition, freeform responses can be constructed with the use of a "mouse-like" button on newly available devices, and/or a choice of pre-canned responses can be sent ("yes", "no", "ETA<5 minutes", "ETA>5 minutes", etc.) from a remote location within the coverage footprint. In lieu of the pre-programmed responses stored in the device, a message originator can send a choice of responses from which the recipient can choose a reply along with the original message. Those responses override the preprogrammed responses stored in the device for that particular message.
- 7.7.5 With increased transmission speeds, higher content messages (such as facsimiles) can also be delivered to paging receivers with reasonable latency. Users of two-way pagers may be alerted about a "large message", and be provided the option to receive it immediately, store it for retrieval at a more convenient time (by

pager or through terminal access), or forward it to an alternate location (such as a preset E-mail address or facsimile number). If no acknowledgment of the alert message is received, the large message is not transmitted unnecessarily.

7.7.6 In wide area two-way paging systems, networks no longer have to send sequenced messages to alternate coverage areas once a page is acknowledged. Confirmation of delivery also reduces caller uncertainty, and should minimize multiple calls with the same message. Messages which aren't acknowledged may be held for retransmission (or confirmation of delivery) after the next successful page, or stored at the terminal for retrieval by other means. All of these methods improve message throughput and allow greater spectrum efficiency.

7.7.7 Advanced paging systems being introduced today allow peer-to-peer communications between pagers, by allowing the initiation of messages from pagers to the network over the reverse channel. Future two-way paging applications are likely to include services like AVL and individual-based GPS services, telemetry services, and interoperable services on dual devices with other wireless providers. These advanced paging systems would likely require connection of a paging device (such as an expansion card) into a personal digital assistant (palmtop computer). Such arrangements could also provide interfaces with existing computer networks to allow transaction processing (HazMat database access, urgent on scene inventory checks and supply/resource requests, etc.) These transactions will likely fit the same unbalanced profile (simple, low content requests, possibly based on menu retrieval and selection; with much larger responses). Information security, and the ability to transparently pass binary objects will become increasingly important as public safety use of these systems expands.

## **8.0 CONCLUSIONS AND RECOMMENDATIONS**

8.1 Technology is constantly improving spectrum efficiency. Improvements in semiconductor processing and materials have resulted in roughly an order of magnitude advancement every five years. Rapid advancements in microprocessor technology has also been observed over the last two decades. Although theoretically possible to approach gains of 8:1 based on 25 kHz analog by the year 2010, it is appropriate to set the factor to 4:1 for planning purposes. A 4:1 efficiency recognizes the practical limit of advances over the intervening years; that is, doubling (2:1) in five years, doubling again in another five (4:1), then doubling again in five more years (for a 8:1 improvement in 15 years). Further, within current public safety bands, there will be an established base of equipment that will have to be amortized and withdrawn from service before full benefits of any advanced technologies can be realized. Additionally, many of the emerging public safety technologies (video and high speed data, for example) will require significantly wider bandwidths than the current 25 kHz channel for analog voice.

8.2 Digital technology will be the key technology for the future. A digital signal format is assumed by most of the bandwidth efficient methods employed today. Digital is essential to data transmission. Digital appears to be superior for secure communications technology. Nevertheless, there is a vast investment in existing analog voice communications technology which meets communications needs today and which will last for a long time. Analog equipment with 10 to 20 year lifetimes will continue to be installed for several years. Current public safety digital equipment offers approximately a 2:1 improvement in spectrum efficiency over 25 kHz analog. Consequently, the public safety community will operate with a mix of analog and digital equipment (a mix shifting towards digital) for the foreseeable future.

8.3 Trunking will become increasingly prevalent as the technology for trunking control becomes deployed and copied in what are currently known as conventional systems.

8.4 Improvement in technology unrelated to voice, such as data, will be driven by dramatic technology improvements in computers. It is quite conceivable that computer spectrum efficiency may be more important than voice spectrum efficiency in 2010. Imaging technology will be driven by improvements in digital signal processing (DSP) technology, which should also be dramatic in a decade.

8.5 Voice interoperability will require pre-planning. This is not a prediction, but rather a direct implication of the first two conclusions.

8.5.1 Spectrum efficient technology includes low bit-rate speech coding. Speech coding trends have already left the concept of "waveform coding" behind, where the ability to reproduce the exact analog speech waveform is lost. This property, employed commonly in land-line telephony where wire bandwidth is less of an issue, permits voice to be converted back and forth from analog to digital at will without loss of quality.

8.5.2 Low bit-rate speech coding also produces greater speech delay. This property is also not an issue in higher bit-rate waveform coding used in land-line telephony which permits voice to be converted back and forth from analog to digital without appreciable increase in delay.

8.5.3 Barring currently unexpected innovation in transcoding, this means that interoperability between systems with different speech coding technologies will likely suffer quality loss and increased speech delay, even when patched through infrastructure.

8.5.4 Direct interoperability over-the-air does not appear possible between systems with different speech coding technologies, bit rates, modulations, formats, access method, or any other attribute associated with the air-interface of a given RF system.

8.5.5 Without any significant coordination, disparate systems will achieve analog interoperability using a common base-line interoperability technology.<sup>26</sup>

8.5.5.1 This can serve both analog speech or data that is converted to a speech bandwidth signal in a fashion similar to using modems over telephone. Data transmitted via analog transmission are subject to no more coordination than generally practiced today requiring compatible modems on both sides of a telephone link. Data speed is significantly less than compared to direct digital transmission.

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<sup>26</sup> We note that the PSWAC Interoperability Subcommittee has recommended such a common transmission mode (analog FM) for such interoperability. We note that current generation digital cellular telephones also support FM transmission mode.

**APPENDIX A****SUMMARY OF TECHNICAL PRESENTATIONS**

1. *American Mobile Satellite Corporation (AMSC)* by Mr. Ed Gilbert, Telecommunications Consultant, American Mobile Satellite Corporation.

Mr. Gilbert indicated that on April 7, 1995, AMSC's first satellite was launched into geosynchronous orbit over the equator south of Brownsville, Texas. This instituted satellite communications from small, mobile, affordable terminals the size of a PC notebook computer, with coverage over most of the continental United States, Hawaii, much of Alaska and the Caribbean to 200 miles offshore. Voice, data and fax are possible through automatic connections to the public networks. AMSC is of the view that, in addition to regular telecommunications, this service provides exceptional backup during emergencies if terrestrial systems are destroyed or overloaded. AMSC is especially interested in public service organizations willing to assist with the testing program for these systems and introduction of initial service.

2. *E.F. Johnson* by Mr. Steve Nichols, Director of Marketing, E.F. Johnson.

Mr. Nichols indicated that E.F. Johnson provides trunked networks and sales and service worldwide, offering a complete turnkey system. They offer trunked systems covering the 450, 800, and 900 MHz bands and conventional products in the 150, 450, 800, and 900 MHz bands. They currently support systems for government and public safety, including the Washington State Department of Transportation (with 3100 radios and over 100 channels in rugged topography), the Island of Puerto Rico (with 1500 radios and 68 channels that include public safety uses), Amoco (at 900 MHz with over 2200 radios using 80 repeaters in 5 states, including refinery and off-shore platform use), and the Interstate Power Company (with 450 radios on 47 channels in 4 states). E.F. Johnson stated that their distributed logic trunking approach creates affordable trunking systems for small departments, municipalities and users who thought they couldn't afford trunking. Also, E.F. Johnson indicates that its flexible system topology and unique simulcast capabilities create an efficient trunking solution for large-scale regional applications. E.F. Johnson advocates their systems as offering a simple, low-cost migration path forward to digital spectrum efficiency. Their "open architecture" protocol is adaptable to all bands, and is easily migratable to a variety of efficient digital modulation schemes. They are continuing to develop improved technology in simulcasting, network architectures, and new spectrum efficient modulation techniques.

3. *AirTouch Cellular* by Mr. Michael Alcalay, Manager Public Relations, AirTouch Cellular. AirTouch Cellular is developing alliances to gain strong working partnerships with law enforcement and emergency response teams. They are working to educate law enforcement agencies on how cellular service differs from landline communications. AirTouch advocates the use of cellular communications during emergency events. Cellular has proven instrumental during emergencies with voice, data, and paging technologies. AirTouch is working to educate Californians on how to use 911 appropriately through a statewide education

campaign with the Cellular Carriers Association of California, the California Highway Patrol and other cellular carriers. AirTouch suggest that alternative star or pound numbers be developed for quicker access to law enforcement. They seek to promote understanding of how cellular technology works, including its limitations. They believe cellular technology is being used to help law enforcement and emergency services communicate effectively during times of emergencies.

4. American Paging, Inc. (API) by Mr. John Schaaf, President and Chief Executive Officer, American Paging, Inc.

API's systems can apply defense technologies for public safety. Through American Messaging Services, a joint venture between API and Nexus Telecommunications Systems, they are developing and marketing patented Nexus spread-spectrum technologies for two-way paging, location, and telemetry services. The Nexus spread spectrum frequency hopping technology provides a low cost return overlay network. It has a 1:1 receiver to transmitter ratio, which lowers capital requirements and lowers operating costs. It provides two-way paging, life paging (for those in need of an organ transplant), vehicle location services, personal location services, and security and monitoring services.

5. Nextel Communications, Inc. by Ms. Natalee Roan, Director, Marketing, Nextel Communications, Inc.

Nextel Communications currently offers a digital product which integrates 2-way dispatch, mobile phone, alphanumeric messaging, and voice mail all within a single hand-set on Nextel's own network. The Nextel system currently covers the east and west coasts, Las Vegas, Reno, as well as the Chicago-Detroit-Milwaukee-Toledo and Denver-Oklahoma-Missouri-Kansas clusters. They employ Motorola's iDen technology, which allows greater privacy than current analog radio or analog cellular networks can offer because it is fully digital. Through the use of Nextel's products and services, agencies which currently have different private communications networks can now communicate to one another over our national network. Examples of successful deployment of inter-agency communications using Nextel's communications system are Oklahoma City bombing, the Northridge earthquake in Los Angeles, as well as the 1995 papal visit to New York and Baltimore.

6. QUALCOMM, Inc. by Mr. Kevin Kelley, Vice President, External Affairs, QUALCOMM, Inc.

QUALCOMM is an integrated wireless communications company that manufactures products and provides service and operations. QUALCOMM advocates and is currently developing secure ubiquitous portable interoperable communications using code division multiple access (CDMA) techniques over the commercial cellular infrastructure. They believe CDMA provides for best frequency reuse and provides control of mobile transmit power by operating at less than one one-hundredth of the power of a typical FM mobile unit. CDMA techniques allow multipath signal combining. CDMA allows soft handoffs between cell sites. CDMA techniques also provide for variable-rate vocoders, sectorization and forward error correction.

7. Ericsson, Inc. by Mr. Ernest Hofmeister, Manager, Advanced Systems, Ericsson.

Ericsson believes that it can support any technology direction to achieve increased spectrum efficiency. Digital technology advances have and will continue to enable spectral efficiency improvements through advancements in digital speech coding, spectrum efficient modulations, and traffic capacity. The accumulated spectral efficiency increase over that for one user in a 25 kHz channel from these three advances is estimated to range from a factor of four conservatively to a factor of 16 optimistically. The additional capacity needed for user growth and the implementation of advanced data services is expected to exceed the capacity growth achieved through spectral efficiency improvement. As a result, Ericsson believes additional spectrum for public safety will be needed. Ericsson believes that TDMA technology is a proper system choice and is developing a next generation Prism digital private land mobile radio system based on TDMA. This system has a factor of four spectrum efficiency increase. A half-rate speech coder which seems feasible within the next five years would further increase the spectrum efficiency by another factor of two. This system also includes a high-data bandwidth-on-demand capability that will aggregate two TDMA slots for a 16 kilobytes-per-second rate in a 12.5 kHz channel to address future data needs for image or video data. Ericsson believes the TDMA system choice allows leverage of the large cellular research and development investment for the benefit of the private land mobile radio community, including public safety.

8. Motorola, Inc. by Mr. Allen Davidson, Electronics Engineer, Motorola, Inc.

Motorola proposes an engineering methodology for projecting spectrum demands. They believe that it is important to separate the technological implementation of solutions from the technological requirements for solutions. The predominant technology in the year 2010 may have just emerged, or may still be waiting to emerge. Because no one knows for sure what the details of the future hold, it is more practical and useful to project the probable attributes of tomorrow's radio environment than it is to guess how product inventories may look in 15 years. This is possible because trends for electronic component integration, cost, size and a variety of other attributes have obeyed the patterns of steep experience curves for at least the last 30 years. Motorola recommends that a mathematical model be developed to project quantities of public safety spectrum required after each of the subcommittees do their respective jobs. This mathematical model could be developed similarly to the one submitted by the Coalition of Private Users of Emerging Multimedia Technologies in their Petition for Rule Making with respect to spectrum allocations for advanced private land mobile communications services, filed with the Federal Communications on December 23, 1993. Except for an optimum channelization structure, which can only be determined as it interrelates with blocking, loading, and other considerations that directly impact the net spectrum requirement, each subcommittee would produce elements of such a mathematical model, describing the relationships between need and required spectrum in terms of objective dimensions, quantities and volumes.

9. *NTT America* by Mr. Steve Crowley, Consulting Engineer, NTT America.

Nippon Telegraph and Telephone Corporation (NTT) has developed a new modulation technology, Real Zero Single Sideband (RZ SSB). The inherent spectrum efficiencies of SSB still make it quite attractive; the SSB modulation process does not take up any excess RF bandwidth with emissions outside the information bandwidth. Two breakthrough receiver technologies provide great immunity against severe fading encountered in land mobile environments. The first is a new demodulation method using the zero crossings of received SSB signals, eliminating performance-limiting circuits found in the conventional SSB receiver. The second breakthrough is a new equal-gain antenna combining method. The information bandwidth of RZ SSB is identical to that of conventional telephone lines, and the technology supports signals on telephone circuits without additional equipment. The entire information spectrum of 300 Hz to 3.4 kHz is carried without degradation. RZ SSB supports multiple media including analog voice with natural sound characteristics and graceful degradation, allowing easy speaker identification. RZ SSB supports digital encrypted voice using recent advanced speech coders such as PSI-CELP. Data transmission is at speeds up to 19.2 kbps in a 5 kHz channel (3.84 bits/sec/Hz). Also possible is image as well as text transmission by facsimile (with unprecedented quality in fading channels), still pictures (JPEG), and slow-scan video. RZ SSB also supports Time Division Duplex technology allowing full-duplex operation in a single 5 kHz channel. Laboratory experiments and field tests of RZ SSB prototype equipment verify predicted performance. The cost of RZ SSB technology is comparable to that of existing equipment.

10. *SEA, Inc.* by Mr. David Thompson, President and Chief Executive Officer, SEA, Inc.

SEA is a manufacturer of narrow-band single-sideband technology, presently used at 220 MHz. SEA does not tout narrow-band technology as a panacea for the solution of all public safety needs; however, SEA finds that 5 kHz narrowband technology works very well. SEA has chosen to utilize linear modulation techniques to achieve spectrum efficiency. Narrowband linear modulation's strengths include coverage, low capital cost, good voice recognition, and excellent audio. Its weaknesses are that it is relatively unknown and pioneered by less well known companies in the mobile communications industry.

11. *Securicor Radiocom, Ltd.* by Mr. Mike Bayly, North American Business Development Manager, Securicor Radiocom, Ltd.

Traditionally, the way to meet shortages of spectrum has been to divide radio channels, generally giving the user poorer quality. Technology can help this spectrum shortage (or spectrum wastage) with improved efficiencies. Specifically, linear modulation can achieve very-narrow-band channelization, down to 6.25 or 5 kHz. This has been accomplished at 220 MHz. Linear modulation is an enabling technology that permits transmission of very-narrow-band digital, analog, voice, data or video information by using (1) transparent tone in band (TTIB), (2) fast feedforward signal regeneration (FFSR), and (3) Cartesian Loop linearisation. Securicor's linear modulation technology is being used in the 220 MHz frequency band in the United States. Linear modulation products are also now being manufactured in the United Kingdom pursuant to the new UK 5 kHz MPT 1376 standard. Linear modulation provides

clear voice signals that can be encrypted. It reduces the adverse effects of Doppler, multi-path, Rayleigh and phase distortion. It provides high speed data capability at greater than 14.4 kilobytes per second. It offers more channels per megahertz. It results in less power consumed and less power transmitted. It offers a graceful transition from today's standards to a new technology.

12. AT&T by Dr. Gary Schlanger, Advanced Communications Laboratory, AT&T Labs.

The wireless telecommunications industry in the United States today is extremely complex with many existing and emerging applications and spectrum allocations. All users are looking for: a single phone, a single address, universal roaming, integrated services (such as paging, voice, image), and performance comparable to wireline. Terminals that support multiple spectrum bands, multiple modes (protocols), and multi-media (voice, data, FAX) can accomplish these objectives. There have been dramatic improvements over the past decade in public commercial cellular service with respect to technology advances (size, battery life, quality, reliability, etc.) and decreased service costs. New features like Priority Access and Channel Assignment are of particular interest to the public safety community. In AT&T's view, the public safety community should leverage Public Network capabilities wherever and whenever possible to satisfy their expanding requirements.

13. Technology for Fire Services by Chief Gary Cates, Berkeley Fire Department, Berkeley, California

Chief Cates made a presentation from the standpoint, he said, of one who is not a technological expert. Still, he must use the technology and sometimes encounters its limitations, especially with regard to interoperability. Chief Cates discussed communications problems experienced during the 1989 Loma Prieta Earthquake and the 1991 Oakland/Berkeley Firestorm, two major situations in the San Francisco Bay Area. Over 400 fire units from throughout the State of California were involved in the 1991 incident. The patchwork of mutual-aid communications meant to facilitate inter-agency communication did not work well due mostly to technical problems. For example, the fourteen fire departments in Alameda County operate on two 800 MHz (Ericsson and Motorola), two UHF, and a number of VHF systems. The Ericsson and Motorola systems are supposed to be interoperable, but technical and operational problems persist. Chief Cates stressed that there is a national need for radio technology that provides the following: (1) initial dispatch capabilities, (2) in route communications, (3) allow for command and tactical subdivisions, (4) compatibility, (5) versatility, (6) interoperability, (7) hardened for severe conditions. Chief Cates made an appeal on behalf of public safety agencies for federal funding assistance to develop and purchase new radio technologies. He said that money spent now in improving public safety communication systems would be paid back many times over in terms in life and property saved in future disasters.

14. Police Full-Motion Video Surveillance Lieutenant Hank Borders, Berkeley Police Department, Berkeley, California

Lieutenant Borders showed a video presentation describing how his police department uses video surveillance as an aid to its narcotics law enforcement program. The video system described uses relatively simple technology, and sends wide-bandwidth National Television Systems Committee (NTSC) video of an RF frequency of 2.475 GHz. The video camera is focused on a park where the transactions are made. The camera is located behind an apartment window and is remotely-controllable from the police department at the Berkeley Hall of Justice. The camera can be panned and tilted remotely by tone control over a standard VHF or UHF radio voice channel. The video from the camera is fed to a microwave transmitter. In terms in practical considerations, it was noted that the system worked fine transmitting through small trees, but with thicker vegetation, or when trees are wet, signal quality can suffer from the increased attenuation. The police department is able, to some extent, to reflect a usable signal off buildings if a direct path does not obtain between the transmit and receive sites. Lieutenant Borders reports some problems using the 2.475 GHz frequency. It is the only frequency available to Public Safety for this type of use. The frequency, however, is shared with broadcasters in the San Francisco area, who use it for electronic news gathering. Many undercover operations involve extended transmissions which causes conflict with some broadcasters who want the frequency for their news gathering purposes.

15. Technology Needs for Emergency Management by Mr. Donald E. Root, Jr., California Governors Office of Emergency Services

Mr. Root described a telephone interconnect system that was successfully deployed during the 1991 Oakland, California fire. Architecturally, the system can be described as a wireless link in the local loop and operates on the 5.850 GHz amateur radio band. The system is described as having several advantages over alternatives. With regard to cellular telephone, cellular frequencies are quickly saturated during a disaster (usually by civilians) and are thus often unavailable to public safety users. Furthermore, cellular telephone antenna towers can themselves become victim to disaster. Another emergency communications technique to which the van-microwave system is favorably compared is one provided by the local telephone company. In major incidents, Pacific Bell will often attempt to deploy additional wire lines at an incident scene. One problem with this is the long time it takes for the phone company to establish such lines. Another problem is that, in the event the incident command center has to be moved (as is often the case in a fire situation), the land lines have to be moved as well, which can take too much time. By contrast, the system described by Mr. Root simply requires driving the van to the new command center.

16. Advances in Wireless Technology by Professor Kamilo Feher, University of California at Davis

Dr. Feher's presentation discussed his company, Digicom, Inc., and his various patented technologies that have applications in wireless communications, generally in the modulation area. Some of these technologies are described in his new book, "Wireless Digital

Communications: Modulation and Spread Spectrum Applications.” Much of Dr. Feher's remarks related to his invention Feher's Quadrature Phase Shift Keying (FQPSK), a spectrally-efficient implementation of QPSK that is said to have an approximately 5 dB performance improvement over GMSK. Dr. Feher says his technologies allow better power and spectral efficiencies than can be achieved with conventional modulation and RF techniques. Ultimately, he says, his technologies can lead to increased battery life and smaller-sized products along with more robust performance.

17. *Overview of Video Technology* by Mr. Thomas Christ, Chairman, HDS, Inc.

Mr. Christ stated that law enforcement entities constitute the largest number of public safety video users. RF video links, such as X-band FM video transmissions, have been used in the federal community for investigative purposes for the last 25 years. Use of video communications for public safety purposes, however, is relatively new. Only since the late 1980's has there been extensive tactical use of video transmissions. Requirements of small size and power efficiency exist for investigative reasons. Public safety agencies are now able to avail themselves of video communications because new technologies permit transmission of video via a voice-grade channel. The critical enabling technologies that permit achievement of this objective are (1) video compression techniques, (2) fast cheap microprocessors, and (3) wireless common carrier communications grids. Small FM video transmitters operating in the 33 MHz slot between 2,450 to 2,483 MHz band constitute the preponderance of current public safety video use. This spectrum was made available for this use in the late 1980's. Most public safety video use is now under Part 90 Subpart B in that spectrum, except for applications for long-term fixed use.

18. *Mobile Satellite Systems* by Ms. Susan Moore, SkyTel, for Mr. Edward Gilbert, AMSC

Susan Moore highlighted dramatic advances in technology that have been made in three areas critical to effective management of emergencies: (1) the ability to communicate anywhere, any time; (2) to know location precisely; and (3) to overlay data base information to assist in response planning and execution. In the U.S., three “Big LEOs” have been licensed by the FCC. Big LEO means satellites in low or medium earth orbit operating above 1 GHz and providing both voice and data. “Little LEOs” operate below 1 GHz and provide data service only. The Big LEOs plan to offer service late in this century or early in the next with dual mode satellite/cellular telephones. Currently, ORBCOMM is the only Little LEO in operation. It has two satellites in orbit, and beta testing is in progress. To provide continuous coverage over the U.S., 26 satellites are necessary. This constellation is planned for full deployment by the end of 1997. As these systems are placed in operation and their user terminals tested in quantity, much more will be learned about their ability to support emergency communications. Satellites permit interoperability via the Public Networks. Interconnections to a common network can satisfy many interoperability requirements, especially for interactions at the command post level. There, if systems can access the public switched telephone network (PSTN), information can be shared and made available to a wide audience of users without creating a new infrastructure. Satellite systems have a particular advantage here when terrestrial systems are stressed. Their access to the PSTN is via a distant gateway station unlikely to be affected by a localized or even widespread emergency.

Additionally, common interfaces lend themselves to interoperability. For example, the link between mobile satellites and SkyTel allows data to pass between two networks based on data protocols and formatting without being restricted by any particular standard.

19. *Advanced Digital Wireless Technologies* by Dr. Gregory Stone, Consultant, INS/CECOM

Dr. Stone discussed certain wireless digital communications fundamentals. He explained that bandwidth and information transfer capacity are not synonymous. Bandwidth is the range of frequencies within which performance, with respect to other some characteristic, falls within specific limits. Information transfer capacity, on the other hand, is the rate of information transfer at maximum channel capacity. He commented on the symbol transmission rate theoretical limit in terms of the Nyquist minimum bandwidth. He discussed the channel capacity theoretical limit in terms of the Shannon-Hartley channel capacity theorem. He explained that the ideal channel: (1) is linear time invariant; (2) has only Additive White Gaussian Noise (AWGN) as a perturbation; and (3) is distortion free. A benign channel is perturbed by some linear distortion and AWGN in the detection system. A mobile radio channel, however, (1) is a randomly time variant linear channel; and (2) is perturbed by (a) lognormal variations in signal amplitude, (b) Rayleigh variation in signal amplitude and phase, (c) Doppler shift in frequency, (d) time dispersion or time variance of the channel's impulse response, and (e) AWGN. The solution is to deperturb a time variant non-linear mobile channel to create a quasi-linear phase time invariant channel. In bandpass (passband) systems (i.e., wireless) digital information is transformed by the modulation process. The parametric performance of any wireless information transport system is dependent upon how each of these transformations is implemented.

Dr. Stone also discussed the following areas of projected technological evolution: (1) source coding and compression; (2) channel coding, EDAC, modulation, and frequency translation; (3) radio frequency power amplification; (4) advanced linearisation and detection techniques; (5) synchronization; (6) digital signal process and signal-to-noise ratio improvements; (7) information transfer capacity and information transfer rate; (8) antenna technology; (9) system architectural features and frequency reuse; and (10) spectrum use efficiency. Dr. Stone then reviewed other advanced digital wireless technological considerations, including: (1) system modeling, simulation and performance validation; (2) common transmission protocols; (3) multimode/multiband subscriber equipment; (4) covert communications support; and (5) public carrier conveyances.

**APPENDIX B  
TECHNOLOGY INVENTORY SUMMARY**

COMPANY	TECHNOLOGY DESCRIPTION - Note 1	SIGNAL TYPES Note 2	BANDWIDTH	CHAN. Note 3	ACCESS	DATA RATES Note 4	VOCODER	ENCRYPTION	C/D/F Note 5
Transcrypt	FDMA Project 25	V, LD	12.5 kHz	1	FDMA	9,600	IMBE	Yes	D
Ericsson	EDACS	V	25/12.5 kHz	1	FDMA	N/A	N/A	No	C
Ericsson	EDACS/Aegis Standard	V, LD, SV	25/12.5 kHz	1	FDMA	9,600	AME	Yes	C/D
Ericsson	EDACS/PrismNarrowband	V, LD, SV	12.5 kHz	1	FDMA	9,600	IMBE	Yes	D
Ericsson	EDACS/Prism-TDMA	V, LD, PIC, VID	12.5 kHz	2	TDMA	16,000	IMBE	Yes	D
Motorola	IDEN/MIRS	V, LD, HD	25 kHz	3 or 6	TDMA	64,000	VSELP	No	C
Motorola	ASTRO-FDMA Project 25	V, LD	12.5 kHz	1	FDMA	9,600	VSELP/IMBE	Yes	C/D
NTT America	RZ SSB	V, LD, SV, PIC	5/6.25 kHz	1	FDMA	19,200	PSI-CELP/VSELP	Yes	D
NTT America	RZ SSB	V, LD, SV, PIC	5/6.25 kHz	2	TDD	19,200	PSI-CELP/VSELP	YES	D
NTT America	RZ SSB	V, LD, SV, PIC	10/12.5 kHz	2 or 4	TDMA	38,400	PSI-CELP/VSELP	YES	D
EF Johnson	LTR	V	25 kHz	1	FDMA	9,600	N/A	No	C
EF Johnson	Multi-Net	V	25 kHz	1	FDMA	9,600	N/A	No	C
EF Johnson	LTR-2	V	25 kHz	1	FDMA	9,600	N/A	No	F
EF Johnson	Multi-Net 25	V, LD	25/12.5 kHz	1	FDMA	9,600	IMBE	Yes	F
Midland	FDMA Project 25	V, LD	25/12.5 kHz	1	FDMA	9,600	IMBE	Yes	D

NOTES:

- #1 Trademark descriptions are used for some descriptors.
- #2 V = Voice, LD = Low Speed data (defined as up to 19.2 kbps), HD = High Speed data (defined as > 56 kbps, SV = Slow video, PIC = Snapshot Picture, VID = Video
- #3 Channels per carrier
- #4 The raw data rate is used.
- #5 C = Currently type accepted, D = Developmental, F = Future technology

## APPENDIX C

### TECHNICAL PARAMETERS FOR FORECASTING SPECTRUM DEMAND

The model which has been selected for the computation of the spectrum need of public safety is described in the report of the Spectrum Subcommittee. That model calls for technological parameters to be projected through the year 2010 for the identified user service needs, and then used to compute the spectrum needed. The user service needs which have been identified by the Operational Requirements Subcommittee are: Voice Dispatch, Telephone Interconnect, Transaction Processing, Facsimile, Snapshot, Remote File Access, and Slow and Full Scan Video. The following provides a detailed description of the technology parameters used in the process and identifies a recommended value for each parameter.

#### TECHNOLOGY PARAMETERS

Description	Abbreviation
RF Transmission Rate	RATE
Error Control and Overhead	ERR
Source Content	SRC
Channel Occupancy	LOAD
Coding Improvement	COD

#### 1.0 RF Transmission Rate (RATE)

The word RATE will be used to designate the RF transmission rate in the model. It is described in bits per second per Hertz (b/s/Hz). The leading edge technology in use was projected to be 3.5 b/s/Hz in the year 2000 and 5.0 in the year 2010. Assuming a 15 year life, the systems in use in the year 2010 will be the accumulation of systems sold starting with those purchased today and including those that will be sold in the year 2010. Those sold today include some which are at the level of about 2.5 b/s/Hz and some that are less than 1.0 b/s/Hz. Those sold in the year 2010 will likewise have a range of values. Projected values are summarized in Table 1.

**Table 1**  
**Transmission Rate**

<b>Service</b>	<b>b/s/hz</b>
all except video and remote file transfer	1.5
video and remote file transfer	3.5

**2.0 Error Control and Overhead (ERR)**

In the model, we will use ERR to represent the subject parameter, and it will be expressed in the average percent of transmitted bit rate that is dedicated to this function.

Coding of the information bits allows more and more compression to take place. However, each bit then becomes more important, and the error correcting function then becomes more important. In addition, over time, linear modulation schemes are being used with higher transmission rates. Because of the multipath propagation environment, it becomes necessary to provide synchronization and equalization functions that also may use some capacity.

**Table 2  
Error Control and Overhead**

<b>Today</b>	<b>Future</b>
55 %	50 %

**3.0 Source Content (SRC)**

The content of the source message to be transmitted is represented by the shortened form SRC in the equations to follow. In the future, it is projected that all services provided will be implemented in a digital format. Therefore, this parameter will be expressed in kilobits per second (kb/s).

The offered load that has been developed in User Traffic Profile White Paper<sup>1</sup> is based on a source content of 6 kb/s per second for all categories except special data, and that will be used herein. For special data, consisting of video and remote file access, it will be prohibitive to limit the channel to such a slow data rate. In Appendix C of the Prediction Model White Paper<sup>2</sup> values are developed for these latter services, and a nominal rate developed there is 384 kb/s. That is the value which will be used for the spectrum computation.

The magnitude of the source content is that which is contained in the state of the art message today, including any coding improvement that has been done to date. Advances in coding in

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<sup>1</sup> United States Department of Justice, Immigration and Naturalization Service, Headquarters Radio Systems Section, "Public Safety Wireless Communications User Traffic Profiles and Grade-Of-Service Recommendations", March 13, 1996, prepared by Dr. Gregory M. Stone. Referenced here as "User Traffic Profiles White Paper."

<sup>2</sup> White Paper "Model For Prediction Of Spectrum Need Through The Year 2010", Version 2.0, May 27, 1996, presented To PSWAC by Motorola Inc. Referenced here as "Prediction Model White Paper."

the future are addressed in the parameter COD developed below. The resulting content of the advanced features for SRC is summarized in Table 3.

#### **4.0 Channel Occupancy (LOAD)**

Channel loading is the portion of time the channel has RF transmitted over it expressed in percent of the total time the channel is available. It is represented by the term LOAD, and is a complex subject that is a function of many parameters. These parameters include the kind and urgency of the message, the number of users of the channel, how many servers are available for the channel, and the length of message and number of them per hour offered by the users.

An example of a situation where a lightly loaded channel is necessary is when a group of scattered police officers are waiting to simultaneously close in on a suspect with a hostage. They operate on a single channel, and it is imperative that when the word go is uttered they all move with the greatest of speed. The channel in use must be **very** lightly loaded, LOAD less than 5 percent, to assure that the short message will not be blocked.

An example of a situation where a heavily loaded channel can be used involves trunked systems that carry routine messages. Data requests for license plate checks can wait two or three seconds as the officer writes a ticket. A dispatcher request for present location usually takes a few seconds for a voice reply as the officer reaches for the radio to reply. That too will not suffer greatly if two or three seconds of blockage occur. LOAD can be 20 to 25 percent on a single channel system and as much as 70 to 80 percent on 20 channel trunked systems and meet this criteria.

Finally, there are messages that can wait for a few minutes before delivery to the intended party. These may include a FAX sent to an individual driving a car (we recommend that they keep their eyes on the road as opposed to reading a FAX), and E-Mail message, or a long file which is to be used at some time in the future. Single channel systems can be loaded up to 50 percent and 20 channel systems up to 95 percent and provide this service. For purposes of the analysis of spectrum need a value of 55 percent is recommended.

#### **5.0 Coding Improvement (COD)**

The coding improvement is a dimensionless factor that describes the anticipated improvement in coding that will take place between the years 1996 and the year 2010. The shortened term COD is used in the model. For various services, the value of COD varies from 1 to 3 as shown in Table 3.

#### **6.0 Recommended Parameters For Model**

Based on the discussions above, the technological parameters have been quantified for each of parameters identified are summarized in Table 3.

**Table 3**  
**SUMMARY OF TECHNOLOGY PARAMETERS**

<b>SERVICE</b>	<b>RATE b/sec/Hz</b>	<b>ERR %</b>	<b>SRC kb/s</b>	<b>LOAD %</b>	<b>COD</b>
Voice Dispatch	1.5	50	6	55	2
Telephone Interconnect	1.5	50	6	55	2
Transaction Processing	1.5	50	6	55	2
Facsimile	1.5	50	6	55	1
Snapshot	1.5	50	6	55	1
Remote File Transfer	3.5	50	384	55	3
Slow Scan Video	3.5	50	384	55	3
Full Motion Video	3.5	50	384	55	3

**6.3 APPENDIX C - Interoperability Subcommittee Report**

PSWAC/ISC 96-05-037/10  
Revised 7/28/96

**PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE**

**INTEROPERABILITY SUBCOMMITTEE**

**FINAL REPORT**

**July 29, 1996**

**INTEROPERABILITY**

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## Interoperability Subcommittee Final Report

### 1.0 EXECUTIVE SUMMARY

#### 1.1 Subcommittee Overview

The Interoperability Subcommittee (ISC) is one of five subcommittees formed under the Public Safety Wireless Advisory Committee (PSWAC). The ISC was developed to identify the interoperability requirements of the public safety community and make recommendations to resolve the historical inability of different agencies to communicate with each other, via radio, during routine, emergency and disaster response operations.

Although the "PSWAC mailing list" was quite extensive, the ISC consisted of approximately 150 members, representing the user community, as well as representatives from industry and commercial service providers.

##### 1.1.1 Charter

The Interoperability Subcommittee (ISC) is to identify the interoperability requirements of the public safety community and make recommendations to resolve the historical inability of different agencies to communicate with each other, via radio, during routine, emergency and disaster response operations.

The Steering Committee also tasked the ISC to define Public Safety and Interoperability for all the subcommittees to use in their respective assessments of the current and future for public safety communications. In addition, the ISC defined the term Mission Critical as it is used to describe the importance and priority of communications, particularly as it applied to interoperability and the utilization of various alternative methods.

##### 1.1.2 Report Scope

This subcommittee report outlines and discusses the current communications interoperability requirements and capabilities, as well as the envisioned needs of the future. The subcommittee has considered the interoperability needs that are currently unsatisfied or that have been unsatisfactorily provided. All phases of interoperability have been explored, including command and control functions. These examinations have generally been neutral on technology. The interoperability issues, identified by the Operational Requirements Subcommittee, have also been considered and are addressed in this report.

#### 1.2 Definitions

The Steering Committee tasked the Interoperability Subcommittee to provide a recommended definition of *Public Safety* to be utilized by all the subcommittees in their

respective assessments of the current and future requirements for public safety communications. Likewise, the subcommittee decided it was necessary to define what is meant by *interoperability*, before the communications capability could be identified and recommendations developed. The need to develop a definition for *mission critical* was identified during subsequent meetings as various levels of communications interoperability were addressed.

### **1.2.1 Public Safety**

Public Safety was generally defined as a function of government, following both what has historically been the accepted practice, as well as addressing the nature of governmental operations and radio system requirements in the future. Many disciplines are included within this definition, but the common thread throughout is that they are functions of government.

Some non-governmental organizations have some functions which are public safety in nature. One such example is the railroads which may have their own law enforcement and fire protection elements. A sub-heading of *Public Safety Services Provider* includes such public safety elements, but only so far as they are authorized by government. Such services can be included within public safety as long as actual radio authorizations are held by the government organizations.

### **1.2.2 Public Services**

A second definition, *Public Services*, was developed because of public safety's need to interoperate with non-public safety organizations. This definition includes organizations which are suppliers of the nations' basic infrastructures which are required to promote the public's safety and welfare. Some examples include railroads and power utilities.

### **1.2.3 Interoperability**

*Interoperability* is a communications link which permits units from different agencies to communicate with each other. This link can involve infrastructure elements, or it can allow direct communications between field units without infrastructure support.

### **1.2.4 Mission-Critical**

A *mission critical* communication is one which must be immediate, ubiquitous, reliable, and in most cases secure. *Mission critical* communications require the highest level of assurance that the message will immediately be transmitted and received regardless of the location of the operating units within the designed coverage area. In such cases, system set-up or processing delays are unacceptable and coverage must extend to the operating location of the field units. Most public safety systems that are built for mission critical applications, are designed with extreme care to assure reliable operation in the face of a series of potential system element failures.

### **1.3 Spectrum**

Federal, state, and local law enforcement and public safety agencies rely on radio spectrum for command, control, and execution of operations. Due to the increase in joint operations, interoperability among law enforcement/public safety agencies is a major concern. The existing spectrum allocation is insufficient to meet these existing and future needs and does not support interoperability.

Widespread implementation of interoperability capabilities are hindered by the diversity of radio frequency spectrum in which public safety agencies operate. Ten disparate and separate segments of the frequency spectrum are used for tactical mobile communications by federal, state, and local agencies, spanning 839 MHz of spectrum. No single radio is capable of operating in the numerous radio bands currently used by the federal, state and local public safety organizations, at an affordable price.

The ability to adequately interoperate on voice channels in the future will worsen, if contiguous or near contiguous bands are not allocated for public safety use. The ability to adequately interoperate in the future may become more complex as disparate and/or proprietary technologies are introduced.

### **1.4 Interoperability Requirements**

The ISC defined Interoperability as an essential communication link within public safety and public service wireless communications systems which permits units from two or more different agencies to interact with one another and to exchange information according to a prescribed method in order to achieve predictable results. This communications link is required not only in voice, but in all modes of communication, including low speed data, high speed data and video.

Three basic and different operational requirement levels of interoperability have been identified by the ISC:

#### **1.4.1 Day-to-day**

This most frequent type of interoperability is commonly used in areas of concurrent jurisdiction where agencies need to monitor each other's routine communications. This minimizes the need for dispatcher to dispatcher interaction in exchanging information among field units. Interoperability is difficult to implement unless all equipment operates in the same frequency band and within the same type of infrastructure.

#### **1.4.2 Mutual aid**

This involves multiple agencies using radios in "on the scene" incidents that are often outside the range of fixed infrastructure. There is often little opportunity for prior planning of different agencies to coordinate the necessary talk groups and frequency assignments.

### **1.4.3 Task Force**

This involves federal, state and/or local agencies using portable and/or covert radios, requiring extensive close-range communications, and roaming in and out of infrastructure coverage. Normally, prior planning opportunity exists.

## **1.5 Interoperability Solutions**

The ISC defined multiple levels of technological solutions to interoperability, both short term (defined to be within five years) and long term. These solutions can be categorized into infrastructure independent versus infrastructure dependent, both of which have ranges from simple to complex solutions. These solutions are not mutually exclusive and the optimum solution may use various combinations, especially as the interoperability requirement escalates from day-to-day to mutual aid or task force levels.

### **1.5.1 Infrastructure Independent**

Infrastructure independent methodologies are communication links directly between radios over a direct RF path. These solutions are typically used for close proximity communications by multiple disciplines and jurisdictions converging on the scene to support the public needs. They are also used when radios are out of range of their infrastructure coverage, such as in rural areas or some in-building communications. Common analog FM technology and mutual aid frequencies allow users to communicate regardless of radio manufacturer.

Widespread implementation of infrastructure independent interoperability is hindered by a number of significant issues. First is the diversity of radio frequency spectrum in which public safety agencies operate. Individual agencies may be prevented from communicating with another agency because their respective radio systems operate in different frequency bands.

Second, there is a critical shortage of spectrum available and designated for interoperability.

Third, introduction of new technology creates the risk that equipment without common communication modes, such as a common air interface, will lack interoperability.

Other issues include non-technological factors, such as the lack of commonly used designators to identify channels among different agencies, the user ability to remember the interoperability channel assignments, and command and control issues allowing interagency communications.

More complex solutions include development of broad band, dual band and multi-band radios. Commercial viability of these approaches is yet to be proven.

### **1.5.2 Infrastructure Dependent**

Infrastructure dependent methodologies and technologies require the use of some item(s) of equipment, other than a subscriber unit (radio), to establish a communications link and for complete radio operation. These solutions are typically used for wide area communications, where individual users are not within direct range of each other, and for on the scene communications where they may not have a common operating channel. This interconnection can be a temporary or permanent connection and can be accessed through a number of locations using various access methods. Once a permanent solution is in place, it can be idle in standby mode and be activated immediately when required, if all participating systems are operational.

Gateways between two or more system infrastructures can provide viable infrastructure dependent solutions at various degrees of complexity and may be one of the few available solutions in the short term. They can interconnect systems operating in different frequency bands, modes of operation, and manufacturer protocols. Most trunked radio systems require predetermined user or "talk" groups to be identified and programmed into the system. As systems become larger and additional user groups are identified, the problem of interconnecting users from other systems or non-trunked users becomes more complex. May be one of few viable short term solutions that can be implemented without modifying existing radios to bridge the different public safety frequency bands.

Infrastructure dependent methodologies and technologies have several disadvantages. First is that each participating network must have similar geographic coverage because interoperability is limited to the common overlap areas of the participating systems. Interoperability fails if any infrastructure is damaged or otherwise inoperable. Networks must generally be in place prior to an incident requiring their use because most often there is neither time nor opportunity to set up these solutions during emergency incidents. Deployable infrastructures can mitigate this problem. However, the degree of delay getting this equipment deployed often depends on the destruction severity of a disaster.

Infrastructure dependent solutions are typically spectrum inefficient because a separate talk path (channel) is required on each system for every simultaneous conversation.

### **1.5.3 Common Access to Infrastructure**

Consolidated systems covering the same geographic area, either conventional or trunked, readily provide interoperability to those agencies sharing the system. Consolidated systems allow multiple agencies to operate in the same frequency band using compatible equipment on the same infrastructure.

Consolidated systems improve spectrum efficiency because they allow multiple agencies to interoperate without the need for additional spectrum. Agencies simply switch to the desired channel or system/talk group of the appropriate agency. Scanning between channels or systems provides for routine monitoring of the other agency's radio traffic on an

ongoing basis. Such shared systems must also be planned to accommodate the combined loading and traffic of multiple agencies.

However, unless non-resident radios are fully compatible with the system infrastructure, interoperability with other agencies not sharing this system will require a different methodology for achieving interoperability. Such interoperability is also subject to the same issues and disadvantages as the above solutions.

#### **1.5.4 Establish New Interoperability Band**

The move of the entire public safety operating environment to a single band is not practical, and cross banding existing bands is far less than fully effective. The former being unworkable financially and the latter being extremely inefficient in terms of spectrum use.

However, creating a single common Public Safety Interoperability Service (which is abbreviated as "PI") in one central band is very possible and very practical. This band would be dedicated exclusively for interoperation applications. This will not eliminate the need for dual band radios or two radio installations, but having a universal declared service gives an absolute common technical solution to the common operating requirements of a mutual aid incident. A field tactical vehicle (or hand-held) with the "PI" capability could interact with any other unit similarly equipped.

As an example, one unit's basic internal system dispatch operation could be in an 800 trunked environment while another unit could be operating in low band. If these field units' second band or second radio in each case were the common "PI" radio, they would technically be capable of true interoperability. Bringing a third unit into the picture more than clarifies the practicality of a common PI service band.

Could be a short term solution, depending on the frequency band that is selected by the Spectrum Requirements Subcommittee. This solution would likely require most public safety agencies to purchase an additional radio for the new "PI" band.

### **1.6 Commercial Services**

Public safety agencies use commercial services, including cellular telephone, paging, satellite communications, and specialized mobile radio (SMR) and enhanced specialized mobile radio (ESMR) systems as an adjunct or supplemental solution for their non-mission critical communications.

Public safety agencies anticipate continued increase in their use of commercial services in the future, particularly for administrative and non-mission critical applications.

Commercial service providers typically do not provide the required features, priority access and command and control required by public safety for mission critical communications. As new and improved technologies and capabilities are introduced some of the problems experienced in the past may be resolved. Commercial systems are not likely to

meet all requirements within the public safety community. As new technologies emerge, objective experiments with and use of these systems will be necessary to determine the portion of public safety needs that can be satisfied.

The primary public safety requirements not provided by commercial services include failure to provide coverage needed by the public safety agencies, particularly in rural areas and inside buildings and tunnels for cellular services, as well as mountains and canyons for satellite services. Priority access is essential for public safety in mission critical situations. The ability to broadcast a message to specific groups and numbers of personnel within the agency is impractical (requiring detailed telephone number listings and numerous repetitive calls) or impossible with commercial service communications.

### **1.7 Costs and Benefits**

*(This section will be completed based on further activity of Working Group #7)*

The cost and benefits of different interoperability solutions are defined in terms of relative comparisons and known relationships, rather than dollar estimates.

- a) Costs are dependent on two main criteria:
  - i) The degree of public safety spectrum dispersion.
  - ii) The complexity of the interoperability solution.
- b) Benefits attained through interoperability are categorized as follows:
  - i) Intangible savings in suffering, lives and property are directly proportional to public safety response time.
  - ii) Spectrum resource efficiencies are realized through infrastructure independent interoperability. Infrastructure dependent solutions normally require at least two channels for each communication.
  - iii) Manpower resources required to attain various interoperability solutions, as well as possibility of human error.
  - iv) Tangible dollar savings are realized through avoidance of property damages or losses as a result of greater interoperability.

### **1.7 Conclusions and Recommendations**

Interoperability cannot be resolved without additional spectrum allocated to public safety. Consolidating the number of bands used by federal, state, and local public safety agencies into fewer bands will enhance the opportunity for interagency interoperability. Such

consolidation must be offset by increases in the total amount of spectrum allocated to public safety use. To promote interoperability, such additional spectrum should be provided immediately adjacent to existing, and possibly consolidated, number of public safety bands.

One of the ultimate and primary goals of the ISC is to reduce the number of bands that the Public Safety community currently operates their land mobile radio (LMR) systems. However, it is the general opinion of the members of the ISC that any significant reduction in the operational frequency bands cannot be realized in the PSWAC timeframe of 2010, without specific mandates and/or regulations. The ISC recommends that PSWAC Steering Committee, as well as the FCC and NTIA keep this recommendation in mind during future deliberations concerning rule-making and regulatory proceedings.

The ISC recommends the establishment of a new interoperability band. This solution may be a short term (less than five years) solution, depending on the availability of spectrum. This would require that a relatively free band of frequencies be identified, preferably central to existing public safety bands. Although the responsibility to identify spectrum rests with the Spectrum Requirements Subcommittee, the ISC suggests the UHF band below 512 MHz. Specific frequencies and pairs of frequencies using developed ICS guidelines should be defined.

The ISC further recommends that the FCC and NTIA freely license these frequencies to all eligible public safety/service providers under operational as well as technical regulations and they restrict use to mutual aid interoperation.

Aggregate numbers for interoperability links in existing bands and the new interoperability band indicate a total need for 21 repeatered voice links and 20 simplex voice links within current bands. It is believed that existing designated interoperability frequencies can be used for 13.5 of the repeatered and 13 of the simplex voice links. In addition, 31 repeatered voice, 70 simplex voice, 2 independent high speed data and 2 independent full motion video links must be provided in the new Public Safety Spectrum. Appendix A of this report further defines this requirement.

A national planning process should be established as soon as possible to address a nationwide mutual aid plan, define operational policies and procedures, provide guidance and procedures for regional planning processes, and define incident command system requirements. All levels of government should be involved in this planning effort and all public safety entities should have access to these interoperable channels. When guidelines are defined for a core nationwide use, individual regional concerns and issues should then be addressed and regional plans developed within two years of the national plan's completion.

The most critical interoperability requirement is for direct unit to unit communications, which requires a common mode of transmission. The ISC recommends that the minimum baseline technology for interoperability, for unit to unit voice communication, be 16K0F3E (analog FM), unless FCC and/or NTIA regulations stipulate a different emission in a specific operational band. This recommendation is applicable to public safety spectrum between 30 MHz and 869 MHz, and should be adopted as soon as possible by the FCC and NTIA.

Effective January 1, 2005, the minimum baseline technology for interoperability, for unit to unit voice communication, should be mandated as 11K25F3E (analog FM) in the public safety spectrum between 30 MHz and 512 MHz, unless FCC and/or NTIA regulations stipulate a different emission in a specific operational band. The maximum allowable interoperability bandwidth in any new spectrum allocation should not be allowed to exceed the bandwidth established for operational communications within that new spectrum.

Although it must be emphasized that the decision is not unanimous (see discussion in Section 10.5 of this report), the majority consensus of the ISC is to recommend that as part of the Final PSWAC Report, a strong recommendation be made to establish a group comprised of experts representing government, industry and users to address baseline technology for interoperability. This effort should be managed by a neutral third party who has no vested interest in the outcome of the effort.

The ISC further recommends that any digital baseline standards for interoperability be open standards, developed/adopted in an open and fair process. With the emergence of digital technology, it is imperative that this baseline be addressed and established within the next two years, to allow the public safety community to develop implementation and migration plans accordingly.

The separation of responsibility for allocation of federal and non-federal spectrum by NTIA and FCC has resulted in some roadblocks to shared use of spectrum in joint operations. To allow multi-level government interoperability, FCC and NTIA regulations must provide for equal access by both federal and non-federal public safety agencies.

The use of shared/consolidated systems by agencies covering the same geographic area has been hindered by the current licensing process, whereby a license to operate on certain frequencies is granted to the person/agency named on the license. This provides the named licensee with a certain amount of control over the unnamed users, such as requiring radio equipment or notice to vacate the system. This lack of control by participating agencies sharing the system needs to be addressed by the FCC and NTIA.

## **2.0 Interoperability Subcommittee Overview**

The Interoperability Subcommittee (ISC) is one of five subcommittees formed under the Public Safety Wireless Advisory Committee (PSWAC). The ISC was developed to identify the interoperability requirements of the public safety community and make recommendations to resolve the historical inability of different agencies to communicate with each other, via radio, during routine, emergency and disaster response operations.

Although the "PSWAC mailing list" was quite extensive, the ISC consisted of approximately 150 members, representing the user community, as well as representatives from industry and commercial service providers.

## 2.1 Charter

The following goals, for the Interoperability Subcommittee, were developed by the PSWAC Steering Committee and approved December 4, 1995.

*The Interoperability Subcommittee will examine the interoperability requirements between and among the various public safety entities and reduce them to writing (who needs to talk to whom and when). All phases of interoperability shall be explored, including command and control functions. The examination shall generally be technology neutral, although certain generic technologies may be suggested (e.g. multi-band radios should be employed that have as a minimum ten simplex and ten repeater pair channels, on all common spectrum nationwide). The subcommittee can also suggest ways to assure that recommendations are implemented in a timely fashion (e.g. no new radio for use on public safety channels will be type accepted after January 1, 1998, unless it contains provisions to operate on the nationwide interoperability channels). The final report of this subcommittee, which will form the basis for system planning by public safety agencies with regard to interoperability, will likely be used as input to the Federal Law Enforcement Wireless Users Group (FLEWUG) and will provide input to the Technology Subcommittee. This subcommittee will also define Public Safety.*

## 2.2 Report Scope

This subcommittee report outlines and discusses the current communications interoperability requirements and capabilities, as well as the future needs of the Public Safety Community at all levels of government. The subcommittee has considered the interoperability needs that are currently unsatisfied. Those that have been unsatisfactorily provided are addressed as future needs. The interoperability issues, identified by the Operational Requirements Subcommittee, have also been considered and are addressed in this report.

The first tasks undertaken by the ISC were to define *Public Safety* and *Interoperability*. The definitions were developed by individual working groups, and a great deal of effort by a diverse group arrived at consensus recommendations which were adopted by the ISC and the Steering Committee. These definitions and supporting discussion are presented in this report. Subsequently, as discussions ensued and various levels of priority and control were addressed, the subcommittee felt there was a need to define the term "mission critical" as it is used to describe system requirements through the course of the deliberations.

After developing the definitions which would be used throughout the report, the subcommittee focused on identifying the current and future interoperability requirements. Three different operational types of interoperability are identified and discussed; Day-to-Day, Mutual Aid, and Task Force.

The report first discusses typical methods and technical solutions that are currently utilized to provide communications interoperability, as well as the problems and shortfalls experienced in today's environment. A number of incidents were identified to typify the

interoperability requirements and problems that the public safety community must routinely address.

These same incidents, involving multiple agencies and jurisdictions, were used to exemplify the scope of the interoperability needs that currently cannot be met and the possible impact in the future. Command and control procedures and policies are also addressed and possible changes are discussed where applicable. Possible methods and procedures to provide future solutions are addressed and the advantages and disadvantages are discussed.

The ISC formed a separate working group to address current policies and procedures that affect interoperability and existing regulatory issues that limit or prevent a cost effective solution to the interoperability problem. The working group then addressed possible changes and/or modifications to the policies/procedures and regulations that could enhance the interoperability capabilities. The working group also addressed the advantages and disadvantages of possible mandates or incentives to ensure interoperability in the future.

Another working group was formed to provide cost and benefit analysis of possible methodologies and alternatives that are identified to provide various levels of interoperability. This working group was also tasked to perform a cost benefit analysis of the recommended baseline technology for interoperability, as well as an analysis of costs versus benefits of utilizing commercial services to support the public safety community. Unfortunately, due to the time constraints for completion of the report and delays in formulating suggested methodologies, this working group was unable to perform a thorough analysis. If time and resources permit, the working group report will be provided as supplemental information to the ISC report.

Commercially provided services were also addressed by a working group. The report discusses how the public safety community currently utilizes commercial services, such as cellular and paging, and how commercial services can further enhance and support the interoperability requirements in the future, as digital and RF data technology matures.

### **3.0 Definitions**

The Steering Committee tasked the Interoperability Subcommittee to provide a recommended definition of *Public Safety* to be utilized by all the subcommittees in their respective assessments of the current and future requirements for public safety communications. Likewise, the subcommittee decided it was necessary to define what is meant by “interoperability”, before the communications capability could be identified and recommendations developed. The need to develop a definition for *mission critical* was identified during subsequent meetings as various levels of communications interoperability were addressed.

#### **3.1 Public Safety/Public Services**

At the first meetings of the five subcommittees conducted in Washington, D.C., in September, 1995, considerable discussion took place concerning the definition of *Public*

*Safety* for the purposes of the Public Safety Wireless Advisory Committee (PSWAC). Shortly after the September meetings, the PSWAC Steering Committee tasked the Interoperability Subcommittee to develop a definition for Public Safety. After considerable discussion of suggested definitions during the October ISC meeting, in Camp Dodge, Iowa, Working Group #4 (WG4) was formed and tasked to develop a definition for *Public Safety* and *Public Services*.

This dedicated subcommittee workgroup consisted of representatives from the public safety community from varying types of jurisdictions and disciplines at the federal, state and local government level, as well as representatives from the commercial and manufacturing community. One obstacle encountered in the process was the fact that the concept of public safety varied throughout the country based on the individual needs of a particular region. The workgroup discussed the idea of creating a “laundry list” of entities, but felt that this might become restrictive and exclude vitally important entities in different regions of the country.

There were basically two distinct opinions offered toward the development of a definition of *Public Safety*. One was a strict law enforcement, fire and emergency medical service definition, commonly referred to as “First Responders” during the discussions. The other was a definition which included the critical thought that public safety is above all a government responsibility, which more closely follows the existing service definitions within the Federal Communications Commission’s rules. The latter opinion allowed for inclusion of government functions which cross the lines of disciplines and allows inclusion of government functions which are economically feasible and vital services provided to the public. The issue of listing or not listing selected entities in the definitions was an important point that many felt would seriously affect the way the definitions would impact various aspects of the public safety community.

The representative from the Union Pacific Railroad Company, representing the railroad industry, suggested that the definition be further expanded to include a paragraph to define *Public Safety Risk Avoidance*, which would more effectively include the railroads in the definition. It was the consensus of the working group, and ultimately of the subcommittee, that the definition did indeed include the railroad industry in performance of their public safety/public service role.

The following definition was adopted by the ISC, with one dissenting vote by the representative for the Union Pacific Railroad, on December 14, 1995. The ISC Chair recognized a letter from the Union Pacific Railroad Company, dated December 12, 1996, as a minority report, which was forwarded to the Steering Committee. The minority report (document number PSWAC/ISC 95-12-059) is included as Attachment One of this report. The Steering Committee unanimously approved the recommended definition on December 15, 1995 at the public meeting in Washington, DC.

***Public Safety:*** *The public’s right, exercised through Federal, State or Local government as prescribed by law, to protect and preserve life, property, and natural resources and to serve the public welfare.*

***Public Safety Services:*** Those services rendered by or through Federal, State, or Local government entities in support of public safety duties.

***Public Safety Services Provider:*** Governmental and public entities or those non-governmental, private organizations, which are properly authorized by the appropriate governmental authority whose primary mission is providing public safety services.

***Public Safety Support Provider:*** Governmental and public entities or those non-governmental, private organizations which provide essential public services that are properly authorized by the appropriate governmental authority whose mission is to support public safety services. This support may be provided either directly to the public or in support of public safety services providers.

***Public Services:*** Those services provided by non-public safety entities that furnish, maintain, and protect the nation's basic infrastructures which are required to promote the public's safety and welfare.

The term *Public Safety*, as defined, extends to all applicable functions of government at the federal, state and local levels, including public safety operations on Department of Defense facilities. There are two levels of public safety providers. The *Public Safety Services Provider* definition is focused toward entities performing such duties as emergency first response and similar activities. The Interoperability Subcommittee Workgroup recognized that this particular definition did not adequately cover the diverse public safety community and it was necessary to include another level of provider, the *Public Safety Support Provider*. This was in accordance with the question encountered by the Operational Requirements Subcommittee during the process to identify entity-specific needs. The Operational Requirements Subcommittee acknowledged that although a particular organization's primary mission might not fall within the classic public safety definition, some aspects of its operations could involve or impact public safety. The *Public Safety Support Provider* definition is meant to include entities whose primary mission is other than public safety services, but which may provide vital support to the general public and/or the Public Safety Service Provider.

The ISC also addressed *Public Safety Service Providers* that were non-governmental. Properly authorized non-governmental, private organizations performing public safety functions on behalf of the government are included in these definitions. The need for this portion of the definition is becoming more evident with the privatization of certain governmental services. For example, a number of local governments contract private organizations for emergency medical and/or ambulance service. Although private, these entities are authorized by the applicable government entity to provide life-saving functions on its behalf. Specific licensing concerns have been surfaced through this mode of operation and will be discussed in a later section of this report.

The *Public Services* definition outlines the basic functions of non-public safety groups and was created primarily to support the discussion of interoperability, among various organizational disciplines, throughout this report.

Dr. Michael C. Trahos, representing the medical interests in the NPSPAC Region 20, filed comments (document number PSWAC/ISC 96-02-020) to the ISC regarding the definitions. Dr. Trahos felt that the definitions, as approved by the PSWAC, were in conflict with proceedings within the FCC concerning definitions for the various radio services. Dr. Trahos' comments which are included as Attachment Two of this report, pointed out a possible problem with the perceived meaning of "appropriate government authority whose primary mission is providing public safety services." The problem was corrected with an editorial change to reflect the true intent of the definition.

### **3.2 Definition of Interoperability**

The following definition of interoperability and supporting information was unanimously adopted by the ISC during the public meeting on December 14, 1995. The Steering Committee unanimously approved the ISC recommendation during the public meeting on December 15, 1995, in Washington, DC.

*An essential communication link within public safety and public service wireless communications systems which permits units from two or more different agencies to interact with one another and to exchange information according to a prescribed method in order to achieve predictable results.*

*The communications link, whether infrastructure dependent or independent, must satisfy one or both of the following requirements:*

*Multi-jurisdictional: Wireless communications involving two or more similar agencies having different areas of responsibility. Some examples include a fire agency from one city communicating with a fire agency from another city and the Federal Bureau of Investigation (FBI) communicating with a County Sheriff.*

*Multi-disciplinary: Wireless communications involving two or more different agencies. Some examples include a police agency communicating with a fire agency and a parks agency communicating with an emergency medical services agency.*

*The communications link may involve any combination of subscriber units and fixed equipment (e.g., repeaters, dispatch positions, data resources). The points of communication are dependent upon the specific needs of the situation and any operational procedures and policies which might exist between the involved agencies.*

*The communications link may be classified as either of the following two types:*

*Infrastructure independent: The communications link occurs between subscriber units over a direct RF path. An example is portable-to-portable tactical communications at the scene of an incident.*

*Infrastructure dependent: The communications link requires the use of some item(s) of equipment, other than a subscriber unit, for establishment of the link and for complete subscriber operation. Some examples include a communications link for which a repeater station is required; a communications link which provides full system coverage for a visiting subscriber unit within a host trunked radio system; and a communications link which provides interconnectivity between two or more otherwise incompatible radio systems by cross-connecting the audio signals and/or appropriate signaling functions at some central point.*

### **3.3 Definition of Mission Critical**

As various levels of communications interoperability were discussed and considered, the term *mission critical* was typically used to describe the importance and priority of communications, particularly as it applied to interoperability and the utilization of various alternative methods.

The ISC introduced a definition for mission critical to be used as a reference and guideline as the interoperability requirements were identified and various methodologies were considered.

The definition of mission critical was introduced during the ISC meeting on May 29, 1996, at Scott Air Force Base, Illinois as follows:

*A mission critical communication is that which must be immediate, ubiquitous, reliable and, in most cases, secure.*

*EXPLANATION: An "immediate" communication must be capable of being transmitted and received instantaneously, without waiting for a system to be set up, a clear channel or a dial tone. A "ubiquitous" communication is that which can be transmitted and received throughout the area that the mission requires. A "reliable" communication system must be designed, constructed and maintained such that short-term disruptions are minimal. Finally, security, while not currently available in many situations, is increasingly a requirement for law enforcement and other sensitive communications. In this case, "security" is provided with "voice privacy" encryption.*

There was some discussion of whether public safety agencies have a requirement to interoperate unless some significant event is occurring. Therefore, all or virtually all

interoperable communications should be defined as “mission critical”. However, there was not a general consensus that this statement was an “absolute” and therefore should not be included as part of the definition.

## 4.0 Background and Overview

### 4.1 Background

Wireless communications interoperability has been a historic problem, almost since the time public safety agencies started using two-way radios. The first need for interoperability became apparent when law enforcement agencies from various jurisdictions attempted to respond to mutual aid requests. As other public safety services and agencies radio communications systems, it became obvious that communications interoperability could lend to the effectiveness of on-scene operations and response coordination.

Interoperability is a formidable problem. It is a problem that is often associated with risk of life during natural disasters and national emergencies.

The use of analog Frequency Modulated (FM) technology has been dominant in the land mobile radio industry and provides the basis for existing infrastructure independent interoperability. As this technology developed over the past forty years, it became well understood and a common set of operating parameters has allowed users in the same frequency band (within limitations) to communicate regardless of manufacturer of the individual radios. Yet, widespread implementation of interoperability capabilities are hindered by a number of issues.

One issue is a limitation of the number of channels that individual users are able to handle. Originally, this issue was a technological issue that related to the number of channels for which a radio could be “programmed”. When crystals were the primary means for selecting the radio frequency, physical limitations and other considerations limited the number of channels (frequencies) available in the radio, which was typically a maximum of four, as well as limited by the frequency spread that the radio could be “tuned”<sup>1</sup>. Thus, users were forced to be very selective of the frequencies that were available in their radios. Oftentimes, the need for “routine” communications prevented inclusion of any frequencies that would provide interoperability with other agencies. Today, as synthesized radios are available with a capability to operate on multiple channels over a wider frequency spread, the problem is less technological, but one of human interface. As the technological problems are solved, the human factors become more important, as most users are unable to remember the specific channels assigned for interoperability and scrolling through the list becomes very time consuming and impractical in an emergency. There have been several recent incidents in which

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<sup>1</sup> Typically, while radios were limited in the number of channels available, due to the physical space required for “crystals” and later “channel elements”, there were also limited by the frequency spread (difference between the highest and lowest frequency) within the radio. Typically, radios were limited to spreads between 2-3 MHz. The combination of these technological limitations limited the capability to operate on multiple channels even within the band.

users operating field units have complained about the inability to communicate with other “on-scene” agencies, only to later discover that they unknowingly had a common channel available in their radios. This problem is sometimes further compounded with a lack of commonly used designators to identify the channels among different agencies.

Widespread implementation of infrastructure independent interoperability is limited by the diversity of radio frequency spectrum in which public safety agencies operate, ranging from the 30-50 MHz portion of the VHF band to 869 MHz in the UHF band. No single radio is capable of operating in the numerous radio frequency bands that the federal, state and local organizations currently utilize. Thus, individual agencies may be prevented from communicating with another agency simply because their individual radio systems operate in different frequency bands. Only until recently, technological problems associated with building wide-band radios resulted in the frequency spread of an individual radio being limited to two or three megahertz. As newer synthesized radios were introduced that were capable of operating in wider bandwidths, new technology also introduced additional barriers to interoperability.

As manufacturers introduced new features and functions within the radio system, many of which were proprietary and not available to other manufacturers, the interoperability problem was amplified. Two specific examples of this problem is the introduction of voice encryption and trunking systems. Voice encryption, which is widely used by the federal law enforcement community was introduced by two major land mobile radio manufacturers. However, the encryption algorithms offered were not compatible with each other and therefore created a situation that did not allow follow-on purchases on a competitive basis. The introduction of trunking systems created a similar problem, in that the trunking systems that were offered utilized proprietary technology and equipment was not compatible among different manufacturers.

Currently, numerous public safety agencies operate multiple radios, not only in different frequency bands, but with different proprietary technologies, to satisfy their interoperability needs with multiple agencies. This practice is not only costly, but also very cumbersome for the users as law enforcement agencies attempt to maintain “low-profile” vehicles and more users operate low power hand-held portable units.

A lack of established policies and procedures among public safety agencies and public service organizations has contributed to the interoperability problem. The Ericsson White Paper (document #PSWAC/ISC 95-10-030/2 included as Attachment 2) states “The real tragedy of the Polly Krause case in terms of radio equipment, was the technology allowed the system to interoperate between adjacent counties, however, interoperation was not part of routine procedures”.

The importance of developing command and control procedures and establishing operational policies is as important as identifying and resolving the technological issues. Mr. Gilbert provides an example of the effects of lack of procedures in his white paper submitted to the ISC (document #PSWAC/ISC 96-02-018 included as Attachment 4). Mr. Gilbert states “During the Titanic disaster, other ships that could have helped were not alerted because standardization on radio frequencies to be guarded had not occurred. Even SOS had

not been designated as a universal call for help, and nearby ships sailed on unaware of the unfolding tragedy. The Titanic's loss caused the first Safety of Life at Sea Convention (SOLAS) that ultimately led to the formation of the International Maritime Organization (IMO) to provide international coordination of maritime telecommunications, training, operational procedures, standards, and the acceptance of new technology".

Mr. Gilbert points out that there is no similar national organization for the public safety community and suggests that one is needed to provide a continuous focus on all the issues important to success in the community.

There have been some improvements that have enhanced the interoperability capabilities in some cases. The NPSPAC identified a national "calling channel" and four tactical channels for mutual aid the new NPSPAC bands in 800 MHz. The NTIA identified specific channels, in both the VHF and UHF portion of the federal government spectrum, for interoperability as part of the narrowband channeling plan. Although this is a clear improvement, these channels are inadequate as it limits interoperability to those users in those specific bands.

Infrastructure independent interoperability will remain to be a significant problem as long as the public safety community operates in multiple bands, until a common channel (or channels) is identified for interoperability or a multi-band radio is available at an affordable cost.

## 4.2 Overview

Almost universally, responses by public safety forces to large scale emergencies and disasters have been hampered by the lack of communications interoperability. The primary reason for this has been the lack of clear and immediately available radio frequency resources devoted exclusively to interoperability. Secondly, there is no nationwide process for standardized link identification nor for other command and control functions for interoperability. On FCC administered frequencies there has never been the luxury for letting an adequate number of interoperability links remain clear waiting until they were needed. Frequency congestion on FCC public safety frequencies has been so severe that virtually all channels must support operational uses. Under NTIA administered frequencies there are some nationwide frequencies assigned to the National Interagency Fire Center for such uses. NIFC uses these frequencies to support their large scale cache operations. Although these frequencies are clear nationwide, NIFC rarely gives anyone else permission to load these frequencies into non-NIFC radios. This is because of the concern that when NIFC needs the frequencies, they cannot afford the time to get the frequency "cleared" because they find someone else is using the channel. NIFC is, however, very responsive in deploying their cache(s) of radios.

Emergency management and response at all levels of government has experienced increased demands for emergency service in recent years with hurricanes and floods in the east, earthquakes and wildfires in the west, and floods and tornados in the heartland, plus recent bombings in New York and Oklahoma. One common problem in each case has been

lack of sufficient frequencies to protect life and property. Dedicated channels are needed to permit immediate communications interoperability between all agencies in these critical incidents.

Emergency operations and disaster response typically involves a large number of resources from many agencies. Organized communications between these agencies is absolutely necessary to place resources where they are needed at the time they are needed. Communications is also needed to get rapid assistance to the public to save lives and protect property. At the same time, effective communications are needed to protect the very forces responding to the event itself. In the face of the need for immediate interoperability links, emergencies simultaneously severely load the available operational links. At the time that these operational links become most needed for interagency or mutual aid communications, they are loaded with internal traffic created by the event. Currently, there is not currently an adequate number of available communication links to support the intra-agency level of communications for most major incidents, let alone the required communications links required for interoperability.

The large incident is not the only example of public safety's need for interoperability resources. Every day there is an enormous number of examples where communications interoperability is required. Some are between jurisdictions such as when a local police department communicates with a county sheriff to coordinate aid or to alert the other agency of an observed problem in their jurisdiction. Not all of these occurrences involve hot pursuit; in fact, many involve the recent trend in the public safety services to have the nearest available unit respond to an incident, regardless of jurisdiction. This "breaking down" of political barriers has proven to be beneficial in reducing response times to emergencies, but interoperability is critical to the success of these mutual aid responses. Helicopters and marine units, as well as other specialized equipment are typically shared among various agencies, each requiring a common mode for communications interoperability. Daily, hundreds if not thousands of similar communications take place across the nation. Some involve police and fire, some are between fire agencies, and some are between fire and EMS providers. Many of these types of needs can be met by shared or "cross" use of each others' operational system or by crosspatches between the respective systems. However, in many cases the number of such cross channel uses can become extremely large. The more frequencies that field units must have, the chance that they will be used decreases. Field emergency forces need communications as a tool to accomplish their job. They cannot be expected to play a radio as one might play a piano. Common, universally identified communications links for interoperability must be made available.

As is discussed throughout this report, one of the most critical needs for the public safety users is direct unit-to-unit interoperability. There are numerous occasions when interoperability is needed in close proximity or in the absence of infrastructure, where gateways and/or interconnects cannot be utilized. As has been mentioned previously and will be discussed throughout this report, the public safety community operates in ten different frequency bands covering 839 MHz (30 MHz to 869 MHz) of the spectrum.

For decades every critique or after incident report of a major emergency contains statements concerning the absence of an adequate ability to communicate between incident responders. Some such events were irritation, some resulted in extreme danger to personnel. Added to this history is the day-to-day need for hundreds of communications between all levels of government. This history is addressed to some degree in this process to identify the interoperability needs of the public safety community.

The need for protected communications on the common communications channels are becoming increasingly evident. This is true not only in the law enforcement environment, but expands into other public safety entities, such as the release of victims names by fire or EMS units, or in the case of the Oklahoma City disaster, when information concerning additional threats that could endanger the safety of the on-scene personnel needs to be transmitted.

The issues of land mobile radio system cost, maintenance, expansion and spectrum support have moved beyond the means of many public safety organizations to afford or acquire. Business as usual in developing land mobile radio systems can no longer be tolerated by many public safety organizations and their governments. Many of the elected officials who serve as the final authorities for sources of funding and other support misunderstand the purpose and the critical services these systems provide. In real terms to the law enforcement and public safety agents and officers, the loss of support to develop or maintain systems or the replacement of systems with commercial services threatens the security, availability, and reliability of vital radio communications.

The regulatory bodies allocating spectrum and the industry which sets the course for equipment and systems abilities, tend to approach their tasks with "efficiency" defined either in terms of users per channel or dollars per some division of air time. Their definition of efficiency is typically not the same as the public safety community where the importance of the systems and spectrum is in terms of safety of the public and the ability to immediately respond to threats to life or property. The importance and amount of radio spectrum in public safety operations is measured by how quickly a clear channel can be accessed and the flexibility for the needed resources to respond to events without overloading the system in times of emergency.

These misunderstandings and attitudes tend to suppress the ability of public safety organizations to establish and maintain sufficient radio communications networks.

These are not the only impediments to attaining sufficient radio systems or more efficient use of land mobile radio resources and radio spectrum. Until the last three to five years, the readily available resources needed for systems development has led to independent and parochial attitudes within the public safety community.

Today the law enforcement and public safety community finds itself in increasing numbers of situations of both disaster response and investigation where interagency support cooperation between multiple and diverse agencies are imperative. The real time coordination in most situations is accomplished through the practical communications medium of land mobile radio systems.

The diversity of systems, spectrum assignments and organization missions compound the effort to interoperate.

A recommendation from Vice President Gore's National Performance Review, IT04: *Establish a National Law Enforcement/Public Safety Wireless Network*, recognizes these issues and provides a basic picture of circumstances associated with law enforcement and public safety land mobile radio systems.

“Whether the situation is responding to a natural or technological disaster, or performing search and rescue or interdiction activities, federal, state, and local law enforcement and public safety workers must be able to communicate with each other effectively, efficiently, and securely. Most of this communication occurs over tactical land mobile radio systems.”

“However, interoperability across these different radio systems is difficult to achieve. Federal, state, and local law enforcement agencies operate in different parts of the radio spectrum.”

Moreover, every federal, state, and local law enforcement agency operates separate tactical networks in every metropolitan area in the country. Often, there are several independent network control centers operating within the same federal building with no interoperation. This expensive duplication of effort prevents the use of spectrally efficient equipment and results in less-than-optimum coverage for many agencies. In addition, technical and administrative support is duplicated throughout the federal government.”

The importance of interoperability has been identified in a number of documents published in the last few years.

The recent airline crashes and Amtrak Train Collision are examples of the inefficiencies experienced with incompatible and noninteroperable radio communications systems. The life saving efforts, speed of rescue and recovery efforts are devastated with the inability to communicate and coordinate actions and resources from different government jurisdictions.

Even as we establish the criteria for today's needs and uses of the spectrum, given time, technology will change the options and services available and present more practical and attractive approaches to providing communications for the public safety community.

## **5.0 Inventory**

### **5.1 Requirements**

#### **5.1.1 Day-to-Day**

- Most often encountered type of interoperability.

- Commonly used in areas of concurrent (shared jurisdiction across common geographic area) jurisdiction.
- Interagency interoperability is a form of day-to-day interoperability that requires users from different agencies which do not share a common communications system to be able to communicate.
- Commonly used where agencies need to monitor each other's routine traffic.
- Commonly used where units from two or more different agencies need to interact with one another and to exchange information.
- Often involves different public safety disciplines responding to the same incident.
- Minimizes the need for dispatcher-to-dispatcher interaction in the exchange of information among field units.

In addition to the time delay involved in establishing a communications path between dispatch centers and the time required to physically restate information, it is a known fact that the more times a message is repeated from one party to another, the chances increase to having error introduced into its content. It is critical for tactical field situations that concise and accurate information is relayed.

There may be events where dispatcher intervention or monitoring of information is appropriate for resource management, administrative command/control, etc. This is especially true when command-level information is being passed between agencies.

- If agencies are in different bands, this may involve the use of multiple radios.
- Difficult to implement for field personnel using portable radios unless all equipment operates on the same band and with the same type of technology.

### **5.1.2 Mutual Aid**

- Can involve multiple agencies with little opportunity for prior planning (riots or wildland fires).
- Often requires assignment of several to many small groups, each on their talkgroup or frequency (tactical communications).
- Once on scene, typically involves use of portable radios.
- Many incidents are in rural areas outside the range of fixed infrastructure.

- Many incidents are in difficult to cover terrain
- Could be solved by deployable units

### **5.1.3 Task Force**

- Usually involves several layers of government (federal, state, and/or local).
- Typically, an opportunity for prior planning exists.
- Usually involves use of portable and/or covert equipment.
- Often requires extensive close-range communications.
- Nature of radio traffic is such that wide area transmission is usually undesirable.
- Users may rove in and out of infrastructure coverage (metro to rural, in and out of buildings).
- Often implemented by exchanging equipment to ensure that all users have identical or compatible equipment.

### **5.1.4 Additional Federal Government**

- typically the federal government interoperability needs are similar to that of their particular state and local government counterparts.
- interoperability becomes more complex for the federal government agencies with a nationwide responsibility.
  - wide area coverage requirement
  - diversity of the communications systems utilized by the various public safety and public service agencies throughout the country.
  - law enforcement agencies have requirement for voice encryption in most cases.

## **5.2 Coordination Issues**

Some coordination issues are identified and discussed in Sections 6 and 7, that users felt limited or hindered their ability to achieve interoperability. Some of these issues are discussed in Section 7.5 (*Regulatory Issues*).

Although all agreed that there are a number of issues that are important, the subcommittee decided that there was insufficient time to properly evaluate the issues.

## **6.0 Interoperability Today**

Federal, state, and local law enforcement and public safety agencies rely on radio spectrum for command, control, and execution of operations. The existing spectrum allocation is insufficient to meet existing and future needs and does not support interoperability. Due to the increase in joint operations, interoperability among law enforcement/public safety agencies is a major concern. Ten different frequency bands are used for tactical mobile communications by federal, state, and local agencies; no single radio that operates on all bands is currently available at an affordable price.

### **6.1 Typical Methodologies and Technologies Employed**

#### **6.1.1 Infrastructure Independent**

Infrastructure independent methodologies and technologies are typically utilized for on the scene communication by individual users or groups within close proximity of each other. Some scenarios are: a highway accident where police secure the scene to conduct an investigation, fire fighting personnel extinguishing or preventing a fire or the numerous instances where police, firemen, emergency medical technicians work in coordinated effort to evacuate and provide critical life saving medical attention to victims. Examples of large scale incidents that require immediate response, with no specific prior warning or planning, are the wildfires and natural disasters, such as earthquakes and hurricanes although in some cases there is some time for prior planning. The Air Florida crash in Washington, D.C., the bombing of the Federal Building in Oklahoma City and the World Trade Center in New York City and the Los Angeles riots are also examples of man-made disasters that have become major incidents. These events required coordinated efforts by the public safety community as well as by civilian services. Such incidents highlight the use of infrastructure independent methodologies and technologies where multiple disciplines and jurisdictions converged to support the public needs.

Today, the use of analog Frequency Modulated (FM) technology is dominant in the land mobile radio industry and provides the basis for existing infrastructure independent interoperability. As this technology developed over the past forty years, it became well understood and provided a common set of operating parameters that have allowed users in the same frequency band to communicate regardless of manufacturer of the individual radios. Yet, widespread implementation of interoperability capabilities are hindered by a number of issues.

Widespread implementation of infrastructure independent interoperability is limited by the diversity of radio frequency spectrum in which public safety agencies operate. No single radio is capable of operating in numerous radio bands that the federal, state and local organizations currently utilize. Some public safety entities operate in the 30-50 MHz portion of the VHF spectrum, while other entities operate in the VHF highband portion of the spectrum between 150-174 MHz. The federal government users operate land mobile radio

systems in the 406.1-420 MHz portion of the UHF band, while the non-federal public safety community utilizes the 450-470 MHz portion of the band, as well as some portions of the UHF-TV Broadcast spectrum in a limited capacity. The non-federal public safety users also operate systems in the 800 MHz portion of the spectrum. Thus, individual agencies may be prevented from communicating with another agency simply because their individual radio systems operate in different frequency bands. Only until recently, technological problems associated with building wideband radios resulted in the frequency spread (the difference between the highest and the lowest frequency) of an individual radio being limited to one or two megahertz. While newer synthesized radios are capable of operating in wider bandwidths than radios produced a decade ago, commercial grade radios are not yet produced which are capable of operating in across all the public safety frequency bands.

There are other issues that limit interoperability that are common to both infrastructure independent and dependent methodologies. These limitations are discussed in Section 6.2.3.

Many agencies utilize multiple radios to resolve some of these problems. However, besides the obvious cost impact of purchasing and maintaining multiple radios, agencies have experienced both technical and physical limitations when dealing with downsized vehicles and multiple antenna systems within the vehicle. Multiple radios create more critical problems for personnel that typically utilize portable (hand-held) equipment.

Public safety agencies have utilized scanning receivers to provide personnel with the capability to simultaneously monitor multiple channels. In some cases, the scanning function is built into the same receiver that is used for primary communications, resulting in some problems associated with priority features to ensure normal communications are not disrupted. Some agencies have used separate multi-band scanning receivers, but have experienced difficulties due to the less demanding equipment specifications, compared to the typical public safety radios. These lower specifications make these units more susceptible to interference. Problems have also been experienced with scanners operating in the trunked radio environment, due to the number of channels involved and the control protocols required.

### **6.1.2 Infrastructure Dependent**

Infrastructure dependent methodologies and technologies typically are utilized for wide area and high density system communications and for on-scene communications wherein the individual users may not have a common operating channel. Typical scenarios include large scale disasters such as an earthquake, flood or hurricane. They also include campaign-type fires such as the Oakland Hills fire or any of the forest or wildland fires that commonly occur each year. These incidents could include any man-made or natural disaster that encompasses a wide geographical area or a number of different incidents that cover a large area, which may cross a number of jurisdictional boundaries. Both preinstalled and deployable units can be within the infrastructure dependent classification.

Infrastructure dependent methodologies and technologies have an obvious application in scenarios in which the individual users are not within radio range of each other, or who do not have a common channel in which to directly communicate. In its simplest form,

communicating through a repeater station, which receives an incoming signal on one frequency and retransmits (repeats) the same signal on another frequency, is an infrastructure dependent methodology. Many of the problems experienced, relative to an infrastructure independent methodology, are also applicable to repeater operation. The individual user radios must be capable of operating on the repeater access channel and the individual users must recognize the availability of this common mode of operation. Finally, the individual users must all be within the range<sup>2</sup> of the repeater station.

Infrastructure dependent methodologies and technologies can also be used to resolve incompatibilities between user radios and systems. For example, a FEMA vehicle with deployable radios and a mobile base station could be sent to the incident. In another instance, a VHF highband radio system could be interconnected to a UHF radio to establish a communications link between field units operating in the two different bands. This interconnection can be a temporary or permanent connection and can be accessed through a number of locations using various access methods. One example of a temporary interconnection would be a connection provided at one or more dispatch console(s), upon request, such as the system currently utilized with Police Mutual Aid Radio System (PMARS) in the Washington (DC) Metropolitan Area. This method is very inefficient, because typically two dispatchers are involved and two channels are used to establish one talk path. Consequently, this system is seldom used by the law enforcement agencies in the region. An example of a permanent interconnection is the cross-connecting of two repeaters or the use of a cross-band repeater, such that all incoming traffic (on one band) is retransmitted on the other. Either interconnection is not spectrally efficient, as at least two channels are occupied to support one communications path. While many agencies utilize the temporary interconnections due to system and budget constraints, most agree that temporary interconnections are less than desirable due to the time required to set-up the connection and the possible geographic limitations of the individual "home" systems. Nonetheless, to date, no other technology solutions can bridge two bands. Therefore, gateways still provide a viable solution.

Trunked radio systems present a further challenge when attempting to interconnect systems. Most systems require predetermined user, or "talk" groups be identified and programmed into the system. As systems become larger and additional user groups are identified, the problem of interconnecting users from other systems or non-trunked users becomes more complex, although it is not an insurmountable requirement. In addition, when interconnecting trunked radio systems which use different proprietary protocols, access times can suffer, and the geographic coverage patterns must be congruent to support field unit use.

### **6.1.3 Commercial Services**

#### Cellular Telephone

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<sup>2</sup> Typically, the limiting factor of the range of the repeater is the transmitter power of the individual user's radio which is normally a mobile or hand-held portable unit.

Public safety agencies make use of commercial services every day. Cellular telephone, for instance, provides access to the public switched telephone network (PSTN) from which many other resources can be contacted. The cellular telephone has proven to be particularly useful when the public or other non-public safety agencies must be contacted. Police and fire units have been able to talk directly with a 9-1-1 caller while enroute to an incident. As a result they were better prepared to handle the situation when they arrived. Cellular telephones have been used to talk with the suspect in hostage and barricade situations, oftentimes resulting in resolution of the situation without injury. Cellular telephones have been used to establish communications between command personnel from different agencies responding to the same incident. They have been used to establish communications with utility companies (electric power, gas, water) needed to assist during an incident. These and many other useful functions have been provided through cellular telephone services.

Cellular telephone services, however, also have limitations when used in the public safety environment. First, they are not ubiquitous and oftentimes do not provide the coverage needed by public safety agencies, particularly in the more rural areas where the customer density does not warrant infrastructure costs. In the more populated areas, coverage problems exist in areas such as tunnels and inside buildings, particularly lower levels and parking garages.

Another limiting factor that has been experienced with cellular telephone service during major disasters and/or emergencies, is system access. Each cell site is capable of supporting a specific number of simultaneous conversations. At any given point in time, all of the available communication links may be fully occupied by other, non-public safety users. While there have been discussions concerning priority access for public safety users, many of the proposals include "top-of-queue" methods, rather than "pre-emptive" or "ruthless preemption" methods. Many users feel that "Top-of-Queue" priority access procedures results in a finite wait for access which will likely be unacceptable for the public safety user in mission critical situations. This has been particularly apparent in emergency situations where the news media access one or more cellular channels and remain "off-hook" for the duration of the event to provide "instantaneous communication links" to their main office or studio. This access problem is exacerbated if the incident is moving or expanding, thereby requiring the communications link to be passed from one cell site to another. In some areas of high use, there have been problems with calls being "dropped" during the "hand-off" process due to all channels already being in use at the new cell site. When this occurs and there is no communication link available in the next cell, the call already in progress is dropped. The user must then re-initiate the call, and then go into "queue" for an available channel at the already fully loaded cell site.

The use of cellular telephone services is also limited by the "one-to-one" nature of the service. Currently deployed technology limits conversations to two people, unless some conferencing capabilities exist, which also takes time. Thus any requirement for broadcasting a

message to a number of people<sup>3</sup> is impractical and in most cases impossible. Currently, the need to remember telephone numbers or maintain a telephone list can become very cumbersome during a major event. Because of access and dialing delays, the only way to have instant use of the channel is to hold it open. This only makes the cell site less effective as channels are taken out of the possibility of reassignment.

### Paging Services

Public safety agencies make extensive use of paging services for alerting personnel. While some public safety agencies may need to maintain their own separate paging systems (such as a paging system within a hospital to alert “code-blue” teams), commercial paging systems are cost effective and provide acceptable levels of service in a great many cases.

### Satellite Services

Commercial satellite communications have also proven to be useful resources. These services provide communications links over virtually any distance with little regard to terrestrial infrastructure. Thus, a satellite link can provide communications from within a disaster area to mutual aid responders outside the disaster area. They also provide a means of rapidly establishing new service at the scene of an incident. The cost of currently available services has been a factor in the limited use of satellite services, due to the air time charges and connection fees, for most routine applications. Historically, available services also have not offered practical solutions to most public safety land mobile communications requirements. The size and weight of the devices needed to operate through the geo-synchronous satellites, as well as the requirement to orient the antenna can make land mobile applications difficult, particularly portable operations. Although improved technologies and equipment have recently been introduced that may resolve some of these issues, public safety users have not yet utilized many of these improved systems.

The use of satellite based systems may be limited by local terrain features, such as mountains and canyons, as well as by man-made structures, which may block the signal path of the satellite. Most public safety users need radio systems which operate in these areas as well as in the more open areas, which might be accessible via a satellite based system.

Transmission delay may adversely impact some of the currently available satellite based systems. Operation of some of the existing systems has required that all messages pass through one of the satellite service provider’s message switches. As a result, a message between two mobile units may pass from one unit, through the satellite, through a terrestrial message center, back through the satellite, then to the other mobile unit. The “double hop” through the satellite (which was geo-synchronous) resulted in objectionable transmission time delays.

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<sup>3</sup> A significant requirement for mission critical public safety communications is the ability for conversations to be heard by a number of personnel within the organization. This has been commonly referred to as “broadcast” or “one-to-many” communications.

### Specialized Mobile Radio

Specialized Mobile Radio (SMR) services were established by the Federal Communications Commission (FCC) in the mid-1970's when the FCC allocated a portion of the 800 MHz spectrum for use in private land mobile communications. Primarily “dispatch communications”, these analog services are commonly employed by companies with fleets of vehicles operating throughout a local area. They typically permit two-way mobile communications between a dispatcher and one or more mobile/portable units, which enables groups of users to communicate simultaneously.

SMR systems are typically configured using a single high elevation tower, high-power station that provides communications coverage throughout a limited geographic local service area. Users can communicate with other members of their talk groups, and in some cases, can access the public switched telephone network (PSTN) through limited interconnection capabilities. Some SMR providers offer limited data capabilities within their local service area.

### Enhanced Specialized Mobile Radio

Enhanced SMR services, also known as ESMR or wide-area SMR services, are digital telecommunications services that offer customers an integrated package of wireless services, including not only dispatch, but also interconnected mobile telephone (cellular), alpha-numeric paging, and data capabilities. The ESMR system is designed and constructed similarly to a cellular system in that it employs a multiple low-power, low-tower configuration that enables telephone call “hand-off” as a user moves through the ESMR network coverage.

Specialized Mobile Radio (SMR) and Enhanced Specialized Mobile Radio (ESMR) systems currently have limited use by some public safety agencies. Some SMR and ESMR providers have responded to major events, such as the Oklahoma City bombing and the Northridge (CA) earthquake. They have installed new radio sites to increase capacity and provided mobile radio units to public service agencies such as the American Red Cross and to some public safety agencies. In general, these services were not used by “first responder” units, but were a valuable resource for public service units, such as the Red Cross, which were providing support and assistance.

Some public safety agencies have entered into cooperative agreements with local SMR/ESMR providers. Through these agreements, the public safety agency may provide one or more radio channels (typically in the 800 MHz band) which is added to the SMR system. In some cases, availability of the “public safety” channel(s) is partitioned<sup>4</sup>, while still retaining access to the remaining channels in the SMR/ESMR system. In this way, the public safety user has access to the full capabilities of the system, plus exclusive access to the partitioned channels.

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<sup>4</sup> A “partitioned” channel is typically reserved for exclusive use of the public safety agency, while other users are “blocked” from access to the channel.

SMR and ESMR systems suffer many of the interoperability problems faced by public safety systems. First, different systems operate with equipment supplied by different manufacturers. Oftentimes, equipment from one SMR/ESMR system may not have the proper signalling and operational protocols programmed to operate within a system provided a another manufacturer. Even if the equipment were technically compatible, many SMR/ESMR systems prohibit “roaming”<sup>5</sup> between systems for economic reasons. Second, SMR/ESMR systems are designed to provide optimal communications to a defined customer base within a specified area of operation. Thus, the amount of service which might be available and the area within which that service is available was defined by the needs of the customer base and not upon the needs of the public safety users. Third, few public safety agencies use SMR/ESMR services on a routine basis, therefore, they are not equipped to utilize the services in an emergency. Thus, any use of SMR/ESMR services requires the public safety agency to obtain the equipment and issue the equipment to appropriate personnel, as well as train the personnel on the use of the subscriber units and the system. Currently, these systems do not meet the public safety requirements for priority access, survivability, and direct unit-to-unit operation.

## **6.2 Operational Policies and Procedures**

### **6.2.1 Operational Control**

Current policies place few restrictions on the use of interoperability channels. For instance, the frequency 155.475 MHz is set aside nationwide for “...use in police emergency communications networks operated under statewide law enforcement emergency communications plans” (47 CFR 90.19[d] and [e][14]). The contents of the statewide plan are not described nor is there an approval process established for the plans. The State of California has established the following guidelines for use of this channel, as well as certain other channels set aside within California for mutual aid purposes. However, it should be noted that these policies are applicable only to California.

- Priority 1: Disaster and extreme emergency operations for mutual aid and interagency communications.
- Priority 2: Emergency or urgent operations involving imminent danger to the safety of life or property.
- Priority 3: Special event control activities, generally of a pre-planned nature, and generally involving joint participation of two or more agencies.
- Priority 3a: Drills, tests and exercises.
- Priority 4: Single agency secondary communications

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<sup>5</sup> “Roaming” is simply defined as the ability of a subscriber unit to operate in other systems when outside the coverage area of its home system.

This system of priorities has served well to encourage agencies to implement some of the mutual aid channels and to use them while preserving their use for higher order events.

### **6.2.2 Operational Security Factors**

Unauthorized use/access to mutual aid/interoperable channels is a significant concern.

### **6.2.3 Interoperability Implementation Limitations**

There are some issues and/or limitations that are common to all types of interoperability, whether infrastructure dependent or independent.

One issue is a limitation of the number of channels that individual users are able to handle. Originally, this issue was a technological issue that related to the number of channels for which a radio could be “programmed”. When crystals were the primary means for selecting the radio frequency, physical limitations and other considerations limited the number of channels (frequencies) available in the radio, which was typically a maximum of four. Thus, users were forced to be very selective of the frequencies that were available in their radios. Oftentimes, the need for “routine” communications prevented inclusion of any frequencies that would provide interoperability with other agencies. Today, as synthesized radios are available with a capability to operate on more than 230 channels<sup>6</sup>, the problem is no longer technological, but one of human interface. As the technological problems are solved, the human factors become more important, as most users are unable to remember the specific channels assigned for interoperability and scrolling through the list becomes very time consuming and impractical in an emergency. There have been several recent incidents in which users operating field units have complained about the inability to communicate with other “on-scene” agencies, only to later discover that they unknowingly had a common channel available in their radios. This problem is sometimes further compounded with a lack of commonly used designators to identify the channels among different agencies.

Another problem is a general lack of channels available for interoperability. Whether the reason has been insufficient planning or a critical need to utilize all available channels to satisfy routine operational demands, few channels have been designated or available to satisfy interoperability requirements.

There is a command and control issue that varies to some degree across the different jurisdictions and agencies, but is basically similar. Many commanders are willing to have personnel from other agencies join “their home” system, but somewhat hesitant to allow the personnel within their own agency to join the radio system of another agency when it jeopardizes the commander’s ability to maintain communications with his own personnel. A user in the field who cannot be contacted is not available for assignment.

## **6.3 Spectrum Use and Considerations**

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<sup>6</sup> The California Department of Forestry and Fire Protection’s Chief Officer radios currently have 320 channels.

Interoperability is hindered by the diversity of the spectrum now used by public safety agencies. Non-federal users are scattered across seven frequency bands<sup>7</sup>, while the federal agencies primarily operate their land mobile radio systems in the 162-174 MHz and 406.1-420 MHz bands, as well as the 138-144 MHz band which is primarily used by the Department of Defense. It is currently not possible to provide a radio that will operate across all these bands, at an affordable cost. Thus, the implementation of full interoperability is dependent upon the involved agencies finding some common frequency band in which both are willing/able to operate.

## **6.4 Regulatory Issues**

### **6.4.1 Federal vs Non-federal Use of Spectrum**

Under current policies, practices and procedures, federal agencies request and coordinate the allocation of spectrum through the National Telecommunications and Information Administration (NTIA). Non-federal agencies request the allocation of spectrum from the Federal Communications Commission through one of several designated frequency coordinators. This separation of responsibility for the allocation of spectrum has resulted in some roadblocks to the shared use of spectrum by federal and non-federal agencies engaged in joint operations. The FCC requires that all non-federal agencies desiring to use “federal” spectrum obtain a license to use that spectrum. The process requires that the non-federal agency obtain concurrence and perhaps “sponsorship” from an appropriate federal agency and submit a copy of that concurrence together with their license application to the FCC. The FCC then takes that request to NTIA for concurrence. Assuming concurrence exists, the FCC then grants a license to operate on the “federal” channel. This process must be repeated every five years as the license comes due for renewal. Some federal agencies, however, are reluctant to grant concurrence for a non-federal user to be licensed on one of their channels. They may well want the non-federal user to operate on their channel for interoperability purposes, however, they do not want that non-federal user to be “licensed”. Thus, there is a dichotomy between the FCC’s demand that all non-federal users obtain a license through them to use federal spectrum and the federal users refusal to allow that process to occur.

Similarly, federal users are hindered in their ability to operate on non-federal spectrum. There is no formal mechanism for this to occur. As a result, non-federal agencies have entered into agreements with federal agencies to grant a “letter license” for the federal agency to operate on non-federal spectrum. These “letter licenses” amount to being a statement from the originator that his/her agency is appropriately licensed on one or more frequencies and that for specified purposes, the federal agency may operate on those frequencies. During such operations, the originating agency accepts full responsibility for proper use of the channel.

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<sup>7</sup> Non-federal (public safety agencies) operate in the 30-50 MHz, 150-162 MHz, 220-222 MHz, limited use in 420-430 MHz, 450-512 MHz and two bands in 806-824/851-869 MHz portion of the spectrum.

The regulations need to provide for equal access by both Federal and non-federal agencies for purposes of interoperability. It may be desirable to restrict this access to certain specified channels, in which case, channels should be designated in each of the frequency bands.

#### **6.4.2 Shared Systems**

The use of shared systems in the public safety community has been hindered by the current licensing process. Under the current process, a license to operate on certain frequencies is granted to the person/agency named on the license. That person or agency then becomes the “licensee” in the eyes of the FCC with certain “rights” to the continued use of that frequency or frequencies. Even though licensees must renew their license at certain specified intervals (currently five years for land mobile licenses) very few renewals are denied and then only upon a showing of cause. Similar “rights” are not granted to the unnamed persons/agencies who may have contributed to the construction of the system and most likely are paying a portion of the operating cost. This affords the named licensee a certain amount of power over the unnamed users. There are numerous examples of the licensee deciding to change operation of the system without consulting the user agencies, perhaps requiring the user agency to replace all the mobile/portable equipment to maintain compatibility with the “new” system. There have also been incidents wherein the licensee decides that the system is no longer capable of providing service to the other users and telling them to find services elsewhere. The notice to vacate may provide for as little as thirty days lead-time to react. This lack of control over one’s destiny is unacceptable to many public safety agencies.

The regulations also need to provide for equal access by both federal and non-federal agencies for the purpose of sharing systems. An incentive for agencies to enter into such shared systems would be to give favorable licensing treatment to these systems.

### **7.0 Future Interoperability Needs**

The future interoperability needs are discussed in detail in Section 12.3, *Working Group #3 Report*.

#### **7.1 Summary of Requirements**

##### **7.1.1 Direct Unit to Unit Interoperability**

The most critical interoperability requirement is for direct unit-to-unit communications, which requires a common mode of transmission.

##### **7.1.2 Additional Channels in Existing Bands**

Working Group #3 identified the need for 51 repeatered voice links and 83 simplex voice links within current bands, plus 2 independent high speed data and 2 independent full motion video links. The distribution of the channels within the existing bands is reflected in Appendix A.

It is believed that existing designated interoperability frequencies can be used for 17.5 of the repeatered and 28 of the simplex voice links. The high speed data and full motion video links must be provided within new spectrum.

### **7.1.3 Additional Channels in Interoperability Band**

Working Group #3 identified the channel requirements for existing bands plus a new interoperability band, if selected. A total need for 21 repeatered voice links and 20 simplex voice links within current bands has been identified. The distribution of the channels within the existing bands and the new interoperability channel is reflected in Appendix A.

It is believed that existing designated interoperability frequencies can be used for 13.5 of the repeatered and 13 of the simplex voice links. 31 repeatered voice, 70 simplex voice, 2 independent high speed data and 2 independent full motion video links must be provided in the new Public Safety Spectrum.

## **7.2 Operational Policies and Procedures**

Although the operational policies and procedures are important concerns that should be addressed, there was insufficient time and/or information available to the ISC to properly evaluate the effects of all the issues.

### **7.2.1 Operational Control**

Operational control of systems and spectrum identified as interoperable channels is an important issue, however, there was insufficient time to properly evaluate the alternatives and provide a valid opinion at this time. The ISC recommends that these issues be addressed as the national and regional planning is accomplished.

### **7.2.2 Operational Security Factors**

As more emphasis is put on sharing systems and infrastructures, the capability for additional users and access points will be provided. As more users are provided access to infrastructure, the system security and protection from unauthorized access must be addressed.

Different factors may require evaluation with the introduction of data capabilities over a wireless media. Unauthorized use/access may have new meaning in a data environment.

### **7.2.3 Liability Concerns**

There was some concerns expressed concerning the possible liability of licensees [system owners] to maintain operational reliability in a shared environment, as well as funding responsibilities. There was insufficient time and information available to properly address this issue in the ISC. It is recommended that this issue be addressed at the Steering Committee

level as appropriate options are decided and possible mandates and/or incentives are introduced.

#### **7.2.4 National/State/Regional Planning**

A national frequency plan and regional frequency plans (as applicable) must be developed and mandated. These plans must include voice (simplex, mobile relay and trunked), data and video.

Standard nomenclatures and identifiers for channels/talk groups must be mandated by the FCC and NTIA for use on all equipment, to include approved identifiers to be displayed for interoperability channels/talk groups on equipment with varying numbers of characters in the channel/talk group display window.

A National Calling Channel and one or more Tactical Channels must be established in **EACH** of the public safety frequency bands. Use of these channels should be similar to that currently designated in the NPSPAC plan (47 CFR 90.16 and §90.34).

As with other mutual aid frequencies, it is important to consider placement within each band. There have been significant problems when mutual aid channels have been placed side-by-side or next to other statewide or nationwide assignments due to adjacent channel interference which can render such channels unusable when operating within close proximity to each other.

### **7.3 Spectrum Use and Considerations**

While the ISC recognizes that the responsibility to identify the spectrum to support the interoperability channels identified is the responsibility of the Spectrum Requirements Subcommittee, some considerations should be addressed.

The ISC recommends that a new Public Safety Interoperability Band be established. Depending on the band selected, this solution could provide some immediate dividends, possibly within two years or sooner, for the public safety community. If at least some of the required channels were provided from existing UHF bands, the benefits could be realized immediately. If the new interoperability band is provided from spectrum that must be vacated by other users, the benefits will not be realized for some time.

### **7.4 Regulatory Issues**

#### **7.4.1 Shared Spectrum/Systems**

Shared systems (i.e., large trunked systems which provide service to many governmental entities in a specific geographic area) offer a high level of built-in interoperability. They also offer greater spectrum efficiency than many smaller non-trunked systems or systems trunked on fewer channels. However, shared systems face difficulties which hinder their adoption. Probably the most significant difficulty of shared systems is that

they require individual agencies to surrender some autonomy in return for the efficiencies and better coverage of the larger system.

The FCC could implement policies which facilitated the adoption of shared systems. For example, the FCC could require a showing (or statement) on license applications that no shared system can meet the agency's needs, similar to the procedures required by the NTIA for the federal agencies. The FCC could also implement policies which help preserve the autonomy of individual agencies and hence lower the threshold for adoption. For example, the FCC could adopt a policy that said that all communications involving safety-of-life were to be carried at equal priorities. Thus, a tenant on a shared system would not need to fear that the landlord would get superior access to channels in a crunch time.

### **7.4.2 Commercial Services**

The role of commercial services in public safety is yet to be determined, however, discussions in the ISC identified some shortcomings of commercial systems ability to meet public safety needs, based on experiences with current systems. The FCC could adopt policies that would remove some such shortcomings. One such policy, which would reduce problems with access to commercial systems during times of peak usage, would be rules that provide for priority access to commercial systems by public safety users.

Regulatory and eligibility issues are being addressed at the national level by the National Security Telecommunications Advisory Committee (NSTAC). In partnership with NSTAC, the Office of the Manager, National Communications Commissions System, is seeking the FCC's approval to establish Cellular Priority Access Service (CPAS). CPAS will offer non-preemptive priority queuing cellular service to the nation's emergency responders who have national security or emergency preparedness functions.

To invoke CPAS, users must have a bona fide National Security or Emergency Preparedness purpose. Their telecommunications are used to maintain a state of readiness or to respond to and manage any event or crisis which causes or could cause injury or harm to the population, damage to or loss of property, or degrades or threatens the National Security Emergency Preparedness of the United States. The proposal urges the creation of a centralized administration within one Federal Government office, to ensure uniform application of eligibility, procedures and rules and to provide a single point of contact for information and problem resolution.

CPAS defines 5 priority levels and supports the activities of both the private and public sectors. A petition for rulemaking was filed with the FCC by the National Communications System on October 19, 1995, recommending that CPAS be a voluntary service offered by the nation's wireless service providers.

Although the most users agree that the recommendations of the CPAS do not go far enough to satisfy the public safety needs, it may be a vehicle to further state the needs of the public safety community.

However, many of the shortcomings identified flow from market forces and are not readily susceptible to regulatory cures.

### **7.4.3 Mandates**

Although the issue of mandates and incentives are considered to be very important if direct unit-to-unit interoperability is achieved at the level that most desire. For a reduction of the number of individual bands used by public safety to be realized, some kind of incentives and/or mandates will likely be required.

### **7.4.4 Standards**

During the deliberations of the ISC, a number of discussions ensued concerning the development of standards. A minimum baseline technology for interoperability was identified and unanimously approved by the ISC. This baseline technology is discussed in Section 11.2.3.

It was further stated that while the Minimum Baseline for Interoperability presented in Section 11.2.3 will suffice for some time, perhaps as long as 2010, the time will come when most, if not all, users in a given area will be using a digital voice communications platform and will not want to give up the capabilities provided by that platform when switching to analog FM for direct unit-to-unit communications.

Considering the evolution to digital technology, we should not limit future interoperability to an analog baseline. Just as the AMPS cellular standard (which clearly goes far beyond simple analog FM) provides North America-wide cellular interoperability, there is clearly a future need for digital interoperability standards for public safety communications. It is imperative that this baseline be addressed and established within the next two years, to allow the public safety community to develop implementation and migration plans accordingly.

The issue of establishing a group to address digital baseline standards for interoperability became a very controversial subject, and is further discussed in Section 10.5.

### **7.4.5 International Considerations**

As new interoperability channels and spectrum are identified, both cross border interoperability issues, as well as cross border frequency coordination issues must be addressed. As specific spectrum and/or channels are identified by the Spectrum Requirements Subcommittee, international border issues must be addressed.

### **7.4.6 Recommendations**

The FCC and NTIA should establish a task force to identify policies that would facilitate joint use of spectrum by federal and non-federal government users. This task force

should also consider policies needed to facilitate the creation of shared systems that support both federal government and non-federal users.

The FCC should consider implementing incentives that facilitate the adoption and use of shared systems for public safety communications.

The FCC should adopt rules that make commercial systems more responsive to public safety needs. Most importantly, the FCC should require commercial systems to offer a priority access option to public safety users.

## **8.0 Overview of Possible Methodologies**

### **8.1 Direct Unit to Unit**

#### **8.1.1 Advantages:**

- Ability to work outside of an infrastructure
- Communications in event of infrastructure failure
- Generally limited range often permits high level of frequency reuse

#### **8.1.2 Disadvantages:**

- Units must be completely compatible, including common frequencies and mode of operation
- Limited range may be inadequate/adequate coverage for some incidents

### **8.2 Common Access to Infrastructure**

#### **8.2.1 Advantages**

- Consolidated systems, either conventional or trunked, covering the same geographic area, readily provide interoperability.
- Spectrum efficient. For example, in some states the following three agencies require continuous (24 hr/day) interoperability to provide effective law enforcement and for officer safety; each must be able to independently monitor and transmit to the other two agencies. The first is a state highway patrol agency with primary jurisdiction for enforcing all traffic laws in unincorporated areas of the state and providing traffic investigation assistance to other agencies on request. The second is a county sheriff's department with primary jurisdiction for enforcing all non-traffic laws within the county, for operating the county's prisoner custody system, and for security in the county's courts and jails. Last is a city police department within the same county responsible

for general law enforcement within its political boundaries. These three agencies operate in the same RF band using compatible equipment. They can interoperate on each other's systems without the need for any additional spectrum simply by switching to the desired channel or system/talk group of the desired agency. Scanning between channels or systems provides for routine monitoring of the other agency's radio traffic on an ongoing basis.

- Appropriate administrative regulations or functional controls (through hardware or software implementations such as control of mobile relays, enabling of trunked talkgroup or roamer access, etc), are desirable to prevent misuse of interoperability features

### **8.2.2 Disadvantages**

- Provisions must be made for outside users to enter a system.
- Incoming units must be fully compatible with infrastructure to function, including identical technical requirements for trunked systems.
- Interoperability fails if infrastructure is damaged or otherwise not operational (until such time as infrastructure is restored).

## **8.3 Interface of Infrastructures**

### **8.3.1 Advantages**

- Any two (or more) infrastructures can be bridged together through gateways
- Systems may utilize different frequencies or modes of operation (conventional and/or trunked) provided suitable gateways are used.
- Once an infrastructure-based interoperability solution is in place, it can idle in standby mode and be activated immediately when required, as long as all of the participating systems are operational.

### **8.3.2 Disadvantages**

- Every participating network must have similar geographic coverage to provide assurance of interoperability.
- Networks must generally be in place before an incident which requires their use.
- This method is spectrum inefficient because a separate talk path is required on each system for each simultaneous conversation on the other incompatible system. For example, if the same three agencies described previously in this

section have incompatible trunked systems, it would require up to six extra talk paths (2 per system) to interlink infrastructures for day-to-day interoperability, the maximum of six being required when all systems were transmitting (3 simultaneous conversations). In most cases of routine day-to-day interoperability, it is not possible to mix the audio from more than one agency's primary dispatch channel/talkgroup because: (a) field units must know which agency is transmitting, and (b) if an agency is not involved in a mutual response, it does not want traffic related to that response on its primary dispatch link.

- Interoperability fails if any infrastructure becomes damaged or is otherwise not operational (until such time as all infrastructures are restored). The use of deployable infrastructures could mitigate this problem, depending upon the specific incident; it is possible that both communications and transportation infrastructures can be totally destroyed in major disasters (as happened with Hurricane Andrew, Hurricane Iniki, and the Loma Prieta Earthquake); in these cases it can be many hours, even days, before transportable infrastructures can be deployed, whether or not they are immediately available for deployment, because of the roadway destruction. In the three events cited, deployable infrastructure were not operational until 72 hours after the event in the areas with the most damage.

- For digital systems, voice intercommunications between infrastructures using incompatible digital vocoders will probably introduce additional transmission delay and reduce voice quality if it is necessary to translate the signal back to analog and reconvert it to the other infrastructure(s) vocoder system.

## **8.4 Separate Emergency Radio**

### **8.4.1 Advantages**

- Could operate on a unique interoperability band without modification to installed base of radio equipment.
- Could be small and low cost due to optimization to specific interoperability requirements

### **8.4.2 Disadvantages**

- Requires each user needing interoperability to purchase, carry and maintain a second radio or to have a separate radio available for deployment..

## **8.5 Commercial Services**

### **8.5.1 Advantages**

- Wide area to Nation-wide coverage is possible using existing cellular, paging or satellite systems.
- Does not require modifications to current installed base of public safety radio equipment.
- Leverages significant commercial investment of infrastructure

### **8.5.2 Disadvantages**

- Concern of lack of access or priority to system during disasters
- Concern of poor reliability
- Concern of delay in access time
- Concern of lack of security
- Concern of coverage due to terrestrial limitations
- Concern of cost of using commercial services
- Requires users needing interoperability to carry and maintain a second radio

## **8.6 Multi-band and/or Wide-Band Radios**

### **8.6.1 Advantages**

- Bridges a communications link between non-contiguous operating bands.

### **8.6.2 Disadvantages**

- May not be commercially viable within the PSWAC time frame of 2010.
- May have significant size, weight, cost and battery life penalties.
- Probably not be able to span the range of operating frequencies listed in section 12.3.2.1

## **8.7 Scanners**

### **8.7.1 Advantages**

- Currently used for many day-to-day interoperability missions.
- Does not require modifications to current public safety radio equipment deployed.

### **8.7.2 Disadvantages**

- Requires the user needing to interoperate to purchase, carry and maintain two radios.
- Susceptible to interference because of low technical specifications and need for wideband operation.

## **8.8 Move All Public Safety to a New Band**

### **8.8.1 Advantages**

- Seamless interoperability possible with an industry supported baseline technology.

### **8.8.2 Disadvantages**

- Requires the replacement of all public safety installed radio equipment.
- May require going beyond the PSWAC time period of 2010 to significantly improve interoperability.
- Requires significant funding to implement.
- May not be practical to reallocate enough contiguous spectrum from other licensees to accommodate public safety needs in one band.

## **9.0 Cost/Benefit Analysis**

There was insufficient information available to Working Group #7 to provide sufficient time to provide a cost and benefit analysis for the interoperability solutions identified in this report. If feasible, the working group will provide a supplemental report which will be included in this section.

The basic conclusion of the ISC was that as interoperability became more complex, they also became more costly in terms of monetary value.

### **9.1 Introduction**

#### **9.1.1 Background**

(This subsection will briefly introduce the cost/benefit analysis and the efforts of Working Group #7)

### **9.1.2 Interoperability Requirements**

(This section will briefly restate the interoperability requirements or missions developed in Sections 5.0, 6.0 and, especially, 7.0)

### **9.1.3 Methods for Achieving Interoperability**

(This subsection will briefly describe the alternative ways or methodologies for achieving enhanced levels of interoperability in each missions. It will draw on the materials from Section 7.0 (especially 7.1) and from various White Papers, including those submitted by Ericsson and Motorola.)

### **9.1.4 Importance of Cost/Benefit Analysis - General**

(This subsection will briefly describe the importance of conducting a cost/benefit analysis in the face of the alternative ways of achieving enhanced levels of interoperability.)

### **9.1.5 Constraints Associated with the Analysis**

(This subsection will describe the constraints placed on the analysis by practical considerations. For example, the alternative of consolidating all public safety communications into a single new band was eliminated from consideration because it was judged that it was unlikely that such a large block of spectrum in a single band could be made available in the time frame of the analysis, the differences in the propagation characteristics of different bands made it unlikely that a single band would be optimum for all agencies (e.g., rural versus urban), and the large investment in legacy systems and the long lead time associated with changing out those systems worked against it. Also, the ISC, for a variety of reasons, chose to recommend 25 kHz/12.5 kHz bandwidth FM as a common mode of communications on channels set aside for interoperability purposes. These reasons included, among other things, previous federal government and Federal Communications Commission actions to migrate to the potentially more efficient channel width, the fact that manufacturers have Intellectual Property Right [IPR] - free access to the technology, the capture effect associated with the FM technology that allows significant frequency reuse, the long history of the technology as an effective communications medium in land mobile applications, and the difficulties associated with selecting another standard given the other challenges faced by the committee and subcommittees.)

### **9.1.6 Limitations of the Analysis**

(This subsection will describe the limitations of the analysis. The limitations stem from the difficulties associated with estimating the benefits and costs in quantifiable/financial terms and from time pressures that, as a practical matter, prevented a full-blown cost/benefit analysis of all the possible alternatives. It will note how the number of alternatives was narrowed based upon the constraints identified in Subsection 8.1.5 and the professional judgement of the participants in the advisory committee and its subcommittees.)

## **9.2 Benefits of Alternative Ways of Achieving Enhanced Levels of Interoperability**

(This section will likely include a number of considerations such as recurring costs of services versus recurring maintenance costs. This section will likely encompass such variables and factors as life cycle costs, experience curves, amortization, economies of scale, etc.)

### **9.2.1 General Benefits Associated with Enhanced Levels of Interoperability**

(This subsection will set the stage for the benefits portion of the analysis by reviewing the generic benefits associated with achieving enhanced levels of interoperability. Examples include the benefits associated with lives saved, property losses averted, additional criminals apprehended, reduced criminal activity because of the increased probability of apprehension, and increased economic efficiency in all types of public safety activities. The latter includes possible reductions in manpower resources due to a reduction in the need for “teaming” across agencies, runners, and the dispatcher time required to repeat messages. It also includes the potential impact on competition in the supply of infrastructure and end user radios and hence on the acquisition and operating costs of such systems and equipment.)

### **9.2.2 Specific Benefits Associated with Different Interoperability Requirements and Alternatives**

#### **9.2.2.1 Additional Background on Interoperability Requirements and Alternatives**

(This subsection will provide more information on the requirements for interoperability, but without excessively duplicating the material contained in earlier sections of the ISC report. Alternatives for achieving enhanced levels of interoperability will also be described. Beyond recognition of the two categories of ways to achieve enhanced interoperability — infrastructure dependent and infrastructure independent — all of the alternatives that will

ultimately be identified by the subcommittee are not clear at this time. Based on the materials produced so far, however, the alternatives include:

- a. Reducing the number of bands used by public safety (with more offsetting increases in the total amount of spectrum allocated to the public safety use)
- b. Providing additional spectrum immediately adjacent to the (possibly reduced) number of public safety bands for interoperability purposes
- c. Requiring a common mode of communications (25 kHz FM) on the specified interoperability channels
- d. Encouraging the deployment of broadband (possibly multimode) radios capable of operating on both the existing and adjacent band
- e. Encouraging the deployment shared/consolidated systems (common access to an infrastructure)
- f. Providing interfaces/gateways between and among the (possibly reduced number of) independent infrastructures
- g. Requiring the limited build-out of some nationwide infrastructure to support interoperability
- h. Encouraging the use of commercial systems where appropriate
- i. Requiring a planning effort to deal with the use of the interoperability channels

In this subsection, it will be emphasized that the most beneficial method of enhancing interoperability in both the short term and the long term will almost certainly involve a combination of these alternatives. For completeness, the alternatives rejected as a result of the constraints addressed in Subsection 8.1.5 will be explained.

#### **9.2.2.2 Day-to-Day**

(In this subsection, the relative benefits associated with each alternative/combination of alternatives will be analyzed and described in terms of the degree to which it enhances interoperability during day-to-day operations.)

#### **9.2.2.3 Mutual Aid**

(In this subsection, the relative benefits associated with each alternative/combination of alternatives will be analyzed and described in terms of the degree to which it enhances interoperability during mutual aid operations.)

#### **9.2.2.4 Task Force**

(In this subsection, the relative benefits associated with each alternative/combination of alternatives will be analyzed and described in

terms of the degree to which it enhances interoperability during task force operations.)

### **9.3 Economic Costs of Alternative Methods of Achieving Enhanced Levels of Interoperability**

#### **9.3.1 Generic Costs Associated with Enhanced Levels of Interoperability**

(This subsection will set the stage for the cost portion of the analysis by reviewing the generic costs associated with achieving enhanced levels of interoperability. Actual estimated costs will not be provided at this point. Rather, the costs will be described in general terms, including the relative complexity of the alternative. The costs will include (a) equipment costs [again, in general terms] associated with the use of multiband or broadband radios as well as (b) other harder to quantify costs such as training costs and the added weight or physical space problems associated with solutions that require the use of multiple radios.)

#### **9.3.2 Specific Costs Associated with Different Interoperability Requirements and Alternates**

(This subsection will analyze and describe the costs associated with each alternative/combination of alternatives identified and used in Subsection 8.2. During earlier teleconferences of Working Group #7 and in discussions at the San Diego meeting of PSWAC, there was some disagreement as to how well these costs could/should be quantified. For example, some participants argued that it would be difficult to assign a believable dollar amount to any one approach or group of approaches to enhancing interoperability, while others argued that public safety users [and the Federal Communications Commission] should be given informed estimates of the total costs that such solutions might entail. It is proposed that this be resolved by, first [and as a minimum] evaluating the costs in terms of relative comparisons and known relationships and then attempting to provide at least “order of magnitude”, quantified estimates of the costs of the most likely alternatives.)

### **9.4 Summary of Costs Versus Benefits for the Alternatives Identified**

(This subsection will display the results of the Cost/Benefit analysis in graphical or tabular form. It will include a small amount of explanatory text in “bulleted” form. In combination, it will allow a reader to quickly grasp the results obtained.)

## **10.0 Conclusions**

There is no single solution that will solve the inter-agency interoperability problem for the public safety community, due to the unique geographic and regional requirements across the country. There are multiple levels of interoperability solutions which have been outlined

and discussed throughout this report. These solutions include both infrastructure dependent and infrastructure independent (direct unit-to-unit) methodologies. Most solutions can be categorized from simple to complex and the optimal solution may use various combinations as the interoperability needs escalate from day-to-day to disaster levels.

## **10.1 Possible Methodologies**

### **10.1.1 Gateways/Crossband Repeaters**

Gateways between two or more system infrastructures can provide viable infrastructure solutions at various degrees of complexity. They can interconnect systems operating in different frequency bands, modes of operation and manufacturer protocols. Most trunked radio systems require predetermined user or "talk" groups to be identified and programmed into the system. As systems become larger and additional user groups are identified, the problem of interconnecting users from other systems or non-trunked users becomes more complex.

Although gateways and cross-band repeaters are not an ideal solution, it is one of the few solutions to achieve interoperability in an infrastructure dependent environment.

Gateways have advantages where they can be set-up and knocked down quickly and where coverage patterns between the systems that the gateway bridges are similar. Gateways are also needed where there is a transfer needed between incompatible systems, protocols, and technologies.

In many cases there is neither time nor opportunity to set up gateways between channels and systems at emergency events. In addition, many users feel that such gateways are chokes rather than outlets, frequently restricting channel effectiveness.

Some of the simplest and least costly forms of gateways and interconnects require the traffic to be broken down to its simplest form (clear analog audio) and requires operator intervention to be accomplished. This type of interconnectivity is the least desirable, but in many cases is the only solution available to the public safety users.

### **10.1.2 Common Communications Mode for Interoperability**

At the very lowest level of use of interoperability channels (one field unit to another - either dependent or independent of infrastructure). There must be a common medium of communications specified for these interoperable channels. Thus, in Section 11.2.3 a minimum Baseline Technology for Interoperability is defined. System configurations and technical offerings vary greatly from one manufacturer to another and most often there is neither time nor opportunity to set up gateways between channels and systems at emergency events. In addition, infrastructure coverage cannot be provided across the entire country and a great reliance must remain on unit-to-unit tactical communications. We must make sure that any radios arriving on an incident have at least a baseline technology capability to talk directly to any other unit on the same frequency band on the scene.

### **10.1.3 Public Safety Interoperability Band**

The concept of establishing a new band exclusively for interoperability is discussed in detail in the White Paper submitted by Ron Haraseth, from the State of Montana. Mr. Haraseth's White Paper is included as Attachment 7.

#### **10.1.3.1 An Operational View**

All participants in any joint endeavor must speak the same language to be fully functional. In this case, we must speak the language of emergency response. This fits in with the operational aspects which have been discussed centering around using the Incident Command System (ICS) architecture to identify channels of operation along the same levels of function and command within ICS. ICS attempts to address the problem from an operational stand as opposed to a strictly technical approach.

At the very least, a strictly technical approach is doomed to failure no matter how many channels or gateways are provided if they do not conform to the manner in which they are used. It has often been repeated in the Department of Defense discussions that the military must train as they fight. The same is no less true for public safety responders.

Any incident includes the functions explained by ICS. Identifying functionality using the ICS structure standardizes operations allowing an understanding of the procedures by all involved. By operating under the assumptions in ICS, all parties are aware of their role and responsibilities within the overall event. Designating common names for common functions is the basic precept that makes ICS work. The same situation must take place in the communications structure of any incident. Channels must have designated names and associated usages so that all involved will understand where and in what manner they are to be used.

The basic command level and subsequent lower command levels must have pre-designated (and named) channels associated with those levels. Lower levels can be more flexible and dynamic. Understanding the operational characteristics does not complete the solution, but once they are defined, the correct technical solutions can then be applied.

A technical solution must be practical, relatively inexpensive, ubiquitous, and above all, attainable. A solution must be available both on the near term as well as the long term. It must work with existing systems without causing interference with standard dispatch systems or creating an undue hardship to implement.

#### **10.1.3.2 PI Service Category**

The move of the entire public safety operating environment to a single band is not practical, and cross banding existing bands is far less than fully effective. The former being unworkable financially and later being extremely inefficient in terms of spectrum use. However, creating a single common Public Safety Interoperability Service (which is abbreviated as "PI") in one central band is very possible and very practical. This band would

be dedicated exclusively for interoperation applications. This will not eliminate the need for dual band radios or two radio installations, but having a universal declared service gives an absolute common technical solution to the common operating requirements of a mutual aid incident. A field tactical vehicle (or hand-held) with the “PI” capability could interact with any other unit similarly equipped. This capability need not be linked in any way to the user’s home system operation.

As an example, one unit’s basic internal system dispatch operation could be in an 800 trunked environment while another unit could be operating in low band. If these field units’ second band or second radio in each case were the common “PI” radio, they would technically be capable of true interoperability. Bringing a third unit into the picture more than clarifies the practicality of a common PI service band.

### **10.1.3.3 Operational Requirements - Unplanned/Planned Incidents**

We can learn much from the communications problems of historical incidents. Those that indicate failures in the communications link may not point directly to solutions. While some failures point to technical deficiencies, many have resulted from operational deficiencies. We also must review the aspects of these incidents that worked correctly and expand on those aspects. Similarly, we must avoid the known points of failure.

Planned incidents fall under the category of preplanned tactical events or locally restricted common action situations that can be anticipated accurately. These events are rarely a problem technically regardless of what systems are involved. By their very nature and description they exist with pre-knowledge and the participants are prepared for the forthcoming actions. Planned incidents are not fully detailed here other than to indicate that they could be handled very easily under the following operational description for unplanned incidents.

By their very nature, unplanned incidents may happen any time and any place. These situations are difficult to plan for in any situation and even the best and thorough plans can not prepare for all of the possible unknowns.

### **10.1.3.4 “PI” System Operation**

Mutual aid operations that are unplanned are unique and go through several definable phases. The first phase is always the “first response” or “initial attack.” Some incidents may never escalate beyond this point. As a typical example, a public safety responder of any service traveling outside of their home coverage area often may be the first contact at a typical accident. Their conventional home dispatch system may be totally unusable. Under the PI scenario, a call on the PI radio to a monitoring station or another mobile in the area may be the one and only response required of the incident.

Other incidents may escalate requiring the same first responder to communicate to more units of various types. As long as the terminology and operating aspects of the PI capable radios are standardized, all units would be compatible. More developed incidents requiring the declaration of a planned operation under ICS would see the command shifted from the first responder to a more appropriate Incident Commander (IC). From this point on,

any units entering the operation and conforming to the PI radio standard would be automatically capable of inclusion into the ICS command structure. Local units working as strike teams or individual resources lower in the ICS structure could use their own internal radio system for their level of operation or if mixed with dissimilar units, they could use assigned PI channels. In either case, communicating up the ICS chain of command would occur on the PI radio channel assigned for that purpose.

It is generally accepted that isolating a unique incident from routine daily radio traffic is to be preferred. A unique PI service would easily allow such an action.

Again this scenario is dependent upon standardized common assigned names associated with standardized associated channels used under standard operating procedures. This requirement, although it may seem extreme, is absolutely required for any successful multi-disciplinary incident. All aspects of a successful incident (not just radio operation), require the same standard procedure.

It is important for full universal utilization that a national standardized plan be devised and tied very closely to operating restrictions and requirements, This should be a basic requirement of any interoperability solution.

#### **10.1.3.5 The PI Solution**

The above descriptions include the following basic requirements:

- \* Find a relatively free band of frequencies, preferably central to existing public safety bands.
- \* Define specific frequencies and pairs of frequencies using developed ICS guidelines.
- \* Freely license these frequencies to all eligible public safety/service providers under operational as well as technical regulations.
- \* Restrict use to mutual aid interoperation.

The preceding requirements may seem somewhat simplistic, however there is a flexibility to the operational aspects of the PI solution that could allow for much higher levels of robust capabilities. **This would be a fresh and new service which could be implemented without regard to any backward compatibility requirements.** It need not be tied to existing technology and modulation schemes. This leads to a plethora of possibilities:

- \* Narrow channel bandwidth (or equivalent) should be specified for maximum spectrum efficiency.
- \* Digital modulation could be required for the same reason.
- \* Digital modulation leads to the fact that data transfer would be a natural possibility.

\* Bandwidth on demand applications (or the equivalent) could also be implemented for the very same reason.

\* Encryption could also be very easily adapted considering the possible digital nature of the service. Over the air rekeying (OTAR) should be a requirement.

\* Although conventional mode infrastructure independent operation is basic and mandatory to support first response capabilities, trunking should be encouraged for escalated incidents. Trunking would have several advantages for implementation of escalated incidents or for systems embedded in local or regional systems. Caches could be developed that include base/controller equipment that would allow dynamic over the air reconfiguration of all units involved in the incident. This could be enhanced by requiring every radio manufactured to have an internal unique ID similar to the NAM in cellular radios. The ID should be easily read by units entering the incident either by physical connection, optical, or wireless. While such advanced types of operations would require knowledgeable and available communications unit leaders, this activity already takes place on large ICS incidents with existing programmable equipment.

Migration to this interoperability solution could take place as soon as rules and regulations were put into place. There are of course stumbling blocks such as adopting standards for a new operation, but these could also be looked upon as building stones. This solution would not require scrapping any existing system or worry about compatibility with existing systems and the associated costs.

#### **10.1.4 Separate Emergency Radios**

Separate radios are currently used by many agencies to achieve direct unit-to-unit interoperability, when the user agencies operate on disparate frequency bands.

This solution could lend to the Separate Interoperability Channel, which could actually reduce the number of radios required by some agencies by having a single common band for interoperability.

This is not the ultimate solution to interoperability, because it still requires a separate radio to achieve interoperability.

### **10.2 Alternatives For Improving Interoperability**

As desirable as the *Long Term Solutions* recommended in Section 11.2 are for ultimately providing a greater level of interoperability between and among public safety and public service agencies, they do not improve interoperability in the shorter term. This is true for two reasons, even if the concept of a separate interoperability band is implemented:

First, in addition to the VHF and UHF bands, public safety and public service entities have large investments in the 800 MHz band and, to a lesser extent, at low band. Moreover,

during the PSWAC process certain users have expressed the opinion that both of these bands have very desirable characteristics in certain applications. For example, public safety agencies in some rural areas have indicated that low band VHF is particularly effective in providing outdoor coverage over vast distances and in rough terrain. Similarly, other public safety agencies have noted that systems operating in the 800 MHz band are particularly effective in urban areas where in-building coverage is crucial to accomplishing their missions. Because of the large investment in systems operating in the 800 MHz band and the desirable propagation characteristics of that frequency range, it is apparent that many agencies will continue to operate in the band for the foreseeable future. Because it is not economically practical to build broadband radios that will operate in both low band and the proposed interoperability channels at high band, or in both the proposed interoperability channels at UHF band and the 800 MHz band, there is some doubt that the final solution would fully solve the interoperability problems even if the new interoperability channels were made available immediately.

Second, even if all public safety and public service operations could be consolidated in the VHF and UHF bands in the shorter term, the interoperability problem would not be entirely alleviated because it is also not economically practical to build a single broadband radio that will operate over both bands. Thus some agencies may continue to operate and invest in VHF systems because, for example, of their superior coverage in rural areas while others may continue to operate and invest in UHF systems. Thus, the Interoperability Subcommittee concludes that other methods may be necessary to assure complete interoperability even with the reallocation of new interoperability channels near the existing VHF and UHF bands.

Based on this analysis we conclude, as stated above, that, as desirable as the long term solutions recommended are for ultimately providing a greater level of interoperability between and among public safety and public service agencies, they do not improve interoperability in the shorter term.<sup>8</sup> Thus, special efforts are required to achieve greater interoperability in the shorter term pending the adoption and implementation of the longer term solutions and as an insurance policy in the event that the longer term solutions are delayed or precluded for unforeseen reasons.

Encouraging the deployment and utilization of shared/consolidated systems (e.g., statewide, multi-agency, multi-discipline networks) in public safety and public service applications can improve interoperability in the shorter term because it does not depend on the reallocating and clearing of spectrum designated for interoperability purposes. It improves interoperability for the obvious reason that, properly designed, any end user unit (or dispatcher) can communicate with any other end user or group of end users. Providing common access to a single infrastructure can solve many, if not all of the problems associated with day-to-day interoperability among the agencies involved. It can also make substantial contributions to meeting the mutual aid and task force requirements for interoperability.

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<sup>8</sup> It should be noted that for similar reasons, agreement on a common mode of transmission (e.g., a common air interface) on existing operational channels alone would not solve the interoperability problem in the shorter term.

Encouraging the deployment and utilization of shared/consolidated systems has other significant advantages as well. When implemented using modern trunked radio techniques, such systems can improve spectrum efficiency and/or improve the level of service (e.g., reduced waiting time), provide a host of advanced features and functions based on software capabilities, and capture potential economies of scale and scope for the agencies involved.

Providing gateways/interfaces between and among independent public safety infrastructures can also improve interoperability in the shorter term because it does not depend on reallocating and clearing of spectrum specifically designated for interoperability purposes nor does it depend on the adoption of a common mode of transmission for all of the independent systems.<sup>9</sup> It improves interoperability for the obvious reason that, properly designed and implemented, any end user (or dispatcher) can communicate with any other end user via the gateway. Gateways also have the advantage that they can accommodate systems operating in different frequency bands and employing different types and vintages of equipment. In particular, they can accommodate systems employing different modes of transmission, thus facilitating competition in the provision of the independent systems. It should be stressed that gateways/interfaces can add to system delay and poorer response times, and this must be factored into the system interface requirements.

Encouraging the use of commercial wireless systems, where operationally appropriate and where adequate coverage exists today, can also improve interoperability in the shorter term because it does not depend on reallocating and clearing of spectrum designated for interoperability purposes. The increased use of public, commercial systems has been controversial in the ISC and in the other subcommittees of PSWAC as well. It is beyond the scope of this Section to review that controversy, but it is clear that a commercial wireless system designed to serve the public at large and interconnected with public voice and data networks can provide improved interoperability at least in some cases. Indeed, public commercial networks are designed by their very nature to offer anyone-to-anyone service. The usefulness of commercial wireless systems in improving interoperability can be further enhanced by providing gateways between public safety systems and commercial infrastructures. Such gateways would (a) facilitate the use of commercial systems where appropriate in routine public safety operations, (b) improve access by the public to public safety agencies and, (c) facilitate the use of commercial wireless systems as backup to public safety systems in emergency situations.

As noted in the table below, promoting or requiring the build-out of some nationwide infrastructure to support interoperability is not a shorter term solution to the interoperability problem if it is interpreted to mean the deployment of a system operating on the new interoperability channels. However, promoting the development and deployment of gateways to facilitate interoperability between and among public safety agencies and between public safety agencies and commercial wireless service providers could, for the reasons stated above, improve interoperability and, at the same time, produce significant other benefits as well.

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<sup>9</sup> Gateways/interfaces do create additional demand for spectrum to replace channels utilized for interoperability which, once again, points to the importance of obtaining spectrum relief expeditiously.

Also, as noted in the table, requiring a planning effort to deal with the use of the reallocated interoperability channels does not represent a shorter term solution because the interoperability channels are not yet available. However, planning aimed at encouraging and facilitating the shorter term improvements described in this Subsection may be useful.

It should be apparent from the analysis contained in the paragraphs immediately above that there are a number of alternatives for improving interoperability in the shorter term. Moreover, these alternatives (encouraging the deployment and utilization of shared infrastructure systems, encouraging the use of commercial systems where appropriate, providing gateways between and among independent public safety wireless infrastructures and between public safety infrastructures and commercial wireless providers, and encouraging increased planning efforts) are all useful in the longer term as well. However, it is evident that these shorter term alternatives do little to relieve the immediate problem of spectrum availability and that they do nothing to meet the requirement for providing infrastructure independent communications between end user radio units over a direct RF path.

These two issues are discussed in more detail below.

As stated at the outset of the section, it is clear that from the work of the ISC and the Spectrum Subcommittee, the loading on existing public safety channels is so heavy that shorter term interoperability requirements can be fully met only through the allocation of additional spectrum. While encouraging the use of shared infrastructure systems, and, where appropriate, commercial systems, may reduce the pressure on existing public safety spectrum resources somewhat, those steps will not solve the basic problem of lack of adequate spectrum to meet interoperability requirements. This conclusion serves to reemphasize the importance of the public safety and public service entities obtaining spectrum relief as soon as possible.

The importance of providing infrastructure independent methods for obtaining interoperability has been stressed throughout the PSWAC/ISC process. As pointed out in the analysis conducted by the ISC, the use of analog FM technology is widespread in the land mobile radio industry and provides the basis for existing infrastructure independent interoperability. The technology is well understood, and a common set of non-proprietary operating parameters has allowed end users to communicate directly over the air using radios produced by different manufacturers.

**Alternatives for Enhancing Public Safety Interoperability**

Alternative	Short Term Applicability (Five Years or Less)	Longer Term Applicability (More Than Five Years)	Notes
<p>1. Providing, for interoperability purposes, additional spectrum immediately adjacent to or within existing public safety bands and requiring a common mode of communications (e.g., analog 25.0/12.5 kHz FM) on the resulting interoperability channels.</p>	<p>1. Represents a potential shorter term solution if suitable channels are made available immediately.</p>	<p>1. Would facilitate interoperability in the long term by providing adequate, common spectrum for interoperability purposes; <i>provides for infrastructure independent, unit-to-unit interoperability via a common mode of communication</i>; not a total solution because of the need for more than one band to meet total public safety spectrum operational requirements and the continued desirability of different bands in terms of their unique technical characteristic; end user radios capable of operating across multiple bands are not technically/ economically feasible.</p>	<p>1. More spectrum within existing bands would be achieved by designating for interoperability purposes certain of the additional channels created through the employment of more spectrally efficient technology (e.g., through refarming); this alternative could include regulations requiring public safety radios to be capable of operating on both the existing operational band <i>and</i> the designated interoperability channels associated with that band.</p>
<p>2. Reducing the number of individual bands used by public safety entities.</p>	<p>2. Not a shorter term solution because the large investment in existing bands, the continued desirability of existing bands in terms of their unique technical characteristics, and the lack of immediately available substitute spectrum mean that, as a practical matter, public safety users will occupy multiple bands for the foreseeable future.</p>	<p>2. Would facilitate interoperability in the long term by reducing the number of bands involved; not a total solution because of the need for multiple bands/radios.</p>	<p>2. Because of public safety’s continued need for spectrum, it is recognized that reducing the number of individual bands may be difficult in practice; nevertheless, this alternative is recommended by PSWAC as part of the long term solution for enhancing public safety interoperability.</p>

Alternative	Short Term Applicability (Five Years or Less)	Longer Term Applicability (More Than Five Years)	Notes
<p>3. Requiring a planning effort to deal with the use of the reallocated interoperability channels.</p>	<p>3. Narrowly interpreted, does not represent a potential shorter term solution because the designated interoperability channels are not available; however, planning aimed at facilitating other shorter term solutions may be useful.</p>	<p>3. Would facilitate longer term interoperability by ensuring efficient and effective use of the designated interoperability channels; also necessary to overcome the non-technical (e.g., political) barriers to interoperability.</p>	
<p>4. Providing, for interoperability purposes, end users with multiple radios; includes two possibilities:</p> <p>a. Providing radios dedicated to interoperability and operating within an existing band using the recommended common mode of communications (analog FM).</p> <p>b. Providing radios dedicated to interoperability on an entirely separate group of new interoperability channels using the recommended common mode of communications (analog FM).</p>	<p>4.a. Associated with a frequent means of achieving interoperability today; hence, it represents a shorter term solution; the drawbacks (including costs) are described in the text of the PSWAC report.</p> <p>4.b. Not a shorter term solution unless suitable channels are made available immediately; however, if such channels were made available immediately, manufacturers could provide the radios quickly because of the ease of developing analog FM equipment.</p>	<p>4.a and 4.b. While the longer term objective is clearly in favor of reducing the need for end users to employ multiple radios, as a practical matter they still may be needed in certain instances; <i>provides for infrastructure independent, unit-to-unit interoperability</i></p>	<p>4.a. Adoption of other PSWAC interoperability recommendations could make the use of multiple radios under alternative 4.a. somewhat more efficient (e.g., by reducing the number of different bands used by public safety systems).</p> <p>4.b. The capability to operate in the dedicated interoperability band could be built into all public safety end user radios in the longer term (multiband radios); alternative 4.b. and alternative 1. could be combined.</p>

Alternative	Short Term Applicability (Five Years or Less)	Longer Term Applicability (More Than Five Years)	Notes
<p>5. Encouraging the deployment and utilization of shared/consolidated systems (referred to by the ISC as common access to an infrastructure).</p>	<p>5. Represents a potential shorter term improvement since it does not depend on the reallocating and clearing of spectrum designated for interoperability purposes; <i>provides for infrastructure independent, unit-to-unit interoperability</i> for users sharing the infrastructure; it does not solve the shorter term spectrum scarcity problems in major urban areas.</p>	<p>5. Would facilitate longer term interoperability by reducing the number of independent infrastructures and the number of required gateways (see alternative 6., below).</p>	<p>5. An example of a positive incentive for the deployment and utilization of shared/consolidated systems would be to offer exclusivity to them; shared/consolidated systems may also improve spectrum efficiency due to gains in trunking efficiency; while listed as a short term alternative, making the necessary political, economic, and technical arrangements and then procuring shared/consolidated systems may take several years.</p>

Alternative	Short Term Applicability (Five Years or Less)	Longer Term Applicability (More Than Five Years)	Notes
<p>6. Providing interfaces/gateways between and among the (possibly reduced number of ) independent infrastructures.</p>	<p>6. Represents a potential shorter term improvement since it does not depend on the reallocating and clearing of spectrum designated for interoperability purposes, nor does it depend on the use of a common mode of transmission; however, it does not meet the requirement for infrastructure independent unit-to-unit communications, nor does it solve the shorter term spectrum scarcity problems in major urban areas; improperly designed, it can add delays in the communications path.</p>	<p>6. Would continue to facilitate interoperability in the longer term; <i>it provides infrastructure dependent unit-to-unit communications across multiple bands</i> while avoiding the need for multiple radios.</p>	<p>6. Gateways and interfaces are general terms for techniques used to allow an end user on one system to communicate with end users on another system even though they are operating in different bands; these techniques can range from simple to complex; nevertheless, because it appears that it is unlikely that all future public safety spectrum requirements can be met in a single band, this method of providing for infrastructure dependent interoperability may remain a critical component in achieving enhanced interoperability in the longer term; issues regarding the potential impact of this alternative on spectrum efficiency have been raised (see the text of the PSWAC report for a discussion).</p>

Alternative	Short Term Applicability (Five Years or Less)	Longer Term Applicability (More Than Five Years)	Notes
<p>7. Promoting or requiring the build-out of some nationwide infrastructure to support interoperability; could include:</p> <p>a. a nationwide infrastructure operating on the designated interoperability channels</p> <p>b. deployment of gateways/interfaces between and among existing infrastructures</p>	<p>7.a. Represents a potential shorter term solution if suitable channels are made available immediately.</p> <p>7.b. Represents a potential shorter term solution. (See 6. above.)</p>	<p>7.a. Could facilitate interoperability in the long term by providing a common infrastructure; not a total solution for the reasons listed in 1. above.</p> <p>7.b. Would also facilitate longer term interoperability. (See 6. above.)</p>	<p>7.a. If the nationwide infrastructure is designed to serve agencies from all levels of government (federal, state, and local), then certain licensing issues must be resolved.</p>
<p>8. Encouraging the use of commercial systems where appropriate.</p>	<p>8. Represents a potential shorter term improvement since it does not depend on the reallocating and clearing of spectrum designated for interoperability purposes; however, does not meet the requirement for infrastructure independent unit-to-unit communications.</p>	<p>8. Could facilitate longer term interoperability for appropriate services; however, does not meet the requirement for infrastructure independent unit-to-unit communications.</p>	<p>8. Might involve gaining priority access within the commercial systems; other advantages and disadvantages associated with the use of commercial systems are discussed in the text of the PSWAC report.</p>
<p>9. Providing gateways/interfaces between public safety and commercial infrastructures to facilitate the use of the latter in public safety/public service applications.</p>	<p>9. Represents a potential shorter term improvement since it does not depend on the reallocating and clearing of spectrum designated for interoperability purposes; however, it does not meet the requirement for infrastructure independent unit-to-unit communications.</p>	<p>9. Could facilitate longer term interoperability between public safety and commercial systems, thus facilitating the use of commercial systems to back up public safety systems and facilitating the use of commercial systems in public safety applications (where appropriate).</p>	

Extensive and effective implementation of infrastructure independent interoperability using this method has been hindered by a number of constraints including the fragmentation of public safety channels across multiple bands from low band to the 800 MHz band, human limitations on the number of channels that individual end users are able to handle, the general lack of sufficient channels for interoperability, and certain command and control issues. Almost by definition, encouraging the use of shared infrastructure systems, and, where appropriate, commercial infrastructure systems, does nothing to solve the infrastructure independent interoperability. Hence, during the transition period to the longer term solution put forth by the ISC, today's largely unsatisfactory solutions must suffice. These solutions include, for example, the use of multiple radios. Such solutions are regarded as unsatisfactory because of both technical and physical limitations.

The analysis contained in this section has focused primarily on voice communications but, as brought out in the Operational Subcommittee report and elsewhere, data, image and video requirements must also be met. Development of the necessary technology, products, and procedures for meeting these requirements in public safety applications is still in the formative stages. Hence, the Transition Subcommittee concludes that, as part of the immediate efforts to improve inter-agency communications, the industry and users should address interoperability issues through standards or other appropriate measures.

#### **10.4 Additional Interoperability Channels**

Appendix A contains recommendations for the number of simultaneous interoperability links required by user service category for two options. The first option is to implement interoperability within existing public safety bands. The second option is to implement interoperability at the minimum level within current public safety bands, while providing the majority interoperability spectrum within a new Public Safety Interoperability Band in spectrum below 512 MHz. After careful consideration, Working Group #3 recommended the second option. Section 12.3.7 discusses these options in detail.

Aggregate numbers for the first option (using existing bands) indicate a total need for 51 repeatered voice links and 83 simplex voice links within current bands, plus 2 independent high speed data and 2 independent full motion video links. It is believed that existing designated interoperability frequencies can be used for 17.5 of the repeatered and 28 of the simplex voice links. The high speed data and full motion video links must be provided within new spectrum.

Aggregate numbers for the second option (new interoperability band) indicate a total need for 21 repeatered voice links and 20 simplex voice links within current bands. It is believed that existing designated interoperability frequencies can be used for 13.5 of the repeatered and 13 of the simplex voice links. 31 repeatered voice, 70 simplex voice, 2 independent high speed data and 2 independent full motion video links must be provided in the new Public Safety Spectrum. The difference in the number of available frequencies in the current bands between the two options is due to eliminating the 220 MHz band in this option.

The basis of the recommendations for additional channels is detailed in Section 12.3 of this report. The Data Collection Instruments (DCIs), that were used to collect the data from the various sub-groups within the working group, are available for review upon request. The size of the data file made it impractical to include as part of this report. The discussion provided below provides the basic rationale for the number of interoperability channels recommended. It should be noted that in the Washington Area Council of Governments (COG) report (reference *Metropolitan Washington Area Interoperability* report at Appendix C) 100 channels were recommended, on a nationwide basis, for interoperability.

Public safety agencies presently have base-mobile frequency allocations in the 30-50 MHz, 150-174 MHz, 450-470 MHz and 806-869 MHz bands. In addition, some major metropolitan areas are allowed shared use of portions of the 470-512 MHz television band. The two primary bands containing the majority of non Federal users are 150-160 MHz and 450-470 MHz. Because many systems retained lower frequencies and added higher frequencies as technology made higher frequency equipment more available and reliable, it is common to see systems that use portions of all of these bands. Reliable and cost effective dual band radios have not been produced to date. However, individual radio users have either been contained on a single band or they have had to use multiple radios. The combinations of multiple bands, nonstandard repeater frequency spacings, nonstandard system access methods and no adequate allocation of clear nationwide emergency channels have contributed toward the inability for public safety users to interoperate with each other, for decades. Interoperability problems cannot be solved without some consolidation of more users on a larger band and without the dedication of specific channels for Interoperability.

Thrown into this mix is the fact that Federal and non-Federal users have been separated even further by philosophy, practice and infrastructure and frequency differences. Thousands of individual agreements have been promulgated over almost 50 years to give very specific system access to some users for interoperability. These cases are generally so specific however that they do not provide for itinerant or large-scale event use. In effect, they are simply band aids on a disabling wound.

The ISC recommends that contiguous bands of frequencies should be allocated for public safety's use to augment the existing public safety spectrum. The addition of spectrum technically close enough to these existing allocations could allow the manufacture of broadband radios capable of utilization of the existing and new allocations. Use of such radios would offer some spectrum relief; they would be economically viable for manufacturers and they would provide unoccupied spectrum for planning spectrally efficient use and, for the first time, nationwide interoperability. Spectrum allocated must be suitable for Land Mobile use. The Commission must concentrate on additional public safety spectrum below 1 GHz and this allocation must be nationwide.

Interoperability requires nationwide allocations of clear channels distributed in each of these new frequency bands. The allocations should be made under the umbrella of "public safety." They should not be made only to specific disciplines within public safety. They should also be usable by all levels of government depending upon the requirements of an event.

The channel recommendation is based upon providing usable communications within the Incident Command System (ICS). ICS is a standardized way for agencies to operate with one another in large-scale emergencies. ICS has a hierarchical structure for event management. It has a Christmas tree type of organizational structure which identifies lines of reporting (communications) throughout the organization. ICS is extensively used in fire and other large-scale emergency management. We offer the following discussion using the fire service as an example because large fires are more common than most other large-scale emergencies. The provision of a solution for fires however envelopes needs of other categories of events.

At the fire ground level, strike teams are composed of five units. These units can be five engines which act together in a specific assignment at a fire. Each engine can be operated with as few as two or as many as four people. The content of messages in incident management is generally less of an emergency nature the higher one goes in the management structure. These field located strike teams are where most emergencies occur. Because the need to communicate immediately and reliably is most severe at this level, each strike team should be able to use its radio channel within the mission group itself, and communications within the group should be interference free. Ten to 20 people at the head of a fire are all such a channel should handle. Present practice however finds multiple strike teams all on the same channel because of the lack of frequencies. The result can be chaos as individuals cannot tell which message is meant for them, and co-channel interference often critically reduces channel effectiveness. At this level of organization, the inability to communicate can be life threatening and such threats are immediate.

Even a medium scale wildfire can often have 10 or more strike teams working at a time. It is not abnormal to have 500-600 fire fighters on such an incident. Fire storms such as those which occurred in Berkeley-Oakland and the Los Angeles area used many more strike teams than that. ISC's recommendation is that there should be 10 channels set aside to support such tactical use. In very large-scale events, frequency reuse should allow multiple strike teams to operate on the same channel. Other interoperable channels could support national and local infrastructure channels for communications between the incident and the base for travel of personnel to the incident and for logistical and other such incident related functions. ISC believes two things must happen: First, there must be a planning effort (similar to NPSPAC) to deal with use of interoperability channels. Second, the FCC will need to mandate some limited buildout of some nationwide infrastructure to support Interoperability. Rules similar to those governing the NPSPAC nationwide Interoperability channels should be used as a starting model.

Going up in the hierarchy, there should be no more than five strike teams on a common upward coordination channel. At this level, there typically are communications responsibility for between 50 and 100 people who are involved in emergency response. The communications at this level are somewhat less peril-related, but they are more complex. These communications are often time-critical matters of logistics and support. They can involve critical communications dealing with situations such as water delivery, electrical power shutoff and gas shutoff. They also are frequently tactics related so strike team leaders know what is going on around them and what is needed from them. Channels close to each

other so that they are operable in one radio are necessary because of the need to separate critical communications while still allowing intergroup communications as they are needed. At the same time, these channels must be spaced far enough apart so that nearby off-channel interference does not disable critical communications paths.

There are many layers in these emergency management organizations. Damages frequently run into the millions of dollars, too often there are lives lost and there is a requirement for functions of mapping, logistics, finance, personnel assignment, emergency crew management and even multiple levels of aircraft coordination. Large fires almost always depend upon the use of aircraft to deliver water and retardant, to locate and map hot spots and to map the spread and direction of the fire. Again, these communications can be critical and they must be interference free. Of necessity in present practice, these communications are often overlaid onto the few channels that are available on the incident. The result is often confusion and danger to the participants.

### **10.5 Establish Standards Working Group**

Working Group #3 recommended that a working group be established to address a digital baseline technology in the future. The specific recommendation in the Working Group #3 DRAFT Report is as follows:

While the Minimum Baseline for Interoperability presented in Section 11.2.3 will suffice for some time, perhaps as long as 2010, the time will come when most, if not all, users in a given area will be using a digital voice communications platform and will not want to give up the capabilities provided by that platform when switching to analog FM for direct unit-to-unit communications. Therefore, it is recommended that, after the PSWAC process is completed, the FCC and NTIA together establish a working group comprised of experts representing government, industry, and federal, state and local government users similar to, but smaller than the PSWAC effort, to address base line technology for interoperability. It is further recommended that another PSWAC should be convened within ten (10) years to evaluate technology development and the effect that actions stemming from this PSWAC have had on meeting the needs of public safety's spectrum and interoperability problems.

Considering the evolution to digital technology, we should not limit future interoperability to an analog baseline. Just as the AMPS cellular standard (which clearly goes far beyond simple analog FM) provides North America-wide cellular interoperability, there is clearly a future need for digital interoperability standards for public safety communications. It is imperative that this baseline be addressed and established within the next two years, to allow the public safety community to develop implementation and migration plans accordingly.

Any group selected for the purpose of such an evaluation should be composed of experts representing industry and users. The selection methodology must be weighted towards the needs of the end user. Refer to Section 12.3.9.5 for further discussion within the working group.

During the ISC meeting on July 18, 1996 an alternative recommendation was offered by representatives from Ericsson, which included specific text referencing Section 273 in the 1996 Telecommunications Act. Many members expressed concern that ISC was establishing rules that should be the responsibility of the group after it was formed, while others expressed unfamiliarity with Section 273 of the 1996 Telecommunications Act, stating that they could support the verbiage.

No members present expressed any reluctance to support open standards that are developed in an open and fair process, but the concerns were whether the ISC was acting within the scope of the subcommittee and the unfamiliarity with Section 273.

Mr. Charles Jackson offered a compromise resolution and it was decided to reconvene the next morning (July 19th) prior to the Spectrum Requirements Subcommittee meeting.

The suggested text offered by Mr. Jackson follows:

*The ISC recommends that the digital baseline standard be an open standard; unconstrained by Intellectual Property Rights (IPR) of any party, and that this standard be developed in an open and fair process, based upon consensus, using an accredited standards making entity.*

There was significant opposition to this verbiage, due to some confusion about definitions and exactly what the procedure would be. There was also concerns again expressed that the action was outside the scope of the subcommittee. After significant discussion a compromised resolution was offered as follows:

*The ISC recommends that any digital baseline standard for interoperability be open standards developed/adopted in an open and fair process, using an accredited standards making entity.*

There seemed to be consensus among those present, although at least two members expressed some concerns that this may put undue restrictions on the group. The ISC Chair stated that in light of the time expended on this issue, any further comments should be submitted in writing after the next revision of the DRAFT Report (Revision 9) was distributed.

There was an overwhelming number of responses submitted objecting to the verbiage in the DRAFT Report (Revision 9, dated 7/22/96). An overwhelming majority of the comments stated that they felt the verbiage put undue restrictions on the group and suggested that new verbiage be incorporated.

Although it is not full consensus, the recommendation provided in Section 11.2.4 reflects the vast majority of the members.

Mr. Jackson in an effort to ensure that everyone understood the standards process and the meaning of Section 273, specifically subsection (d) (4), provided the following text to be included in the report:

*Formal development of industrial standards grew to a large scale activity in the late nineteenth century with the rise of standards organizations. Today, the primary body overseeing the development of standards in the U.S. is the 76 year old American National Standards Institute. ANSI does not write standards, but serves as an impartial organization which, through its procedures, validates the general acceptability of the work of the technical experts. It ensures that any standards writing group uses democratic procedures that give everyone who will be “directly and materially” affected by the use of the standard an opportunity to participate in the development work or to comment on the document’s provisions. ANSI voluntary standards include more than 100,000 product standards developed by more than 400 standards development organizations, including government, industry, technical societies, trade associations and companies. ANSI, with its nearly century of experience has developed procedures for assuring fairness and openness in the standards process. Becoming ANSI accredited is normally not difficult and many organizations have done so.*

*At times, the development of standards has been contentious and difficult. The current process of the accredited standards organizations reflects decades of experience with these sometimes difficult tasks. In extreme cases, groups engaged in standards development have been found to have violated the antitrust laws.*

*Congress, in the recently enacted Telecommunications Act of 1996, recognized the important role of accredited standards organizations. In Section 273(d)(4) of that act, it imposed special obligations on other groups (not-ANSI accredited) engaging in standards development in telecommunications. Those requirements were the basic elements of fairness and openness including:*

- i. Public notice of the development of a standards,*
- ii. A public invitation to interested parties to participate in a a reasonable and nondiscriminatory basis, administered in such a manner as not to unreasonably exclude any interested industry party,*
- iii. Texts shall be published with opportunity for comment and response,*
- iv. Final texts shall include, if requested, additional comments by participants,*
- v. The group must attempt to establish a mutually satisfactory dispute resolution process.*

*Openness, permitting all to participate, transparency, open procedures allowing all to see how decisions are made, and fairness (due process requirements) are the heart of these congressional requirements.*

However, there were a number of members that felt that Section 273 of the 1996 *Telecommunications Act* was not applicable to the land mobile radio environment and maintained that it was inappropriate to put restrictions on a group before it is formed.

## **10.6 Availability of Commercial Services**

Information gathered about the current use of commercial services shows continued growth. The experience with commercial services in the public safety community is based on currently installed and available commercial services and while these experiences are indeed valid some of the emerging technologies may solve some the problems experienced in the past.

Commercial systems are not likely to meet all requirements within the public safety community, at all times and at all locations. Objective experiments with and use of these systems will be necessary to determine the portion of public safety needs they can satisfy. Issues such as costs, transmission delays, size of units, building penetration, and coverage in rugged terrain will need too be assessed.

As commercial vendors have added increased capabilities,

Applications focused on:

- *productivity gains*
- *faster access to data*
- *facilitation of increased mobile communication with public assistance groups*
- *emergency back-up use where there is a lack of private infrastructure*

First response, and life threatening applications still depend on private radio. Public safety describes these as time critical and mission critical applications.

A short-term migration to commercial services for first response, and/or life threatening applications is not realistic. Commercial infrastructure presently does not generally serve the best interest of the public, the public safety agencies that, provide these services, nor the commercial vendors that would need to support these applications.

The initial effort would require a thorough understanding by commercial interests of the coverage, security, reliability, and immediate access needs of public safety. After these system design parameters are fully known, then trust, familiarity, tradition, training, perceived network control and investment in private radio are all issues which would have to be addressed before commercial services could be fairly evaluated.

Working through each of those issues will require information exchange, planning, educating, building relationships, testing in controlled environments, and perhaps incentives for both public safety agencies and providers to work together.

Today the manner in which commercial services are often offered to, and evaluated for use by public safety agencies is inconsistent.

Vendors, anxious to do business, often provide products without fully understanding the application environment. Some offer products without providing an effective evaluation plan. Few provide training, troubleshooting and/or escalation procedures.

Agencies, often agree to test or purchase products without adequately explaining the application environment to vendors. In some cases, an agency will accept a product for evaluation and refuse training, because the product is considered to be a commodity item in the marketplace, and is assumed to be "user friendly". Although it may be true that users are familiar with the devices they are issued, the services activated in conjunction with those devices can vary greatly in coverage, reliability and levels of service offered.

Commercial providers often sell services through resellers. Some resellers work from a storefront to offer a variety of services. In small towns, local agencies may find themselves testing commercial services where the actual providers have no idea that the agency is actually using their service. Unless commercial providers have special programs for their resellers specific to public safety, agencies will often receive service commensurate with the general public.

Vendors and agencies that have entered into casual business arrangements, without taking the time to set objectives, to establish measurements for performance based on the application environment, and to understand troubleshooting procedures, etc., have walked away with disappointing results.

Test plans must be carefully conceived and executed before conclusions can be reached. Valid tests cannot be performed without realistic measurement criteria.

Standards for emergency communication services have only been addressed in private radio today.

Commercial performance criteria for reliability, security, access time, coverage, etc. like private system performance, are application specific. They have not been globally established by public safety agencies for different types of applications.

Once performance criteria are established, providers can evaluate their own capabilities and assess any shortfalls they may have against a standard of measurement. Based on the results, they can take steps to market to the public safety community for applications where their offering already fits, or they can modify their networks to meet more exacting defined criteria.

However, even if providers find that they meet public safety criteria for performance, there are no guarantees that they will commit to supporting public safety as a market segment either directly or in conjunction with value-added resellers. They may have already made a decision to support other vertical markets, or believe that they do not have the resources to effectively support public safety.

From another perspective, providers may be anxious to commit to supporting public safety as a vertical market, and not fully comprehend what that commitment requires. Without a full understanding of the Public Safety market, their actions could result in a poor showing for commercial vendors in general.

So far, inconsistent and uncontrolled evaluations of commercial services have not shed a lot of light on the effectiveness of their use. In general, misconceptions providers have about what is required to support public safety communications, and agency misconceptions about actual provider capabilities are major issues. They are issues unlikely to go away without a plan for vendors and agencies to educate one another.

A formal planning and evaluating process would help zero in on what agencies today see as unsettling issues about the effective use of commercial services in their environment.

The process should allow for open information exchange between agencies and vendors, with easy access for both, to information regarding the other's environment. Consistent and controlled evaluations must be conducted for specific technologies in specific environments with defined applications. The costs of services could then be compared as part of the evaluations.

Tests should be rolled out cautiously, taking into account environmental factors specific to each agency. Ongoing evaluations and modifications should be performed to ensure that services continue to meet performance standards.

In conclusion:

- a) Performance criteria for public safety requirements to be met with commercial resources, are application specific and have yet to be defined by the public safety community.
- b) A consistent plan needs to be developed for evaluating and integrating commercial services.
- c) Public safety agencies and providers need incentives to work together to develop long term relationships.

Much work needs to be done to prepare commercial providers to support public safety as a vertical market.

An equal amount of work needs to be done to help public safety agencies evaluate where commercial services are effective and appropriate.

Both will take time, when the need for interoperability is now.

Vendors and commercial service providers need to spend the next five years making plans and conducting evaluations to determine where commercial services are appropriate for public safety applications and where vendor services need to change in order to support other public safety applications.. Migration to some commercial services will continue to evolve as certain technologies are seen as suitable by public safety communication officials within that time frame.

It is likely that widely accepted use of commercial services may take longer than five years. The need for spectrum to provide interoperability is immediate, and the alternatives for short-term solutions are limited.

Public safety cannot afford to wait five or more years for spectrum relief assistance from the commercial sector as a solution to pressing interoperability problems today. By the time commercial services become more widely used for Public Safety applications, the amount of spectrum needed to accommodate yet-to-be-discovered applications will likely increase with those new requirements.

## **11.0 Recommendations**

One of the ultimate goals of the ISC is to reduce the number of bands that the Public Safety community currently operates their land mobile radio (LMR) systems. However, it is the general opinion of the members of the ISC that any significant reduction in the operational frequency bands can be realized in the PSWAC timeframe of 2010, without specific mandates and/or regulations. The ISC recommends that the PSWAC Steering Committee, as well as the FCC and NTIA keep this recommendation in mind during the deliberations concerning future rule-making and regulatory proceedings.

### **11.1 Short Term Solutions**

Reflecting the analysis and conclusions contained in Section 10.1.3, the Interoperability Subcommittee makes the following recommendations for improving interoperability in the shorter term. Namely, the FCC and the NTIA:

1. Should take steps to immediately allocate additional spectrum adjacent to current operational bands in order to minimize the time period needed to reach the longer term solutions.
2. Should take pro-active steps to encourage the deployment and utilization of shared/consolidated systems (referred to by the ISC as common access to infrastructure).
3. Should encourage the provision of interfaces/gateways between and among remaining independent public safety and public service infrastructures.

4. Should take pro-active steps to encourage the use of commercial systems where appropriate.
5. Should encourage the development, provision, and utilization of interfaces/gateways between public safety and commercial infrastructures.
6. Should encourage coordinated planning at the federal, state, and local levels of government in order to facilitate implementation of the previous five recommendations.
7. Should recognize and take into full consideration in their deliberations that the ultimate solution to the interoperability problem is critically dependent on additional spectrum.

## **11.2 Long Term Solutions**

Based on the discussion provided in previous sections of this report and the supporting detailed information in Section 12, the Interoperability Subcommittee (ISC) has adopted the recommendations provided in the following sub-sections to satisfy the interoperability requirements that have been identified and addressed.

### **11.2.1 Additional Interoperability Channels**

Appendix A contains recommendations for the number of simultaneous interoperability links required by user service category for two options. The first option is to implement interoperability within existing public safety bands. The second option is to implement interoperability at the minimum level within current public safety bands, while providing the majority interoperability spectrum within a new Public Safety Interoperability Band in spectrum below 512 MHz. After careful consideration, the ISC recommends the second option (see Section 10.3 and Attachment 7). Section 12.3.7 discusses these options in detail.

Aggregate numbers for the first option (using existing bands) indicate a total need for 51 repeatered voice links and 83 simplex voice links within current bands, plus 2 independent high speed data and 2 independent full motion video links. It is believed that existing designated interoperability frequencies can be used for 17.5 of the repeatered and 28 of the simplex voice links. The high speed data and full motion video links must be provided within new spectrum.

Aggregate numbers for the second option (new interoperability band previously discussed in Section 10.1.3 and later in Section 11.2.2) indicate a total need for 21 repeatered voice links and 20 simplex voice links within the existing bands. It is believed that existing designated interoperability frequencies can be used for 13.5 of the repeatered and 13 of the simplex voice links. It is further recommended that 31 repeatered voice, 70 simplex voice, 2 independent high speed data and 2 independent full motion video links be provided in the new Public Safety Spectrum. The difference in the number of available frequencies in the current bands between the two options is due to eliminating the 220 MHz band in this option.

### 11.2.2 Establish New Interoperability Band

Although this solution is listed as a long term (longer than five years) solution, depending on the availability of spectrum, this new band could be available within the short term.

#### The PI Solution

The descriptions outlined in Section 10.3 and in Attachment 7 include the following basic requirements:

- \* Find a relatively free band of frequencies, preferably central to existing public safety bands. The ISC recommends the UHF band below 512 MHz.
- \* Define specific frequencies and pairs of frequencies using developed ICS guidelines.
- \* Freely license these frequencies to all eligible public safety/service providers under operational as well as technical regulations.
- \* Restrict use to mutual aid interoperation.

The preceding requirements may seem somewhat simplistic, however there is a flexibility to the operational aspects of the PI solution that could allow for much higher levels of robust capabilities. **This would be a fresh and new service which could be implemented without regard to any backward compatibility requirements.** It need not be tied to existing technology and modulation schemes. This leads to a plethora of possibilities:

- \* Narrow channel bandwidth (or equivalent) should be specified for maximum spectrum efficiency.
- \* Digital modulation could be required for the same reason.
- \* Digital modulation leads to the fact that data transfer would be a natural possibility.
- \* Bandwidth on demand applications (or the equivalent) could also be implemented for the very same reason.
- \* Encryption could also be very easily adapted considering the possible digital nature of the service. Over the air rekeying (OTAR) should be a requirement.
- \* Although conventional mode infrastructure independent operation is basic and mandatory to support first response capabilities, trunking should be encouraged for escalated incidents. Trunking would have several advantages for implementation of escalated incidents or for systems embedded in local or regional systems. Caches could be developed that include base/controller equipment that would allow dynamic over the air reconfiguration of all units involved in the incident. This could be enhanced by

requiring every radio manufactured to have an internal unique ID similar to the NAM in cellular radios. The ID should be easily read by units entering the incident either by physical connection, optical, or wireless. While such advanced types of operations would require knowledgeable and available communications unit leaders, this activity already takes place on large ICS incidents with existing programmable equipment.

Migration to this interoperability solution could take place as soon as rules and regulations were put into place. There are of course stumbling blocks such as adopting standards for a new operation, but these could also be looked upon as building stones. This solution would not require scrapping any existing system or worry about compatibility with existing systems and the associated costs.

### **11.2.3 Establish Planning Process**

The ISC recommends that a nationwide planning process should be established as soon as possible which provides guidance and outlines procedures for a regional planning process to be completed within two years from completion of the national plan.

The nationwide planning effort should identify and address operational policies and procedures. This process could be accomplished with a FCC comment and reply procedure, however it is the general consensus that a definitive interoperability process would be more effective and provide a better solution. All levels of government should be involved in this planning effort and all public safety entities (as defined in Section 3.1) should have access to these interoperable channels. Most of the concerns of the federal users, including the use of the United States Search and Rescue Teams (USART) established by the Federal Emergency Management Agency (FEMA), should be addressed during the national process. While regional differences are certain to occur, nationwide concerns should be addressed only once during the national process as much as possible. When guidelines are defined for a core nationwide use, individual regional concerns and issues should then be addressed and regional plans developed.

### **11.2.4 Baseline Technology (for Interoperability)**

The ISC recommends that a common mode of transmission be adopted, by the FCC and NTIA, as a mandatory requirement for interoperability on these channels.

The ISC unanimously adopted a revised recommendation from Working Group #10 on April 12, 1996, in San Diego. For detailed information concerning the adoption of this recommendation, refer to the Working Group #10 Report at Section 12.10. The following recommendation was adopted and forwarded to the Technology and Spectrum Requirements Subcommittee Chairs:

*It is the recommendation of the Interoperability Subcommittee that the minimum "Baseline Technology for Interoperability", for unit-to-unit voice communication, be 16K0F3E (analog FM), unless Federal Communications Commission (FCC) and/or National Telecommunications and Information Administration (NTIA) regulations*

*stipulate a different emission in a specific operational band. This mandatory requirement should be adopted as soon as possible by the FCC and NTIA. This recommendation is applicable to the public safety spectrum between 30 MHz and 869 MHz.*

*Effective January 1, 2005, the minimum "Baseline Technology for Interoperability", for unit-to-unit voice communication, should be mandated as 11K0F3E/11K25F3E (analog FM) in the public safety spectrum between 30 MHz and 512 MHz, unless FCC and/or NTIA regulations stipulate a different emission in a specific operational band.*

*The maximum allowable interoperability bandwidth in any new spectrum allocation should not be allowed to exceed the bandwidth established for operational communications within that new spectrum.*

### **11.2.5 Establish Standards Working Group**

Although it must be emphasized that the decision is not unanimous (see discussion in Section 10), the general consensus of the ISC is to recommend:

The ISC recommends that as part of the Final PSWAC Report, a strong recommendation be made to establish a group comprised of experts representing government, industry and users to address baseline technology for interoperability. This effort should be managed by a neutral third party who has no vested interest in the outcome of the effort.

The ISC recommends that any digital baseline standards for interoperability be open standards, developed/adopted in an open and fair process.

With the emergence of digital technology, it is imperative that this baseline be addressed and established within the next two years, to allow the public safety community to develop implementation and migration plans accordingly.

### **11.2.6 Recommendation for PSWAC Committee**

It is further recommended that another PSWAC should be convened within ten (10) years to evaluate technology development and the effect that actions stemming from this PSWAC have had on meeting the needs of public safety's spectrum and interoperability problems.

## **12.0 Working Group Reports**

The product of some of the working groups was directly reflected in specific text within the main body of the report.

### **12.1 Working Group #1 Report (Define Interoperability)**

Working Group #1 was the first working group formed in the ISC. The output of this working group is reflected in Section 3.2 of this report.

### **12.2 Working Group #2 Report (Develop DRAFT Report Outline)**

Working Group #2 developed the outline and list Addressable Issues from which this report was developed. The members of Working Group #2 were then assigned to Working Group #6, which was assigned the task to develop the DRAFT Report.

### **12.3 Working Group #3 Report (Define Future Interoperability Requirements)**

#### **12.3.1 Introduction and Overview**

This working group report describes possible methodologies, operational policies and procedures, spectrum use and considerations and regulatory issues as they pertain to future interoperability needs.

The report proceeds in six steps. First, the three major types of interoperability (day-to-day, mutual aid and task force) are addressed. Second, we discuss a number of major mutual aid and task force incidents requiring significant use of interoperability which have occurred in the past few years; these are broken down by type of service (emergency medical, fire, general government, law enforcement, etc.) and summarize unmet needs. Third, we summarize the possible methodologies which might be employed to meet these and future requirements. Fourth, we discuss operational policies and procedures based on experiences from the major incidents and current trends in incident management. Next, we present and discuss spectrum issues related to interoperability. Finally, regulatory issues related to interoperability are presented and discussed.

#### **12.3.2 Key Conclusions**

**12.3.2.1** The single greatest impediment to interoperability is the large number of radio frequency bands assigned to the Public Safety Radio Services by the FCC and administered by the NTIA for federal government users.

Current bands spread 839 MHz from 30 MHz to 869 MHz for normal land mobile radio (LMR) systems in 10 major bands:

\* 30-50 MHz (federal, state and local)

- \* 138-144 MHz (federal, primarily Department of Defense)
- \* 150-162 MHz (state and local)
- \* 162-174 MHz (federal)
- \* 220-222 MHz (state and local)
- \* 406-420 MHz (federal)
- \* 420-430 MHz (state and local in two N/E Canadian border areas only)
- \* 450-512 MHz (state and local)
- \* 806-815 and 851-860 MHz (state and local)
- \* 821-824 and 866-869 MHz (state and local; National Public Safety Planning Advisory Committee - NPSPAC or national plan band)

Radio equipment manufactured today is limited to an operational bandwidth that is approximately 24% of its center operating frequency. Therefore, the operational bandwidth is inadequate to cover the 839 MHz frequency spread listed in the previous paragraph.

The assignment of new bands for use by public safety agencies will only increase the interoperability problem for the near future.

Future technology developments, including wide-band and/or multi-band radios will offer some relief, but radio equipment manufacturers have publicly stated that it is doubtful that one piece of equipment, particularly the important personal portable radio, will be able to function adequately to meet public safety requirements across the entire 839 MHz range (or even the narrower 150 MHz to 869 MHz range where most LMR communications occurs) in the foreseeable future.

**12.3.2.2** The introduction of equipment using newer technology during the past 10-15 years without appropriate standards leaves this equipment unable to communicate with that of other manufacturers' equipment with dissimilar protocol and modulation techniques. For example:

- \* Analog trunked LMR equipment introduced into the 800 MHz public safety market by the three major US-based equipment manufacturers is not compatible in analog trunked mode.
- \* Digital encryption provided by the two major US-based equipment manufacturers is not compatible in protected

(encrypted) mode. Indeed, some of these manufacturers own lines are not compatible with each other.

- \* New equipment introduced in the past three years for the 220-222 MHz band, primarily based on advanced single-sideband technology, is not compatible between manufacturers, nor with other technologies
- \* The baseline technology for voice interoperability within existing compatible bands is the use of analog frequency modulation (FM), potentially leaving the user without some critical features such as encryption (see Section 12.3.3.2).

**12.3.2.3** *There is a critical shortage of frequencies specifically designated for interoperability uses in all 10 of the public safety bands, although some regions of the country have opted to designate additional frequencies beyond the 5 pairs mandated in the 821-824/866-869 MHz NPSPAC band thereby minimally meeting the interoperability needs of that region.*

**12.3.2.4** *The grade of service (GOS) for interoperability paths can be no less than that for operational paths as detailed in Appendix A of the Operational Requirements Report. Interoperability is often used under circumstances that are less tolerant of error than during normal operations, therefore a similar GOS is required.*

### **12.3.3 Key Recommendations**

#### **12.3.3.1 Additional Channels for Interoperability**

Appendix A contains recommendations for the number of simultaneous interoperability links required by user service category for two options. The first option is to implement interoperability within existing public safety bands. The second option is to implement interoperability at the minimum level within current public safety bands, while providing the majority interoperability spectrum within a new Public Safety Interoperability Band in spectrum below 512 MHz. After careful consideration, this Working Group recommends the second option. Section 12.3.7 discusses these options in detail.

Aggregate numbers for the first option (using existing bands) indicate a total need for 51 repeatered voice links and 83 simplex voice links within current bands, plus 2 independent high speed data and 2 independent full motion video links. It is believed that existing designated interoperability frequencies can be used for 17.5 of the repeatered and 28 of the simplex voice links. The high speed data and full motion video links must be provided within new spectrum.

Aggregate numbers for the second option (new interoperability band) indicate a total need for 21 repeatered voice links and 20 simplex voice links within current bands. It is believed that existing designated interoperability frequencies can be used

for 13.5 of the re-peated and 13 of the simplex voice links. 31 repeatered voice, 70 simplex voice, 2 independent high speed data and 2 independent full motion video links must be provided in the new Public Safety Spectrum. The difference in the number of available frequencies in the current bands between the two options is due to eliminating the 220 MHz band in this option.

### **12.3.3.2 Baseline Technology for Interoperability**

The most critical Interoperability requirement is for direct unit-to-unit communications. Normally, a common over-the-air interface must be used for direct unit-to-unit communications; to that end, the Interoperability Subcommittee adopted a recommendation for a *Baseline Technology for Interoperability* on April 12, 1996. The text of that resolution is included in the main body of this Interoperability Subcommittee Report.

### **12.3.3.3 Establish Standards Committee**

While the Minimum Baseline for Interoperability presented in Section 11.2.4 will suffice for some time, perhaps as long as 2010, the time will come when most, if not all, users in a given area will be using a digital voice communications platform and will not want to give up the capabilities provided by that platform when switching to analog FM for direct unit-to-unit communications. Therefore, it is recommended that, after the PSWAC process is completed, the FCC and NTIA together establish a working group compromised of experts representing government, industry, and federal, state and local government users similar to, but smaller than the PSWAC effort, to address base line technology for interoperability. It is further recommended that another PSWAC should be convened within ten (10) years to evaluate technology development and the effect that actions stemming from this PSWAC have had on meeting the needs of public safety's spectrum and interoperability problems.

Considering the evolution to digital technology, we should not limit future interoperability to an analog baseline. Just as the AMPS cellular standard (which clearly goes far beyond simple analog FM) provides North America-wide cellular interoperability, there is clearly a future need for digital interoperability standards for public safety communications. It is imperative that this baseline be addressed and established within the next two years, to allow the public safety community to develop implementation and migration plans accordingly.

Any group selected for the purpose of such an evaluation should be composed of experts representing industry and users. The selection methodology must be weighted towards the needs of the end user. Refer to Section 12.3.9.5 for further discussion within the working group.

### **12.3.3.4 Establish National Frequency Plan**

A national frequency plan and regional frequency plans (as applicable) must be developed and mandated. These plans must include voice (simplex, mobile relay and trunked), data and video.

Standard nomenclatures and identifiers for channels/talk groups must be mandated by the FCC and NTIA for use on all equipment, to include approved identifiers to be displayed for interoperability channels/talk groups on equipment with varying numbers of characters in the channel/talk group display window.

A National Calling Channel and one or more Tactical Channels must be established in **EACH** of the public safety frequency bands. Use of these channels should be similar to that currently designated in the NPSPAC plan (47 CFR 90.16 and §90.34).

As with other mutual aid frequencies, it is important to consider placement within each band. There have been significant problems when mutual aid channels have been placed side-by-side or next to other statewide or nationwide assignments due to adjacent channel interference which can render such channels unusable when operating within close proximity to each other.

Some of the Interagency Frequencies identified in Appendix B may be candidates for this use. However, many of these have already been designated for specific purposes in state and regional plans. Caution is urged; a great deal of research must be done prior to making any reassignment of the Interagency Frequencies.

### **12.3.3.5 Establish Incident Command System**

Appropriate regulatory agencies (including the Congress and state legislatures) must enact legislation requiring use of the Incident Command System for multi-agency incidents.

If addressed by the federal government and other states in a manner similar to that implemented in California, this becomes not an unfunded federal or state mandate but a requirement for disaster relief reimbursement from FEMA or the affected state(s) following any declared disaster.

## **12.3.4 Review of Working Group 3 Process**

### **12.3.4.1 Background**

The Interoperability Subcommittee (ISC) was formed in conjunction with the establishment of the PSWAC. One of its first tasks was to develop a report outline and divide into appropriate Working Groups to prepare its report. Working Group 3 (WG-3) was established to address Future Interoperability Needs.

During the Interoperability Subcommittee Meeting on January 9, 1996, at the University of California, Berkeley, ten subgroups were established within WG-3 to collect data for specific public safety services; membership of these groups is listed in Appendix A. The groups are:

- WG-3-1: Fire/Emergency Medical Service (EMS)
- WG-3-2: Emergency Management

- WG-3-3: Forestry-Conservation
- WG-3-4: General Government
- WG-3-5: Highways (including Intelligent Transportation System)
- WG-3-6: Infra-structure
- WG-3-7: Criminal Justice
- WG-3-8: Public Transportation
- WG-3-9: Public Service
- WG-3-10: Federal Government

#### **12.3.4.2 Methodology**

The co-chairs of each of the subgroups began a series of weekly meetings by telephone conference call or in person at the scheduled meetings of the Interoperability Subcommittee.

The co-chairs of the subgroups selected a series of major incidents occurring in the United States during the past 14 years which involved the use of inter-operability. Each of the ten subgroups was tasked with the collection of information on these incidents as follows:

- WG-3-1 Fire/EMS: Oakland Hills & Old Topanga (Los Angeles) Fires (populated areas)
- WG-3-2 Emergency Management: Loma Prieta & Northridge Earthquakes, PA Flood
- WG-3-3 Forestry-Conservation; Yellowstone Fire (unpopulated area)
- WG-3-4 General Government: Assist WG-3-1 & WG-3-2
- WG-3-5 Highways: Assist WG-3-8 & WG-3-9
- WG-3-6 Infrastructure: Assist WG-3-2
- WG-3-7 Criminal Justice: LA Riots, OK City/World Trade Center Bombings
- WG-3-8 Public Transportation: DC/NJ Train Collisions
- WG-3-9 Public Service San Bernardino Train Derailment & Haz Mat Release
- WG-3-10 Fed Gov: Air Florida Crash in DC, Political Conventions

Prior to the ISC meeting on February 29, 1996 in Orlando, Florida, a draft Data Collection Instrument (DCI) was prepared to standardize the gathering of information on the major incidents by members of the WG-3 subgroups. This instrument was approved at Orlando with one minor modification. It was subsequently used for all data collection. The completed DCIs are available for review, upon request.

Simultaneous with the collection of data by the WG-3 subgroups, Motorola began to interview a number of the key persons involved in several of the more recent incidents. The purpose of these interviews was to capture a clear picture of the incidents in the words of the participants and to gather insight into interoperability problems, particularly with respect to issues of command and control. Motorola's report is included as Attachment 5 in this report.

Finally, using all of the above information, this report was prepared and circulated for comment. The first draft was circulated prior to the April 12, 1996 meeting in San Diego, CA.

### **12.3.5 Types of Interoperability**

#### **12.3.5.1 Day-to-Day**

- the most often encountered type of interoperability. It is commonly used in areas of concurrent jurisdiction and is usually tactical in nature.
- Interagency interoperability is a form of day-to-day interoperability that requires users from different agencies which do not share a common communications system to be able to communicate
- typically is used:
  - where agencies need to monitor each other's routine traffic, and
  - where units from two or more different agencies need to interact with one another and to exchange information
  - often involves different public safety disciplines responding to the same incident.
  - minimizes the need for dispatcher-to-dispatcher interaction in the exchange of information among field units.

In addition to the time delay involved in establishing a communications path between dispatch centers and the time required to physically restate information, it is a known fact that the more times a message is repeated from one party to another, the more prone it is to having error introduced into its content. This is critical for tactical field situations.

There may be events where dispatcher intervention or monitoring of information is appropriate for resource management, administrative command/control, etc. This is especially true when command-level information is being passed between agencies.

- if agencies are on different bands, day-to-day interoperability may involve the use of multiple radios in each vehicle.
- difficult to implement for field personnel using portable radios unless all equipment operates on the same band and within the same type of infrastructure.

#### **12.3.5.2 Mutual Aid**

- Can involve many agencies with little opportunity for prior detailed planning (riots or wildland fires).

- Often requires assignment of several to many small groups, each on its own talkgroup or frequency (tactical communications).
- Once on scene, generally involves use of portable radios.
- Many incidents are in rural areas out of infrastructure range.

### **12.3.5.3 Task Force**

- usually involves several layers of government (Federal, State and/or local)
- typically opportunity for prior planning usually is present.
- usually involves use of portable and/or covert equipment.
- often requires extensive close-range communications.
- radio traffic is such that wide area transmission is usually undesirable.
- users may rove in and out of infrastructure coverage (metro to rural, in and out of buildings, etc.).
- often implemented by exchanging equipment such that all users have identical or compatible equipment.

## **12.3.6 Selected Major Incidents Requiring Interoperability**

### **12.3.6.1 Oakland Hills**

The Oakland Hills Fire which occurred in the metropolitan Berkeley/Oakland, California area beginning on Oct. 20, 1991 represents the ultimate test - and importance - of interoperability. A once-in-a-lifetime experience for most participants, this wildland and structure conflagration resulted in the loss of 25 human lives and 3,354 private residences. Dollar loss exceeded \$1 billion.

The progress of the Oakland Hills Fire and its overwhelming growth can be measured in the times of successive alarms: the First went out at 10:58 a.m., the Sixth (highest in the system) was called at 11:26 a.m., less than a half hour later.

Before all was over, aid arrived in Oakland from no fewer than 9 cities, 32 counties (115 mutual aid fire departments), 6 State agencies and 4 Federal agencies.

The following are quotes from the 1992-93 Alameda County Grand Jury report following their detailed investigation into the Oakland Hills Fire:

“The Oakland Fire Department Dispatch Center had two frequencies on which they could communicate with Oakland’s 35 companies and several fire departments could communicate on a State-wide fire mutual aid frequency.” [154.280 MHZ known as “Fire White 1” in California is authorized for base and mobile use and is the channel referenced by the Grand Jury; 154.265 and 154.295 MHZ are also known as “Fire White 2” and “Fire White 3” and are restricted to mobile and portable use only. These three frequencies are reserved nationwide for Fire Intersystem Operation by FCC Rules Section 90.21(c)(2).]

At the height of the fire, all radio communication was “almost hopelessly jammed.”

The following are quotes from the California Department of Forestry’s Fire Management Team’s Incident Commander assigned to the Incident Command System’s (ICS) Unified Command Post at the Oakland Hills Fire:

The basic problem was the large influx of mutual aid resources, 400+ engines through the [California Governor’s Office of Emergency Services] OES system. With only [3] mutual aid (White) channels, we ran out very quickly. Likewise, many of the resources came in without multi-channel capabilities.”

“Communications with cooperating agencies (PD, CHP, public works, etc) was limited to whatever communications were available within the com vans in base camp [setup in the middle of State Route 24 west of the fire]. Very little communications went from fire resources to other agencies other than face-to-face.

### **12.3.6.2 Old Topanga (Los Angeles County, CA) Fire**

The Old Topanga Incident most likely represents the largest deployment of fire fighting resources in California’s history. It is best described as a wildland-urban interface fire. The Incident spanned 10 days beginning on November 2, 1993. During that time frame, over 7,000 fire fighters from 458 separate agencies participated in the effort. The incident was managed via a fully developed Incident Command System (ICS).

During the Old Topanga Fire, the County of Los Angeles Fire Department and assisting/ coordinating agencies were charged with protecting the lives of thousands of citizens and more than 22,000 structures; 3,634 structures were directly exposed to the fire and 18,870 more were threatened had the spread not been contained. The fire consumed 16,516 acres within a 48-mile perimeter. At the point of full development, the ICS operations Section encompassed 5 geographic branches and an air operations branch. These branches were supported by 16 divisions with over 1,000 separate fire companies.

The Old Topanga ICS was responsible for information management that dealt with 165 engine strike teams (generally consisting of 5 engines each), 10 single engine resources, 129 hand crews, 31 fixed-wing aircraft, 23 helicopters, 13 dozers, 50 water tenders, 11 fuel tenders, 8 food dispensers and thousands of fire fighters and support personnel. Interagency coordination was required for hundreds of resources from 12 different states and 458 agencies.

The Old Topanga Incident resulted in the loss of 3 human lives and injuries to 21 others. The reported number of injuries to fire fighting personnel was 565. Property losses were estimated at \$10.8 million from damage to utilities, \$208 million due to damage or destruction of 460 structures and their contents, \$68 million due to hazardous waste control and the process of reseeded to prevent soil erosion was estimated at \$0.44 million.

The Rand Corporation Report, PM-309-LACFD, issued in Sept. 94 discussed both the Oakland Hills and Old Topanga Incidents. The following are quotes from that report:

“The lack of communication had several effects. It (1) caused inefficient operations; (2) interfered with command and control; (3) contributed to endangerment of fire fighters; and (4) may have contributed to losses.”

“Valuable resources were used purely for communications. Examples include that LAFD sent an extra strike team to check on the safety of Strike Team 1064 in La Costa; LAFD kept command resources on top of Old Topanga strictly for communications; several resources were used purely as messengers throughout the fire.”

“In the initial dispatch, strike teams were told not to use the radio, due to overload, but to go to staging area for face-to-face assignment. Some may have passed their assignments on the way.”

“Lack of communications probably contributes to endangerment of fire fighters in at least 3 incidents where engines were cut off from any communications with command. Requests for water drops probably went unheard...in some cases they were heard, but communications were intermittent and it was impossible to establish their location. Strike Team 1204A decided not to move from its positions because it did not know where to go or the condition of the roads and several fire fighters were subsequently injured.”

“...incident commands frequently could not rely on radio contact to position units or to warn them of changes in fire conditions. In addition, the communications system was badly overloaded in all the fires. With involved personnel trying to transmit messages over two or three channels, fire fighters could not get through to incident commanders to advise locations or confirm assignments. Aerial spotters and forward observers on the ground had difficulty sending important tactical input to incident command. Incompatible systems also hampered communications between fire departments and other public agencies. Overall, communications technology shortfalls meant that prescribed command and control systems operated at less than peak efficiency and effectiveness.”

“Just as the Oakland Fire sent lessons to the fire officers who would lead the fire fight at the Old Topanga Incident, the [Old Topanga] incident should send lessons to future incident commanders. We judge that a major lesson is that the time has come to update communications and information systems so that they provide more effective

support to the fire fighters who will be on the front line of future fires at the wildland-urban interface. The last five years have seen enormous advances in computers, communications systems, surveillance and detection systems, and the availability of GPS receivers for civilian purposes. These technologies can be combined into an effective command and control system to provide the next Incident Commander with the ability to greatly increase both effectiveness of wildland fire fighting and the safety of fire fighters.

### **12.3.6.3 Loma Prieta Earthquake**

On October 17, 1989, at 5:04 p.m. (PDT), a M6.9 earthquake centered under Mount Loma Prieta in Santa Cruz County, CA (60 miles southeast of San Francisco) shook a 400,000 square mile area of the western United States. Major aftershocks continued for weeks. There were 62 deaths as a result of the earthquake, and more than 3,750 injuries. More than 22,000 residential and 2,000 commercial/public-owned structures were impacted, resulting in more than 12,000 people left homeless. Physical damage estimates exceeded \$7 billion, including more than \$1 billion in damage to the Interstate Highway System. Ten contiguous counties in the San Francisco Bay and Monterey Bay regions and two cities in the Sacramento - San Joaquin Delta region were included in the President's declaration of a Major Disaster area. Overall, State agencies and more than 100 County and City governments in the impacted area activated their Emergency Operations Centers (EOCs) and field forces.

Damage to utility lifeline systems was extensive in many areas while other areas experienced no damage. Firefighting water supplies were a problem in parts of Santa Cruz County and in San Francisco; either the distribution systems broke due to ground shift, or power to operate distribution pumps failed.

Electrical power was knocked out throughout much of the area for a number of hours as power generation plants shut down due to the shaking. These plants had to be assessed for damage prior to being restarted. The natural gas distribution system in many areas fractured, creating additional concerns about restoring electrical power in these areas; as a result power restoration was often delayed until the gas lines could be secured.

Telephone service throughout the region fared very well in general. Shaking in some Switching Offices exceeded design criteria, causing structural damage to the buildings, however the switches remained in service. The two major problems to the Public Switched Telephone Network (PSTN) were: (a) failure of back-up power systems in Central Offices, and (b) overload conditions caused by too many calls trying to be placed into Northern California. To maintain the health of the national long-distance network, carriers restricted calls into and between four Northern California Local Access Transport Areas (LATAs). These overload conditions in the PSTN continued for almost two weeks following the main quake.

Cellular telephone service in the region generally remained operational for calls between cell phones. Calls into and from the PSTN were hampered by congestion at the gateways, and by the problems in the PSTN.

The Loma Prieta Earthquake, while causing major damage, was not catastrophic. Damage in individual neighborhoods varied by type and age of building construction. Areas closer to the epicenter, or built on "fill" soils at the edge of San Francisco Bay were hardest hit. As a result, the emergency response was handled as a series of simultaneous local disasters, with State and Federal assistance initially being targeted to the hardest hit areas of the region.

Widespread severe damage (resulting in concentrated heavy rescue efforts) was limited to three areas -- Oakland (collapse of 1.5 miles of double-decked freeway, resulting in 42 deaths), San Francisco (numerous building collapses in areas susceptible to liquefaction of the ground), and Santa Cruz County (partial failure of buildings in a shopping mall). The response activities in these areas continued for up to four weeks.

Due to the high population density, public safety and governmental public service communications systems in the San Francisco Bay area tend to be built in a regional fashion, with individual dispatch channels and common countywide tactical operations frequencies. Most governmental agencies in California have built their radio facilities with earthquakes in mind, securing equipment to prevent it from moving or falling over due to the intense shaking ("non-structural" hazards) and providing redundant back-up power systems (batteries and an AC generator). From a technical standpoint, the public safety communications systems withstood the earthquake's wrath with only sporadic system outages. However, some State agency, county and city communications centers were knocked off the air due to structural damage to the facility or non-structural damage in the Communications Center (unsecured consoles falling over, etc).

Operationally, public safety radio systems throughout the 10-county area quickly overloaded under the strain of the numerous simultaneous incidents. Common channels (both regional and the State-wide Mutual Aid frequencies) in these areas became unusable as multiple adjoining agencies attempted to use their tactical frequencies.

Mutual Aid and disaster relief efforts were coordinated through the California Office of Emergency Services' Coastal Region EOC near Concord, CA. Communications with the impacted county emergency management agencies (particularly at the south end of the disaster zone) were hampered by the overload conditions on the Mutual Aid radio systems, and the restrictions in the PSTN. These problems were solved (in part) through the use of a network of Amateur Radio Service repeaters intertied by microwave in the 5.8 GHz Amateur band. This network remained in service throughout the entire two week recovery period and provided the only portable-to-portable communications throughout the impacted area.

It should be noted that commercial land mobile radio systems in the region suffered much more damage than the public safety systems, mostly due to a difference in radio site construction design. Many commercial "community" systems failed due to a lack of back-up

power. Others suffered physical damage as base stations toppled under the shaking. At one major commercial mountaintop site the tower toppled, pulling numerous unsecured base stations towards the antenna cable feed through plate in one corner of the building before the cables broke under the strain. In some cases systems were overloaded with too many clients involved with response and recovery work in the same frequency pair (i.e. a number of ambulance companies, plumbing companies and general contractors sharing a single channel).

#### **12.3.6.4 Northridge Earthquake**

At 4:31 a.m. (PST) on January 17, 1994, millions of Southern California residents were roused from bed as a M6.7 earthquake shook the region. Centered under the heavily populated Northridge community in Los Angeles, the earthquake was felt in many locations as far as 250 miles from the epicenter. 57 people died, and more than 9,000 were injured. Eleven freeway structures at 8 locations collapsed, cutting off 14 major thoroughfares. More than 3,000 aftershocks were recorded in the first few days after the main quake. Three counties (Los Angeles, Orange, and Ventura) were included in the President's declaration of a Major Disaster Area. Direct damage estimates have exceeded \$20 billion. More than 215,000 people applied for Federal assistance in the first two weeks following the event.

Ground shaking in this earthquake was the highest recorded to date in California, with peak accelerations approaching 2x gravity. Damage to structures and utility lifelines was extensive in many areas of the City of Los Angeles and surrounding communities in a 45-mile radius of the epicenter. Out of 114,000 structures assessed for damage, approximately 14,500 buildings were declared unsafe to occupy.

Within hours of the first shock, the American Red Cross and the Salvation Army were opening shelters. Ultimately, 49 shelters were established, serving more than 22,000 homeless. Local jurisdictions and the California National Guard established tents and additional services that at one point sheltered an additional 20,000 individuals.

Electrical power was interrupted to approximately 2.5 million customers throughout Southern California. Impacts to the power grid were felt as far away as Idaho, where 150,000 customers were without power for 3 hours. Major components of the high voltage (>230,000 Volt) distribution grid located in the immediate area of the epicenter failed, however the majority of outages were caused by downed wires. Restoration of the distribution system was rapid, with the majority of customers back on within 12 hours, and more than 90% on-line within 24 hours. Virtually all of the distribution was restored within 72 hours. Individual reconnections to the distribution system continued for a number of days.

Telephone service in Southern California is provided by two local operating companies. As has been the case in almost every major incident in California in recent years, the earthquake and each major aftershock led to overload conditions in the PSTN, as phones were knocked off-hook or were picked up by anxious citizens attempting to make calls (peak call volume on January 17th was 225% of normal). Physical damage to telephone network switches themselves was minor (dislodged circuit cards, etc.) and quickly repaired. Like the

electrical system, the majority of service outages were caused by breaks in the distribution system, typically involving a downed "drop" wire at the customer's premise.

General Telephone of California (GTE) provides service to almost 3.5 million customers in the greater Southern California area. GTE reported approximately 400,000 of their customers were affected by the quake for a short period of time. Two switching offices suffered structural damage. Primary and emergency power systems in one of these offices failed, leaving 25,000 customers without service for 10 1/2 hours.

Pacific Bell (PacBell) serves 3.8 million customers in the Los Angeles area. PacBell advised the State that less than 10% of their customers were directly impacted by the quake, most for only a brief period of time. The company had structural damage to 31 of its 78 switching offices in the service area, with severe damage to only 5 of these buildings. One switching office stopped providing service due to a failure of its emergency power; this office was back on-line within one hour. 30,000 customer connections were repaired in the week following the quake.

Cellular telephone service in the region generally remained intact, although there were outages due to damage or a loss of power at individual cell sites. Congestion in the interface to the PSTN was another problem for about 10 days. The two carriers provided approximately 4,000 loaner telephones to response and relief organizations, along with free service for a 90 day period.

Water systems were heavily damaged in the hardest hit areas. Forty above-ground water tanks had some failure. Sixteen fractures of major distribution lines were reported in the areas of ground deformation; repairs took up to two months.

Damage to the distribution systems caused drinking water supply lines in some communities to be out for up to four weeks. At one point, 72 tanker trucks were used to provide drinking water to these neighborhoods.

The overall response to the Northridge earthquake was very effective. Local officials quickly identified their problem locations and responded. The recent introduction to the area of 120 new UHF-TV frequency pairs greatly eased channel congestion for those agencies who have built new systems; even so, all public safety radio systems within the impacted area were overloaded.

The great majority of public safety radio systems remained intact. Some communications facilities in structures (e.g.: hospitals) suffered from structural and non-structural damage. Some single-site failures in multi-point systems happened due to loss of power or other non-structural damage. This is noteworthy, considering one mountain ridge north of the epicenter (Oat Mountain, home of numerous public safety and commercial land mobile radio systems) was reported by USGS to have shifted 5' north, 2' west, and grew 14" during the initial event.

Many commercial radio systems in the same area suffered a higher rate of failure. Unsecured radio racks in buildings and at remote sites shifted in the quake, taking the radios off the air as antenna lines snapped. The tower at one Oat Mountain remote radio site was damaged in the main quake, and toppled during a major aftershock.

The State of California pushed additional law, firefighting, and communications resources into the region in anticipation of need. Six of the eight California Urban Search and Rescue (USAR) task forces created following the Loma Prieta earthquake were sent into the area. Two additional Federal Emergency Management Agency (FEMA) USAR task forces were also moved into the area. Mutual Aid activities were coordinated through OES' Southern Regional EOC in Los Alamitos, near Long Beach.

Due to overload in the established radio systems, it was determined that additional radio systems would be necessary to coordinate the extensive response and recovery process. A 'Unified Communications Command' was developed between OES, the California Dept. of Forestry and Fire Protection (CDF), and the U.S. Forest Service (USFS) to coordinate communications augmentation. Systems were deployed using cached radio equipment from OES and CDF on state-wide frequencies, and equipment from USFS and the National Incident Radio Support Cache (NIRSC) operating on USFS and NIRSC frequencies in the 160-171 MHz and 406-420 MHz spectrum. In-state communications caches were staged at Los Alamitos within 18 hours of the initial event and NIRSC equipment was being deployed within 30 hours.

Four of the 56-member USAR task forces are based in the immediate area. Three task forces were able to use their home radio systems. The remaining three California task forces and the FEMA task forces shared NIRSC UHF Logistics frequencies for their tactical operations.

A network of 2 inter-connected repeaters on NIRSC VHF Command frequencies was built to provide safety communications for the teams of structural engineers providing initial damage assessment surveys, and joint teams of geologists assessing the effects of the event.

A NIRSC UHF network was deployed to handle the coordination between the state's Constitutional Officers and other executives, relieving this load from a statewide law enforcement frequency overloaded with operational traffic. While operating without encryption, an additional benefit was a level of communications security provided by not operating in "normal" public safety spectrum.

One of the three OES statewide Mutual Aid radio networks was used to coordinate make safe operations (removal of damaged chimneys and property walls) of the California Conservation Corps. An additional (portable) repeater was deployed to enhance coverage. This repeater was placed on a mountaintop providing coverage of the impacted area. Because a 4-wheel drive vehicle was not available immediately, this repeater could not be deployed for 4 days.

One of CDF's statewide networks was used to handle the coordination of the delivery of drinking water, including water tanker dispatch operations. This network was also used to coordinate the logistical needs of the government-provided shelter operations. Additional repeaters were deployed to provide coverage in populated canyons.

More than 6,000 mobile homes were knocked off their foundations and damaged. FEMA and the CA Department of Housing & Community Development provided funds to make minimal repairs and place these units on seismic foundations. Program administration and inspection of this 10-month program was accomplished using commercial land mobile radio systems and cellular telephones.

### **12.3.6.5 Los Angeles Riots**

A major urban Civil Disturbance began in the Los Angeles basin on April 1992 after four Los Angeles Police Officers were found Not Guilty by a State court for the alleged beating of Rodney King. This disturbance lasted for a period of 5 days during which time thousands of mutual aid police officers from throughout California, the California National Guard, and federal troops were deployed throughout the area.

In response to the urban violence in the greater Los Angeles area, nearly every police department in Los Angeles County, as well as many in neighboring counties, fully mobilized in order to coordinate personnel and resources. The County's Chief Administrative Officer declared a countywide State of Emergency. Court orders were prepared restricting the sale of gasoline and ammunition in the affected riot areas and a dusk to dawn curfew was established. Major city and county governmental facilities such as City Hall, the County Criminal Court Building, and the Sheriff's Department Headquarters were attacked by rioters. Los Angeles Area light rail transportation systems were shut down and the air traffic pattern at Los Angeles International Airport was altered to minimize exposure of aircraft to sniper fire. Major rioting erupted throughout the County jail system in reaction to rioting in the streets. As a result of the mass number of riot arrests, the LA County Presiding Judge relaxed normal court arraignment procedures.

Governor Wilson mobilized the California National Guard and the California Highway Patrol (CHP) within 24 hours of the start of rioting to assist local law enforcement. Approximately 3100 CHP officers were assigned to the incident over a 5 day period. Because fire personnel were being attacked as they responded to fire & EMS calls, the CHP was asked to provide security for fire personnel and their facilities. The CHP responded to an average of 250 emergency calls per hour during the 5 day period with a total of 6,000 emergency escort missions.

President Bush nationalized and augmented the nearly 7,000 national guardsmen already deployed with federal troops. Public transportation was used extensively to carry national guard & mutual aid law enforcement personnel to various sites in area..

By May 6, 1992, a total of 14,615 riot related arrests had been made and 58 deaths reported. Several hundred buildings were destroyed by fire. Property loss due to arson and looting reached one billion dollars.

#### **12.3.6.6 District of Columbia Metropolitan Area Transit Authority (WMATA) Train Derailment**

On January 13, 1982, A WMATA passenger train derailed. While this incident, in itself, was a serious accident affecting public safety it occurred during two other major incidents in the DC area: a crash of an Air Florida jet in the Potomac River and an area paralyzing snow storm. The concurrent multiple disasters endangered the public safety of the region. It is being included in this report because it highlights the confusion that can result without interoperability among local, regional, state, and federal agencies. Interoperability is critical to effective handling of these or similar situations.

The Washington D.C. metropolitan area was being hit with a major snowstorm which had yielded approximately six (6) inches of accumulation in a short period of time. During the day, as the storm worsened, plans were made for the early release of workers throughout the area so that homeward travel could commence before the height of the snowstorm.

At 2:00 P.M., the area's largest employer, the federal government, released a majority of its workforce. Driving conditions had become difficult making traffic flow minimal and creating extreme congestion. Gridlock conditions occurred throughout the entire area. The snowstorm was at its peak by 3:00 P.M. and many commuters in vehicles had come to a complete stop on roadways due to the adverse conditions.

Many commuters used the WMATA subway system as a means to complete their trip home. The WMATA system was carrying peak hour passenger loads due to the mass exodus of employees who decided to take mass transportation home.

At approximately 3:45 P.M., Air Florida Flight 90 crashed on the Fourteenth Street bridge and created a multi-sector and multi-agency response condition. This, coupled with the weather, created massive traffic congestion which further complicated matters (see Section 11.3.4.13 for the description of this incident.)

During the height of the Air Florida river rescue efforts, a WMATA subway train, transporting peak hour passenger loads, derailed in the tunnel between the Federal Triangle and Smithsonian Stations.

The accident occurred when a train, eastbound toward the Smithsonian Station, entered a crossover switch and moved onto the westbound track. This unexpected crossover was immediately recognized by the WMATA operating personnel on the scene, and the train was stopped. An attempt was made to reverse the train's direction to pull it back onto the eastbound track. At that time, the front wheels of the lead railcar pulled back into a concrete bulkhead, straddling both tracks, cutting off service between McPherson Square and Federal Center S.W. There were three (3) fatalities, at least twenty-five (25) passengers injured, the

railcar severely damaged, and thousands of other commuters in trains following behind this one were affected.

The first report of the derailment was received from a WMATA employee, a Transit Patrolman, riding in the lead car of the train. He contacted Metro police communications via his portable radio advising of the accident with injuries to passengers and the fact that special equipment was needed to perform the rescue efforts. The damage to the train resulted in the loss of both power to the tunnel area and on-board emergency battery electrical power, thus, disabling the public address system and normal lighting. Rescue efforts would have to be conducted over a considerable distance in underground tunnels with limited access points.

Emergency responses to the Metro crash were made difficult by the extensive traffic congestion and the congestion caused by of large numbers of rescue equipment at the Air Florida crash site. Some equipment needed to be diverted from the Air Florida crash site to the Metro crash site located across town. Because of the lack of sufficient emergency aid responders and equipment, some necessary medical attention was given on the scene, extending the time from injury to arrival at area hospitals for definitive care. Time lapses in some of the Metro rescue activities were extensive due to the logistical problems the rescue presented.

Decision making for Metro rescue efforts were difficult because of the isolated location of the emergency. Since the location of the incident was between stations and because a substantial amount of sparking and smoke occurred in the area of the crash, evacuation of passengers was made more difficult. Within the damaged railcar, there was a failure of the emergency lighting. Outside the car, sparks were visible, even though power had been shut off.

Communications problems arose because of the difficulties in communicating via radio within the Metro system tunnels. Communications from the train had to be radioed to Metro Police Communications center and Metro Train Communications center and then telephoned to responding police and fire services. Since neither D.C. Police nor Fire Department radios could transmit from within the underground system, a similar lengthy sequence of relayed transmissions was necessary to effect communications from an inter-agency standpoint not to mention the intra-agency problems experienced.

Public awareness & notification difficulties existed. Passengers who were not in the damaged car were not notified of the scope of the emergency since the public address system was not functioning due to the power failures. Passenger fear was heightened by the lack of information as to what was happening around them and misconceptions of the power in the third rail.

#### General Summary of Metro type Incidents and the need for Interoperability.

- There is a need for implementation of an underground communication systems infrastructure that is capable of handling not only the communications of personnel normally engaged in operations of transit systems, their personnel and transit police

forces, but also incoming personnel from police, fire, emergency medical and possibly public service sectors.

- Transit incidents consist of many complexities that can hamper routine rescue efforts. Transit personnel must be involved in supporting and providing information to responders that generally are unfamiliar with the environment of mass transit systems.
- Unfortunately, the conditions that existed at the time of the 1982 derailment continue to exist today - emergency first responders generally cannot communicate in underground subway facilities. There continues to be a lack of interoperability among emergency first responders and the providers of mass transportation services. Communications concerning an ongoing subway or mass transportation incident (including providing updates as conditions change) must be transmitted to a central communications command center for relay to emergency personnel on the scene.

#### **12.3.6.7 New Jersey Train Collision**

On February 9, 1996, at about 9:00 am, a collision between two commuter filled trains in-bound to their terminals occurred in a difficult to reach portion of track located in the marsh area of the New Jersey Meadowlands near Secacus, NJ, just west of the Hudson River and New York City.

Three fatalities were attributed to this collision, two transit personnel and one passenger. There were a number of critical or unstable victims requiring immediate medical care, in addition to a multitude of potentially unstable victims out of the 1200 passengers on both trains. An exact number of injuries is unavailable since there was poor interoperability communications among the diverse response agencies. The response agencies included: New Jersey Transit Railroad; New Jersey Transit Police; New Jersey State Police; Port Authority Police; ConRail Police; municipal, county, & local police; municipal & volunteer fire; and municipal and volunteer ambulance/First Aid & Rescue.

Basic communications for entities on their respective channels was a staple and interoperability was required to coordinate the response of emergency responders and transit personnel.

The passenger rail service on this portion of the New Jersey Transit Railroad operates in conjunction with other railroad entities. The tracks are a common highway for the massive heavy rail equipment in the area. Since very few properties are available for rail expansion in the major metropolitan areas, it is common practice to coordinate use of tracks for freight and hazardous materials, in addition to passengers. The incident required the cooperation of many entities as this was a mutual thoroughfare.

The initial call for assistance came from the train conductor on his portable radio. Just after the collision, the conductor assessed the scene and notified his dispatcher of the condition. This call for assistance was routed from the train dispatch center and given to the Transit Police and other railroad response departments. Minutes later, numerous calls to 9-1-

I were being received by the police from injured commuters aboard the trains via their cellular telephones.

The New Jersey Transit Police dispatched their field personnel and began emergency management procedures. A NJ Transit field command post was dispatched to the scene, local jurisdiction police, regional fire and EMS services were also notified.

Due to the difficulty in arriving at the scene and the lack of exact locations, the first to attend to crews and passengers were not police, fire, or EMS personnel but train crews (conductors & other train personnel in the area). The crash location vehicle access was through a dirt service road along side the track through a marsh. Communications were extremely important to determine the need for personnel at the scene. Unnecessary personnel or inappropriate equipment at the site would hamper scene operations and accessibility. Due to the lack of common interoperability channels, this service road became blocked with vehicles.

Transit personnel were called upon to remove uninjured passengers from the scene in addition to stabilizing the wreckage for other responders. Transit personnel created a medical transportation train that could transport the uninjured as well as the injured from the incident site. This train was staffed by transit personnel, police officers, fire personnel, EMTs and paramedics who began triage and medical treatment while enroute to an accessible treatment/ambulance transportation area away from the crash site.

Coordination of the transit agencies (rail, bus, and transit police) were handled by the NJ Transit Police through their on-scene command post. Transit and Transit Police agencies in the area are predominately on VHF high band frequencies and 800 MHz trunked systems.

Fire and EMS services had a mix of coordination since lack of common channels existed. Fire and EMS communications were localized and decentralized. Fire and EMS personnel use various frequencies from VHF low band through UHF & 800 MHz.

Transit personnel have incorporated a type of interoperability within their VHF radios by programming everyone else's frequencies into their radios and by having a separate link to an 800 MHz trunked mobile radio within their vehicle. The Transit Police can communicate with Police personnel from the adjacent Transit Police agencies (NYCPD's Transit Bureau, MTA-Metro North Commuter Rail Police, and ConRail - a freight carrier). NJ Transit Railroad personnel can be reached by the Transit Police through operational frequencies for trains, maintenance, and electrical distribution.

NJ Transit Bus, an operating department of NJ Transit, has a VHF linked frequency through an 800 MHz system talkgroup. The NJ State Police Emergency Network (SPEN) is used by a variety of public safety groups.

Although the NJ State Police operate on a statewide 800 MHz trunked system, some coordination within the state continues to occur on a set of four (4) VHF simplex frequencies designated as follows:

- SPEN (Statewide Police Emergency Network) 1 is used to coordinate emergency police activities.
- SPEN2 is the national police emergency channel used to coordinate with out of state and federal units also serving as a back-up for SPEN1.
- SPEN3 is a common frequency for police agencies for non-emergency communications.
- SPEN4 is a common frequency for all public safety agencies for tactical, routine and emergency use (any police, fire, EMS, HAZMAT, etc).

The NJ Transit Police Central Communications Center communicates through all of the above methods in addition to accessing the marine radio channels. Since portions of the track cross over navigable bodies of water, it is necessary to have access to US Coast Guard resources.

Communications interoperability for this incident was accomplished in an extremely decentralized fashion. NJ Transit, through its Police and Emergency management groups, coordinated all scene and rescue activities. When coordination of Fire or EMS resources was necessary, a Transit officer stopped a Fire or EMS person and told him to relay a message to his/her scene coordinator on their own frequency. The scene coordinator of New Jersey Transit did not fully control the efforts of fire suppression or medical care. Fortunately, the departments and responders on-scene performed their respective tasks with few difficulties since ultimately, each responder was at the mercy of the rescue train for transportation.

The focus of Transit workers was scene safety and management of its passengers. Transit workers stabilized the scene by supporting the locomotives, track, railcars, and ensuring electrical power and locomotive diesel fuel did not pose a hazard to passengers and rescuers. In addition, transit workers arranged and coordinated the evacuation and transportation of uninjured passengers through buses and a "rescue" train. Transit agency communications were well coordinated since NJ Transit police and personnel could communicate on their own frequencies. Police agencies utilized the SPEN channels while Fire and EMS only communicated with each of their respective departments. Except for those departments with access to VHF SPEN4, Fire and EMS had no interoperability with Transit personnel.

#### **12.3.6.8 San Bernardino (CA) Train Derailment Hazardous Materials Release**

A derailment of a freight train in the Cajon Pass, near San Bernardino, CA resulted in an explosion followed by flames and toxic fumes. The danger presented by the toxic fumes made it necessary to close a 15 mile section of Interstate 15. There were eight governmental agencies and three railroads involved in the incident.

The primary agency in charge was the California Department of Forestry and Fire Protection (CDF). They established an Incident Command (IC) post for coordination with other involved agencies.

The California Highway Patrol was called in to close Interstate 15 in the affected area. They were also involved in the evacuation process of motorists on the highway at the time of the incident.

The San Bernardino County Sheriff's Department was brought in for assistance with the closing of the Interstate as well as providing evacuation support for any residents in the area.

The California Department of Transportation and the San Bernardino County Roads Department coordinated the rerouting of the traffic around the incident.

The California Environmental Protection Agency was notified and they established monitoring posts to track the release of the toxic fumes into the air.

In conjunction with the California EPA, the United States EPA was involved in coordination efforts.

The monitoring posts for the California EPA were established and managed by the South Coast Air Quality Management District. They provided air sample information to the agencies involved in the incident.

There were three railroads involved with the incident. Santa Fe, Southern Pacific and Union Pacific share a common right-of-way through the Pass. The railroad special agents were utilized to coordinate containment and clean up efforts with the other agencies involved in the incident. The railroads also coordinated rerouting of train traffic to avoid the area.

The California Public Utilities Commission is responsible for investigation of all train derailments within the state.

#### Communications summary of the current communications system.

Cellular telephone service was available due to the proximity of the derailment to Interstate 15. However, the cellular system did not provide dispatch-type services, leaving it useful only for cell phone to cell phone and cell phone to public switched network use. Additionally, only a single, low capacity cell site served the incident area.

The agencies involved in this incident utilized the 30 to 50 MHz, 130 to 174 MHz, 800 to 900 MHz, and the 406 to 512 MHz bands. Typically, multiple radios were required in order to coordinate efforts at the scene.

#### Recommendations for future communications.

This incident could have been handled more efficiently if proper administrative procedures (pre-planned channels and telephone number lists, for example) had been established between participating agencies prior to the incident. For this area, the CALCORD network should have been the primary communications path. CALCORD is a simplex VHF system (156.075 MHz) licensed to the State of California for mobile and portable use only; all first responders and support agencies (including some private organizations such as utilities) operating on the VHF band are encouraged to place this channel in their radios. Unfortunately, few agencies had the capability of utilizing CALCORD or refused to use it for fear of losing contact with their field personnel.

A video surveillance system would have been extremely helpful for allowing experts not located at the scene to view the incident and to recommend procedures for the field personnel to follow.

Data communications would have been helpful to obtain the latest inventory and handling practices for the hazardous materials on the train.

Access to facsimile machines would have been helpful for transferring written information to and from the scene.

A remote control crawler/robot would have been useful for obtaining fire fighting and hazardous material information from the wreckage without endangering personnel.

### **12.3.6.9 Incidents Involving Public Service Providers**

Public Service Providers such as the gas, water, and electrical utilities are involved with supporting public safety agencies on a regular basis. During the suppression and containment of fires, the utilities are called upon to disconnect services to structures in an effort to minimize additional problems related to electrical short circuits and gas line ruptures. Communications between the utility companies and the Public Safety agencies are typically done through the dispatchers.

Disaster assistance agencies such as the Red Cross provide a valuable support service to Public Safety agencies when disasters involve the public.

### **12.3.6.10 Alberton (MT) Train Derailment and Chlorine Spill**

The Alberton hazardous materials incident is reported to be the second largest chlorine release in history and resulted in the longest interstate highway closure ever. The magnitude of the chlorine hazard was exceeded only by a catastrophic release some twenty years ago with few of the cleanup problems faced in Montana. From the derailment on April 11, 1996, 1000 residents were evacuated and 80 miles of highway were closed for 18 days. Over 300 responders from 21 separate agencies were involved in the emergency response and cleanup effort. Local, state, and federal (including military) resources were deployed. One death resulted and direct government costs exceeded \$1 million. Total costs for all aspects are undetermined at this time, but are expected to be several times that figure.

The derailment occurred just inside rural Mineral County which borders the much more populous Missoula County. Among a number of hazardous material-bearing cars, four chlorine tankers at the center of the derailment proved to be the biggest problem. One was punctured and began venting during the accident, resulting in extremely lethal chlorine concentrations until emptied 18 days later. An immediate threat was posed to the town of Alberton (pop. 350), but of greater worry were larger towns along the dispersal path in Missoula County.

ICS with a unified command structure was employed immediately. Primary responsibility was given to Missoula County with its greater resources and better access to the site. A formal communications unit and trained leader were deployed within hours, serving until the last incident resources were released. Through most of the incident, four dispatch positions split between two field communications centers implemented a communications plan of a dozen formal frequencies (and several adopted ad hoc), 10 telephone lines, and 35 cellular phones. A communications technician and the unit leader rounded out regular staffing of six communications unit slots. All these were on-scene, incident resources and in addition to those used at the regular dispatch centers and EOCs.

Montana's extensive mutual aid radio plan was the basis for incident communications, with wide-area links provided by local agency mobile relays. A transportable, field-programmable remote base station served as the hub for the incident's critical evacuation net. This net was used to prompt emergency evacuation of all incident personnel when chlorine levels became too high, occasionally exceeding even that permissible with the most extensive personal protective gear. It was tested every two hours due to its importance.

Missoula is the site of two large state and federal wildland fire caches, so communications equipment suitable for interagency emergency deployment was plentiful and readily available. The National Incident Radio Support Cache in nearby Boise, ID, offered even greater numbers of identical kits if needed. In conjunction with a well-recognized mutual aid radio plan compatible with their technology, these interagency caches supported interoperability very well. Access to them and their field programmable radios is given key credit for communications successes during the incident. Incident command staff have concluded that communications problems during this incident were significantly less than previous ones and none were life-threatening.

### **12.3.6.11 Air Florida Crash**

On January 13, 1982 at approximately 3:45 p.m, Air Florida Flight 90 took off from Washington National airport and moments later crashed into commuter traffic on the northbound span of the Fourteenth Street Bridge, which spans the Potomac River between Northern Virginia and Washington, DC. After striking the bridge, the 737 jetliner broke in two pieces and fell into the ice-covered Potomac River near the Virginia side and quickly sank below the icy surface.

This tragic occurrence instantaneously created a multi-sector emergency response encompassing two geographic areas, both requiring emergency rescue and medical services.

Each site represented a different combination of equipment and personnel to be assembled from the resources available to the Federal, State and local agencies in the surrounding area.

A helicopter, boats, life rafts and divers were needed to attempt a rescue of the aircraft passengers and crew members in the Potomac River. Rescue workers equipped with tow trucks, hydraulic jacks, acetylene torches and related equipment were needed to rescue passengers from the crushed automobile wreckage on the bridge. Both sites needed emergency medical services to stabilize and transport the rescued to nearby hospitals. Both sites needed a law enforcement response to assist in rescue efforts and provide traffic and crowd control.

The two sector aircraft and motor vehicle rescue operation quickly escalated to a multiple incident rescue operation a half hour later when a Metro subway train derailed in an underground tunnel near the Smithsonian Station of the Metro subway rail system. Here, another group of rescue workers similar to those deployed on the bridge were needed to rescue passengers from the subway train wreckage.

To further complicate matters, massive traffic jams would impede the progress of the responding emergency personnel as they traveled toward the sites of the emergencies. The diminished road conditions coupled with the early release of Federal employees due to the day long snow storm produced traffic nightmares and gridlock throughout the area.

#### Public Safety Notification and Response

Public safety officials were notified of the air crash through two different means. The United States Park Police Communications Center received the initial call from a commuter on a mobile phone who advised that there was a plane crash in the Gravelly Point area (just north of the airport) of the Virginia shoreline of the Potomac River. The Park Police Communications Center called the control tower at National Airport and the FAA advised that they had no knowledge of an airplane crash. The District of Columbia Fire Department received notification from a commuter calling through the IMTS mobile telephone operator. The IMTS mobile operator connected him directly to the DC Fire Communications Center. The majority of the public safety agencies received notification when the FAA at National Airport broadcast an alert on the Washington Area Warning and Alerting System (WAWAS), a wireline network connected to the public safety agencies in the region sponsored by the Federal Emergency Management Agency (FEMA).

The response included the following number and types of organizations:

- Five county/regional Fire/EMS agencies
- National Airport Fire Dept.
- Five state/local police agencies
- Two federal police agencies

- Two Department of Defense agencies (Army and Navy)
- Three transportation agencies (Coast Guard, FAA & Virginia DOT)
- RACES and Red Cross volunteer support agencies

A helicopter was provided by the U.S. Park Police. Divers from Fairfax County, Virginia, as well as the District of Columbia Police and U.S. Navy participated in the rescue effort, which basically turned into a recovery effort.

Three types of problems were encountered by responders

- **Situational problems:**

Multiple Incidents - The Metro subway train crash siphoned off personnel and communications resources.

Traffic Gridlock - Bad weather and heavy traffic from early release of Federal employees produced impeding traffic conditions.

Multiple Geographic Sectors - The fact that responders were needed on the bridge and at the riverbank divided available personnel and created an increase in communications traffic.

Notification Delay - The driving snowstorm produced very low visibility at the time of the incident. This limited the number of people who could have witnessed and reported the incident to those in very close proximity of the accident. Most witnesses were in their cars and unable to report since cellular telephone service had not been implemented yet.

- **Organizational problems:**

Lack of Command and Control - At the time of the Fourteenth Street Bridge disaster, there was not a formal Incident Command System (ICS) in place. Command and Control protocol was inadequate. Likewise, communications protocols and channel utilization procedures were inadequate.

Undetermined Controlling Jurisdiction - The fact that the incident involved both the bridge and the river made it difficult to determine jurisdictional authority.

- **Communications problems:**

Lack of Mutual Aid Channels - There were only two Mutual Aid channels available to public safety agencies, one for fire and one for police. The Fire Mutual Aid Radio System (FMARS) channel operated on 154.280 MHZ and was used for base-to-base, base-to-mobile, and mobile-to-mobile communications. The Police Mutual Aid Radio

System (PMARS) channel operated half duplex on 458.550/453.550 MHZ, available for base-to-base communications through a manual patch at the communications center. Interoperable communications during an incident like the Fourteenth Street Bridge disaster are conducted on the FMARS channel. The PMARS channel is used primarily for interjurisdictional vehicle pursuits and is spectrally inefficient in that it ties up three voice channels when in use.

Equipment Incompatibility and Channel Overloading - The communications problems agencies encountered during the Fourteenth Street Bridge rescue operation principally centered around an inability to utilize the mutual aid channels. This was generally caused by either radio incompatibility or severe overloading of the single available mutual aid channel. Some agencies did not have the capability to access the mutual channels at all because their radios operated outside the frequency band of the FMARS channel. Even those agencies that operated radios compatible with the mutual aid channel sometimes could not communicate effectively because the single mutual aid channel was severely overloaded. There is a peculiar irony in what has just been said. Some agencies could not access the already overloaded mutual aid channel. If these agencies were somehow able to access the mutual aid channel, the result would have been an even more overloaded mutual aid channel.

- **Specific Communications problems:**

Inadequately Informed Responders. Due to lack of early situation reports and congested radio communications channels, responders were not informed about what to expect, where to go, etc., as they responded to the scene.

Functional Contention on Channels. Fire/EMS personnel had to compete for airtime with traffic and routing communications that were being carried out on the only common channel.

Telephone Overload. A heavy increase in wireline telephone calls blocked wireline telephone circuits. This further complicated communications because the telephone was a primary link between communications centers due to the congestion of the single mutual aid channel.

Dispatcher Overload. Use of only a single mutual aid channel resulted in too much communications to a single dispatch point and resulted in overload. Lack of channels did not allow distribution of communications.

Manual Patching. Some responders with radios that operated in a frequency band incompatible with the mutual aid channel were required to patch through the dispatcher to communicate with others on the mutual aid channel. This is a highly undesirable solution because it is extremely cumbersome and ties up the channel that is patched to the mutual aid channel.

Helicopter Communications. The lone helicopter involved in the initial rescue operations was equipped with a synthesized aircraft radio capable of “dialing up” on other agencies frequencies. The hindrance to interoperability was not hardware based but administrative procedures. At the time many agencies did not want any “outside” agencies operating on their systems. Discussions in the Council of Governments Police Communications subcommittee following the Air Florida incident highlighted concerns over use of the FMARS channel and that helicopters operating in support of one jurisdiction on a medical evacuation were causing interference to ground units responding to other calls. The thrust of the discussions by some of the participants was that aero use of the FMARS channel be limited to ground use and in effect no airborne operation was authorized. It should be noted that much of the resistance has disappeared and there is now more interaction between helicopters and ground stations.

Hospital Communications. Due to inadequate radio communications, hospitals were not kept informed of the number of casualties that would be transported to them and their arrival times. Transporters were unsure of hospital capacities and therefore unsure of how to distribute transport of the casualties across the hospital network.

### **12.3.7 Methodologies to Meet Future Needs**

#### **12.3.7.1 Fire/EMS**

##### **Overview of Requirements and Methodologies**

Fire and EMS resources are among the “front line” responders of all public safety agencies. Their communications needs, both for technology and for transmission of information, are critical.

As first responders to “all risk” incidents, they are often involved with multiple agencies, either responding or at scene.

Many of these agencies are dispatched by different command or dispatch centers across a wide range of frequencies and jurisdictional responsibility.

At times, these incidents are critical or catastrophic in nature, ranging from low-risk medical aids to vehicle and aircraft crashes, haz mat spills, and structural and wildland conflagrations.

Fire and rescue members are increasingly exposed to law enforcement activities with all of the attendant risks.

Efficient, concise and interoperable communications is the foundation for all fire and EMS operations, potentially determining whether human life and property is saved or lost.

##### **Day-to-Day Interoperability Requirements**

- takes place between personnel outside of their own jurisdictions (acting as reporting parties) and dispatchers, dispatchers to other dispatchers, dispatchers to responding field units of other agencies, and unit to unit.
- Available and adequate spectrum and radio systems dynamic enough to handle the entire range and complexity of the incident (or multiple incidents) are a necessity.
- Infrastructures have to be maintained and expanded, either on demand or as the result of population and workload.
- Available and adequate training is essential for all personnel dealing with day-to-day communications.
- The importance of “Automatic Aid” agreements must be understood by all participating parties. Automatic-aid agreements are one of the keys to successful operations. Resources from any agency may be dispatched automatically on the first alarm to any type of incident. The closest resource responds, be it federal, state or local.
- Automatic-aid agreements require preplanning, especially for communications interoperability; dispatch procedures, what frequency are we going to talk on, and who to contact at scene, all are very basic principles.
- It is absolutely essential that technology and spectrum be made available for Auto-aid resource dispatching and communications.

#### Mutual Aid Requirements

- Mutual aid occurs at two levels.
  - The first is comprised of long term, preplanned agreements, utilized on an occasional or seasonal basis, such as fire season in the Western states.
  - The second is the “cry for help” when everything is unraveling, and the Incident Commander, resources assigned or dispatch centers need additional resources, either in numbers or uniqueness of function.
- Preplanning of communications scenarios is essential. Jurisdictional program managers have the direct responsibility to talk to one another and play the “what if” game.
- Technology and available spectrum have to exist for mutual aid to actually perform as designed.

- Common interoperable frequencies must be assigned for the worst case scenario; the small county, perhaps out of state, local government resource responding to Oklahoma.
- A nationwide Mutual Aid Frequency plan should be mandated.
- This frequency concept already exists in the Aviation community; 121.500 MHZ and 243.00 MHZ were both used for declaring emergencies and communications with aircraft in distress.

#### Task Force Requirements

- Task force is group (typically five in the ICS) of like resources, usually with a leader, responding or assigned to a specific task.
- Fire task forces often are preplanned at local levels, their assignments triggered by auto or mutual aid agreements, or by escalating incident demands.
- Unit to unit communication within the Task Force and Task Force leader to next command level communications is essential.

#### Conclusions and Recommendations

- The basic responsibility of fire and EMS resources is to protect and serve the population.
- Through general awareness, consolidation and necessity, multi-jurisdictional participation in emergency incidents is becoming the norm rather than the exception.
- Without the ability to communicate, the fire and EMS mission is severely compromised, exposing all participants (civilian as well as responder) to loss of life and property.
- Interoperability must be self evident to all levels of governmental leaders; public safety communications needs should never become subordinate to any other sector.
- Additional dedicated VHF aircraft spectrum is needed for air-ground and air-air support of fire suppression missions.

#### **12.3.7.2 Forestry Conservation**

The Forestry-Conservation classification covers a broad range of operational tasks and requirements. These include:

- Forest Fire Detection and Suppression;
- Wildfire and Structure Arson Investigation and Enforcement;
- Wildlife and Fisheries Management and Enforcement;
- Urban Wildlife Mitigation and Public Protection;
- Environmental Protection and Enforcement;
- Habitat Management and Mining Enforcement;
- Boating Safety Enforcement;
- State Parks operations and Law Enforcement;
- Land Reclamation activities.

Protection of the public welfare is of paramount importance in each Forestry-Conservation endeavor. The Conservation Officers, Game Wardens, Forest Rangers and Firefighters, Boating Safety Enforcement Officers, Environmental Protection Officers and Park Rangers are quite often the only public officials in remote locations, becoming the sum total of the Law Enforcement and Fire Protection known by the citizens in the area.

In many areas, the specialized equipment operated by Forestry-Conservation agencies is quite often the only equipment available to mount rescue efforts during natural disasters:

- Patrol boats and expert operators during floods;
- Earth moving equipment in rural communities during fires or other disasters;
- Helicopters and experienced pilots for rescue efforts in mountainous terrain where main rotor clearances are measured in inches;
- Tranquilizing equipment and tactical knowledge used in subduing mountain lions, bears and other large carnivores in Urban settings;
- Fire fighting equipment able to leave paved roads to attack fires threatening structures in remote/rural settings.

#### Day-to-Day Interoperability

- The governmental entities charged with these Forestry-Conservation responsibilities require voice and data communications over wide geographical areas to accomplish their mission goals.

- Air-to-Ground communications are often used during forest wildfire detection and suppression operations, wildlife and fisheries surveillance, investigation and patrol, environmental hazard detection, cleanup and enforcement, land reclamation evaluation and personnel transport in support of all these activities.
- Radio telemetry and tracking is utilized in the management of fish and wildlife species.

#### Mutual Aid Interoperability

- Due to the scope of wildfires, and the mobility of wildlife and persons in the outdoors, mutual aid is the rule rather than the exception in Forestry-Conservation. Multi-jurisdictional fires, wildlife crime, environmental disasters and search and rescue operations are only a few of the events which demand communications between Forestry-Conservation agencies and other Forestry-Conservation, Fire and Criminal Justice agencies.
- This interoperability is most often accomplished at the field level by unit-to-unit communications; however, it is common for radios in one agency's vehicles to have the frequencies for other cooperating agencies already installed and ready for use. This provides for the widest possible number of systems and frequencies to be used in a given situation, even when circumstances dictate operations across system, geographical or political boundaries.

#### Task Force Interoperability

Forestry-Conservation Task Force operations fall within two broad categories:

- *Wildfire Suppression Task Forces*: Federal, state and local government agencies concerned with fighting wildfire and boundary wildfire/structure fire have joined together in nearly every area of the nation. They have established standards, procedures and priorities in the area of radio communications. When a wildfire occurs, the responding units may come from the affected jurisdiction or a cooperating agency under terms agreed to in the cooperative's charter or procedure manual. If a large wildfire develops, units from any or all of the cooperating agencies respond. This could be in the form of Automatic Aid as previously discussed.
- *Natural Resource Law Enforcement Task Forces*: The federal, state and local government agencies concerned with Natural Resource Crime have established short and long term cooperative agreements to assist in the enforcement of natural resource laws. These activities include:
  - joint "sting" operations with the U.S. Fish and Wildlife Service, State Wildlife agencies and local law enforcement agencies;

- covert operations involving organized crime and international sales of wildlife and parts of wildlife;
- radio, video and telemetric surveillance of known wildlife violators, environmental polluters and others who endanger the public and the natural resources of our nation and the world.

#### Conclusions and Recommendations

- Forestry-Conservation operations contain the essence of Fire and Criminal Justice operations found in other Public Safety services, while operating in places and in ways which are unique to natural resource agencies.
- Radio communications in the pursuit of Forestry-Conservation objectives are essential to the preservation of life, limb and property; both for the agency personnel in the course of their duties and for the public at large.
- Any operation achieved to date has been through cooperation and recognition of goal similarity between various governmental agencies. Any future legislation regarding interoperability must enhance actual interagency operations without eroding existing capabilities.

#### **12.3.7.3 General Government**

General government can be loosely defined as all governmental communications other than criminal justice, fire, emergency medical, highways, forestry-conservation, and emergency management. General Government services are generally related to basic infrastructures or they are necessary for the internal support of operational units of government. These support services are those which government undertakes for the public welfare, general economic betterment and for furnishing basic services to the populace. These include building inspection and public works engineering, water supply, solid and liquid waste management, streets and traffic signals, street lighting and often through government-owned utilities, electrical power and natural gas delivery. Some jurisdictions also include public health services and hazardous waste response and management separate from first responder organizations. Functions such as governmental administration (communications for elected officials, tax collection, etc.) may also be supported, particularly if immediate communications between these functions and first responders is required during emergencies. These services and facilities are taken for granted because of government's stewardship of them. In emergency conditions, however, these same services become critical to the protection of life and property.

Within the Federal Government (Department of Defense and Department of Energy facilities, for example) and on state college and university campuses, both of which are examples of wholly contained operations similar to a city, all functions are governmental in nature and are conducted on General Government communications systems.

General government communications is a vital component to most jurisdictions. Typically, these systems act in load sharing on communications systems as their use is heavy during day time and on week days. These are the off-peak times for the majority of police, fire and emergency medical activities. They are not a burden on public safety systems as much as they allow more efficient and economic use by the jurisdiction. Because these systems are so interwoven into the fabric of governmental services, they provide a significant amount of intrajurisdictional interoperability. Police and fire units often need to communicate directly with personnel who furnish and maintain these general government services. In addition, most city and county services have continuing needs to talk between departments as field units go about the public's business.

#### Day to Day Interoperability Requirements

- Interoperability for general government most often occurs at the field level in unit-unit communications.
- Some interjurisdictional situations include government utilities such as water system construction and maintenance where individual public utilities share parts of larger systems.
- The most prevalent interoperability occurs within the jurisdiction itself. Police frequently need to communicate with street and transportation units as traffic signal problems occur. Police frequently must communicate with public works barricade people for hostages, SWAT, traffic, parade and many other reasons. Fire units very often must coordinate water delivery and pressure needs during major fires (more than two alarms). Fire also uses traffic and barricade personnel for landing helicopters and cordoning off fire scene. Fire also must communicate with local natural gas and electrical power agencies to shut off utilities during fires. Often these agencies are government-owned utilities belonging to the same, to a neighboring or to several jurisdictions.
- Local governments have many duties. Public works groups engineer infrastructure and public facility projects. These groups then oversee both public and private organizations which do actual construction. Building and engineering inspectors then perform code and specification adherence duties. Public utilities must coordinate with police, fire and street departments for construction and maintenance of utility infra-structure. Many cities maintain parks and recreational facilities which are publicly owned. There is often a need for these parks people to communicate with the police for law enforcement purposes. Police and fire also frequently must communicate with streets personnel for barricading and cleaning of roadways from accident and weather.

#### Mutual Aid Requirements

- The day-to-day load sharing mentioned above becomes critical during major incidents or disasters. The system capacity required to support General

Government activities during day-to-day activities provides the paths to support the dramatic increase in communications paths required by first responders for mutual aid incidents. Using a pre-planned system of priorities on conventional systems or automatic access priorities provided by modern public safety trunked systems, those who need capacity to support safety of life and property functions can have that capacity. *If General Government did not share these systems (by using commercial providers, for example) that capacity would be there but under utilized during non-emergency periods. More likely, this excess capacity would not even exist due to spectrum shortages.*

- The first example of interjurisdictional general government interoperability is transportation related. Coordination of street clearing and barricade efforts goes across political boundaries during wide area emergencies. Wind, storm, blizzards and flooding are all events which require massive general government response for the protection of life and property.

- During flooding, protection of the public's water source becomes a critical issue.

- During emergency conditions of snow, rain, wind and flooding, there is a critical need for interoperability between first responders and those responsible for maintaining open roadways. The ability of first responders to assist citizens in need is severely hampered if roadways are restricted or impassable.

#### Task Force Requirements

- Uses of task force interoperability for General Government is limited, but does exist.

- It is said in many parts of the country that there are two seasons; "winter and road construction". Particularly in rural areas, State, County and local road departments have the need to communicate with each other and with agencies having responsibility for traffic management and law enforcement. During non-emergency situations, maintenance and construction activities require coordination. Since state roads pass through communities, the maintenance of these roads (and the traffic signaling along the roads) is most often the State's responsibility. Joint efforts for maintenance and construction are usually preplanned and involve a number of different organizations.

#### Conclusions and Recommendations

- As communities better manage and coordinate their systems and as governmental systems consolidate, the infrastructure capacity provided to support General Government functions becomes critical for supporting the

activities of first responders during daily peak traffic periods, as well as during major incidents or disasters.

- Access to interoperability must include general government. Specific communications paths that are allocated for interoperability must be allocated under the definition of public safety. These allocations should not be narrowed. They must not be restricted to only narrow portions of the public safety community. Users should be able to decide what interoperability needs are and use the resources to fit those needs.

#### **12.3.7.4 Highway Operations**

Highway operations organizations have generally been viewed as non-emergency agencies dealing with routine road construction and maintenance situations. This perception has never been accurate. Highway agencies have always had an important function in preserving and protecting the public well being. Highway operations agencies will play an increasingly critical role in the public safety effort as governmental budgets decrease and technology advances.

Highway operations agencies vary in size, funding and responsibilities. They include state-wide Departments of Transportation (DOT), large city departments of Public Works (DPW) and small road crews. While these organizations have many differences, they have one common function; each must ensure that other public safety agencies can move the necessary vehicles and personnel from staging locations to emergency situations as quickly as possible. This access is often taken for granted since the transportation infrastructure is well developed and maintained. When the infrastructure is unavailable due to damage, weather conditions or traffic congestion, it becomes very obvious that highway agencies are a key component of the public safety response. Given the importance of their functions, it is critical that highway operation agencies have communications access to all other public safety agencies.

The numerous benefits of highway operations interoperability can be seen by examining the workings of a major toll road utilizing a common radio channel for each division. This channel is typically controlled by the division dispatcher and shared by the highway maintenance vehicles, state police, tow truck operators, selected fire/EMS agencies and toll collectors. All the user groups have direct, instantaneous access to the others. The members of these user groups act as additional sets of eyes for the dispatcher and state police. Highway maintenance personnel frequently provide the first report of traffic accidents; unsafe driving and many other incidents requiring police intervention. Toll collectors transmit information on incidents reported by exiting drivers. Dispatchers often ask maintenance to check accidents or disabled vehicles since they are or may be the closest unit to the scene. All users will report vehicle sightings if they know the police are in a pursuit. All users on the system also hear notices broadcast on missing or wanted persons. There have been numerous instances where maintenance drivers or toll collectors have reported a wanted vehicle and the police have followed through with an arrest. Police, maintenance and tow truck drivers also use the channel for tactical purposes during accidents and lane closure incidents. The

instantaneous sharing of real time information among the user groups allows an integrated public safety response that minimizes response time and maximizes efficiency.

This type of system would not be workable in many environments. Even in the controlled toll road environment, users complain of channel congestion and monitoring of unnecessary transmissions. However, if this type of interoperability could be provided on an as needed basis, integration of the public safety response would be significantly improved.

#### Day-To-Day Interoperability

This section details the day to day highway operations interoperability requirements with various other public safety agencies:

- Other Highway Operations Agencies:

Adjacent highway agencies have critical day to day interoperability needs since their operations often impact each other. At a minimum, highway agencies should be able to report incidents or conditions that require response from an adjacent agency. Beyond this minimum, the future of highway operations points to consolidated efforts from multiple agencies to provide overlapping services. To meet this need, the agencies must have communication links at all levels. This includes wide area voice connectivity, tactical voice, data and video. Wide area voice connectivity is needed so overall efforts can be coordinated. Agencies may move to consolidated dispatch/supervisory operations similar to 9-1-1 centers. Field units from multiple agencies will need the ability to contact a central dispatch point. Field units from multiple agencies will also need mobile to mobile communications to coordinate local efforts. Agencies will be sharing ITS and telemetry data. This data must be available to any highway agency within the region. Sharing of incident or site video from the mobile units will allow remote supervisors from multiple agencies to determine if additional resources are required.

- EMS/Fire

A major interoperability requirement will be incident detection reports from highway field units to EMS/fire dispatch points. Incidents could include fires, accidents, personal injuries/illnesses and dangerous conditions. These incidents could happen as a result of highway maintenance operations or could be incidents the highway crew observes. Voice connectivity between the field units and EMS/Fire dispatch points is required on an as needed basis. The fire/EMS dispatch points should know the locations of highway work sites and be able to contact field crews if a fire/EMS vehicle will be responding past that location. This will require voice connectivity between the dispatch point and field location. It will also require highway maintenance location data transmission to the dispatch point. The fire/EMS dispatch point should also have access to road/weather conditions, road closure information, and traffic conditions that can be provided by a highway operations organization. This will also require data connectivity between the field units and the dispatch point. A

tactical voice channel is required between highway field units and responding EMS/Fire units. EMS/Fire needs to advise highways if a clear route is required. Highway needs to be able to inform EMS/Fire of the best route to take to respond to incidents near construction sites or congested traffic areas.

- General Government

Interoperability in this area should be focused on improving the efficiency of general government response. Highway operations needs voice connectivity to a general government dispatch point to report incidents such as water main breaks, health hazards and unsafe work sites. Data connection is also required to acquire and transmit GIS based information from General Government databases.

- Law Enforcement

As with EMS/Fire, a major interoperability requirement is incident detection. Highway operations needs a voice connection to a law enforcement dispatch point to report accidents, criminal acts, suspicious behavior and any other observed activity requiring law enforcement intervention. Law enforcement should also have the capability to transmit wanted person/vehicle notices to highway field units in specific areas. Highway units can act as additional observers and report any observations to a law enforcement dispatch point. The law enforcement dispatch points should also be aware of significant highway work sites and be able to contact field crews if a law enforcement vehicle will be responding past that location. This will require voice connectivity between the dispatch point and field unit. It will also require highway maintenance location data transmission to the dispatch point. The law enforcement dispatch point should also have access to road/weather conditions, road closure information, and traffic conditions that can be provided by a highway operations organization. This will also require data connectivity between the field units and the dispatch point. A tactical voice channel is required between highway field units and active law enforcement units. Law enforcement needs to advise highway if a clear route is required in a construction area. Highway needs to be able to inform law enforcement of the best route to take to respond to incidents near construction sites or congested traffic areas.

- Mass Transportation

The main day to day interoperability requirement will be sharing information on traffic flow, weather and unsafe conditions. This will require voice and data connectivity. A tactical voice channel is needed to route mass transit vehicles around work sites that disrupt normal traffic flow.

- Public Service

The main interoperability requirements will be a voice link to report incidents that require public service response. These could be fallen power lines, damaged poles

or unsafe track conditions at grade crossings. Highways also need a data link to access utility infrastructure information such as buried pipelines or power feeds. Public service agencies may need assistance from highway crews to reach remote sites during inclement weather.

- ITS

The majority of Traffic Management Centers will be run by highway operation agencies. The TMCs will make the most of the ITS network. These centers will be information hubs for public safety as described in the ITS section of this report.

Mutual Aid Requirements

This section details the mutual aid highway operations interoperability requirements with various other public safety agencies:

- Other Highway Departments

Full interoperability is needed between all highway departments that could be involved in mutual aid operations. This could include state DOTs with local departments, cities with counties, towns with villages and many other combinations. Wide area voice channels, tactical voice channels, data and video connections are all required to achieve the required level of interoperability. Wide area voice is needed to coordinate overall operations. Tactical voice is needed between crews to coordinate local efforts. Data and video are required to share unit location and weather information among departments.

- EMS/Fire

EMS/Fire mobile units need a voice channel to a highway dispatcher to request road clearing during emergency response. This connectivity is critical during snowstorms or other events that make roads impassable. Fire/EMS also needs a tactical voice channel to ask for road closure assistance from on-scene highway crews. During major fires in cold weather, fire crews need a voice channel to highway crews to request road/sidewalk deicing operations at the scene. A data channel is needed to provide incident commander highway crew location information. Tactical voice channels are needed between EMS/Fire and highway so on-scene activity can be coordinated.

- Forestry Conservation

Interoperability is required with highway agencies during floods, fires or major storms. Forestry will require assistance from highway agencies in operating roads, repairing dams, shipping supplies and providing heavy equipment. Voice and data connectivity is required from highway field units to forestry supervisory locations.

Forestry field units also require connectivity to highway agency supervisory locations. Field units need tactical voice channels to coordinate local efforts.

- General Government

Interoperability will be needed for highway agencies to contact general government vehicles and supervisory locations. This will require voice connectivity. Highway agencies will also require a data connection to general government to acquire GIS database information.

- Law Enforcement

The incident commander in a mutual aid operations needs voice and data connection to highway crews. Voice connections is also required to highway dispatch centers. Voice will be used to direct crews in road clearing/closing operations, development of detour routes and numerous other operations. Data connectivity is required to show location and status information of the highway and crews. There are many scenarios in which highway operations will be part of a mutual aid operation. Most major incidents result in disruption of normal traffic flow. During these disruptions, highway operations has the main responsibility for ensuring congestion is minimized and routes are available for emergency vehicles. The incident commander will also rely on information provided by local Traffic Management Centers as detailed in the ITS section of this report.

- Mass Transportation

Mass Transit needs connectivity to highway operations to plan emergency evacuation routes and coordinate the movement of on-scene transit vehicles. Highways must also be able to provide real time detour information to mass transit during incidents. Voice and data connectivity area required.

- Public Service

Public service needs connectivity to highway operations to provide road clearance or closure during emergency repair work. Highway operations could also be involved when a train derailment results in a haz mat incident requiring containment/clean-up assistance from a highway agency. Voice and data connectivity is required.

- Emergency Management

Interoperability is required with highways during major incidents such as hurricanes, tornadoes, blizzards and earthquakes. Full connectivity is needed between highway agencies and the Emergency Management Command Center. Voice, data and video links are required from field units and supervisory locations to the command center. Since the command center has wide area responsibilities, the links must be

available on a statewide basis. Sufficient capacity must be provided to accommodate multiple simultaneous incidents.

### Task Force Requirements

This section details the Highway Operations task force interoperability requirements.

Highway operations needs wide area voice, tactical voice, data and video connection interoperability during task force activities. Highways will play a key role in planning and implementing traffic routing measures needed to ensure the success of the task force. Highway vehicles may be used as observation points for other task force members and should be capable of transmitting data and video from the vehicle to the task force operation center. Highway crews may be needed to quickly close or open roads if plans are changed during the operation.

### Conclusions and Recommendations

Highway operation agencies play a key role in preserving the safety and well being of the general public. The scope of their obligations goes well beyond the routine tasks of road maintenance and construction. Within the period considered by this report, highway agencies will have the main responsibility for implementing and monitoring ITS systems. The combination of ITS systems and expansive field operations will force highway operations to play a key role in creating the shared information environment needed to develop an integrated public safety response.

In order to fully utilize highway operations resources, well developed communications interoperability is required with other public safety organizations. Achieving the required level of interoperability will require sufficient spectrum, funding, technological compatibility and well defined interagency policies.

#### **12.3.7.5 ITS (Intelligent Transportation System)**

The relationship between ITS and public safety has several aspects including the safety of the traveler, whether on public or private vehicles and the array of new technologies and services that will be available to personally owned vehicles as well as vehicles owned and operated by emergency service providers and traditional public safety agencies. The ITS user services involve the use of in-vehicle electronics as well as roadside and other types of electronic communications systems. There will also be a mix of procurement, installation, and operation of systems by state and local governments, and fee-for-service functions provided by private service providers. Existing communications services and equipment will be used provided they can meet ITS requirements. The decision on which system is chosen will be made by the implementing jurisdiction. Information requiring wide-area distribution will require either broadcast (e.g. FM subcarrier) or two-way wide area wireless systems (e.g. data over cellular radio, PCS, or an agency's privately owned system). Some ITS services (for example, most of the commercial vehicle safety-related functions) will require dedicated short range communications (such as microwave systems that use roadside readers and vehicular

mounted transponders). Other safety-related functions may require the use of systems such as collision avoidance radar.

One of the functions of ITS is to collect and provide information on real time traffic conditions. Traffic control and incident response decisions are made based on analysis of the data. Since ITS may cover multiple jurisdictions, the information must be distributed quickly to multiple agencies and field units. The public safety community must develop ways to allow the seamless transfer of data among organizations. Institutional agreements on distribution and use of information among agencies and organizations must be developed in parallel with technological advances.

The issue of wireless communications interoperability for Intelligent Transportation Systems should be focused on two major categories:

Interagency Interoperability: Interoperability among Traffic Management Centers (TMCs), Emergency Management Centers, and deployed public safety and public service personnel is needed. These agencies need connectivity with all other public safety agencies that can provide or need access to traffic flow, incident detection and response, emergency response and safety-related information. In most cases, multiple centers are in operation within a geographical region and inter-jurisdictional cooperation is necessary.

ITS Device Interoperability: Public safety mobile units need direct access to ITS related information on a nationwide basis using either the primary radio system deployed by public safety organizations or by procuring multiple communications equipment. The key issue is how public safety field units will exchange data with numerous ITS information sources without purchasing different equipment for each system for each region of operation.

#### Interagency interoperability

Interoperability between traffic management centers and other public safety agencies will be a mutually beneficial relationship. Traffic management centers will benefit by receiving real time traffic and incident information from public safety mobile units. Public safety and public service agencies will use ITS data to improve incident detection/response time and to aid in law enforcement. Public Safety agencies will also benefit from being able to make traffic control recommendations during incidents.

One of the goals of the traffic management centers is to improve traffic flow and reduce congestion. In order to meet this goal, the traffic control agencies need real time data from incidents that will disrupt normal traffic patterns. While some of this data can be provided by ITS devices, the majority will come from reports by field deployed public safety units. A consistent, automated path for funneling this information from the field to the traffic management centers is needed.

Other public safety organizations will benefit if relevant information collected by the traffic management centers can be forwarded to the agencies responsible for incident and emergency response. This will allow the responding agencies to maximize the efficiency and expediency of their response.

Key Issue: Do public safety field units need a direct communication channel with traffic management centers? Field units need to provide incident data to the traffic management centers. Traffic management centers need to provide information on incidents, traffic control decisions, road hazards etc., to public safety field units. What is the most effective means of transferring this information?

#### Day-To-Day Interoperability

The following sections detail the ITS user services listed in the “ITS and Public Safety Wireless Services” report and the operational requirements from the Operational Requirements Subcommittee report that would benefit day-to-day interoperability with public safety communications systems.

#### Automatic Collision Notification; Driver and Personal Security

These systems will be used to notify monitoring organizations that an incident or collision has occurred. A RF data channel is needed from private vehicles and public transit vehicles to a network access point for the monitoring organization. If a public safety response is warranted, the appropriate agencies must be notified. Since the vehicle could be moving during the incident, a RF data channel is needed to provide incident location information to the responding public safety units. The key requirement for this process will be an automated, electronic transfer function for routing the data from the monitoring agency to the public safety agencies. The data must be in a format that the public safety agencies can immediately transmit to their field units.

#### Enroute Driver Information; Incident Detection

These systems will be used to inform drivers with in-vehicle ITS equipment of relevant traffic conditions. Traffic management agencies need access to real time incident, weather, and traffic data so drivers can be notified. A source of information will be field reports over voice and data channels from public safety units. Network connections will be used to transfer the field data to traffic management centers. Drivers of public safety vehicles will need to receive the notifications expeditiously over various communications links.

#### Emergency Vehicle Route Guidance

This service will have a function similar to Enroute Driver Information. In order for the system to be successful, accurate, real time incident data must be available to traffic management agencies, and efficient routing information must be provided to drivers of public safety vehicles.

### Emergency Vehicle Signal Priority; Priority Treatment for Transit

This service will enable adjustments to be made to traffic control devices to maximize the efficiency of the transportation systems, minimize response time by emergency service providers, and aid in law enforcement. Traffic management will need real-time incident data in a format that can be processed by traffic control decision-making systems. Traffic management agencies will also collect requests for traffic control that public safety vehicles and transit vehicles will need. Devices that allow direct traffic signal pre-emption from a public safety vehicle may be required.

### Public Travel Security

Alarm systems installed in transit stations, bus stops, and public transit vehicles will be monitored by private or public agencies depending on the location and scope of the system. Private agencies will need a communications path to notify public safety agencies when assistance is required.

### On-board Safety Monitoring

Data monitoring and communications systems onboard commercial vehicles collect safety data pertaining to critical vehicle components, condition of the cargo, and the fitness of the driver. Law enforcement officials need to be notified of the vehicle, its location, and the nature of any safety violation requiring attention.

### Mutual Aid Requirements

The following sections detail the ITS user services listed in the “ITS and Public Safety Wireless Services” report and the operational requirements from the Operational Requirements Subcommittee report that would benefit from mutual aid interoperability with public safety communications systems.

### Route Guidance and Enroute Driver Information

Incident liaison officers will need to provide incident data to the traffic management agencies. The incident commander may make recommendations on data that drivers should receive. RF data, voice, and video channels will be needed to connect the liaison officer to the traffic management center.

### Incident Detection and Management

Data, voice, and video connectivity via RF channels are required between the incident liaison officer and the TMC. The TMC will be making decisions about wide area traffic flow while the incident commander makes decisions at the site of the incident. These decisions need to be closely coordinated.

### Traffic Control

Data and voice RF connectivity are required between the incident liaison officer and the TMC. The incident commander needs to be informed of traffic control decisions made at the TMC that impact the area of operations. The incident commander also needs the ability to request specific traffic control measures be taken.

#### Enroute Transit Information

The incident liaison officer will need to provide incident data to the transit management centers and traffic management centers. The incident commander may make recommendations on data transmitted to transit vehicles. Voice and data channels are required between the incident liaison officer and the agency controlling transit information.

#### Public Transportation Management

System operators will need accurate information from the incident liaison officer to verify that management recommendations produced the desired effects. Voice and data connectivity is required. The incident commander needs the capability to dispatch these vehicles if large scale evacuations are required. This will require RF voice/data connectivity with the agency responsible for controlling these vehicles.

#### Public Travel Security

The incident commander may need access to data from wide spread security devices. Data connectivity is needed between the incident liaison officer and the organization monitoring the security devices.

#### Hazardous Materials Incident Response

The incident commander needs access to all HAZMAT data collected by the responsible monitoring organization. This will require voice/data RF connectivity between the incident commander and the agency. The incident commander will need a portable reader if the HAZMAT vehicle has HAZMAT data stored in an on-vehicle Dedicated Short Range Communications (DSRC) transponder.

#### International Border Crossing

DSRC systems are used to allow pre-cleared (safety status, credentials, weight etc.) commercial vehicles to proceed across international borders without stopping. Location and other pertinent information on commercial vehicles attempting to cross in violation needs to be sent to registration, fuel tax, immigration, law enforcement, customs, and state transportation agencies.

#### Emergency Vehicle Management (EVM)

The incident commander needs full access to this system. A real time GIS display showing vehicle locations would be invaluable. Since the response will involve multiple agencies, the individual emergency vehicle tracking systems must be compatible. Data connection via an RF channel is needed to each responding agency that is utilizing an EVM system.

#### Task Force Requirements

The following sections detail the ITS user services listed in the “ITS and Public Safety Wireless Services” report and the operational requirements from the Operational Requirements Subcommittee report that would benefit from task force interoperability with public safety communications systems.

#### Enroute Driver Information; Route Guidance, Enroute Transit Information

Task force commanders need the ability to coordinate with the TMC responsible for sending information to drivers so that traffic flow would be routed to aid the task force operations. This will require a voice/data RF channel between the task force and the TMC.

#### Incident Management

Data and voice connectivity via RF channels are required between the task force commanders and the Traffic Management Center. The task force commander needs to be aware of any TMC decisions impacting the operations of the task force such as traffic flow, safety messages, traffic alerts.

#### Traffic Control

Data and voice RF connectivity are required between the task force commander and the TMC. The commander needs the ability to request specific traffic control measures be taken.

#### Public Transportation Management

System operators will need accurate information from the task force commanders to verify that management recommendations will produce the desired effects. Voice and data connectivity is required. The incident commander needs the capability to dispatch these vehicles if large scale evacuations are required. This will require RF voice/data connectivity with the agency responsible for controlling these vehicles.

#### Emergency Vehicle Management

Task force commanders need full access to this system. A real-time GIS display showing vehicle locations would be invaluable. Since the response will involve multiple agencies, the individual EVM systems must be compatible. Data connection via an RF channel is needed to each agency that is utilizing this system.

### **Interagency ITS Interoperability Conclusions**

The following items must be addressed to achieve a high degree of interoperability:

- Standardized ITS data formats and interfaces are required to ensure that real time incident data can be shared by multiple agencies.
- Agencies need an automated, electronic means of sharing incident data on a day to day basis.
- Agencies need to develop policies to ensure that relevant data is shared with other organizations.
- Incident and task force commanders need full coordination capabilities with all affected traffic management centers. This will require voice/data/video connectivity over RF channels.

#### **ITS Device Interoperability**

The second aspect of ITS interoperability is the requirement that data from ITS devices must be accessible to field deployed units from multiple agencies on a nationwide basis. Technology and frequency plan standards must be developed and implemented if this goal is to be reached using public safety radio systems for wide area communications. ITS communications based on one-way broadcast (likely using FM subcarrier) or DSRC transponders will require public safety vehicles to be equipped with these new systems. Efforts are underway by various organizations to standardize the protocols for reception of FM subcarrier and DSRC. If successful, single nationwide interoperable devices will be available for use by public safety personnel. Wide area communications are expected to be based on commercially available services such as cellular radio, ESMR and PCS and is expected to vary from region to region.

The key issue is how public safety field units will receive data from numerous types of ITS devices without purchasing a different receiver for each system and for each region of operation. Wide area mobile communications for ITS will be selected by the locality or the service provider offering the ITS user service. Public safety agencies have the option of installing a data interface with a TMC, transit management center, or independent service provider, and integrating the required ITS-related information onto the public safety radio systems. If these systems have interoperable modes, then ITS information can be made interoperable provided the message formats are standardized.

#### **ITS Device Interoperability Conclusions**

The following areas must be addressed to achieve the desired interoperability:

- Technology and message format standards are required for broadcast and DSRC systems providing ITS-related information. Message format standards are required for wide area wireless systems.

- Public Safety agencies that are not leasing commercial wide-area wireless communications services have the option of integrating information from traffic management, transit management, and emergency management centers over their own radio system, and developing the ability to share the information over mutual aid, task force, or any other interoperable wireless channel. Agencies leasing commercial wide area wireless service will likely have to lease equipment from a service provider that is offering the ITS services in the location the agency needs to operate in.

- A national frequency plan would ensure data are available to any responding agency in any location.

### **12.3.7.6 Criminal Justice**

#### **Overview of Requirements & Methodologies**

Within the Criminal Justice community, law enforcement resources are among the “front line” responders of all public safety agencies. Their communications needs, both for technology and for transmission of information, are critical.

As first responders to “all risk” incidents, they are often involved with multiple agencies, either responding or at scene.

At times these incidents are critical or catastrophic in nature, ranging from low-risk reports of cold crimes to in-progress felonies with armed suspects, vehicle and aircraft crashes, and haz-mat spills.

Fire and rescue members are increasingly exposed to law enforcement activities, with all of the attendant risks.

Efficient, concise, and interoperable communications is the foundation for all law enforcement communications, potentially determining whether human life and property is saved or lost.

#### **Day-to-Day Interoperability**

More than any other public safety discipline, law enforcement officers use day-to-day interoperability to enhance their own safety and that of the public. In many cases this is due to the overlap of jurisdictions, a phenomenon not commonly found with other public safety disciplines.

*Interagency Operations* links used by law enforcement officers during pursuits and other similar incidents (particularly those with the potential to rapidly cross

jurisdictional boundaries represent a special case of day-to-day interoperability which must be met.

Many law enforcement field units routinely monitor neighboring agencies or agencies with concurrent jurisdiction. As required, they interact with field units of these other agencies either on their own link (with the other agencies monitoring their link), through a dispatcher, or preferably directly on the other agencies working link. One of the classic day-to-day interoperability situations is the "officer needs help" call which normally elicits an emergency response from all units within the officer's agency, as well as from all surrounding communities and concurrent jurisdictions. It is not unusual to have 30 or more field units arrive at the scene of one of these incidents which are usually initiated only when the officer's life is in immediate danger.

For corrections agencies, in particular probation/parole agents and corrections transportation units, interoperability with the agency having jurisdiction where they are working or traveling may be the only communications available and is critical in high-risk situations.

Interoperability takes place between personnel outside of their own jurisdictions (acting as reporting parties) and dispatchers, dispatchers to other dispatchers, dispatchers to responding field units of other agencies, and unit to unit.

Criminal justice agencies often install multiple radios into field units to provide interoperability with other agencies. For example, the FBI annually budgets \$2-3M to provide radios for interoperability with other federal, state and local agencies.

Available and adequate spectrum and radio systems dynamic enough to handle the entire range and complexity of the incident (or multiple incidents) are a necessity.

Infrastructures have to be maintained and expanded, either on demand or as the result of population and workload.

Available and adequate training is essential for all personnel dealing with day-to-day communications.

As with Fire and EMS, the concept of "Auto-Aid", dispatching of the closest available unit to an incident regardless of jurisdiction, is beginning to take hold in the law enforcement community. Auto-aid is a preplanned response; it is not called for by an on-scene incident commander. The importance of "Auto-Aid" agreements must be understood by all participating parties. As with Community Based Policing, auto-aid agreements will increasingly play a key roll in successful operations. Resources from any agency may be dispatched automatically on the first call to any type of incident. The closest resource responds, be it federal, state, or local.

Auto-Aid agreements require pre-planning, especially for communications interoperability; dispatch procedures, channel/talk-group assignment(s), and on-scene contacts; all are very basic principles.

It is absolutely essential that technology and spectrum be made available for Auto-Aid resource dispatching and communications.

### Mutual Aid Requirements

Mutual aid occurs at two levels. The first is comprised of long term, pre-planned agreements, utilized on an occasional basis, such as civil disorder or riots.

The second is the “cry for help” when everything is unraveling, and the Incident Commander, resources assigned, or dispatch centers need additional resources, either in numbers or uniqueness of function. This should not, however, be confused with the “officer needs help” interoperability described previously.

Mutual aid is normally requested by the on-scene incident commander. While there are often general response plans and guidelines, mutual aid differs from auto aid discussed previously in that the response is not automatic.

Pre-planning of communications scenarios is essential. Jurisdictional program managers have the direct responsibility to talk to one another, and play the “what if” game.

Technology and available spectrum has to exist for mutual aid to actually perform as designed.

Common interoperable frequencies must be assigned for the worst case scenario: the small county, perhaps out of state, local government resource responding to an Oklahoma City bombing type of incident.

A nationwide Mutual Aid Frequency plan should be mandated.

### Task Force Requirements

Perhaps more than any other public safety discipline, the criminal justice community uses Task Forces made up from federal, state and local resources to address major problems such as drug enforcement, and smuggling

Unit to unit communication within the Task Force, and Task Force leader to next command level communications is essential.

## **Conclusions and Recommendations**

The basic responsibility of criminal justice resources is to protect and serve the population.

Through general awareness, consolidation, and necessity, multi-jurisdictional participation in emergency incidents is becoming the norm rather than the exception.

Without the ability to communicate, the criminal justice mission is severely compromised, exposing all participants (civilian as well as responder) to loss of life and property.

### **12.3.7.7 Mass Transportation**

#### **Overview of Requirements & Methodologies**

Public Mass Transit entities are governmental providers of a service at regional, state, and local levels. Public Mass Transit entities are a specialized form of General Government.

Mass Transportation personnel are often the first to report, respond to, and arrive at incidents within their respective transportation systems. Immediate action and incident information transferal to the appropriate entity are critical for effective public safety service resource management.

The regions that are covered by mass transportation entities often bisect numerous local, county, and state jurisdictions. Each jurisdiction may have different Incident Command Structures and separate radio frequency operational bands.

Mass Transportation incidents have the potential to become large scale multiple casualty incidents due to the large number of passengers often carried within regional transportation systems.

Rail Mass Transportation systems areas of operation are often "harsh" areas which vary from highly populated urban areas through rural areas. Areas of operation include underground tunnels, bridges over land and water, marshes, deserts, forests, and mountains.

Communications capabilities in remote areas, underground areas, and similar harsh areas may not be available or very limited to Police, Fire, and EMS personnel.

Emergency interoperability needs are based on the need to contact and to be contacted by response agencies during an emergency.

Interfacing with Public Safety agencies in large urban areas is a daily occurrence with respect to medical emergency calls and police activities.

Interfacing with Public Service entities is a daily occurrence and a major part of routine operations. Commuter rail service often operates in conjunction with other railroad entities. The tracks are a common highway for the massive heavy rail equipment. Very few properties are available for rail expansion in major metropolitan areas. It is a common practice to coordinate usage of tracks for freight, hazardous materials, in addition to passengers.

#### Day-to-day Interoperability

- Interoperability occurs at all levels of communications infrastructure:
  - Transportation Communications Center dispatchers to other Communications Center dispatchers of Police, Fire, EMS, General Government, Environmental Conservation, Public Service (Commercial Railroads, Utilities etc...);
  - Field Transportation Units to other Communications Centers & Field Units; and
  - Field Units to other Field Units.
- Communications difficulties arise due to the highly specialized functions of mass transportation entities. Specifically, communications in the harsh areas as described previously in this section.

#### Mutual Aid Requirements

- Governmental agencies as well as Emergency Management personnel recognize the importance of mass transportation as a viable tool for the evacuation of a large number of personnel, when necessary.
  - Mass Transportation vehicles are used to support public safety operations during mobilizations of enforcement personnel, creation of remote or multiple field command posts, and to access remote areas on railroads.
  - During severe weather conditions, Mass Transportation may be the only safe and effective means of transportation for the general public.

#### Task Force Requirements

- For preplanned events affecting the transportation of the general public, public safety entities must notify mass transportation providers to divert operations.
  - Constant communications are necessary during the progress of an event to ensure mass transportation can meet the needs of the public safety community without affecting the general public.

### **Conclusions and Recommendations**

- The Mass Transportation Provider requires interoperability capabilities to immediately relay information on transit vehicle locations, access, & preliminary on scene incident reports to effectively advise responding public safety agencies.
- Common communications infrastructures are required to furnish communications in harsh areas where limited or no communications exist for public safety agencies.
- Multi-jurisdictional and multi-discipline coverage areas require state, regional, and national Interoperability plans utilizing common frequencies and baseline technologies.
- Governmental Transportation entities require dedicated communications links with Public Service entities in order to fulfill their mission.

#### **12.3.7.8 Public Service**

##### **Overview of Requirements & Methodologies**

Public Service entities typically require a single point of communications with the Public Safety agencies as opposed to in-depth interaction with many levels of operations associated with multiple agencies. Instances such as firefighters requesting the interruption of utility service typically could be accomplished with communications between the Fire Department dispatcher to the utility dispatcher. The utility dispatcher would then utilize the communications system developed for the utility organization to communicate the request to the field personnel.

Train derailments also require a single point of communications with the Public Safety agencies. When a derailment occurs, the Public Safety agencies and the railroads perform initial coordination relating to the specifics of the derailment, i.e. hazardous materials, collisions with other trains or vehicles, etc. After this initial communications, both groups commence handling their duties external to each other's communications networks with periodic communications between the Public Safety entities and the railroads on an as needed basis.

Disaster assistance agencies require initial coordination to establish the proper care for the situation at hand, i.e. food, shelter, and or clothing for victims of disaster. Periodic communications with the Public Safety agencies is needed to assist in maintaining the proper amount of effort and supplies for the duration of the incident.

##### **Day-to-day Interoperability**

Day-to Day communications between the Public Service and Public Safety entities is typically in the form of dispatcher to dispatcher links, which may be via radio

or land-line, or both (one is a back-up to the other). The respective dispatchers then communicate the requests to the field personnel, via their own communications systems, for implementation. However, unit to unit communications between Public Service and Public Safety entities does occur on a small scale. However, the Public Safety activities need to be restricted to Public Safety personnel to minimize interference and misunderstandings of verbal instructions.

The Department of Energy (DOE), a department within the Federal Government, has a requirement for direct communications with a number of power utility companies throughout the country. For example, the Western Area Power Administration (WAPA) operates and maintains a power transmission system (grid) for a fifteen (15) state region has requirements for voice interoperability with both federal and non-federal entities, in the course of operating the system. These requirements include electric power utility companies that are interconnected to the WAPA power transmission grid or that are customers serviced by WAPA, the U.S. Army Corps of Engineers and the U.S. Bureau of reclamation personnel associated with operating power generation facilities that provide power generation for WAPA, and local law enforcement and emergency response that operate within the WAPA operational area. The Bonneville Power Administration (BPA) has similar requirements, although a smaller coverage area. In some cases, BPA has given permission for mission specific use of BPA mobile radio frequencies by the Bureau of Reclamation, as well as public utilities' vehicles and aircraft, to achieve unit-to-unit interoperability. Typically, both the WAPA and BPA provide interoperability through their respective dispatchers to the utility or other entities' dispatcher to achieve interoperability.

#### Mutual Aid Requirements

Mutual Aid communications may be required between Public Safety agencies and utilities, Red Cross and other support organizations during major events. For example, communications between a water utility and fire agencies handling a major fire may be critical. Likewise, communications between Red Cross shelters and public safety agencies responsible for law enforcement, fire protection and emergency medical services is essential in the early stages of a disaster when commercial telephone service is not available.

Mutual Aid communications may be required between and among public safety agencies and public service agencies responding from wide areas for major disasters. For example, after hurricanes or earthquakes, it is common for utility companies from a wide area to be involved in restoring service. Their interface with public safety agencies must be coordinated.

#### Task Force Requirements

Task Force interoperability with Public Service entities is limited to the initial establishment of need for the entity's expertise or function. There are, however,

periodic communications for the purposes of ensuring that any status changes are communicated.

*It is recognized that public service agencies will require communications links for interoperability between agencies of their own disciplines. However, these links must be provided from spectrum within the radio services provided for these organizations, and not from public safety spectrum.*

### **Conclusions and Recommendations**

Voice communications between Public Safety agencies and Public Service agencies is necessary for unit to unit on-scene use, primarily at the command level. Additionally, a common on-scene tactical voice link should be available to all on-scene responders. For incidents where extensive communications is necessary, a radio could be loaned to the agency performing a task or function.

Data communications interoperability appears to have the most value for augmenting the interactions between Public Safety and Public Service entities. A common data base and wireless access method structured for each type of Public Service entity would enhance the safety, accuracy and efficiency of operations for all involved.

Data communications could aide in the response and containment of hazardous material derailments by providing critical information on a timely basis. This same data communications network could be utilized to collect and assimilate sensor information from EPA sites and provide an estimated area to be evacuated.

Fire departments could utilize data communications to request utility disconnect by type and location. As each utility complies with the request to disconnect, they could log the information in a record associated with the address of the structure. Fire department personnel would then have a record of which utilities were disconnected at the address in question.

Disaster support agencies could utilize data communications with the Public Safety entities for the purposes of inventory assessment . As the magnitude of the disaster changes, the support agency would be able to respond more effectively by knowing what is needed as well as the amount needed for the incident.

For future communication interoperability between Public Safety and Public Service entities the recommendations are as follows:

If a high degree of interaction is required, and where practicable, a common command-level voice communications link should be made available for all Public Service functions involved in an incident.

Where a dedicated channel is not available for communications with Public Service entities, a radio from a pool of Public Safety radio equipment should be assigned to the Public Service entity for the duration of the incident.

A common platform for data communications and associated data bases should be established for the purposes of communicating with Public Service entities. This will primarily involve development of infrastructure gateways.

### **12.3.7.9 Federal Government**

#### **Overview of Requirements & Methodologies**

Much of the Federal Government agencies' communications interoperability needs are similar to those already addressed. In many cases the requirement itself is very similar to the state and local entities, but the fact that the coverage area expands beyond the typical state or local jurisdiction(s) creates some unique problems.

The Department of Energy (DOE) has some unique interoperability requirements as discussed previously. The U.S. Coast Guard (USCG), the primary federal agency with maritime authority, has unique interoperability requirements while performing its four main missions; maritime law enforcement, maritime safety, environmental protection and national security. The USCG must maintain interoperability with the maritime public, as well as both law enforcement and emergency response agencies.

Federal law enforcement personnel often depend on state and local law enforcement for support, and also coordinate their operations with other state and local agencies. Most federal agencies operate their own systems, on the federal government frequency bands, and rely on additional radios, on applicable state/local frequencies, to satisfy the interoperability capability. In cases where the local law enforcement entities operate in an adjacent band (such as 150-164 MHz) to the federal government band (such as 162-174 MHz), there are mutual aid agreements negotiated to utilize one or more of the local law enforcement channels for interoperability.

Federal law enforcement agencies often install multiple radios in field units or provide the users with multiple portable radios to provide interoperability with other agencies. For example, the Justice and Treasury Departments combined have expended over \$10M to provide radios for interoperability with other federal, state and local agencies.

#### **Day-to-day Interoperability**

The day-to-day requirements vary among the various federal agencies, but are similar to the requirements of the law enforcement and search and rescue activities previously defined.

Although gateways and manual interconnects are used to some extent, they are rarely used due to the time involved for set-up and the coverage limitation.

### Mutual Aid Requirements

Most of the mutual aid requirements for the federal government are similar to those previously outlined for criminal justice and emergency response agencies.

### Task Force Requirements

Federal government agencies are significantly involved task force operations throughout the country. These task forces typically include personnel from federal, state and local law enforcement entities.

In most cases, the lead agency of the task force distributes radios to the task force members to ensure interoperability.

### Conclusions and Recommendations

For the most part, the interoperability requirements of the federal government users are similar to that of their state/local counterparts. Some of the problems are compounded due to the geographic coverage required.

## **12.3.8 The National Public Safety Wireless Network Initiative**

### **12.3.8.1 Background**

Vice-President Gore, in his program for a National Information Infrastructure<sup>10</sup>, called for development of a national law enforcement and public safety wireless network. This network would provide the backbone and distribution medium(s) for voice and for advanced technology between information processing centers/repositories and field personnel at all layers of government.

On April 20, 1994, the Federal Law Enforcement Wireless Users Group (FLEWUG), co-chaired by the Justice and Treasury Departments, was formally chartered and tasked with research and planning for such a network. The FLEWUG plays an important function within the National Performance Review's charter to Reengineer Through the Use of Information Technology. Its mission is clearly stated in the NPR Information Technology IT-04 Vision Statement:

“To provide law enforcement and public safety an integrated wireless/wireline network that meets the functional requirements of the user community. As envisioned, the network will incorporate spectrally efficient technologies, support interoperability, and be secure. Network planning and development will be sensitive to individual agency issues such as priorities and privacy, will provide virtual autonomy and non-interfering operations, and will include flexibility to expand and extend capabilities. Cooperative

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<sup>10</sup> NTIA Docket 930940-3240: Federal Register, Vol 58, No. 181, September 21, 1993, pg 49035

and coordinated system development efforts between multiple agencies will relieve the effects of diminishing resources such as funding and radio spectrum and will result in numerous cost and quality of service advantages.”

In April, 1996, the US Justice Department formally authorized and funded the FLEWUG Program Management Office (PMO). The purpose of the PMO is to organize, direct and manage the multitude of tasks that must be completed.. the PMO will receive guidance and direction from the FLEWUG in coordination with participating state and local partners. The PMO will establish project teams made up of experts drawn from government, industry and academia to address specific items of interest. Such teams will be assembled on an as-needed basis and dismissed when their work is completed.<sup>11</sup>

APCO, the National Association of State Telecommunications Directors (NASTD) and several federal agencies, through the Project 25 series, have offered to develop a public safety standard for the advanced technology transport portion of this network. Planning for this standards process has already begun.

### 12.3.8.2 The Need

There is perhaps no better way to exemplify the need for the PSWN than to examine the growth in automated inquiries to state and federal databases by law enforcement agencies for wanted person and motor vehicle license inquiries. APCO submitted a White Paper to the FCC in 1994<sup>12</sup> which showed the steady increase in inquiries for the states of California, Florida, Illinois, New York and Texas over the years 1991-1993. The number of transactions per officer for these states, largely conducted by voice over standard mobile radio networks, was contrasted with the number of transactions per officer for the Los Angeles County Sheriff's Department which uses an advanced mobile data terminal (MDT) system. The use of automated systems in the field increased the number of transactions per officer by up to six times the overall average. The data collected by APCO has been updated below to include information for 1994. *It is critical to note that none of these transactions represent the new fingerprint and mugshot technologies supported by NCIC-2000.*

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<sup>11</sup> The Public Safety Wireless Network of the Future Draft 2nd Edition: FLEWUG, October, 1995, pg 10.

<sup>12</sup> The Impact of Advanced Technologies on Public Safety Spectrum Requirements - A White Paper: APCO, August 1994, pp. 9-13.

**Figure 1**  
**Wanted Persons Transactions by State (to State Files)**  
 (Millions)

<i>Year</i>	<i>CA</i>	<i>FL</i>	<i>IL</i>	<i>NY</i>	<i>TX</i>
<b>1991</b>	N/A	7.50	19.43	9.93	12.19
<b>1992</b>	23.3	7.80	20.77	10.52	15.83
<b>1993</b>	N/A	8.70	22.29	10.82	17.53
<b>1994</b>					

California data not available for 1991 and 1993

Figure 1 shows the actual numbers of transactions related to Wanted Persons inquiries for 5 of the most populous states for the period 1991-1994. Figure 2 shows similar data for in-state Criminal History transactions. Each transaction includes an inquiry and its associated response(s). If more than one match results from an inquiry, there may be more than one response. With NCIC-2000, Wanted Person and Criminal History transactions will be made by a fingerprint inquiry with a potential mugshot response.

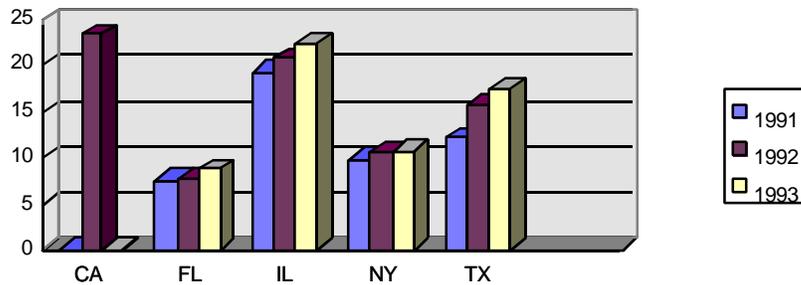
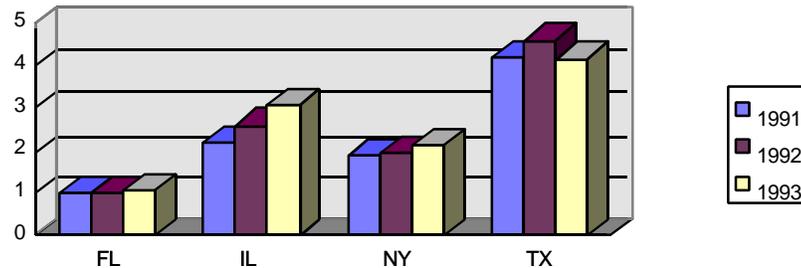


Figure 2  
 Criminal History Transactions by State (to State Files)  
 (Millions)

<i>Year</i>	<i>CA</i>	<i>FL</i>	<i>IL</i>	<i>NY</i>	<i>TX</i>
1991	N/A	1.00	2.21	1.90	4.20
<b>1992</b>	30.80	1.00	2.62	1.98	4.58
<b>1993</b>	N/A	1.00	3.06	2.11	4.17
<b>1994</b>					

California data not available for 1991 and 1993



The other transaction set that will likely produce a data file response is related to motor vehicle inquiries. In this case, a name or operator's license number may result in a photograph being sent from the motor vehicle file to the officer's vehicle. Figure 3 shows the number of transactions for 4 major states. Again, a transaction includes an inquiry and related response(s).

Many states are now automating the collection of operator license photographs. California, for example, no longer takes film photographs. At application or renewal time, the Department of Motor Vehicles (DMV) captures the image on a computer at the DMV field office. It is then transferred to Sacramento where it is stored electronically after the new license document is produced. The National Law Enforcement Telecommunications System (NLETS), a system separate from the FBI's NCIC network, links the criminal justice computers in the 50 states. NLETS recently completed standards to allow the interchange of these operator license photographs. The intent of these standards is the eventual delivery of the photo from any state database to a data terminal carried by a field officer anywhere in the country.

**Figure 3**

**Motor Vehicle Transactions by State (to State Files)**

(Millions)

<i>Year</i>	<i>CA</i>	<i>FL</i>	<i>IL</i>	<i>NY</i>	<i>TX</i>
<b>1991</b>		15.80	32.94	36.01	
<b>1992</b>	107.30	16.00	35.25	37.29	
<b>1993</b>		16.50	38.43	37.62	
<b>1994</b>					

California data not available for 1991 and 1993

Texas data not available

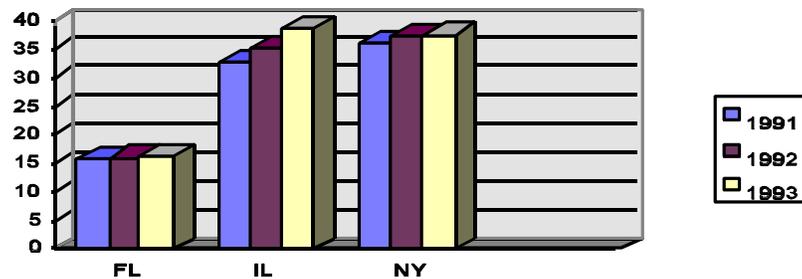


Figure 4 shows the number of sworn officers by state for these same states. Unfortunately, multi-year statistics were only available for Florida and Texas. However, it can readily be seen that, even with fiscal restraint in most states, the number of law enforcement officers continues to grow. The added 16% from the Crime Bill has dramatically impacted these numbers since 1994.

**Figure 4**

**Number of Sworn Officers (Local/Sheriff/State/Special)**

(Source: US DOJ Bureau of Justice Statistics)

<i>Year</i>	<i>CA</i>	<i>FL</i>	<i>IL</i>	<i>NY</i>	<i>TX</i>
<b>1991</b>		33,120			47,278
<b>1992</b>	65,797	32,390	35,674	68,208	49,050
<b>1993</b>		32,818			51,042
<b>1994</b>					

Perhaps no agency in the United States makes as much use of MDTs as the Los Angeles County Sheriff's Department (LASD). MDTs are an integral part of the Sheriff's new multi-million dollar UHF radio system. The system became fully operational in May, 1990. Using 8 duplex radio channels, the MDT system processed 10.3 million transactions in 1991, 12.8 million in 1992, and 13.2 million in 1993.

Figure 5 shows a comparison of the number of transactions per officer for LASD as compared to Florida and Texas, the other two states that provided sufficient data for comparison. *It should be noted that these computations are based on the total LASD sworn compliment; in reality over 25% of LASD's staff is assigned to custody facilities where they do not use MDTs.*

**Figure 5**

**Annual Transactions Per Sworn Officer**

<i>Year</i>	<i>FL</i>	<i>TX</i>	<i>LASD</i>
<b>1991</b>	236	258	1264
<b>1992</b>	241	323	1636
<b>1993</b>	265	343	1778
<b>1994</b>			

It can be readily seen from these figures that the number of transactions from agencies that make extensive use of MDTs can be up to 6 or more times higher than the overall state averages.

The advent of Community Based Policing (CBP) in the early 1990's is now being credited with the sometimes dramatic reduction in violent crime starting in 1993. Importantly, CBP involves getting officers out of their vehicles and directly in touch with more of the population. CBP is, therefore, placing increased demands on public safety communications systems to provide personal based, rather than vehicle based, communications. The widespread use of notebook and, more recently, palmtop personal computers is rapidly driving these personal communications requirements beyond voice to high speed data and eventually full NCIC-2000 capabilities. In fact, the Communications Committee of the International Association of Chief's of Police has estimated that as much as 75% of the state/local government field patrol force could be equipped with such palmtop devices by 2010 if the equipment is available and inexpensive and the infrastructure is available to support the application. This market penetration is based on the similarly rapid introduction of personal portable radios into the field force beginning in the early 1970's. The FBI today issues notebook computers to each of its new agents as they graduate from the FBI Academy. This phenomenon will not be limited to law enforcement, but will similarly impact fire and emergency medical services, and general government applications, particularly as government manpower levels continue to be reduced and the workforce is required to work smarter" to provide a similar level and quality of service.

It has been estimated that, if developed individually on an agency-by-agency basis, up to 400 additional mobile data networks could be required in Southern California to support the needs of the various public safety agencies as we move into the 21<sup>st</sup> century. With the need for high speed data and associated wideband RF channels for carriage, the spectrum

demands for these individual networks would be phenomenal. Similar requirements can be expected in other metropolitan areas of the United States.

More importantly, the development of individual uncoordinated networks will leave data interoperability in the same state as voice interoperability is today.

Data interoperability for criminal justice users will allow investigators and field agents to travel anywhere in the country and still access not only federal and state criminal justice systems, but also the systems of her/his own agency.

Data interoperability will allow agencies responding to large-scale mutual aid events such as wildland fires to transmit staffing, equipment and related logistics information to distant Emergency Operations Centers and receive specific incident briefing and assignment data potentially long before arriving at the scene, potentially saving hours of initial downtime at incident staging areas.

Data interoperability provides the potential for Internet-like communications between any terminal or group of terminals, provided the addresses of the terminal(s) are known and such access is permitted by administrative authorities and policy.

### **12.3.8.3 The Network**

The PSWN has often been described as public safety's wireless lane on the information super highway. As envisioned, it could be a cellular-like network in major metropolitan areas moving to wide-area systems supported by high level sights in rural areas. Minimum raw data rates of 64 kbps will be required to support public safety's future data and voice requirements. Depending upon the individual application, maximum data rates could reach a requirement of 384 kbps.

The network would be designed for the transparent and secure transport of transactions nationwide between terminals and between terminals and hosts. Additional terminal-level encryption would be provided for users requiring higher levels of security than that provided by the network.

User terminals would be based on an open architecture design allowing an array of off-the-shelf devices to be connected to the network using a standard interface card such as a PCMCIA card or external RF modem readily available today.

By selecting appropriate spectrum for the RF subsystem, it is hoped that technology developed for the emerging PCS industry can be readily transferred and applied to the PSWN.

Because of the mobile nature of this service, the current belief is that spectrum below 2 GHz will be required to provide satisfactory coverage. The 1710-

1755 MHz band and potential new spectrum below 800 MHz are being considered.

The network is envisioned to be government owned RF nodes using a standardized open architecture interface allowing multiple vendors to supply both sides of the link, thus providing multiple sourcing and competitive procurement.

It is anticipated that interconnections between wireless nodes will be made using several different mediums, Government-owned microwave and fiber backbones will play a significant role, particularly in more rural areas. Commercial networks will undoubtedly provide the large share of links, particularly in metropolitan areas.

In order for commercial carriers to be considered for the RF backbone to meet procurement requirements of many state and local governments, the following conditions may have to be met:

- At least two carriers (although not necessarily the same two carriers) must be available in all parts of the country;
- Carriers would have to provide coverage to rural areas of the country where there may be little or no demand for commercial services;
- Carriers would have to provide sufficient coverage to meet potentially high demands of public safety users in areas where commercial demand may be very low (areas of depressed income, for example).
- Priority access is required at all times, especially during periods of network blockage.
- Any participating carrier would have to subscribe to the open architecture required by the network;
- Carriers would have to provide for seamless handoff of in-progress transmissions from units leaving one service area and entering that of another ;
- Participating carriers would all have to be linked to the network;
- Participating carriers would have to operate in the same band using some network management technique that would make "channel" selection transparent to the user;
- Local laws in some states may not allow the transport of criminal history information over public access networks.

### **12.3.9 POLICIES AND PROCEDURES**

### **12.3.9.1 Overview of the Incident Command System**

The Incident Command System (ICS) (reference Appendix D) has been developed to provide a common system which public safety agencies can utilize for response to local or wide area emergencies.

The basic organizational structure of the ICS is based upon reviews of large incident responses in the past; organization needs were subsequently identified. Incident related management organizations in the past were organized informally as needs were identified. Under ICS the organization is pre-identified and is applicable to both small day-to-day situations as well as very large and complex incidents.

#### ICS Structure

Incident Commander and Command Staff

Operations Section

Planning Section

Logistics Section

Finance Section

### **12.3.9.2 Laws Impacting Use of ICS**

- California Code of Regulations, Title 19, Division 2
  - Standardized Emergency Management System (SEMS) Defined
  - §2443 Compliance required for Reimbursement

### **12.3.9.3 Impact of Policies and Procedures on Specific Services**

#### Public Transportation

- Mass Transportation Providers need to be on the same spectrum bands as public safety entities in their respective jurisdictional areas.
- Policies relating to the implementation of common infrastructures in “harsh” environments (underground tunnels, remote areas, forests, deserts etc...) where other public safety entities do not generally operate must address the financial impact of systems implementation.

- Procedures for Interoperability must be especially insightful as to the potential for large scale public safety consequences in high density urban mass transportation systems.

### **12.3.10 Conclusions**

- The grade of service (GOS) for interoperability paths can be no less than that for operational paths as detailed in Appendix A of the Operational Requirements Report. Interoperability is often used under circumstances that are less tolerant of error than during normal operations.
- Day-to-day interoperability includes both monitoring another agency's traffic for informational purposes, and response to a particular incident. In the latter case, the simple fact that multiple agencies are involved means that the risks associated with these incidents are probably higher than those involved with routine intra-agency operations. This interoperability can include coordinated use of cross-jurisdiction frequencies, use of structured interagency networks, and gateways between systems.
- Mutual aid interoperability, at least during initial stages of an incident, implies an emergency or disaster situation is imminent or has occurred. The quantity of traffic is often at its peak and personnel are usually under a high degree of stress. As incidents progress, particularly for long term disasters, personnel become fatigued and are more prone to making errors; their attention span is shortened and transmissions may be missed. Personnel operating in the field may be in high noise environments performing crowd control, rescue operations or fighting fires.
- Task force operations often involve providing for close-in protection of undercover operatives, coordination of personnel involved in narcotic raids, and related incidents with life-threatening potential.

### **12.3.11 Recommendations**

#### **12.3.11.1 Additional Channels**

- Appendix A contains recommendations for the number of simultaneous interoperability links required by user service category for two options. The first option is to implement interoperability within existing public safety bands. The second option is to implement interoperability at the minimum level within current public safety bands, while providing the majority interoperability spectrum within a new "Public Safety Interoperability Band" in spectrum below 512 MHz.

- Aggregate numbers for the first option (using existing bands) indicate a total need for 51 repeatered voice links and 83 simplex voice links

within current bands, plus 2 independent high speed data and 2 independent full motion video links. It is believed that existing designated interoperability frequencies can be used for 17.5 of the repeatered and 28 of the simplex voice links. The high speed data and full motion video links must be provided within new spectrum.

- Aggregate numbers for the second option (new interoperability band) indicate a total need for 21 repeatered voice links and 20 simplex voice links within current bands. It is believed that existing designated interoperability frequencies can be used for 13.5 of the repeatered and 13 of the simplex voice links. 31 repeatered voice, 70 simplex voice, 2 independent high speed data and 2 independent full motion video links must be provided in the new Public Safety Spectrum.

- To implement interoperability using the first option (exclusively within existing bands), the aggregate numbers indicate a requirement for the following quantities of links:

#### Voice

A total of 49 repeatered and 52 simplex voice interoperability links are required. Some of these requirements are met by existing Intersystem links, as described in Appendix B.

#### In the major bands establish the following repeatered links:

- A service independent National Calling link as described in Section 7.5.7 in each of the 42-50, 150-174, 406-420, 450-470 and 806-824 MHz bands (total of 5 links).
- One service dependent emergency-only link in the 42-50, 150-174, 450-470 and 806-824 MHz bands for each of the fire, emergency medical and law enforcement services (total of 12 links).
- One service dependent day-to-day interoperability link each for fire and law enforcement services in the 42-50, 150-174, 450-470 and 806-824 MHz bands (total of 12 links).
- Four service independent tactical links as described previously in each of the 150-174, 406-420, 450-470 and 806-824 MHz bands (total of 20 links).

#### In the major bands establish the following simplex links:

- A total of 24 general access tactical links whose use is according to a priority system in each of the following bands: 42-50 MHz (2 links), 150-174 MHz (16

links), 450-470 MHz (6 links), 806-824 MHz (6 links).

- One day-to-day interoperability link each for fire, emergency medical, general government law enforcement and public service in the 42-50, 150-174, 450-470 and 806-824 MHz bands (total of 20 links).

#### High speed data

High speed data links must be supported within the Public Safety Wireless Network as described in Section 6 both as an operational requirement and for interoperability.

In addition to the voice requirements listed above, spectrum must be dedicated nationwide in one of the bands above 150 MHz for two independent duplex links for high speed data. These links must be able to operate co-site without mutual interference.

#### Full motion video

Spectrum must be dedicated nationwide for two independent video links each with sufficient bandwidth to support full motion video. These links must be able to operate co-site without mutual interference.

Interoperability frequencies must be carefully chosen by the FCC/NTIA to minimize mutual interference between mutual aid channels when they are used co-site. For example, receiver desensitization can occur when a strong signal is present near the receiving frequency of a radio. Furthermore, the use of 25 kHz bandwidth equipment on 15 kHz channel centers in the 150-162 MHz band. Last, the lack of standard pairing of mobile relay frequencies in this same band can lead to a distant base station causing interference to an adjacent mutual aid channel.

- The most critical Interoperability requirement is for direct unit-to-unit communications. Normally, a common over-the-air interface must be used for direct unit-to-unit communications. On April 12, 1996, the Interoperability Subcommittee adopted a resolution to establish a baseline technology for interoperability. The text of that resolution is included in the main Interoperability Subcommittee Report.

- Interoperability will use the following functions if they are supported on the equipment and infrastructure (as applicable). Again, these imply that a common over-the-air interface be used for direct unit-to-unit communications. Where equipment is in use that does not support these features, communications must not be substantially impaired by these features.

*Emergency Signal:* Personnel who need emergency assistance must be able to activate an alarm that sends an automatic distress notice to other

personnel in the field who are involved in the incident on that communications path and optionally to a central monitoring point.

*Unit ID:* when a transmitter is keyed, a unique identifier must be sent to other personnel in the field who are involved in the incident on that communications path and optionally to a central monitoring point.

### **12.3.11.2 Establish Standards Committee**

While the Minimum Baseline for Interoperability presented in Section 11.2.3 will suffice for some time, perhaps as long as 2010, the time will come when most, if not all, users in a given area will be using a digital voice communications platform and will not want to give up the capabilities provided by that platform when switching to analog FM for direct unit-to-unit communications. Therefore, it is recommended that, after the PSWAC process is completed, the FCC and NTIA together establish a working group comprised of experts representing government, industry, and federal, state and local government users similar to, but smaller than the PSWAC effort, to address base line technology for interoperability. It is further recommended that another PSWAC should be convened within ten (10) years to evaluate technology development and the effect that actions stemming from this PSWAC have had on meeting the needs of public safety's spectrum and interoperability problems.

Considering the evolution to digital technology, we should not limit future interoperability to an analog baseline. Just as the AMPS cellular standard (which clearly goes far beyond simple analog FM) provides North America-wide cellular interoperability, there is clearly a future need for digital interoperability standards for public safety communications. It is imperative that this baseline be addressed and established within the next two years, to allow the public safety community to develop implementation and migration plans accordingly.

Any group selected for the purpose of such an evaluation should be composed of experts representing industry and users. The selection methodology must be weighted towards the needs of the end user. There has been significant discussion regarding the use of an accredited standards making entity in the development of digital baseline standards. The consensus of the working group is that such a requirement would be overly restrictive.

The Telecommunications Industry Association (TIA), the ANSI-accredited SDO for the telecommunications industry has stated: "...not all documents called *standards* are issued by American National Standards Institute (ANSI)-accredited Standards Developing Organizations (SDO). The ATM Forum is issuing standards for Asynchronous Transfer Mode (ATM) systems and the ATM Forum is not ANSI-accredited. The Internet Society also issues publicly available specifications<sup>13</sup>."

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<sup>13</sup> Letter from Matthew J. Flannigan, TIA President, to Dennis Connors, Ericsson Inc., dated April 12, 1995.

Vice President Albert Gore has stated “All parties should participate in the development of private-sector, voluntary, consensus standards through the existing international organizations, such as the International Telecommunications Union, the International Standards Organization and the Internet Society. The creation of truly global networks will require a high degree of interconnection and interoperability<sup>14</sup>.

Indeed, the two technology developments arguably having the largest impact on American society during the past decade were not developed through an accredited SDO, but rather are proprietary: the IBM-PC bus architecture and the Microsoft Disk Operating System (DOS) Windows software. It is interesting to note that the primary competition to these, Apple with its closely held proprietary hardware and software platforms, is currently experiencing significant financial problems.

It is therefore recommended that any digital baseline standards for interoperability be open standards developed/adopted in an open and fair process. Clear user concerns in selecting any baseline standard include the issues of graceful migration and competitive procurement.

While it is desirable that interoperability technologies be in the public domain, several key issues surface with respect to technology development and its associated Intellectual Property Rights (IPR). These include:

- Heavy research & development (R&D) expenditures are normally made in those areas which appear to be promising for future applications; most resulting technology is patented, with resulting IPR belonging to the developer. As a result, many promising technologies often have associated IPR.
- There is clearly a possibility that the benefits resulting from use of proprietary technologies could result in a solution whose value (in speed, performance, elegance of implementation, overall cost, etc) clearly outweigh the associated costs of the IPR. A detailed cost-benefit analysis may need to be performed as part of the process of selecting one proposal over another, whether or not one or more of the offerings are in the public domain.
- Limiting the consideration in choosing a technology to public domain offerings will potentially eliminate solutions which, in the overall picture, could provide the greatest benefit.
- Providing a platform for holders of IPR to propose their proprietary developments for use by the general community at fair and reasonable terms may bring technology into the open market that would otherwise be held only by the IPR

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<sup>14</sup> Vice-President Albert Gore's key note address to the G7 meeting in Brussels, Belgium, discussing the Global Information Infrastructure, February 26,1995.

developer with all of the benefits from the sale of that technology ensuring exclusively to the IPR holder.

### **12.3.11.3 Establish Standard Identifiers**

Standard nomenclatures and identifiers for channels/talk groups must be mandated by the FCC and NTIA for use on all equipment, to include approved identifiers to be displayed for interoperability channels/talk groups on equipment with varying numbers of characters in the channel/talk group display window.

It is recommended that manufacturers provide software that only permits FCC/NTIA approved identifiers to be programmed into radios for national interoperability channels/talkgroups.

### **12.3.11.4 National Calling Channel**

A National Calling Channel” and one or more “Tactical Channels” must be established in **EACH** of the public safety frequency bands. Use of these channels should be similar to that currently designated in the NPSPAC plan (47 CFR 90.16 and 90.34).

The National Calling Channel in each band should:

- Be clear nationwide (ideally North America-wide as in the NPSPAC band) and restricted to this use.
- Be available for use by ANY public safety user at ANY level of government and should also be available for use by private companies which provide public safety services (such as a private ambulance company).
- Be used in the non-encrypted mode only.
- Be restricted to the use of clear text voice only. The use of 10-codes and other short-cuts may result in a garbled message.
- Be monitored by dispatch centers to allow “visiting” units needing to report an emergency or obtain emergency information a means of contacting a local agency. The use of a regional planning process to designate a “monitoring” agency in each area is desirable.
- Be limited to very short transmissions. For longer messages, participants should be instructed to change channels to one of the “National Tactical Channels” or some other channel for the exchange of information. This will allow the dispatch facility to routinely monitor only one channel which normally is quiet (i.e. dispatchers are less likely to mute the channel as a means off-loading extraneous radio traffic).

- Not be used by “visiting” units for non-emergency traffic. The “monitoring” agency should not be asked to be a “message center” for “visiting” units. Messages related to the reporting of emergencies by “visiting” units or messages related to directing a “visiting” unit to respond to an emergency are appropriate. Messages related to administrative matters are not appropriate.

### 12.3.11.5 Tactical Channels

The Tactical Channels in each band should:

- Include a very limited number of channels (similar to the four channels provided in the NPSPAC band) to which visiting units might be instructed to change for the exchange of information. The number of channels should be limited as a matter of equipment of the “visiting” mobile/portable unit (encouraging the equipping of all mobile/portable units with these channels---asking that all of the 100± “mutual aid” channels be “equipped” in each unit may be a negative factor.)
- Be clear nationwide and designated for this use.
- Be used for the lengthy exchange of information.
- Have a common nomenclature (reference Section
- Be available for use by ALL public safety agencies at ALL levels of government and by those private companies performing a public safety service under contract to a government agency so long as the government agency holds the license. It may be desirable for repeater stations to be under the control of the “monitoring” agency and their use subject to assignment by the “monitoring” agency.
- Be restricted to “visiting” units with use by “local” units restricted to the need to communicate with “visiting” units. Agencies should not be allowed to use these channels for their own tactical operations within their jurisdiction (they should either obtain their own tactical channels for this function or, possibly, use one of the other 100± mutual aid channels being discussed.) However, agencies conducting tactical operations outside of their jurisdiction might be allowed to use these channels as a means of minimizing disruption to local agency operations. For instance, a dignitary protection unit covering a governor should operate on their own channels when the governor is within the state but might be allowed to use these “National Tactical Channels” when the governor is traveling outside the state.
- Be in the non-encrypted mode unless prior permission had been obtained from the “monitoring” agency. Encryption may be needed by the “visiting” unit for any number of reasons (for instance, the dignitary protection unit in the

example above may need to operate in the encrypted mode to provide an appropriate level of security). It may be desirable for the “monitoring agency” to establish a method by which the encrypted visiting user can be contacted (possibly by having the “visiting” unit scan the National Calling Channel).

As with other mutual aid frequencies, it is important to consider placement within each band. There have been significant problems when mutual aid channels have been placed side-by-side or next to other statewide or nationwide assignments due to adjacent channel interference which can render such channels unusable when operating within close proximity to each other.

Some of the Interagency Frequencies identified in Appendix B may be candidates for this use. However, many of these have already been designated for specific purposes in state and regional plans. Caution is urged; a great deal of research must be done prior to making any reassignment of the Interagency Frequencies.

#### **12.3.11.6 Establish ICS (Incident Command System)**

Appropriate regulatory agencies (including the Congress and state legislatures) must enact legislation requiring use of the Incident Command System for multi-agency incidents.

It is essential that plain voice and plain text be used, particularly for mutual aid interoperability.

A national method for certifying Communications Unit Leaders (CUL) must be developed and implemented. A trained CUL to manage communications at major incidents must be mandated.

Certification and regular training on the ICS must be mandated for all public safety field personnel.

### **12.3.12 REGULATORY ISSUES**

#### **12.3.12.1 Administration and Planning**

The examination of incidents and deliberations within Working Group 3 have clearly shown that the implementation of interoperability, particularly for mutual aid operations, is now, and by its very nature must remain, a state/regional controlled function.

Most mutual aid planning is conducted at the state level. While the Federal Emergency Management Agency (FEMA) has significant responsibility at the national level to coordinate and provide for disaster response and relief, in any major incident the bulk of the response and responders are provided from state and local resources.

FEMA was specifically invited to participate in the deliberations of the PSWAC and chose not to participate. The lack of participation by FEMA is an

indication to this Working Group that they are willing to abide by the decisions of the federal, state and local government and various non-government participants who prepared and reviewed this effort.

Radio coverage plays a significant role in the development, operation and effectiveness of interoperability plans. Because radio waves do not recognize jurisdictional or political boundaries, it is critical that development of interoperability plans include those agencies, organizations and political entities which are within typical radio coverage areas, even if those involve multiple states.

The federal agencies are not restricted by state boundaries. However, a significant amount of their interoperability communications requirements, and virtually all of that requirement with state/local government entities, takes place on a state or regional basis. This is particularly true for day-to-day federal/state/local and for task-force interoperability. There is, however, the need for some spectrum to be reserved specifically for federal agency interoperability.

There is clearly a need for a number of radio frequencies to be assigned on a national basis for use as previously described in Section 12.3.11.

It is strongly recommended that these frequencies to be administered on a national basis by an organization established for that purpose whose membership, while limited to the fewest numbers possible, is representative of the broad user categories at the federal, state and local governmental level, with advisory participation, as deemed appropriate, by non-governmental organizations which provide support services to government.

The designation of these national interoperability frequencies must take place in conjunction with the designation of all recommended interoperability frequencies and the general ground rules for their implementation, operation and administration needs to be in place prior to state/regional groups developing plans to implement and administer the remaining interoperability frequencies.

### **12.3.12.2 Specific Regulatory Changes**

It is critical that the FCC and NTIA rapidly initiate the regulatory changes to support the interoperability platform described in this report. In particular, the changes to support the following interoperability provisions need to be provided:

Interoperability Communication Plans (ICPs) shall be established at the State and/or multi-state Regional level (where radio coverage and significant local demographics include more than one state), so that operational procedures can be developed which meet local needs as well as provide the nationwide uniformity of use required to ensure that resources from distant jurisdictions can effectively and efficiently participate in mutual aid events. Examples of multi-state regional areas include the New York City, Chicago and Washington, DC greater metropolitan areas.

In order to establish general uniformity of use, regulations should be established by the FCC and NTIA to formally certify State or Regional Interoperability Communications Planning Organizations and their areas of jurisdiction. These Planning Organizations shall each be charged with developing an ICP which establishes, in accordance with FCC/NTIA regulations, the operational procedures for use of each of the FCC/NTIA designated interoperability links, and such other links as may be deemed appropriate within that state/region. Regional ICPs shall coordinate with State ICPs. Each State or Regional ICP shall include within its plan organizational rules of procedure, which shall include the eligibility criteria and method by which members of the organization are installed so as to maintain an approximately even balance amongst the user service categories of Criminal Justice (including, corrections, courts and law enforcement), Emergency Medical, Fire, and General Government, and include federal, state, and local government representation. Each Planning Organization shall include liaison with the Public Service sector. Members of each such State or Regional Planning Organization shall be reported to the FCC/NTIA and be formally acknowledged. A mechanism shall be established by FCC/NTIA to reimburse the reasonable operating expenses of these Planning Organizations. Adjacent Planning Organizations shall coordinate with each other. At least one meeting of all Planning Organizations shall be held each year, coincident with a meeting of a national organization representative of the eligibles, for the purpose of coordination, discussion and recommendation for correction of any relevant issues.

Regulations should be established by the FCC and NTIA, assigning the specific interoperability frequencies and, where a frequency's use is service dependent, stipulate the relevant condition and eligibility criteria. Except for the National Calling Channels, the regulations should permit state/regional ICPs to allow for temporary exception to the normal use of a link when exigent circumstances indicate such a need.

Fixed base stations operating on ICP frequencies shall only be licensed to state and federal governmental entities, conditioned upon operation in accordance with the appropriate ICP. Other governmental and public service entities may own and/or operate such equipment for the purposes and uses identified in the FCC/NTIA Regulations and the appropriate ICP. The ICP shall require such other entities to discharge the licensee's responsibilities under FCC/NTIA regulations for fixed station operation, maintenance, and record keeping as appropriate, by the use of a written agreement.

Mobile and Control Stations may be used by public safety eligibles, either under a formal license, or without licensing by the FCC or NTIA as long as the equipment is type accepted for use on the intended interoperability links, and is operated in full conformance with FCC/NTIA regulations and the applicable ICP. Public service mobiles may be operated on appropriate interoperability links by written agreement with the licensed state entity, in full conformance with the FCC/NTIA regulations and as provided in the appropriate ICP.

### **12.3.12.3 Summary of FCC-Related Issues**

- Need to provide for joint licensing with federal agencies.
- Reallocation of 220-222 MHz for USART use.

### **12.3.12.4 Summary of NTIA-Related Issues**

- Need to provide for joint, co-equal assignments with state/local agencies.
- Recommendation to implement sufficient interoperability frequencies in the 402-420 MHz band to support federal agency requirements.

## **12.4 Working Group #4 Report (Define Public Safety/Public Service)**

Working Group #4 was assigned the difficult task to develop a definition of Public Safety/Public Services. The product of this group's work is reflected in Section 3.1 of this report. The definitions were approved by the Steering Committee on December 15, 1995.

## **12.5 Working Group #5 Report (Identify Existing Interoperability Requirements)**

Working Group #5 was formed to identify the existing interoperability requirements within the public safety community. This working group worked closely with Working Group #3 in identifying the inventory reflected in Section 5 of this report. Section 6 is the product of this working group's endeavors.

## **12.6 Working Group #6 Report (Develop DRAFT ISC Report)**

Working Group #6 was established to develop the DRAFT Report for the Interoperability Subcommittee. This group worked closely with and then merged with Working Group #2. The entire report is the product of this working group's work.

## **12.7 Working Group #7 Report (Provide Cost/Benefit Analyses)**

There is no report available from Working Group #8 at this time, due to the time constraints of this report. Working Group #8 will likely submit a supplemental report which will be reflected in Section 8 of this report.

## **12.8 Working Group #8 Report (Address Regulatory Issues/Mandates)**

### **12.8.1 Purpose**

Working Group #8 was assigned the task of identifying and recommending changes to statutes or regulations that would facilitate interoperability. The focus of the working group was to be on more fundamental changes. For example, a recommendation by the ISC that a

specific frequency be used as an interoperability channel would require a change in FCC regulations. However, such a change lies in the day to day activities of the FCC and requires no special analysis.

### **12.8.2 Federal/Local Coordination**

A repeated theme in discussions at the ISC were problems with coordination and Interoperability between federal and local officials. These problems appear, in significant part, to flow from or be exacerbated by the split in spectrum authority under the Communications Act between the president and the FCC.

Typically, a local user operating on a federal frequency is given secondary status — which puts their investment at additional risk. Similarly, federal users are restricted from being authorized to operate on FCC controlled frequencies except for limited communications with FCC licensees.

Consider a hypothetical example which illustrates elements of this problem. Suppose that a large western state builds a statewide mobile system. Some federal law enforcement agencies could (technically speaking) operate on this system and forego the expense of building their own statewide infrastructure. Clearly, interoperation between such federal users and local users using the statewide system would be greatly facilitated in these circumstances. However, under current rules, the state authorities cannot accept federal agencies as “tenants” on such systems.

The essence of the problem is that public safety radio is supported by two pools of spectrum, one controlled by the FCC and the other controlled by the NTIA. Historically these areas of spectrum were managed separately. But, the separate policies have inadvertently resulted in barriers to the efficient operation of shared systems and in barriers to Interoperability. These problems become more acute as technology improves, radio communications become more essential and large scale systems are used to gain efficiencies.

### **12.8.3 Shared Systems**

Shared systems (i.e., large trunked systems which provide service to many governmental entities in a specific geographic area) offer a high level of built-in interoperability. They also offer greater spectrum efficiency than many smaller non-trunked systems or systems trunked on fewer channels. However, shared systems face difficulties which hinder their adoption. Probably the most significant difficulty of shared systems is that they require individual agencies to surrender some autonomy in return for the efficiencies and better coverage of the larger system.

The FCC could implement policies which facilitated the adoption of shared systems. For example, the FCC could require a showing (or statement) on license applications that no shared system can meet the agency’s needs. The FCC could also implement policies which help preserve the autonomy of individual agencies and hence lower the threshold for adoption. For example, the FCC could adopt a policy that said that all communications involving safety-

of-life were to be carried at equal priorities. Thus, a “tenant” on a shared system would not need to fear that the “landlord” would get superior access to channels in a crunch time.

#### **12.8.4 Commercial Systems**

The discussions in the ISC identified significant shortcomings of the ability of commercial systems ability to meet public safety needs. The FCC could adopt policies that would remove some such shortcomings. However, many of these shortcomings flow from market forces and are not readily susceptible to regulatory cures. One such policy, which would reduce problems with access to commercial systems during times of peak usage, would be rules that provided for priority access to commercial systems by public safety users.

#### **12.8.5 Recommendations**

The FCC and NTIA should establish a task force to identify policies that would facilitate joint use of spectrum by federal and non-federal government users. This task force should also consider policies needed to facilitate the creation of shared systems that support both federal government and non-federal users.

The FCC should consider implementing incentives that facilitate the adoption and use of shared systems for public safety communications.

The FCC should adopt rules that make commercial systems more responsive to public safety needs. Most importantly, the FCC should require commercial systems to offer a priority access option to public safety users.

### **12.9 Working Group #9 Report (Address Commercial Services Access/Availability)**

#### **12.9.1 Introduction**

This report describes the role commercial wireless services can play in public safety to compliment and interoperate with existing services, and public safety issues that impact the acceptance and proper use of commercial wireless services in that environment.

Commercial services can augment day-to-day, mutual aid and task force communications interoperability beyond use of private land mobile radio technology. In particular, administrative and logistical types of traffic can find uses within commercial services.

Public Safety Agencies can relieve some traffic congestion on crowded radio channels by allowing that appropriate traffic to be handled by commercial providers with commercial-off-the-shelf (COTS) equipment and services.

Primary public safety systems can use commercial wireless services to provide critical backup networks based on different technologies. Reliance on multiple backup technologies is important should a single source of failure affect undifferentiated private systems.

Commercial services can be used on an "as needed" basis. The technology and services can be easily acquired and used for optimum efficiency when specific needs arise. Overhead associated with ownership and ongoing maintenance of underlying infrastructure is eliminated.

Wireless commercial services are growing dramatically. For example, mobile data networks are expected to grow at an annual rate of over 38% per year, with the number of users increasing from 300,000 in 1993 to over 1,400,000 users in 1998. That rate of growth will result in lower costs and improved service, and will make commercial options in data communications increasingly attractive in the future.

### **12.9.2 Background**

Working Group #9 was established to address Access and Availability of Commercial Services. The co-chairs of Working Group 9 established group leaders to address:

- Commercial capabilities by technology
  - Satellite
  - Paging
  - Cellular
  - PCS
  - SMR/ESMR
- Commercial applications in public safety
  - Public safety awareness of commercial wireless services
  - Commercial interoperability approaches

#### **12.9.2.1 Public safety issues regarding the use of commercial wireless services**

Commercial providers were encouraged to contribute individually and/or in conjunction with trade associations.

Input was provided in approximately 60 documents including:

- White papers
- Surveys
- Studies
- Articles

### **12.9.3 Possible Commercial Wireless Services Role in Public Safety**

Studies show increasing interference and congestion on existing telecommunication systems used by public service organizations<sup>15</sup>.

#### **12.9.3.1 A Major Incident Review**

##### **12.9.3.1.1 Overview**

###### Air Florida Flight 90 Crash

The Interoperability Subcommittee of the Public Safety Wireless Advisory Committee (PSWAC) prepared a case study of the crash of Air Florida Flight 90 on January 13, 1982 (see document # 96-04-024/2). The purpose of the case study was to identify the communications interoperability problems that occurred and determine what interoperability problems still exist today and finally, make recommendations to satisfy the existing and future interoperability needs should a similar incident occur again. This includes what role commercial wireless service providers' offerings might have played in the management of the numerous public safety efforts required to manage the incident. This contribution will identify the technological capabilities of existing cellular, paging and the emerging PCS systems in the United States.

This particular study focuses on the Air Florida airplane crash that took place on the Fourteenth Street Bridge in Washington, DC, over fourteen years ago.

According to the case study, the first notifications of the Air Florida crash were from a commuter using a mobile telephone, and separately, from the Washington National Airport over the Washington Area Warning and Alerting System, a wireline network sponsored by FEMA.

Although agencies were alerted in both instances, there was no central plan in place at the time. No one knew what agencies had received the alert, and were responding.

Today, a Mutual Aid Plan (MAP) is in place that provides an Incident Command Structure (ICS) for respondents.

Although the ICS provides a plan for command/control, there is insufficient communications capabilities to properly implement the plan to its fullest extent when an incident occurs.

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<sup>15</sup> Reference ISC WG 9048, Maryland Law Enforcement Telecommunications Interoperability Analysis, Focused Research International, Inc., pgs.20 & 21, ISC 96-04-02412, Metropolitan Washington Area Interoperability, Case Study

### Addressing the Mutual Aid Plan (MAP)

For purposes of illustration, paging, cellular and PCS services will be used as examples of commercial services which could have assisted public safety representatives in the Air Florida crash.

Today, the use of commercial paging in conjunction with existing radio equipment can relieve some of the traffic congestion which occurs as responders contend for the channels. If group dispatch communications containing discreet information like location, equipment needed, changing conditions, etc. can be off-loaded to text pagers carried by emergency response personnel, traffic loads on the MAP channels would likely decrease.

Today, MAP procedures could include group paging to accommodate broadcast announcements including the initial alert. Two-way paging could allow respondents to answer calls without having to wait for a channel, or interact directly with a dispatcher. The dispatcher could receive replies into a paging device or portable computer, and further coordinate communications without dispatcher intervention.

Notifications of emergencies could be sent to participating MAP agencies on pagers, in addition to the wireline system. On-call agency representatives could carry pagers configured for the Washington Area Warning and Alerting System. If they were away from a telephone, they could respond back to the notification system, a dispatcher or dispatch network, by sending a pager reply.

Paging systems can receive alerts directly from network-based host computers, stand-alone PCs, a dispatcher, or any of the three. A computer software program could be configured so that if a designated agency representative had not responded back within a certain period of time, an escalation procedure would activate, either alerting the dispatcher, or initiating a page to a back-up representative at the same agency.

If a MAP included the use of commercial services, it would be important to have uniform training guidelines that include training prior to an actual incident, a consistent inventory plan, registered groups with operator dispatch services, and potentially, pre-loaded groups in the paging software with up-to-date information about group leader and individual team member identification numbers.

Pagers are small, easy to store, and spares can be kept on emergency vehicles. Replacement batteries (AA or AAA) batteries are readily available. If an incident requires unexpected interoperability with an agency or organization outside of the MAP, it becomes easy to distribute activated pagers from a central location. Some commercial paging organizations now provide an idle status program, which allows agencies to activate and deactivate pagers on an as needed basis for emergency services, via a phone call to a central 24 hour a day, 7 day a week support number. Examples of the need for additional pagers might be to help coordinate activities with utility companies, or to provide information to the press, especially if there is a need to keep those organizations at a distance from the immediate scene.

Future use of GPS in conjunction with commercial paging networks will allow command posts to track vehicles equipped with AVL/paging capabilities, send messages to vehicle occupants, and provide for message responses. Message responses may include the use of a "panic button" for vehicles in distress.

In the Air Florida incident, the use of GPS tracking would have relieved communication traffic on the existing communication channels concerned with coordinating the arrival of emergency vehicles and workers. GPS information is sent automatically at specific intervals, to a central location where information matching the vehicle ID, with latitude and longitude is translated into text, maps or both. The central dispatch center could conceivably be a laptop computer at the command site.

#### Incident Command Structure Uses for Paging Services

A few ideas about how paging could be used in a command/control structure, based on the expanded organization chart in the Air Florida Case Study are outlined below:

When the Washington National Airport broadcast a notification of the disaster over the Washington Area Warning and Alerting System, agencies began responding by sending equipment and personnel. Today, coordination of arriving vehicles and personnel once they are rolling, can be accomplished with the assistance of commercial paging.

If, participating MAP agencies are equipped with pagers, groups have been established in the paging software or with operator dispatch, and spare pagers are available on the MAP vehicles, the incident commander will have the ability to send messages to incoming groups to:

- provide specific incident location information and changing conditions
- change intended routes due to reported traffic congestion
- change assignments as more information becomes available
- determine estimated time of arrival for each MAP vehicle

A message could be sent asking for ETA. Replies can be easily originated from a paging device or a handheld device interoperable with a pager. For example, a message from the incident commander may read, *How many minutes, ETA?* The reply could simply be, *1, 10, 45, etc.*

Determine the quantity and types of supplies & equipment coming in, to know whether to dispatch for more. For example, an incident commander may send a broadcast message to all incoming units that reads, *Do you have the following? (see replies).* The unit replies may read, *extra blankets, bandages, life vests*

The responder only has to select the appropriate responses from the choices given. The command post can automatically determine who sent the response and log the information accordingly.

Off-loading incoming unit coordination communications to paging should free up mutual aid channels for those already on the scene.

Medical units need to stay in touch with local hospitals. Participating hospitals within a MAP jurisdiction need to be prepared for the incoming injuries. Designated hospital personnel can wear two-way pagers during the course of an incident in order to receive messages from on-site rescue workers. On the-scene public safety rescue workers and/or staging personnel can be equipped with a palm-sized HP200LX that has two-way paging software that allows workers to access a directory of contacts at local hospitals. On-site workers can send messages from the HP200LX via a pager cable connection, to local hospital personnel, alerting them of ETA, the number and the extent of incoming injuries.

On-the-scene supply units can stay in touch with mobile rescue workers to send text messages announcing incoming supplies, and ask individual task groups what is needed by providing them with a selection of canned responses, or allowing them to send freeform responses from message origination pagers.

Staging area personnel can send group messages to rescue workers, providing them with logistics and transport information, along with any changes. Rescue workers can send freeform messages from message origination pagers or a palmtop device back to staging areas to alert them to the number and extent of incoming injuries.

The food unit can provide up-to-date information to personnel responsible for scheduling rescue worker and/or victim meals, keeping everyone informed about logistics on receiving meals, and updates on food supplies available.

The compensation unit can receive authorization for payments from incident command personnel, and have a history log of requests made, and authorizations received.

Ground transportation can be easily coordinated with two-way paging directly to vehicle occupants and visa versa. Air control can be coordinated with ground dispatch, however ground-to-air, or air-to-ground communications will only work when airborne vehicles are within range of transmitters. Helicopter communications in major metropolitan areas, where transmitters are densely configured should work.

Where helicopter communications work effectively, passengers can receive requests from the ground to search specific locations, rescue victims, and/or deliver supplies. Helicopter passengers can send short messages back to control personnel on a message origination pager and/or palmtop letting them know the extent of the situation directly to their two-way units, without having to go through a dispatcher.

Demobilization activities can be coordinated to allow commanders to send notification for break-down, departure or changes in plans to group participants. If a participant is not ready, he/she would have the ability to notify the command from the paging device.

The documentation unit, can check communication data logs from the dispatchers' PC(s), pages stored in the units themselves and/or the provider's network operating center(s) to help construct their reports.

### Multiple incidents

Where multiple incidents occur simultaneously, like the metro crash which occurred during the rescue efforts responding to the Air Florida airplane crash, commercial paging services can help. Since paging infrastructure is not limited to one jurisdiction, dispatchers can access commercial paging networks as a common way to achieve cross-jurisdictional communication. Personnel located outside of the immediate jurisdiction where an incident takes place, have the ability to communicate with one or more individuals within the jurisdiction, on a device-to-device basis or a dispatcher-to-device-to dispatcher basis.

### Interoperability on a device independent, infrastructure dependent basis

a) Participating Mutual Aid Plan public service organizations, like the utility companies, may use their own local paging providers during normal operations. Paging software can now allow MAP dispatchers to send messages to digital and/or alphanumeric pagers from a single directory and user interface, even though the pagers reside on multiple networks. That means that utility companies can use their existing equipment as long as dispatchers have the appropriate software on their computers, along with the appropriate pager identification numbers listed in their directories. Dispatchers can send messages to news media personnel in the same manner.

If a MAP calls for the centralized management of pagers across agencies and/or organizations, some providers will offer those services, even though the pagers operate on multiple networks.

On two-way networks, peer-to-peer communications are possible between two-way pagers in multiple jurisdictions where coverage exists. Coverage is the strongest in the major metropolitan areas.

b) Commercial providers using other technologies have already recognized the need to interoperate with paging providers on a device independent, infrastructure dependent basis. They are working together to develop gateways to move data messaging traffic across diverse infrastructures, where the goal is to deliver information to individuals based on their requirements for specific form factors, enhancements or coverage. Today, a message could be originated on a satellite terminal located outside of the United States and delivered to a pager in the United States. A two-way pager can then send a response back to the satellite terminal originating the page.

Discreet data messaging helps rescue workers:

- a) net it out. They are forced to communicate in an efficient, abbreviated manner.
- b) keep a history log. After the fact, it is often necessary to reconstruct who said what to whom.
- c) communicate without the aid of a dispatcher minimizing potential for human error, expediting the communication process, and freeing mutual aid channels for voice communications.

Cellular/PCS definitions

**a) Cellular.**

Cellular in this usage denotes a commercial radio-telephone service enabling a subscriber to make and receive telephone calls with no operator intervention. The transmission path, once established, may be used to transmit voice, data or video information. Cellular service was first authorized by the FCC in 1982. In any of 734 Metropolitan or Rural Service areas (MSAs and RSAs), there are two cellular licensees, each of which is authorized to operate systems using 25MHz of spectrum in the 824-849/869-894 MHz range. Because all cellular systems operate on the Advanced Mobile Phone System (AMPS) air interface, all cellular phones are capable of operating on all cellular systems in the United States, irrespective of ownership or manufacturer. As of December 1995, the CTIA estimates that there are some 33.8 million cellular subscribers using over 22,600 cell sites in the United States. Other industry sources estimate that over 95% of the population of the United States lives within range of a cellular telephone system.

**b) PCS.**

Personal Communications Services (PCS) were authorized by the FCC in 1994. Like cellular, the principal use of PCS will be to provide direct dial radio/telephone service, with a variety of new services as well as integration of telephony with paging and other data services.

Three 30-MHz blocks and three 10 MHz blocks of spectrum in the 1850 - 1990 MHz band of the radio frequency spectrum are allocated to PCS systems. Licenses are being auctioned off by the FCC. A and B block licenses, which grant rights to operate on 30 MHz of spectrum within very large geographic areas of Major Trading Areas (MTAs) were awarded in April of 1995. C-block auctions, which include the right to operate on 30 MHz within smaller geographic areas designated as Basic Trading Areas (BTAs) concluded in May of 1996. Two systems are in commercial operation in the Washington-Baltimore MSA and the Honolulu MSA, with numerous system launches anticipated for late 1996. Unlike cellular, no standard air interface was mandated by the FCC, so a variety of digital air interfaces will be deployed within the PCS allocation. The digital interfaces offer improvements over analog systems (such as AMPS cellular) in system capacity, signal quality, privacy and feature sets.

### Capabilities Analysis

The case study notes flaws in three basic areas:

- 1) situational problems
- 2) organizational problems
- 3) communications problems

To varying degrees, the widespread availability of wireless telephone devices would have had a positive impact on the management of the situation, as outlined below:

#### a) **Notification**

The key to the role that cellular and PCS systems might have played in the Air Florida disaster begins with the fact that the first notification of the accident was transmitted via mobile telephone. At the time of the accident, there were only about 150,000 mobile telephones in commercial operation, with the Improved Mobile Telephone Service, or IMTS, being the most advanced technology available. Although IMTS is a direct dial technology that required no operator intervention, it was technically possible to use IMTS units to hail a mobile operator on an older so-called manual system, in which the mobile operator would place a call after receiving verbal instructions from the mobile unit operator.

Both CB radios and IMTS mobile units have largely been displaced by the wireless telephones in service today. Every day, some 50,000 calls are made to 9-1-1 and other emergency numbers from wireless phones, and the wireless industry has collaborated with the National Emergency Number Association (NENA), the National Association of State Nine-One-One Administrators (NASNA) and the Association of Public Safety Communications Officials (APCO) to ensure that public safety requirements are met.

Undoubtedly, the Washington area Public Safety Answering Points (PSAP) would have received numerous calls within seconds of the Air Florida crash onto the Fourteenth Street Bridge. The numerous calls would have provided Public Safety officials with a much more refined picture of the situation at hand, perhaps allowing for more efficient deployment of personnel and equipment. Unfortunately, as the report states, "most witnesses were in their cars and unable to report the incident since cellular telephone service hadn't been implemented yet."

#### b) **Inadequately Informed Responders**

As outlined above, commuters and other eyewitnesses using wireless phones would have proven to be a valuable source of information about the accident site, enabling better information to reach the various response teams.

### **c) Telephone Overload**

Although wireless phones depend upon the underlying wired telephone network, their facilities do not necessarily overlap. Congestion on the telephone network may have been bypassed by wireless telephone systems. Many calls that were blocked owing to overload in the serving central office would have been successfully completed on a wireless system. It must be recognized, however, that cell sites themselves can easily become overloaded immediately following an unusual event. In fact, there are generally fewer possible cross-connect paths in the cell site itself than there are in the wireline system.

### **d) Manual Patching**

The requirement for command personnel from different response teams to speak with one another could have been handled with the use of wireless telephones, thus freeing the scarce radio channels for tactical applications. This assumes that the caller could call into a facility which had conferencing or call forwarding capabilities. It must be recognized that although possible, these connections take time to establish.

### **e) Hospital Communications**

Emergency medical teams could have utilized wireless telephones to place telephone calls to emergency rooms of hospitals, thereby communicating the number and condition of incoming victims to aid in their rapid treatment.

In general, wireless telephones would have been an asset in facilitating command and control communications between the twenty participating agencies. By using wireless telephones for those functions which could be handled in the point-to-point mode inherent to wireless telephony, scarce radio channels would have been freed up for use in the tactical working groups. Also, the spectrum-inefficient patching (which ties up two or three channels to sustain one conversation between incompatible radio systems) could have been greatly reduced or eliminated by the use of wireless telephones.

Wireless telephone systems, especially mature ones, have tremendous capacity. As the report noted, "as response builds and tactical teams deployed, the current designated mutual aid channels quickly become overloaded. As this occurs, the functions suited to a telephone environment but which also require portability, could be offloaded to wireless telephony systems, again preserving scarce channels for tactical demands. The already-robust capacity of commercial wireless systems might be further enhanced by the deployment of a priority access capability, which would create a hierarchy of access granting priority to the public safety community.

### Cellular Data

This report has focused solely on the voice capabilities provided through wireless telephone service providers, but numerous data transport capabilities currently exist that

would have been of use in the Air Florida disaster.

At its simplest level, the cellular telephone provides data transport capability just like any other telephone circuit. Thus, essentially any facsimile or circuit-switched data application capable of operating over a wireline phone circuit can operate via a cellular phone. Had portable facsimile machines been available in 1982, they could have been used to fax site sketches to various responding agencies through cellular telephones, enabling considerable refinement in the deployment of personnel and rescue equipment. Similarly, digital cameras, unavailable at the time, could connect to a laptop in the field to transmit photographs of the scene for analysis at remote locations. And, the broadcast capabilities inherent in email networks could have been easily accessed via a keyboard or laptop linked to a LAN via a cellular dial-up connection. Again, less time-critical information could have been transmitted via wireless telephones to preserve the scarce tactical communications capacity. It must be recognized that these messages generally take longer than most public safety voice messages, and while underway they lessen the cell sites' ability to handle more intermittent voice traffic.

In addition to the circuit-switched capabilities consistent with the capabilities of wireline telephones, wireless services also offer packet-switched capabilities. The Cellular Digital Packet Data (CDPD) protocol offers the potential of integration seamlessly with the TC/PIP protocols in universal use, allowing full data interoperation. Coupled to a Global Positioning System (GPS) receiver, such CDPD modems would enable automatic position reporting of vehicles and other rescue equipment which would have assisted in more efficient deployment. At the time of this report, CDPD is in its infancy in deployment and its full capabilities have yet to be tested.

### **12.9.3.2 Major event preparation**

#### **12.9.3.2.1 Overview**

The upcoming Summer Olympics in Atlanta, Georgia will use non-traditional wireless services for public safety. Arrangements include the use of radios, cellular phones and pagers.

#### **12.9.3.2.2 Private network support**

Law enforcement supervisors will be outfitted with private radios. However, 1700 law enforcement officials will be outfitted with text pagers operational on a private, Georgia statewide network. The infrastructure includes 68 transmitters around the State. The six Atlanta-based transmitters will include redundancy at each location. An additional fourteen transmitters will have redundant backup. Multiple commercial lines will run to the inter-exchange carriers. The central operating center which houses store-and-forward messages, will have "hot" standby capability.

Computer terminals and dumb terminals will allow command posts and designated centers to send individual or group pages.

Alpha paging was selected as an alternative to radio dispatch for several reasons:

1) Private radio was determined to be too difficult to operate in high noise level operations. There was a concern that instructions would be difficult to hear.

2) Instructions would be printed out on the LCD screen of the alpha-numeric pagers, so there would be no need for the recipient to call in, to have the instructions repeated.

3) Most of the information transmitted will not require a response. It will primarily direct the activities of groups of officers.

#### Commercial wireless services

Additionally, 2500 commercial pagers on a single frequency, are anticipated to be distributed for operations by the Olympic Committee. They will be used by the Committee to communicate with ushers, guides and couriers. VIPs will be offered a commercial package that includes a digital cellular phone.

Fifteen thousand reporters will be offered packages to include a choice of devices supported either by SMR or cellular. Event results will be broadcast via wireless e-mail to laptops.

#### Intelligent Transportation System demonstration:

The Federal Highway Administration has a Traveler Information Showcase package called Project Peachtree that will allow VIPs to receive a palmtop device loaded with a memory card containing digital maps and yellow pages information, and a two-way pager. Turn-by-turn route instructions, as well as traffic updates, can be obtained automatically by sending a page which will access the TIS's main data server in Atlanta. The response will be sent back to the recipient through the two-way paging network. Visitors don't have to disturb law enforcement personnel for directions, allowing them to focus on public safety activities.

#### Recommended Study

When the Olympics are over, it may be interesting to study what impact the preplanning process for wireless communications had on the success of the event, and what changes, if any would be made for future events.

### **12.9.3.3 Commercial Wireless Service Applications in the Public Safety Environment**

#### Current uses in Public Safety

According to an article in Communications, August 1994, entitled, 1994 Public Safety Profile, Radios, pagers, and mobile data terminals and laptops are out there in abundance. If you were to compile a profile of the "average" professional, his/her agency has the following

in the field: 304 mobile two-way radios; 293 handheld two-way radios; 260 pagers; 209 dedicated mobile data terminals; 12 laptops; 34 cellular phones and three AVL units...Fully 57 percent of the respondents say that there are no repairs done in-house.

### Services Used by Federal Agencies

#### Satellite

Currently satellite technology is used primarily for incident communications in remote areas of the country where private radio or cellular infrastructure does not exist. It is also used where emergency communications are needed while fighting wildfires to remote fire camps. Satellite based GPS is used for vehicle tracking on prisoner transport buses traveling through remote locations. Several federal agencies carry mobile satellite terminals for wireline backup and wireless communication in the event of a catastrophic system failure. Satellite terminals are also used for secure voice, fax and data communications, telephony, facsimile hard copy data transfer, data file transfer, position reporting and high speed data, supporting imagery and mapping. Video teleconferencing supports teletraining and telemedicine applications. A recently introduced satellite provider has placed 500 satellite radiotelephones into the public safety market during its early months of commercial service. These are used for law enforcement, disaster response, emergency medical services, forestry support and regular operational communications.

#### Paging

Paging is thought to be a way to achieve limited low cost interoperability between federal, state and local law enforcement agencies. It is commonly used throughout the federal government. When immediate notification of key personnel is required local or nationwide paging services are often used. Some agencies travel with portable paging transmitters to use in remote locations. Newly introduced two-way paging services are used for the message store-and-forward capability, so that when personnel leave a coverage area and return, they still receive their messages. Agencies also use the two-way services to receive confirmation that a recipients have received their messages. Paging is an effective alerting tool, but it may not be appropriate in time critical or mission critical applications.

#### Cellular

Cellular communications is used to achieve interoperable voice communications between federal agencies, and to facilitate coordination efforts, or arrange logistics with state and local agencies. Cellular is a unit-to-unit system and does not currently support broadcast requirements unless some system related conference calling capability is available. Cellular services supplement the Federal Government privately owned land mobile radio systems where there is a need for nation-wide wireless voice communications. Cellular services are also used for criminal investigations, covert operations, logistics, interoperability between jurisdictions and task force operations involving several disciplines. Additionally, they are used by protective support agents for the President and Heads of State.

Services used by State and Local Agencies

Cellular

a) The Governor's Office of Emergency Services for the State of California indicated that over 4,000 cellular phones were used during the Northridge Earthquake. The Agency itself uses 450 cellular phones.

b) Bergen County Police in New Jersey are trialing CDPD with the use of Mobile Data Terminals.

c) The Virginia Department of State Police uses 175 cellular telephones for voice transmission.

d) California State freeway call boxes use cellular phones. The California State Highway Patrol has responded to numerous callers.

e) The California State Highway Patrol uses some cellular phones.

f) The New York State Police use cellular telephones for Hazardous Material situations, certain investigative and coordinated arrest activities, and other administrative activities. Cellular telephone service is usable along the major arteries in population centers. They use cellular telephones for time critical communication and where coordination in a flexible environment is an essential requirement.

g) Cellular is the back-up system to the traditional public safety dispatch radio and MDT trunked 800 Mhz frequency in the city of Plano, Texas.

h) Groton, Connecticut Police Department uses CDPD with mobile data computers for messaging and to query the National Crime Information Center run by the FBI and motor vehicle bureaus throughout the country. Public safety officials can wirelessly exchange forms or messages from their vehicles or desktops within seconds. Previously, if an officer needed certain information, he/she had to call into the dispatch operation to get someone to pull the data and they relay it verbally. This was a slow process and discouraged people from asking for what they needed. (Ref. ISCWG9025)

i) The Alexandria, Virginia Police Department is evaluating the use of laptop/notebook computers in conjunction with CDPD to request tag checks, wants and warrants from the cruiser.

j) The Mesa Arizona Police Department has eight mobile computers operating over a cellular network which provides integrated voice, circuit switched data, and CDPD transmissions. Mesa's utilization is to access Mesa data applications other than criminal history files. Mesa also uses 325 units in their own data system which do not support criminal history inquiries.

k) Jefferson Borough, PA, uses mobile computers operating over a cellular network, paying a flat fee to a cellular provider for unlimited usage.

l) The Philadelphia Police Department has plans to install 70 laptop computers into Philadelphia Police vehicles to give officers access to reliable, timely information before they approach a vehicle, house or suspect, allowing them to accurately assess potentially dangerous situations. The software allows officers to connect to national, state, and federal data bases, police computer, the National Crime Information Computer (NCIC) and the Bureau of Motor Vehicles.

The Philadelphia Police Department may eventually equip more than 1000 vehicles with CDPD capabilities.

m) The California Department of Forestry and Fire Protection has cellular phones installed in all of their Chief Officer command vehicles statewide. The Majority of their Command Centers have access to one, in case of a catastrophic in-house telephone system failure.

#### Paging

a) The Governor's Office of Emergency Services for the State of California uses a total of 768 pagers, 237 of those classified as numeric, with the remaining 531, classified as text pagers (or alpha-numeric).

b) Bergen County Police in New Jersey use alphanumeric paging to dispatch weather information to emergency management coordinators in the County's seven municipalities.

c) The Virginia Department of State Police uses 500 numeric pagers.

d) The California State Highway Patrol uses many leased pagers.

e) The California Department of Forestry and Fire Protection maintains hundreds of pagers-including alphanumeric-throughout the state of California. The pager are of two configurations...in the radio frequency spectrum for alerting personnel of an emergency incident, and secondly, pagers using commercial vendor telephone systems for administrative type messages.

#### Satellite

a) The Governor's Office of Emergency Services for the State of California has 8 INMARSAT transportable terminals. They use OASIS Hughes Satellite Systems with 2 major hub terminals, 60 earth stations and 5 trailer mounted stations.

b) Bergen County Police in New Jersey use fixed satellite services for weather information and flood gauge information.

c) The Virginia State Police are planning to purchase three mobile satellite terminals for emergency backup communications.

d) The California State Highway Patrol has two satellite telephones.

e) The California Department of Forestry maintains five mobile communications units statewide. These units, capable of stand-alone operation, have satellite systems on-board, along with the full array of equipment necessary to communicate with the multitude of resource normally assigned to "all risk", multi-agency incidents in the State. They are also purchasing units packaged in suitcases for use in remote locations, or outside cell site areas.

#### Specialized Mobile Radio (SMR)

a) The Virginia Department of State Police has begun a mobile data project where 50 patrol cars will be initially equipped with mobile computer terminals. Since state-wide coverage is required, radio transmissions will be through several wireless service providers. The network will be expanded to 350 vehicles after the initial deployment.

b) The California State Highway Patrol is using leased services for data transmission in several parts of the State with significant expansion planned.

### **12.9.3.4 Examples of current public safety applications**

#### Portable Systems

a) Satellites

Public safety agencies can now obtain and store in secure locations small aperture satellite terminals which operate under standby agreements with the various carriers. These small terminals can be man-carried in two or three suitcases, and will operate on batteries long enough to establish permanent power. It is necessary to obtain at least two terminals. When a storm or other occurrence eliminates a microwave tower or terminal, the portable SAT is deployed to the terminal and the far side of the breach. This provides a link via the satellite between the isolated point and the surviving connection to the system. A California Emergency Satellite Communications System proposal is now being reviewed by a task force representing a number of State of California agencies including the Highway Patrol and Department of Motor Vehicles<sup>16</sup>. These units are effective in administration and logistical uses. They may not be appropriate for tactical types of operations.

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<sup>16</sup> ref.1, APCO Bulletin article, Applications for VSAT Satellite Systems in Emergency Management, March 89

b) Paging

Some paging providers have developed portable transmitter systems that can be deployed for emergencies where there has been a disruption of normal service. The transmitters are stored in hard cases on wheels, packaged as “shippable” containers. Portable transmitters have been used extensively during cleanup efforts following floods, hurricanes, disasters relating to marine spills and remote investigation work.

c) Cellular

Some cellular companies offer portable cell sites on wheels (COWs). When Hurricane Opal hit Panama City, Florida, COWs were rolled in to assist with the recovery efforts.

Disaster Recovery

a) Special Mobile Radio

After the Northridge earthquake the Red Cross, Federal Emergency Management Agency (FEMA), California Office of Emergency Services and the Los Angeles County Emergency Operations Center received 82 mobile dispatch special mobile radio units to assist workers in establishing a communications pipeline to coordinate the Red Cross’ efforts with other disaster relief teams in 18 cities. The devices were mobile units and multi-service digital terminals that gave agencies the ability to coordinate efforts through digital cellular text messaging and digital dispatch capabilities. They contained features including Private Network Dispatch, which allowed each agency to establish individual or group communications to link relief efforts to specific areas, and it guaranteed message delivery, giving the Red Cross and other agencies instant access to each other while using only a limited band on congested airwaves. Each disaster team was able to monitor each other’s needs over a wide coverage area. Volunteers used the handsets to coordinate activities required to serve nearly 300,000 meals and deliver supplies including toothbrushes and blankets for more than 15,000 displaced residents.

b) Cellular

During the Georgia Floods of 1995, the American Red Cross used cellular phones for their tri-state relief operation. It allowed agency representatives to get vital information about needs in the field to headquarters and warehouses so assistance could quickly be dispatched to those in need.

A tornado struck Albany, Georgia, injuring 36 persons and causing substantial property damage in the Fall of 1995. Disaster recovery agencies including the City of Albany and the Dougherty County disaster Relief Team used cellular phones which allowed officers at the command center to communicate with officers on the streets in a timely manner.

### Back-up

With only four telephone company central offices (COs) in Plano, Texas public safety officials must prepare for any possible disruption to phone service. Should one or more of the COs be damaged and cease operations, cellular communications allows public safety officials to remain in contact with hospitals and utility companies.

A large shopping mall in Plano, Texas served as the catalyst for a new ordinance requiring builders to include a conduit system for wireless communications microcell systems. Because the mall is built on the side of a hill with parts of the structure underground, police and fire department personnel have had emergency radio contact with the dispatch center prematurely terminated, or have found traditional dispatch communications unavailable. When radio communications fail, the only available communications source is telephone communications, usually involving cellular phones.

### Reports/tickets

#### a) Incident Reports

Officers will utilize a CDPD system to enter incident reports from the scene via mobile terminals currently being tested by the Alexandria, Virginia Police Department.

#### b) Parking Tickets

Parking meter attendants carry a portable wireless terminal to write tickets, and send the information back to the office. This application could be supported on most commercial wireless data systems.

#### c) Community Policing

Some local law enforcement agencies provide a cellular telephone to their officers involved in community policing. Community residents are given the cellular telephone number to report suspicious activities or provide information. Community residents are encouraged to direct all non-emergency calls directly to the community policing officer by calling the cellular telephone number. This reinforces the bond between the community policing officer and the community. It also off-loads dispatch traffic since the officer is, in effect, dispatched by the citizen who is directly calling for service via cellular, as opposed to the radio dispatcher via the PLMR system.

### Call Boxes

Call boxes containing telephones are often placed along freeways and on campuses to provide a measure of safety for the general public and a means to call for help. Today, cellular service is primarily used for these connections. Satellite, PCS, SMR or paging could also be used for this application. An interactive voice response

message could direct callers to page for specific help, or provide an option to go directly to a live dispatcher.

### Status updates

Two-way paging devices can allow public safety representatives to send one or more canned messages to a dispatcher, or other personnel monitoring the activities associated with a specific incident. Those messages could include officer status information (in-service, at-the-scene, out-of-the vehicle, etc.), or sensitive information that should not be scannable by the public or overhead by the public within ear-shot of a public safety radio speaker. A data log containing date/time stamps with each transmission make incident report writing much easier and more accurate.

### Portable Telemetry

#### a) Vital signs

Emergency Medical Service workers use telemetry to provide patients' vital signs to destination hospitals. Some agencies are experimenting with using CDPD to send this information to free-up PLMR channels. The traffic load fill-in characteristic of CDPD makes it cost effective. However, in some EMS management regions primary use of cellular telephone service for the transmission of biomedical telemetry is not authorized because the availability and continuity of such transmissions cannot be ensured.

#### b) Equipment Monitoring

Software can be written to monitor vehicle engine performance, and when necessary, transmit a wireless message to a dispatcher or maintenance shop personnel to call the vehicle in for repair. Messages can be sent via CDPD, two-way paging, satellite, PCS or SMR.

### Fixed Telemetry

#### a) Emergency weather information

Satellites are used to relay, from fixed monitoring points, information on weather conditions, flood level conditions, etc. to keep tabs on emergency weather information.

#### b) Security

Commercial wireless data services are used for remote monitoring of building doors, alarm systems. Messages can be sent via paging, satellites, PCS or cellular CDPD.

c) Highway signs

Portable message signs can be set up along the side of highways to advise the public of hazards and/or road closures ahead. As conditions change the message signs can be updated without need for actually driving to the sign and manually changing the message. Most commercial wireless data services could support transmission of those messages in conjunction with an integrated software application.

d) Vehicle monitoring

Fixed points are established gather information and relay wireless messages regarding truck weight and motion. This enables the highway patrol to detect illegal trucks from 5 miles distance. Software integration with most commercial wireless vendors is required to support this application.

Distress alerting

a) Security personnel

Security personnel can carry a two-way pager to send a canned message to the local police and/or fire department to report an incident, and send location information.

b) Global Positioning Systems

Automatic Vehicle Location (AVL) is used to determine longitude, latitude. A Mayday system which is planned for the consumer market in automobiles they purchase, will activate during an emergency (possibly via expansion of airbags) to automatically signal an emergency dispatcher with location information. Field trials are currently being conducted. Commercial satellite and paging services are being used to transmit emergency alerts. Where traditional GPS accuracy is not sufficient, differential GPS corrections are available via commercial satellites.

Remote Control

a) Canine Units

Most commercial wireless data technologies can be integrated with software containing control commands. Messages can be transmitted across most networks that would, for example, automatically open a patrol car door for canine units to release dogs if the officer were away from the auto and immediate danger was impending.

b) Traffic light control

A command could be sent to activate traffic signal pre-emption during emergencies or pursuits. Authorized agencies could change upcoming traffic lights from red to green to facilitate the pursuit.

#### Air Surveillance

Voice and data messages can be transmitted from aircraft to ground dispatch or command personnel via satellite. Terrestrial based systems would not be able to provide consistent coverage across remote locations and certain terrain. At the present time, virtually all state and local government air-to-ground communications for agency tactical operations is handled on agency owned operations systems along with the rest of the agency's field traffic.

#### Database queries

Public safety personnel already have the ability to send queries to the National Crime Information Center, Department of Motor Vehicles and hazardous materials (HAZMAT) databases, via mobile data terminals on CDPD and SMR networks databases. Many are able to access other federal, state or local databases as well. These inquiries offer a direct connection without human intervention, or transmission over private radio spectrum. Security of criminal history information may be subject to state and federal law which could limit their applicability within commercial networks.

#### Alert Notification

Databases can be configured to perform an automatic outdial to one or many public safety individuals carrying pagers. Computer-based first notification applications could alert public safety personnel at home via pagers, should an impending event, like a tornado, hurricane or other type of occurrence require their response.

#### Group calls

Satellite technology permits up to 16 talk groups per handset as well as establishment and reconfiguration over the radio channel within a few minutes with no local operator intervention. SMR supports dynamic regrouping. Paging technology permits group messaging.

#### Personal productivity

Cellular phones and pagers have are now often used by management level public safety representatives to provide them with the freedom to be out in the field close to their team and the community while retaining the ability to handle communications that would otherwise keep them in their office.

### 12.9.3.5 Examples of future public safety applications

#### Remote control

Remote control sensors could monitor vehicle direction and speed via intelligent software, and could send a commercial wireless message enabling a collision over-ride command, to force a vehicle to stop or slow down when in immediate danger of impact. Additionally police could stop a fleeing vehicle via circuit board melt down, or disabling the engine in some manner. Responses could be transmitted to police officers on their wireless data inquiries containing a vehicle's identification number, license number and (with GPS) the current location of a stolen vehicle. Consumer automobiles would need to come equipped with the appropriate hardware and software to make these types of applications possible.

#### Early warning

The first step in mitigating the effects of a disaster is to warn those who are most at risk. Towns isolated by difficult terrain from main population centers are particularly vulnerable. If the normal communication lines are disrupted, there is no way of informing the community of the impending danger or advising them on how to prepare. A Low Earth Orbit (LEO) satellite system will not be tied to terrestrial interfaces. Therefore handset that are in the affected area will be able to receive the information needed to adequately prepare and save lives and property. An example would be to have an emergency LEO based handset at a local health clinic.

#### Assistance and relief

Typically there is a two to three day lag between the arrival of relief teams in response to a disaster, and establishment of a communications network to assist. During that period of time, before an emergency high frequency communications network is established, satellite handsets can be used in field operations. Even after an emergency communications network is erected, satellite handsets will allow relief workers to roam beyond the footprint of the high frequency network, and into areas where there is no available infrastructure.

#### Distress alerting

*...consider a police officer stopping a motorist in a remote area. He advises his dispatcher via voice that he is on county road X, and is stopping a motorist with a broken tail light. He then leaves his car and proceeds toward the motorist. He then notices a weapon being pointed at him. The officer ducks behind his car and pushes the emergency button on the... (satellite) terminal his belt (10 oz.) as he draws his weapon. The system automatically sends a preprogrammed alerting message and the precise location of the scene to the dispatcher. The dispatcher acknowledges and sends backup, the message received light illuminates on the officer's terminal, confirming to him*

*that help is on the way precisely to his location, **without a word being spoken.** Dramatic, yes, but in routine use a much more common situation might be one wherein a single channel is overcome with congestion due to a relatively minor traffic mishap or interference and contact with a needed officer cannot be established. Dispatch simply types a quick message: Proceed to 5th and Main St. Assist MD St. Pol. Unit. His address is MSP-I-12. Not only does the message tell the officer where to go and what to do, but provides him with the ability to use his terminal to be interoperable with the unit he is going to assist. The officer acknowledges the message without saying a word or struggling with a congested channel<sup>17</sup>.*

## **12.9.4 Commercial Interoperability**

### **12.9.4.1 Current interoperability**

Public Safety agencies have the ability to tap a goldmine of resources that are currently available in the private sector. It should be recognized that these commercial solutions have typically been between two units, and have not supported immediate broadcast to multiple units, although a number of providers are developing technologies and procedures to address this capability.

#### a) Multi-frequency communications in an ECOMM situation

Today there is a Mutual Aid Plan (MAP) that provides an Incident Command Structure (ISC) for its responding agencies. Although the ISC provides a plan for Command and Control, implementation to the fullest extent remains a challenge due to limited communications capabilities.

Using commercial-off-the-shelf (COTS) products and services, with limited R&D, it is feasible to develop an electronic switching matrix that will have the capability to provide full cross band, multi-mode, secure to unsecure RF communications. This would require cooperation between agencies (local, county, state and federal) and the commercial sector. This system could be developed by a cooperative venture between the commercial and public sectors. This system could also provide cross connects to satellite links, local telephone interconnect and microwave relay stations if necessary. The effort would require planning and communicating with each of the participating agencies and commercial sector companies.

#### b) The use of commercially available multi-format voice & data equipment in the public sector

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<sup>17</sup> pg. 32, of ISCWG9048, Maryland Law Enforcement Telecommunications Interoperability Analysis produced for The Maryland State Police in October 1993.

A fully integrated system can have total interoperability with other agencies without discarding their current voice and data system.

Interoperability is a key issue which needs to be considered by public safety agencies as they plan the integration of new technologies into their existing systems. Digital system integrators have been successful in the commercial sector with the proliferation of client/server applications and the globalization of branch internetworking.

An emerging technology that lends itself well to wired and some wireless system integration is Frame Relay. It is a low delay, high performance system with on-demand bandwidth efficiency. It reduces transmission line costs, reduces equipment costs, provides a multiprotocol encapsulation and a single physical connection to the network. Frame Relay Devices can work with any RF system that would provide a full duplex channel with a low Bit Error Rate (BER). Testing would have to be done to ensure that the RS232 Port (19.2kbs) on LMR equipment would be compatible. Frame Relay devices may not be applicable with the current narrowband LMR wireless environment, but can provide a gateway between current LMR systems and other RF systems as well as to land-based communications command posts.

With frequency allocations at a premium, the commercial sector has been able to use major voice and data compression. A typical voice channel is 64 Kbs. Commercial integrators have produced systems that reduce a single voice channel to 8Kbs with the clarity of a 64Kbs channel. This means an agency could have up to 8 voice channels where they currently have one voice channel, if they have enough bandwidth to support a 64Kbs data rate. LMR channels currently support up to 19.2 Kbs data rate.

In the case of a major catastrophic event, this allows the Public Safety Sector to have eight times the capacity of a standard voice grade circuit, producing a major increase in capabilities. In times of non-emergency communication, the bandwidth requirements can be reduced, producing lower monthly operating costs. FCC rules and frequency allocation changes would be necessary to support the 64 Kbs data rate on LMR channels.

One integrator has been able to multiplex SNA data from mainframe to mainframe, or mainframe to remote controllers and LAN traffic, all on the same circuit. They have developed the capabilities to cross-link simple key systems on one end, and a full-blown PBX with E&M signaling on the other end. Currently, this is not applicable on LMR channels.

They have identified a way to integrate two-way radios into a Frame Relay Multiplexer. This would give the end-user the ability to use their standard key system or PBX on one end and access a two-way radio on the other end of the circuit to communicate with their field staff. This communications can be secure or non-secure depending on the application. The link between locations can be a hard-wired link or an RF link. Currently, they are using 2 Mbs spread spectrum microwave links on a

routine basis. Such links are infrastructure extensions; they can be of support in tactical situations to remote command posts.

Current technology has provided the ability to have a central site with an omnidirectional antenna with 6-8 sites on line, using directional antenna arrays. Each site can have compressed voice, LAN traffic, mission critical data, i.e. SNA & other legacy protocols, fax, one and two-way paging and video conferencing on these circuits. This technology even provides the ability to prioritize delay sensitive traffic. Such links are infrastructure by design. They can be of support in tactical situations to remote command posts, but may have limitations to current mobile and portable communications systems.

Frame Relay is just one of the new emerging technologies that offer high speed multimedia applications with an optimized throughput and response time over lower speed networks. Their applicability in a LMR wireless environment depends upon the availability of suitable bandwidth.

There are currently hundreds of major corporations around the world that are using this technology, and they have incorporated both public and private voice/data networks into their overall telecommunications infrastructure design.

c) Gateway technology for data communications

Gateways consist of computer hardware and software that allow networks to communicate. Internet communications have been conducted via gateway technology from the time it became operational. Communication via the Internet is achieved across thousands of disparate networks located throughout the world.

Many commercial wireless vendors conduct data transmission via the Internet today. Paging vendors allow pages to be sent to recipients off of a homepage. E-mail transmissions using special mobile radio are conducted through the Internet.

The same techniques used to connect computer networks, can be used to allow wireless data vendors to send messages back and forth. In the same way, client computers can vary on a network (i.e. different brands, different functionality's, etc.), mobile receiving devices supported by different wireless vendors can differ. For example, a mobile data terminal supported on a CDPD network today, could send a text message originating in e-mail on the terminal, to one or more individuals carrying one-way or two-way alphanumeric pagers. In addition, a two-way pager allows a recipient to send a reply back to the originator through his/her remote e-mail on the mobile data terminal. The same holds true for satellite terminals, and SMR networks.

Working Group #9 distributed a capabilities guideline to multiple vendors to determine what levels of interoperability between commercial vendors may exist based on gateway technology. Responses came in from the satellite, PCS, SMR and paging industries. The results indicate that a level of interoperability could be achieved today

across satellite, SMR and paging networks based on their support of the Transmission Control Protocol/Internet Protocol (TCP/IP). Each also support the X.25 wide area network communication standard which allow connectivity provided that network protocols are supported.

If public safety private radio networks supporting digital, (or adapted to transmit analog to digital), can set up a communications server that supports TCP/IP transmission, data messages could be transmitted to commercial wireless networks in the same way that commercial networks achieve connectivity today.

d) Examples of current interoperability

Agencies may use their own local paging providers on an intra or interagency basis. Paging software allows dispatchers to send messages to digital and/or alphanumeric pagers from a single directory and user interface, even though the pagers may reside on multiple networks. As long as dispatchers have the appropriate software on their computers along with the appropriate pager identification numbers listed in their directories, they can send individual or group messages throughout multiple jurisdictions from one or more central locations.

Some providers today offer centralized management of pagers across agencies and/or organizations, even though the pagers operate on multiple networks.

Paging has been interoperating with existing network infrastructures for many years supporting notification applications. Many popular software packages for network management today offer options to allow the software to automatically outdial messages from the network to a commercial paging network, should certain criteria exist. For example, if a computer on the network crashes, the network management software will generate a page to one or more technicians, letting them know that a problem has occurred. Some very sophisticated software packages, will send very specific information to technicians carrying text pagers, indicating the exact location and nature of the problem. Those capabilities can be used today for alert notification of emergency personnel to let them know that a particular event is about to take place (like a tornado), or of a disaster that has already occurred and requires their response.

Interoperability exists between paging and satellite providers today. The paging industry has taken the lead in developing gateways with satellite vendors which will allow data messages to be originated on either provider's network. Messages are then transmitted to other, and delivered to a device supported by the subscriber's vendor. When recipients reply, the reply is again transferred across multiple networks in a manner transparent to users. For example:

Today it would be possible for an enforcement officer to send a message from a remote location along the US border from a satellite terminal to an admissions clerk carrying a pager at the police station in a nearby US town. The message may let

him/her know that a truck load of illegal immigrants will be arriving, the estimated time of arrival, and that they need to be booked. A message may also be sent to the same station asking for additional transportation. Messages can be sent back to the satellite terminal directly from the clerk's two-way pager, through a dispatch operator, or from a PC. Data logs of those transmissions can be printed for reports.

The cellular industry is embracing interoperability agreements between carriers to facilitate nationwide deployment of Cellular Digital Packet Data (CDPD).

Because cellular digital packet data (CDPD) is an open product third party vendors are developing complimentary products for multiple carriers. They include:

- A client-only software solution that allows wireless access to a network LAN
- A PCMCIA card adapter and new wireless modem that accommodates CDPD transmission
- Mail and database connectivity support with major software vendors (ISCWG9027)

The Washington (DC) Metropolitan Police, Alexandria (VA) Police, Virginia State Police, Montgomery County (MD) Police and the Uniformed Division of the Secret Service are all looking at pilot tests to install computer terminals in their cruisers utilizing the CDPD network. It is envisioned that interoperability will be achieved between the above disciplines through the commonality of the CDPD network.

e) Dual-mode devices

This year handheld dual mode satellite and cellular telephones providing voice, fax and data services to and from the PSTN and private networks will become available.(ISCWG9007)

f) Third-party products

Mobile data terminal products

As Commercial Wireless Network Providers rush to launch new services in a highly competitive environment, the ability to focus resources on specialized market segments is somewhat limited.

As new wireless technologies mature, vertical market specialists will develop value added products and services specific to the Public Safety market place.

Third party products that operate on diverse infrastructures, will be key to interoperable communications across commercial networks. Where third party developers support multiple protocols, information exchange between dissimilar networks and devices can be achieved.

Products have already been produced which run on multiple network infrastructures.

An example, is supplier of software and systems for public safety that runs on Cellular Digital Packet Data (CDPD) networks, and a variety of radio networks, including single radio channels, conventional repeaters, and multi-site trunked radio networks. See document ISCWG9053.

The product has been installed in close to 100 sites including Jefferson Borough, Pennsylvania and West Bridgewater, where officers on routine patrol can check for stolen motor vehicles, verify license information, and identify missing and wanted persons. The system will also allow transmission of dispatch information directly to each officer's mobile computer. Exact geographic locations from police cruisers can also be relayed directly to a base unit.

- Each vehicle is equipped with a laptop or "mobile computer" which connects to a wireless network. The department owns the computer hardware and software, but pays a nominal monthly fee to the wireless service provider.
- The Jefferson Borough system relies on an automatic link to the Pennsylvania Criminal Justice Information Network, which in turn is linked to the National Crime Investigation Center (NCIC) and NLETS.
- A Jefferson Borough spokesperson reported that the system, streamlined the flow of critical information, and eliminated redundant tasks". During the first two weeks of operation, the system helped the department identify and capture several wanted persons and recover a number of stolen vehicles.

West Bridgewater police officers, can enter a subject's license plate number in to the computer mounted in the cruiser, and get almost instant feedback on all automobile violations, such as expired licenses, expired automobile insurance, stolen vehicles and outstanding tickets.

- Their system allows access to three different sources for information: The Automobile License and Registry System (ALARS) which accesses registry information, the Law Enforcement Processing System, located at the State Police headquarters, allowing the officers access to outstanding arrest warrants and other information, and the National Crime Information Center (NCIC) for data on all out-of-state vehicles.

- With the new computers, an officer in a cruiser can get a response on the computer screen in 5 - 10 seconds, before he or she gets out of the cruiser.
- A silent dispatch feature allows for silent transmission between cruisers and the base unit at police headquarters, preventing anyone with a police radio from listening in.
- If an officer is driving behind a suspicious vehicle, the license plate is placed in the system, and a "reported stolen" message comes up on the screen, officers would call for help with the silent dispatch feature. Another cruiser or unmarked car would go to the scene and work its way in front of the vehicle. With a police car in front of the subject vehicle, at the appropriate, the lead car stops. This allows both police vehicles to box-in the reportedly stolen vehicle, eliminating a high speed chase and possible injury to officers.

This type of system is beneficial to departments that:

- 1) have a large number of units
- 2) need to patrol a large geographical area
- 3) are unable to dedicate a radio channel to data
- 4) who prefer not to operate their own data system
- 5) need to communicate among several departments within a county, city or town
- 6) need back up communications when normal circuits are interrupted

### Secure calls

A third party vendor has received a "notice of allowance" by the US Patent and Trademark Office for an attachment to portable cellular phones that scrambles users' voices in order to secure call from unwanted monitoring or eavesdropping. The device is an electronic extension system for a portable cellular phone that does not require any modification to the phone for use. It slides between the phone and its battery. It is electronically connected to the phone through a specially designed floating connector that plugs into the peripheral port of the phone. The extension uses electronics that are independent from the phone's speaker and microphone to provide voice capabilities.

### ANI/ALI Integration

Nearly all public safety dispatch centers are equipped to accept 911 emergency calls. In it's basic form, a 911 system captures the calling party's telephone number, and displays it to the dispatcher. In enhanced versions, the telephone number is cross-referenced to an address file and the calling party's street address is also displayed.

Some dispatch centers are equipped with Computer Aided Dispatch (CAD) systems that can take this a step further. CAD systems are typically developed by

third-party vendors. Most of them cross-reference files with other important information such as number of prior disturbances or calls to a location, presence of hazardous materials at the location, etc.

Developers could program CAD software to forward this information to public safety representatives carrying portable devices. The information would arrive in a text message format supported by most commercial wireless data vendors.

g) E-mail support

Popular third-party e-mail vendors have supported messaging across a wide variety of wireless carriers. Today, many wireless carriers will accommodate e-mail data traffic. That means that an e-mail message generated on a remote wireless device could be received by another portable device on a different type of network.

An example would be an e-mail message originated on an SMR network and received on a pager. In a public safety environment, e-mail transmission would be most suitable for non-critical communications, like transmission of reports, notification of meetings, etc.

h) Third-party product information

Public safety organizations such as the Association of Public-safety Communications Officials (APCO), and Public Safety publications such as the Public Safety Product News, make third-party value-added products and services information available to public safety agencies. APCO publishes an annual Communications Buyer's Guide which lists public safety products and suppliers.

i) Internet support

Internet addressing is another way for wireless providers to send messages across disparate networks. As with e-mail, in the public safety environment, Internet messages would be most suitable for non-critical, non-secure communications like notification of meetings, etc.

j) Public Switched Telephone Network (PSTN)

According to a representative from the New York State Police, "So far, access to the PSTN, as a mechanism for interoperability between individual users of different systems and between individual members of a group with no other common system, have been described. In these modes, the common denominator has been the PSTN, where standards already exist to ensure that different systems can communicate with each other".

Satellite, paging, cellular and PCS commercial services interoperate through the public switch.

Satellite, systems have a particular advantage regarding PSTN connectivity when terrestrial systems are stressed. Their access to the PSTN is via a distant gateway station unlikely to be affected by a localized or even wide spread emergency.

#### **12.9.4.2 Future interoperability**

##### a) Planned networks

Interoperability is a key component of emerging Low Earth Orbit technology. When a call is made from the satellite handset, the handset first searches for a local cellular network. If one is found, the phone will function as a normal cellular telephone and the call will be routed along standard cellular paths. If no cellular network is found, the handset becomes a satellite transceiver. It makes contact with one of the satellites which then routes the call through the satellite/gateway constellation. The signal passes from satellite to satellite until the call is sent to the appropriate gateway, nearest to the call's destination, where it is then transferred into the public switched telephone network.

Additionally, LEO representatives now believe it is possible through their relationship with manufacturers to adapt private land mobile radio equipment to interface to LEO networks in addition to cellular. The introduction of those interface services will depend on market demand.

#### **12.9.4.3 Commercial Wireless Interoperability Initiatives**

Not unlike the market forces that are creating wireline interoperability at multiple levels on the Internet, commercial providers portend that market conditions will encourage the same level of interoperability in the wireless world.

To that end, commercial initiatives have begun to focus at minimum, on gateway technology that will allow vendors to transfer short data messages at a basic level of service across disparate networks. Where standards are needed to achieve ubiquitous user interface for emergency services, vendors are voluntarily participating in working groups to explore solutions.

Examples of some of those initiatives would include:

- 1) The Satellite Communications Division of the Telecommunications Industry Association (TIA) to address Communications and Interoperability.

*The Satellite Communications Division of TIA had it's first meeting on January 17, 1996, and was attended by 48 representatives of the satellite industry from over 25 companies and government agencies. A Communications and Interoperability Section was formed.*

*The first meeting of the Communications and Interoperability Section of the Satellite Communications Division was held on March 20. The mission of the group was defined.*

*The mission states:*

*The mission of the Communications & Interoperability Section is to address issues that affect the continued development of the satellite industry. These issues include and are not limited to:*

- (1) Identification of technical issues relevant to Global Communications which need to be investigated for interoperability*
- (2) Investigation of high level hybrid reference models within the context of interoperability*
- (3) Development of detailed contributions and position papers proposing possible solutions for interoperability*
- (4) Modification of existing standards and develop new standards and advocate their adoption in national and international standards bodies*
- (5) Consideration of experiments to test interoperability and validation of the protocols and standards”*

2) The Commercial Mobile Satellite Systems (CMSS) Working Group of the Interagency Committee on Search and Rescue, was created to address how mobile satellite services can support remote area distress alerting and locating, including first response operations support of search and rescue.

*The CMSS Group has representation from all the major mobile satellite communication system suppliers (existing and planned), and most of the government agencies concerned including: DOT (USCG & FAA), DOD (USAF), NOAA (NESDIS), FEMA, DOI (NPS), FCC & NASA.*

*This government-industry task group was formed to review the issues involved in distress alerting and locating using mobile satellite systems. Standard user interfaces, alert routing, common PSTN/PSDN interfaces, priority access and other desirable features are issues explored.*

3) Focus Group IV of the Network Reliability Council was asked to focus on how effectively new technologies, e.g., commercial mobile radio services (CMRS) or cable television, can back-up existing essential communications networks such as 9-1-1. The Focus Group, for purposes of the following report, is referred to as the Essential Communications During Emergencies (ECOMM) Team.

*Early this year, their report was produced, entitled, Network Reliability Council Focus Group IV. Essential Communications During Emergencies Team Report, Findings and Recommendations, dated January 12, 1996.*

*That document stated, It is important to understand how current and future networks that rely upon new technologies, e.g., commercial mobile radio services (CMRS) or cable television, can back-up existing essential communications networks such as 9-1-1. Focus Group IV of the Network Reliability Council (NRC) was asked to focus on how effectively these new services can augment and/or replace essential emergency communications networks that may be unavailable in case of a network outage.*

4) Regional consortia of agencies such as the Washington-Baltimore High Intensity Drug Trafficking Area (HIDTA) and the Local Government Information System (LOGIS) in Minnesota are conducting research of the potential application of commercial wireless to their operations.

### **12.9.5 Commercial Coverage Options**

Often, lack of coverage availability is confused with lack of network reliability. Knowing which commercial service vendors provide coverage throughout the geography users most frequently travel is a major key to the successful use of commercial services. It is also important to understand how network and device characteristics vary. Providers have different strengths and weaknesses depending on the environment.

#### **12.9.5.1 Remote locations**

Terrestrial-based systems are expensive to build and maintain in sparsely populated locations. Unless provisions have been made for portable terrestrial systems to be furnished for specific requirements, a more suitable means of communications is more likely to be satellite. Since satellite communications rely on line-of-site, indoor applications will require other options.

Marine-based and remote disaster relief operations are best served by satellite systems. Wildfires, agricultural, environmental (hazardous spills) and weather related applications require non-terrestrial based systems. Although use of such links have typically been limited to administrative and logistical support, recently introduced technologies and equipment may lend to increased utilization.

Other applications include remote surveillance and border patrol activities.

Small towns often have local cellular, SMR and/or paging vendors that operate within a well-defined footprint around the population center. Public safety providers may find it necessary to understand how well local vendors interoperate with vendors outside of those immediate footprints should an incident occur requiring remote, interjurisdictional or interdisciplinary support.

### **12.9.5.2 Urban locations**

Cellular, PCS, paging and SMR terrestrial infrastructures are more densely concentrated in the heavy population centers around major cities. Generally, carriers in the higher MHz frequency range are more successful with applications requiring in-building penetration, although system design may not be intended for the in-building coverage required for public safety. These services, though generally available above ground, may not be available below ground as in subways and tunnels.

## **12.9.6 Public Safety Issues That Impact the Use of Commercial Wireless Services**

### **12.9.6.1 Planning**

#### Command/Control

Some commercial wireless services could be effectively incorporated into command/control procedures for mutual aid if those procedures are written to include the use of commercial services. Clearly outlined communication protocols based on identified resources would help providers understand their role.

Using commercial-off-the-shelf (COTS) products and services, with limited R&D it is feasible to develop an electronic switching matrix that will have the capability to provide full crossband, multi-code, secure to non-secure RF communications. It would require cooperation between local, county, state and federal agencies and the commercial sector. This system could be developed by a cooperative venture between the commercial and public sector. It could provide cross connects to satellite links, local telephone interconnect and microwave relay stations if necessary. Planning and communicating with each of the participating agencies and commercial sector companies would be essential to the success of such a project.

Today bottlenecks often occur because Public Safety agencies may not identify what commercial wireless communications options exist prior to an actual event. In addition, the application of appropriate wireless communication tools based on protocol, procedure and the environment setting where the event occurred, may not be defined.

The Metropolitan Washington Area Interoperability case study (refer to document #PSWAC/ISC 96-04-024/2 at Appendix C) about the Fourteenth Street Bridge disaster which occurred on January 13, 1982, outlines deficiencies in available wireless communication resources. Additionally, per the study, subsequent efforts to address communication needs via a formal Mutual Aid Plan have still not satisfied requirements. On page 11, MAP participants list communication difficulties they have continued to experience in responding to other disaster situations.

The lack of a clear command/control organization from the onset of an event, makes it difficult for well-intentioned commercial vendors to provide assistance.

On May 11th, 1996, ValueJet flight #592 crashed in the Florida everglades. According to sources called to the scene, 30 hours elapsed before a formal command/control center was established by the National Safety Transportation Board. In the meantime, three quasi-command posts/staging areas were established. They were:

- 1) an EMS staging site/command post at the Opa-Locka airport
- 2) a Dade County police staging site/command post on the Tamiami Trail
- 3) a Dade County fire department staging site/command post on a service road along the L 67 canal

Additionally the FAA established a level of command from the Miami airport.

Apparently media coverage of the disaster varied, depending on which command site they were quoting.

In this particular incident:

- 1) *Were the command posts in communication with one another?*
- 2) *Which command post was taking the lead to provide cross jurisdictional, cross agency wireless communications?*
- 3) *If a commercial wireless provider were willing to offer assistance, who would they contact?*

Under these types of circumstances, the role commercial services can play in mutual aid, joint or task force operations gets lost. In the future, if emergency preparedness plans include the use of commercial services, commercial providers can play key roles in supplementing existing communication capabilities.

Dade County Officials could have incorporated the use of commercial satellite services, or potentially portable PCS, cellular or paging services in a Mutual Aid Plan prior to the crash. That way, rapid deployment of communication terminals, PCS/cellular phones, or paging devices on a single or interoperable commercial frequency(ies) from designated emergency preparedness locations could have helped designated authorities make faster, more collaborative decisions, and establish levels of command quickly. Even with the deployment of a portable cell site, there does need to be a way to connect that cell site from the remote location into the provider's infrastructure, typically a microwave link, or links, will be required.

Wireless data updates to handheld satellite terminals or alpha pagers from a central dispatch point, could have kept media stories straight.

Information about the arrival and location of Salvation Army representatives who provided food and beverage, could have been quickly shared and updated with rescue and staging personnel. According to workers, dehydration was a serious concern for workers. It was difficult to work more than fifteen minutes at a stretch without liquids due to the extreme heat. Although this operation was initially characterized as a rescue operation the designation quickly progressed to a retrieval operation as it became apparent that there were no survivors.

Under those circumstances, life threatening decisions are not eminent, but operations will continue. Commercial wireless services can fulfill a major role in providing alternate communication resources in order to free up existing private radio spectrum for other use.

### ECOMM findings

Network Reliability Council Focus Group IV, Essential Communications During Emergencies Team Report, Findings and Recommendations, dated January 12, 1996.

*The Focus Group, for purposes of their report, is referred to as the Essential Communications During Emergencies (ECOMM) Team.*

*Their report states: The cellular industry handles over 18,000 call daily to 9-1-1. Routing and identification of wireless callers are considered significant problems for emergency service providers.*

#### a) Recommendations included:

1) *CMRS (commercial mobile radio services), and cable television operators should develop, in partnership with the PSAPs (public safety answering points), work plans to support essential communications during emergencies. (pg 3)*

2) *Network service providers, 9-1-1 administrators, and public safety agencies should continually strive to improve communications among themselves. They should routinely team to develop, review and update disaster recovery plans for 9-1-1 disruption contingencies, share information about network and system reliability and determine user preferences for call overflow routing conditions. (pg. 52)*

3) *Contingency plan development is the process of planning for recovery from a disaster that could impact the critical functions of a business operation. In broad terms, disaster recovery planning involves the following elements:*

- Advance planning and arrangements necessary to ensure continuity of critical business functions.
- Making sufficient agreed-upon preparations and designing and implementing a sufficient set of agreed-upon procedures for responding to a disaster event.
- Developing a plan which covers events that could result in the total or partial loss of operational capability or destruction of a physical facility.
- Developing a plan which includes procedures and availability of critical equipment and personnel for both automated and manual functions.

The service provider (i.e., LEC, ATP, or CATV) has the responsibility to ensure continuity of service to the PSAP in the event of a disaster impacting their service delivering networks.

Some alternate technology providers have supplied their critical employees with portable computers, equipped with high speed modems, for them to remotely access switches. Critical employees are expected to work from a location that allows them access to the switches during times of emergencies/disasters.

Most alternate technology providers do not have a formal plan on where employees are to report for work if their primary work place is inaccessible, for whatever reason. Some alternate technology providers have indicated they are investigating this issue and that they intend to develop plans in the future.

PSAP administrators have responsibility for developing a plan to ensure continuity of 9-1-1 service in the event of a disaster which impairs the functionality of a PSAP. In so doing, PSAP administrators must evaluate and plan for response to a range of risks to PSAP functionality, including but not limited to:

- Loss of commercial power
- Physical damage to the PSAP (natural or man-made disasters), including fire, earthquakes, etc. (pg 48)
- System software and hardware failures
- Communications link failures (network redundancy and diversity issues).
- PSAP center evacuation and relocation of personnel.

With the current availability of alternate technologies, PSAP Administrators should more aggressively pursue use of these technologies during wireline network failures. However, it is critical that the alternative providers support and implement Enhanced 9-1-1 features equivalent to wireline ANI and ALI service.

Wireline and wireless network providers should develop response capabilities to meet communications demands during large-scale emergencies/disasters. Plans should include, as a minimum, such topics as mutual aid agreements, NSEP issues, contact lists, and locations of critical equipment. (pg 49)

Steps toward planning commercial service interoperability

The success of commercial services in the public safety market will depend on how well they are assimilated by public safety agencies into application environments. Planning the intended use of commercial services for specific purposes is essential. When a major event occurs without planning, circumstances make it difficult for providers to offer effective service.

In some cases:

- 1) providers may not have plans of their own to support public safety applications
- 2) providers may have plans to support public safety applications that fall short of requirements
- 3) circumstances may have changed a provider's capability to support public safety requirements

Steps that would optimize the use of commercial wireless services in the Public Safety environment would include agency initiated action to:

- 1) identify requirements that lend themselves to commercial provider services
- 2) identify commercial services that may meet some of their requirements
- 3) test potential commercial services prior to an actual event
- 4) stay current on newly introduced technologies
- 5) use (commercial-off-the-shelf) COTS services when it makes sense to keep costs in check
- 6) use providers in applications that capitalize on their strengths
- 7) always have primary and alternate commercial providers in queue when available
- 8) look for providers that have open architectures for interoperability
- 9) make certain providers understand each application's requirements (take them on a field trip)
- 10) develop detailed implementation plans for commercial services

The more agencies provide vendors with clear expectations about when and where they plan to use commercial services, the more likely they will get the information they need to determine whether a vendor can meet their coverage requirements.

A recommendation that addresses planning procedures for interoperability was submitted to Working Group #9 by a Research Firm which specializes in public safety. The recommendation, originally intended for a regional law enforcement effort,

suggests that an interoperability manual be constructed containing critical communications parameters of each of the participating jurisdictions and supporting agencies which may be called upon to support operations conducted by the lead agencies. Please see attachment A.

### **12.9.6.2 Public Safety Awareness of Commercial Wireless Services**

Careful evaluation of commercial wireless services will require agencies to analyze a broad range of issues.

Commercial wireless communications providers have different standard operating procedures (SOPs) from one another. Each vendor's SOPs may reflect different response times, mean-time-between-failure (MTBF) statistics, service and repair procedures including escalation and troubleshooting, relationships with their support vendors, acceptable quality of service and security procedures. As with all products and services (as well as private public safety network providers), some vendors simply do a better job than others in some or all of those areas.

Public safety agencies need to clearly and realistically assess which applications are appropriate for commercial service support, and define the requirements for those applications clearly and realistically to potential vendors.

Distinctions should be made between providers, based on evaluations and pilot tests. Acceptable models and methodologies for comparison should be developed to compare all wireless service offerings, including in-house capabilities for optimal results. Models and methodologies need to be flexible enough to consider requirements for each application individually. Application requirements may differ significantly based on urgency, priority, geography, interoperability, security, immediate environment (on foot, in autos, in buildings, in remote or urban settings, etc.), length of message, need for history logs, etc.

If there are special circumstances that require a customized service not available in the commercial marketplace, agencies should consider the cost of developing and maintaining a custom solution in-house versus the costs associated with managing a third-party relationship for the development and maintenance of the same.

If an agency chooses commercial solutions for some applications, then it is up to the agency to develop the expertise necessary to manage a third party relationship effectively. Skillsets needed for successful program/project management may differ considerably from existing skillsets acquired to manage/operate and in-house network.

Some local agencies are not large enough to have a technical telecommunications staff capable of conducting independent research and technical evaluation. Contract officers who may, or may not have a technical background, look

to vendor representatives as sources of technical information. Acquisitions of systems resulting from this process may not fully consider system performance, ease of integration and scalability.

Studies regarding public safety familiarity with commercial wireless service capabilities and their current role in public safety are not encouraging. According to a study conducted for The Maryland State Police of police departments throughout the country. Although police identified many problems with their telecommunications systems, they were unable to express high levels of knowledge of current and future systems. They were unable to identify sources of knowledge for telecommunications information other than vendors and other police units<sup>18</sup>.

One state-wide research effort of all law enforcement organizations in the state showed less than two percent of the agencies were aware of the impending arrival of numerous space based telecommunications systems. Low levels of knowledge of current and impending technology combined with a tendency to use other public service agencies as a primary source of reliable information on communications systems.

Data bases of commercial firms products, capabilities, limitations, and current customers exist in a few, primarily large, jurisdictions. In some of these, the officers responsible for the development of requirements, requests for proposals, requests for quotes and the like are denied access to the data base for fear of impropriety or favoritism, the data base being used only by contractual personnel. In other locations where data bases do not exist, and the organizations are not large enough to have a technical telecommunications staff capable of conducting independent research, non-technical officers often resort to vendor representatives with a vested interest or to fellow officers in other organizations (who are also usually not technically qualified) as sources of information. Acquisitions of systems resulting from this process thus tend to be influenced by marketing hype rather than performance in relationship to performance requirements or by performance results in other organizations whose operating environment may not be similar to the acquiring organization.

The initial acceptance of commercial wireless services as a viable alternative to private systems will depend on the context in which they are employed. Recognizing the strengths and limitations of commercial services will be the first step toward applying them to achieve the most effective results.

Efforts to increase public safety awareness of commercial wireless services could conceivably include a variety of approaches. One such approach has proven effective in an industry that has experienced comparable challenges.

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<sup>18</sup> pg 23 , Maryland Law Enforcement Telecommunications Interoperability Analysis, Focused Research, Oct. 93.

The health care industry has experienced paradigm shifts similar to public safety communications. The consolidation of private healthcare providers into a managed care environment in some ways parallels the move towards national interoperability in public safety communications. In both cases, a lack of resource and solidarity has resulted in serious introspection of business as usual, and intense exploration of alternative approaches.

The healthcare industry is slightly ahead of the public safety communications in experiencing the effects of their consolidation (verses standardization).

As a result, one can find no shortage of industry briefings, seminars, educational forums, etc. geared for every level of professional in the healthcare industry. These symposia are sponsored by healthcare associations, managed healthcare organizations, academia, industry experts, etc. An entire industry has emerged to address the issues associated with the changes in health care. It is still early in the change cycle for public safety communications, but programs are beginning to surface.

Two major Universities, the University of Maryland in College Park, MD and the University of Massachusetts in Lowell, MA are developing unique approaches that address these needs. Maryland's approach is a for credit, multi-disciplinary masters curriculum for law enforcement that includes a technology sequence teamed with small and large business.

Massachusetts is considering a series of continuing education courses for public safety which would include a similar team approach. Teams made up of academic, federal labs, and business would provide intensive insights into the technologies selected for study. Proceedings of these courses could be converted to CD-ROM for retention by those attending.

Undergraduate courses such as the intelligence analysis curriculum at Mercyhurst College in Pennsylvania have the potential of developing research staff for public service organizations which lack a research capability, but nationwide expansion of similar courses would be needed to provide an adequate base in reasonable time.

The next step academia must consider is how to link educational activities to communications goals through practical application.

Academia will attract an audience interested in exploring alternative approaches to wireless communications assessment.

Firms with telecommunications products and services can sponsor forums to meet with public service organizations wherein the public service organization users communicate with TECHNICAL staff of the companies relative to their operational environments.

Federal technology transfer symposia attract public service representatives. However, they are often heavily represented by federal laboratories and participating consultants. In many cases, the concepts presented are quite developmental in nature. With limited financial resources, public safety agencies often choose not to invest in immature technologies unless supported by demonstration grants. Further, systems highlighted as being available for transfer from DoD and other federal research are often cost prohibitive to the small and medium sized organizations that make up the vast majority of the public service community.

Commercial technology expositions and symposia often attract attendance by public service organizations but result in little progress. The current tendency to large trade shows dominated by marketing efforts does not provide the learning environment needed to provide public safety officials with the awareness and background to make adequate decisions. Marketing personnel at trade shows do not always include balanced discussions that address the limitations of their products.

Only if public service organizations, industry, and academia combine their efforts in consortia, partnerships and demonstration projects will the current multi-disciplinary shortfalls be overcome. Manufacturers and Commercial Service Providers desiring to present and field test new products, can demonstrate those products more readily by providing shared financing with the public safety agencies to do so.

#### **12.9.6.3 Commercial Wireless Service Providers' Awareness of Public Safety**

Firms introducing new wireless telecommunication products are often not experienced in marketing to the public service community and may not be aware of the potential application of their products and services to public service.

Firms need encouragement to conduct technical research and development that includes potential application to public service employment of their products. Research programs in both industry and academia could establish industrial internships wherein employees serve in public service organizations to learn the overall environment of specialized organizations.

Most vendors are very concerned about doing the right thing when it comes to public safety. They have been looking to the public safety community for guidance. Vendors are anxious to learn what services they can provide that would prove acceptable in the public safety environment.

#### **12.9.6.4 Third-party firms specializing in commercial wireless and/or public safety communications**

Third party companies offering research, assessment and consulting services with experience in public safety communications are beginning to appear. Third parties are often able to offer an unbiased assessment of current and planned

communications technologies. Some also operate as information brokerage firms using global access to on-line information to support their analyses.

Other information service companies provide subscriptions that can provide agencies with access to information regarding emerging wireless technologies on CD-ROMs. Areas that they claim to address include:

- 1) How wireless communications is defined and ways it can be used.
- 2) Whether commercial wireless networks and wireless data communications are economically feasible. alternatives to building and maintaining networks.
- 3) What products are available for wireless data communications and what technologies are available.
- 4) Vertical applications for wireless computing.
- 5) Comparisons between PDAs and notebook computers.
- 6) The market status of PDAs and pagers.
- 7) Narrowband PCS paging, its technologies, applications, market status and products.
- 8) Applications for wireless telecommunications
- 9) Standards and technologies.
- 10) Cellular technology.
- 11) Selection of wireless service providers.

#### **12.9.6.5 Network Availability/Priority Access**

The need for commercial service providers to support priority access has been recognized as a key issue during the PSWAC process. However, priority access should be considered one component of overall network availability to deliver information. The ability for service providers to deliver information reliably while meeting public safety response time and throughput needs requires end-to-end service and support.

Even if commercial providers comply with priority access practices in order to deliver messages to the public switch, accurate and timely routing and handling of those messages from the switch to the end office is necessary to guarantee successful delivery. Priority designations are lost when communications enter the Public Switched Networks as they are currently configured, unless dedicated lines are provided between gateway stations and public service agencies.

The findings of the Network Reliability Council Focus Group IV, document number ISCWG9047, emphasizes the importance of Public Safety Answering Point (PSAP) wireline backup (pg 41), and hot site back-up contingency plans (pg. 48).

In order to achieve priority throughput, calls through the PSAP, cannot be interrupted by (PSAP) facility incapacity. According to the study, "To accommodate instances where these facilities are interrupted or it becomes necessary to evacuate the PSAP location, some PSAPs have established mobile PSAP systems that may be

connected to phone jacks at the serving end office. The phone jacks, although usually installed inside the end office for security purposes, are typically installed in an accessible location for ease in locating them during an emergency.

Some PSAPs have prearranged with the serving LEC to permit a jurisdictional employee having an emergency vehicle (e.g., police car) equipped with radio capability to retain a key to the LECs end office and to connect to an RJ-11 jack for 9-1-1 call interception. (pg 41)

It may also be possible to bypass wireline outages by using a cellular-to-cellular link within a cell site or through a cellular network infrastructure. The New Jersey State Police uses cellular bypass of failed tandem circuits in their E9-1-1 systems.

Surprisingly, fewer than 50% (of PSAPs) have current plans for what they would do during a network failure. (pg 30)

Separately, commercial priority access compliance loses significance if the commercial network fails to meet reliability criteria. Lack of redundancy can produce weak links even if traffic is carried on a "first-in, first-out" basis. First-in, first-out becomes meaningless should a vital network component go down with no backup.

Some commercial systems are being designed to provide several levels of priority access. Public safety organizations will need to establish procedures for their use. This emphasizes a need for a national focus on operational procedures, standards for systems, training and interoperability.

Priority access procedures have been outlined by marine and aeronautical agencies for satellite services. Cellular service priority access issues are currently being addressed in the Cellular Priority Access Service Subgroup (CPAS) of the Wireless Services Task Force, National Security Telecommunications Advisory Committee.

Details regarding CPAS as outlined by a representative of the CTIA follow:

#### Situation Analysis

*Wireless telephone systems are typically designed to a 0.02 grade of service or better. This means that, during the system's peak busy hour (any one-hour interval during a 24-hour period during which overall call volume is at its highest), callers attempting to place a call over the wireless system have a 2% or less probability of being unable to complete the call due to the unavailability of a radio circuit. A user attempting to call during a period when all channels are busy will receive a reorder tone, more commonly known as the fast busy. By the time the caller re-attempts the calls, the strong probability is that a channel will be available. The traffic engineers for wireless telephone systems strive to strike an optimal and economically-sound balance between average traffic demands and peak traffic demands. The inconve-*

*nience of having to place a call again during times of peak system busy is offset by the lower overall expense associated with using the system.*

*A familiar example will help to illustrate this point. If Interstate 95 were built to handle all vehicular traffic presented on the Wednesday night before Thanksgiving, it would be 14 lanes wide in each direction. During the rest of the year, however, most of the capacity would be idle, representing a waste of the taxpayers' money. Motorists traveling at peak travel times experience delays on the highways, just as callers calling during peak traffic times on wireless systems experience delays.*

*During periods of emergency, traffic on wireless networks increases significantly for a variety of reasons. First, there is diversion of traffic from wireline to wireless systems. In the case of natural disasters such as hurricanes and earthquakes, the wireless systems may continue to operate even though overhead phone lines have been severed. Calls that would otherwise have been placed over the wireline network migrate under these circumstances to the wireless network. Second is a sharp increase in overall calling volume, as citizens affected by the natural disaster call to seek relief, to notify family members, to report emergencies and the like. Third is the increased call volume from the mass media covering the disaster and the corresponding relief efforts. Fourth is the increased use of wireless networks by the public safety agencies engaged in responding to the disaster. These conditions can develop on an area-wide basis, as is the case with hurricanes and earthquakes, or they can develop on highly localized basis as is the case with airplane crashes or train wrecks. When emergencies develop, the sharp increase in call volume taxes the system beyond its capacity, either system-wide in the case of regional disasters or site-specific in the case of localized disasters.*

*The public safety agencies seek to gain priority access to the wireless networks, so that telephone traffic associated with emergency relief efforts can take precedence over all other utilization of the system.*

*It is important to note the distinction between having priority access to a particular network and having assurance of call completion. Wireless carriers control only the access to the wireless portion of a telephone call's path. In times of emergency, a radio channel may be available, only to have the call blocked due to unavailability of long distance circuits or central office facilities. In the simplest analysis, wireless carriers obviously can exert no control over whether a user receives a busy signal because the dialed number is already in use. This same admonition applies to other components of the telephone network as taken in its entirety.*

### Regulatory Issues

*Regulatory and eligibility issues are being addressed at the national level by the National Security Telecommunications Advisory Committee (NSTAC). In partnership with NSTAC, the Office of the Manager, National Communications*

*Commissions System, is seeking the FCC's approval to establish Cellular Priority Access Service (CPAS). CPAS will offer non-preemptive priority queuing cellular service to the nation's emergency responders who have national security or emergency preparedness functions.*

*To invoke CPAS, users must have a bona fide National Security or Emergency Preparedness purpose. Their telecommunications are used to maintain a state of readiness or to respond to and manage any event or crisis which causes or could cause injury or harm to the population, damage to or loss of property, or degrades or threatens the National Security Emergency Preparedness of the United States. The proposal urges the creation of a centralized administration within one Federal Government office, to ensure uniform application of eligibility, procedures and rules and to provide a single point of contact for information and problem resolution.*

*CPAS defines 5 priority levels and supports the activities of both the private and public sectors. A petition for rulemaking was filed with the FCC by the National Communications System on October 19, 1995, recommending that CPAS be a voluntary service offered by the nation's wireless service providers.*

#### Technology Issues

*The technical issues associated with implementing a priority access system appear to be manageable. The architecture of all wireless telephone networks includes a signaling component which operates discretely from the actual service channels. Thus, even when all of a cell site's voice channels are occupied, the signaling channel is still processing requests for channels.*

*Historically, the Advanced Mobile Phone Service (AMPS) specifications identified a field in the Number Assignment Module (NAM) of the subscriber equipment called Access Overload Class (ACCOLC). Valid values for the ACCOLC range from 00 to 15. During provisioning of the subscriber unit, the value entered in the ACCOLC field was typically zero followed by the last digit of the subscriber's telephone number, or more accurately the Mobile Identification Number (MIN). During times of traffic overload, it was originally contemplated that cellular carriers could invoke a rolling "brownout" by denying system access to all ACCOLC values of 00 for, say, ten minutes, then all 01 values for the next ten minutes, and so forth until call attempts fell back within system traffic design limits.*

*This implementation of ACCOLC left available the higher values from 10 through 15 for assignment as priority units. Such an implementation would have permitted cellular operators to deny service to all values of ACCOLC below 09 during extreme conditions. However, no systems in operation today are known to have implemented full Access Overload Class operations.*

*More recently, the cellular industry has defined a service called Priority Access and Channel Assignment (PACA), which allows a subscriber to have priority*

*access to voice or traffic channels on call origination. As described in TIA/EIA SP-3545, this feature permits a subscriber to obtain priority access by queuing eligible subscribers' originating calls when channels are not available. When a channel becomes available, the queued subscriber is served on a first-in-first-out basis.*

*Subscribers are assigned one of n priority levels at subscription time (where n has a minimum of eight and a maximum of fifteen). Priority levels are defined as 1,2,3,...n, with 1 being the highest priority level and n being the lowest priority level.*

*The invocation of PACA is determined by subscription to one of two options: Permanent or Demand.*

*- In the Permanent option the feature is always available and is used automatically whenever the subscriber attempts to originate a call.*

*- In the Demand option the feature is available only on request. The subscriber requests PACA by using a feature code with an origination request. To invoke priority access, callers would enter a string of digits such as \*44. The mobile switching center would recognize the mobile unit as having priority access, and could move the call to the front of the queue. This feature could be modified to offer priority on a per-call basis (requiring the user to enter the feature code on each call for which priority access is desired) or on a set interval basis (which would maintain priority access for a predetermined interval such as 4 hours). This switch-based approach works universally with any subscriber unit.*

### Security

*Implementation of priority access would require security measures to ensure that only authorized agencies can avail themselves of the priority access.*

*During the early development of the cellular industry, programming the NAM required expensive special equipment and considerable technological acumen. All cellular units today, however, can be programmed through the handset of the phone. This creates a security issue in that subscribers not authorized for priority access could nonetheless program their own ACCOLC to the higher values. A feature-code approach would be similarly vulnerable to compromise.*

### Universality

*Disaster relief often brings specialized teams in from distant areas. Any priority access scheme must be nationwide in scope, to ensure that visiting relief agencies are afforded access privileges consistently.*

Type of Priority

*Priority access can take any of several forms. In its simplest configuration, calls held due to system unavailability are placed in a queue. Users with priority access would go to the top of this queue ahead of all other non-priority callers. A more complex scheme would create a hierarchy of access, in which fire and rescue users might have a higher priority, for example, than traffic control personnel. Such priority assignments are discussed above in the Regulatory section. Finally, in extreme cases, a high priority user might cause a low- or no-priority call to be terminated in progress.*

Priority to terrestrial and satellite communications systems may be assured in several ways. Channel priorities may be implemented by techniques ranging from access to the next available channel to preempting existing users. Preemption has practical and public relations difficulties. A critical EKG transmission could be preempted inadvertently by an operator for another emergency.

**12.9.6.6 Spectrum relief**

Public safety agencies are increasingly finding new roles for commercial services which did not previously exist, yet substantially lighten the load for dispatchers, by directing routine traffic to alternate, commercial spectrum. This is achieved by shifting computer inquiries from voice to direct data interface thereby relieving the voice channel loading.

The Alexandria, Virginia Police Department provides a good example of how moving to a commercial data service may relieve an overcrowded voice channel.

According to PSWAC/ISC 96-04-036 notes from a meeting at the Alexandria Police Department Headquarters, a cellular digital packet data system is under current evaluation as part of a pilot test. A CDPD network will be used to support laptop/notebook computers with wireless modems for data transfer. According to the report:

*The Alexandria PD representative stated that the system initially will be used to request tag checks, wants and warrants, which are currently handled on a voice channel through the central dispatcher, who then accesses the data base in Richmond. The Alexandria PD currently operates on one dispatch channel and it routinely becomes overloaded during peak traffic periods. This has created delays of up to fifteen (15) minutes, during some peak periods, to get a routine license check called in to dispatch, and depending on the dispatchers' traffic load, the response back to the officer is significant. Consequently, in some cases the officers do not conduct a query due to the time required to get on the channel. They feel the use of CDPD, will help to minimize both problems, first it is estimated that the voice traffic will be reduced by at least 30%, while reducing the response time of such data queries, and second, the officers will accomplish more queries, which they feel will increase the capability to recover stolen vehicles and apprehend offenders. The response time experienced during the test has been as little as two (2) to three (3)*

*seconds from the time an officer inputs the data until the time he/she receives the response. Realizing as the system is loaded the response time will likely increase, the users are confident that the response time will remain significantly short.*

*If the initial pilot test is successful, the officers will eventually utilize the system to provide incident reports from the scene, which will relieve some of the officers' administrative burden, as well as possibly further reduce voice traffic by as much as another 15-30%*

Groton, Connecticut Police Department uses CDPD with mobile data computers for messaging and to query the National Crime Information Center run by the FBI and motor vehicle bureaus throughout the country. Public safety officials can wirelessly exchange forms or messages from their vehicles or desktops within seconds. Previously, if an officer needed certain information, he/she had to call into the dispatch operation to get someone to pull the data and they relay it verbally. This was a slow process and discouraged people from asking for what they needed. (Ref. ISCWG9025)

The Philadelphia Police Department plans to install 70 laptop computers into Philadelphia Police vehicles to give officers access to reliable, timely information before they approach a vehicle, house or suspect, allowing them to accurately assess potentially dangerous situations. The software allows officers to connect to national, state, and federal data bases, police computer, the National Crime Information Computer (NCIC) and the Bureau of Motor Vehicles.

According to the software vendor, the software package saves precious time by only requiring police officers to make a single entry on their mobile data terminals versus what may now require a number of inquiries through the police dispatcher.

#### **12.9.6.7 Commercial Security**

The Philadelphia Police Department has plans to install 70 laptop computers into Philadelphia Police vehicles to give officers access to reliable, timely information before they approach a vehicle, house or suspect, allowing them to accurately assess potentially dangerous situations.

In addition to saving time, the mobile data terminals will increase the security of police department communications, because data is currently more difficult to monitor. Messages carried by CDPD are "encrypted" or scrambled with a "public" key to increase protection from unauthorized reception. The system is also capable of end-to-end Type 3 (DES) encryption with the addition of encryption devices on all the mobile units.

#### **12.10 Working Group #10 Report (Address Baseline Technology for Interoperability)**

### 12.10.1 Report Scope

This report outlines the activities of Working Group #10 of the Interoperability Subcommittee (ISC), which was formed on February 29, 1996. Although the report addresses the comments and proposals introduced during the working group activities, all the details of the comments and/or recommendations are not reflected. However, all comments submitted are available for review.

### 12.10.2 Background

A proposal to adopt a baseline technology for interoperability was introduced in January, 1996 at the University of California Berkeley during the PSWAC Technology Subcommittee (TSC) meeting. Subsequently, during the same meeting, a proposal was introduced to identify the APCO Project 25 Common Air Interface (CAI) as the “air interface” to provide “unit-to-unit” interoperability. The Vice-chair of the TSC “tabled” both proposals for further consideration and there was little discussion at that time. After some deliberation, the PSWAC Steering Committee considered the subject and tasked the ISC to “address a baseline technology for interoperability”, with the concurrence of the chairs of both the TSC and ISC.

The original proposals, previously introduced in January, were then introduced to the ISC members during the meeting in Orlando, Florida on February 29, 1996. The ISC Chair emphasized that the “tasking” was to “address a baseline technology for interoperability and consider a recommendation which may be that no recommendation be made”. Recognizing that no conclusion would be reached during the meeting, the chair allowed extensive discussion concerning the proposals. However, during the discussions the subcommittee did agree to “address and consider” a Baseline Technology for Interoperability, with no further commitment at the time.

The ISC Chair requested that comments be submitted within two weeks with recommendations. The chair also formed Working Group #10 (WG10) to address and consider a *Baseline Technology for Interoperability*.

### 12.10.3 Task

The Chair of the ISC formed WG10 with instructions to consider and address a baseline technology for interoperability. The working group was tasked to consider the following:

- Should a baseline technology (for interoperability) be recommended?
- If so, what technology or methodology should be considered?
- Should the recommendation be mandatory?

#### **12.10.4 Working Group Members**

The ISC Chair solicited volunteers to participate in the working group and thirty-two (32) people, six (6) representing the manufacturing community and commercial service providers and twenty-six (26) from the user community. A chairperson was appointed (by the ISC Chair) from the list of volunteers.

#### **12.10.5 Comments/Discussion**

During the discussion that ensued during the Orlando meeting, it became somewhat clear that there was some confusion between what was meant by the word “technology”, as opposed to the word “standard”. The ISC Chair stated that it was outside the scope of the subcommittee to consider or recommend a “standard” and the discussion should focus on basic technology, such as wideband (25 kHz channel bandwidth) analog FM<sup>19</sup>, narrowband (12.5 kHz or other bandwidth) analog, or narrowband digital.

In addition to the three recommendations introduced in Orlando, during the ISC meeting, there were eleven additional comments/recommendations provided, two were from manufacturing representatives, one from a commercial services provider and the remaining eight from the user community. The two responses from the manufacturers’ representatives were in basic agreement that the baseline technology should be analog FM.

All respondents, representing the user community, agreed that analog FM technology be adopted as the baseline technology for interoperability, and after discussion, all agreed that the immediate technology should also be 25 kHz channel bandwidth, because that is all that exists in commonality today. However, the users expressed a desire that the baseline specify a narrowband (12.5 kHz channel bandwidth) analog FM technology as equipment migrates to narrowband operation in accordance with the NTIA mandate, for the federal users, and the FCC Re-farming Report and Order.

Most commenters agreed that the recommended baseline should be a mandatory requirement, but there was no clear choice on how the requirement should be enforced.

#### **12.10.6 Recommendation**

A conference call, for all members of Working Group #10, was conducted on April 4, 1996. The conference call was announced to all WG members, via facsimile, on March 29, 1996.

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<sup>19</sup> One working group member pointed out that FM (frequency modulation) is a “defacto standard”. While there is no “numbered” standard for FM, it is codified in FCC Rules and Regulation and NTIA requirements, as well as IEEE and TIA publications.

Thirteen, of the thirty-two members, participated in the conference call. The eleven written comments, which were previously distributed, were discussed and a number of recommendations were introduced.

The participating members of WG10 unanimously adopted the following recommendation to be submitted to the full subcommittee for consideration:

*It is the recommendation of the Interoperability Subcommittee that the minimum "Baseline Technology for Interoperability", for unit-to-unit voice communication, be 16K0F3E (analog FM), unless Federal Communications Commission (FCC) and/or National Telecommunications and Information Administration (NTIA) regulations stipulate a different emission in a specific operational band. This mandatory requirement should be adopted as soon as possible by the FCC and NTIA. This recommendation is applicable public safety spectrum between 30 MHz and 869 MHz.*

*Effective January 1, 2005, the minimum "Baseline Technology for Interoperability", for unit-to-unit voice communication, should be mandated as 11K25F3E (analog FM) in public safety spectrum between 30 MHz and 512 MHz, unless FCC and/or NTIA regulations stipulate a different emission in a specific operational band.*

*The maximum allowable interoperability bandwidth in any new spectrum allocation should not be allowed to exceed the bandwidth established for operational communications within that new spectrum.*

It should be noted that the above recommendation was modified during the full ISC meeting on April 12, 1996, in San Diego.

#### **12.10.7 Dismissal of Working Group**

Upon the revision and unanimous adoption of the recommendation by the working group, the ISC Chair thanked the members for their timely effort and dismissed Working Group #10 from further activity.

## APPENDIX A

### Interoperability Link Implementation Option Matrices

#### A-1 Interoperability Implementation Options

1.1 The following general abbreviations and structure are used in this Appendix:

1.1.1 *The “General Govt” category pertains to those important general governmental operations of local, state and federal agencies (general administration, hazardous materials management, mass transportation, public works, school bus safety, etc) which are eligible under the accepted definition of public safety, but which do not fall into one of the other established service categories.*

1.1.2 *Those function of general government, forestry conservation and highway maintenance which would make them eligible to use criminal justice, EMS or fire frequencies for their daily operations (eg: the fire suppression functions of state forestry agencies) also make these agencies eligible to use corresponding interoperability frequencies defined in this Appendix.*

1.1.3 Each use is designated by a number and a letter (1R, for example). The number represents the quantity of links required for this specific application. The letter is either “R” for repeated links, or “S” for simplex links. Note that each “R” link requires 2 separate talk paths (eg: a “4R” designation requires 8 talk paths).

1.1.4 With the exception of the 806-824 MHz band which has no service-dependent designations for any frequencies, the designation of a link under a specific category generally means that the link is being recommended to be provided from frequencies assigned to that service.

1.1.5 Footnotes are listed for each use which show where it is recommended that currently assigned frequencies be used to meet the requirement. If the requirement can be fully met using currently designated interoperability frequencies, it is marked with an asterisk (\*), if the requirement can be partially met, it is marked with a plus (+).

1.1.6 An “X” in any column indicates that this user category has full access to this link, unless a specific footnote states otherwise.

1.1.7 Channel Numbers shown in footnotes represent FCC-designated channel numbers; reference Appendix B.

**1.2** *Tables A-1.1 through A-1.7 show the assignment of frequencies for each of the seven major uses described in the report utilizing Implementation Option #1: Interoperability Implementation Utilizing Existing Bands.*

1.2.1 Figure A-1 is an example of how these matrices could be applied in responding to a major wildland fire in Southern California (typical of those studied in this Report).

**1.3** *Tables A-2.1 through A-2.7 show the assignment of frequencies for each of the seven major uses described in the report utilizing Implementation Option #2: Interoperability Implementation Utilizing A Minimum of Interoperability Links in Existing Bands With A Majority of Interoperability Links in a Separate “Public Safety Interoperability Band”.*

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<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
42-50	1R	X	X	X	X	X	X	X
150-174	1R* (1a)	X	X	X	X	X	X	X
220-222	1R* (1b)	X (1b)	X (1b)	X (1b)				
406-420	1R* (1c)	X	X	X	X			X
450-470	1R* (1d)	X	X	X	X	X	X	X
806-824	1R* (1e)		X	X	X	X	X	X

Table A-1.1: National Calling

- (1a) Two frequencies from NTIA 10 frequency interoperability reserve
- (1b) Channel 161 - Restricted to use by Urban Search & Rescue/Disaster Medical Assistance Teams nationwide
- (1c) Two frequencies from recommended NTIA 10 frequency interoperability reserve
- (1d) 460/465.525 MHz
- (1e) Channel 601

<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
42-50	N/A	1R	1R	1R	X (2a)	X (2a)		
150-174	N/A	1R* (2b)	1R	1R	X (2a)	X (2a)		
220-222	N/A							
406-420	N/A	1R			X (2a)	X (2a)		
450-470	N/A	1R	1R	1R	X (2a)	X (2a)		
806-824	N/A	1R	1R	1R	X (2a)	X (2a)		

Table A-1.2: Emergency Only, Service Dependent

- (2a) For Cons and Gen Govt criminal justice, EMS & fire functions may use the systems of corresponding services
- (2b) 155.475 MHz, plus one frequency from NTIA 10 frequency interoperability reserve

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<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
42-50	N/A	1R+(3a)	1R	1R+(3b)	X (2a)	X (2a)		
150-174	N/A	1R	1R	1R* (3c)	X (2a)	X (2a)		
220-222	N/A							
406-420	N/A	1R* (3d)		1R* (3d)	X (2a)	X (2a)		
450-470	N/A	1R	1R* (3e)		X (2a)	X (2a)		
806-824	N/A	1R	1R	1R	X (2a)	X (2a)		

Table A-1.3: Day-to-Day, Service Dependent

- (3a) 45.86 MHz
- (3b) 45.88 MHz
- (3c) 154.280 MHz, plus one frequency from NTIA 10 frequency interoperability reserve
- (3d) Four frequencies from recommended NTIA 10 frequency interoperability reserve
- (3e) 460/465.550 MHz

<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
42-50	2R	X	X	X	X	X	X	X (4a)
150-174	4R+ (4b)	X	X	X	X	X	X	X (4a)
220-222	1R* (4c)	X	X	X				
406-420	4R	X	X	X	X	X	X	X (4a)
450-470	4R	X	X	X	X	X	X	X (4a)
806-824	4R* (4d)	X	X	X	X	X	X	X (4a)

Table A-1.4: Tactical, Service Independent

- (4a) If permitted by State/Regional Plan
- (4b) One half of requirement for each repeater pair met from NTIA 10 frequency interoperability reserve (total of 4 frequencies required)
- (4c) Channel 170
- (4d) Channels 639, 677, 715, 753

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<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
42-50	2S+ (5a)	X	X	X	X	X	X	
150-174	16S+ (5b)	X	X	X	X	X	X	
220-222								
406-420	4S+ (5c)	X	X	X	X	X	X	
450-470	6S	X	X	X	X	X	X	
806-824	6S	X	X	X	X	X	X	

Table A-1.5: Tactical, Service Independent

- (5a) 39.46 MHz
- (5b) Remaining two frequencies from NTIA 10 frequency interoperability reserve; it is suggested that the remaining frequencies come from the pool maintained for the NIFC caches.
- (5c) Remaining four frequencies from recommended NTIA 10 frequency interoperability reserve

<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
42-50	N/A	1S	1S	1S	1S	1S	1S	1S
150-174	N/A	1S	1S* (6a)	2S* (6b)	1S	1S	1S	1S
220-222	N/A							
406-420	N/A	1S				1S		
450-470	N/A	1S	1S	1S	1S	1S	1S	1S
806-824	N/A	1S	1S	1S	1S	1S	1S	1S

Table A-1.6: Tactical, Service Dependent

- (6a) 155.340 MHz
- (6b) 154.265 and 154.295 MHz

<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
220-222	N/A		9S* (7a)	9S* (7b)				

Table A-1.7: Urban Search & Rescue/Disaster Medical Assistance Teams (7c)

- (7a) DMAT Channels 162, 164, 168
- (7b) USART Channels 163, 165, 167, 169

- (7c) Based on the individual incident, these channels can be used simplex or paired for repeater operation.

APPENDIX A  
Interoperability Link Implementation Option Matrices

THIS PAGE RESERVED FOR FIGURE A-1

**NOTE:** *The electronic version of this figure was unavailable at the time this report was prepared. Readers can find the full text of this figure in FCC WT Docket No. 96-86.*

APPENDIX A  
Interoperability Link Implementation Option Matrices

<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
42-50	1R	X	X	X	X	X	X	X
150-174	1R* (1a)	X	X	X	X	X	X	X
406-420	1R* (1b)	X	X	X	X	X	X	X
450-470	1R* (1c)	X	X	X	X	X	X	X
806-824	1R* (1d)	X	X	X	X	X	X	X
New Band	1R	X	X	X	X	X	X	X

Table A-2.1: National Calling

- (1a) Two frequencies from NTIA 10 frequency interoperability reserve
- (1b) Two frequencies from recommended NTIA 10 frequency interoperability reserve
- (1c) 460/465.525 MHz
- (1d) Channel 601

<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
42-50	N/A							
150-174	N/A							
406-420	N/A							
450-470	N/A							
806-824	N/A							
New Band	N/A	1R	1R	1R	1R	1R	1R	1R

Table A-2.2: Emergency Only, Service Dependent

<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
42-50	N/A							
150-174	N/A							
406-420	N/A							
450-470	N/A							
806-824	N/A							
New Band	N/A	2R	2R	2R	2R	2R	2R	1R

Table A-2.3: Day-to-Day, Service Dependent

APPENDIX A  
Interoperability Link Implementation Option Matrices

<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
42-50	2R	X	X	X	X	X	X	X (4a)
150-174	4R+ (4b)	X	X	X	X	X	X	X (4a)
406-420	2R+ (4c)	X	X	X	X	X	X	X (4a)
450-470	4R+ (4d)	X	X	X	X	X	X	X (4a)
806-824	4R* (4e)	X	X	X	X	X	X	X (4a)
New Band	10R	X	X	X	X	X	X	X (4a)

Table A-2.4: Tactical, Service Independent

- (4a) If permitted by State/Regional Plan
- (4b) Seven frequencies from NTIA 10 frequency interoperability reserve, 1 additional frequency required
- (4c) Two frequencies from recommended NTIA 10 frequency interoperability reserve, 2 additional required
- (4d) 460/465.550 MHz
- (4e) Channels 639, 677, 715, 753

<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
42-50	N/A							
150-174	N/A							
406-420	N/A							
450-470	N/A							
806-824	N/A							
New Band	30S	X	X	X	X	X	X	

Table A-2.5: Tactical, Service Independent

APPENDIX A  
Interoperability Link Implementation Option Matrices

<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
42-50	N/A	1S* (6a)	1S	1S* (6b)				
150-174	N/A	2S* (6c)	1S* (6d)	2S* (6e)				
406-420	N/A	3S* (6f)	1S* (6f)	2S* (6f)				
450-470	N/A	1S	1S	1S				
806-824	N/A	1S	1S	1S				
New Band	N/A	8S	6S	12S	4S	4S	4S	2S

Table A-2.6: Tactical, Service Dependent

- (6a) 45.86 MHz
- (6b) 45.88 MHz
- (6c) 155.475 MHz plus remaining frequency from NTIA 10 frequency interoperability reserve
- (6d) 155.340 MHz
- (6e) 154.265 and 154.295 MHz
- (6f) Remaining six frequencies from recommended NTIA 10 frequency interoperability pool

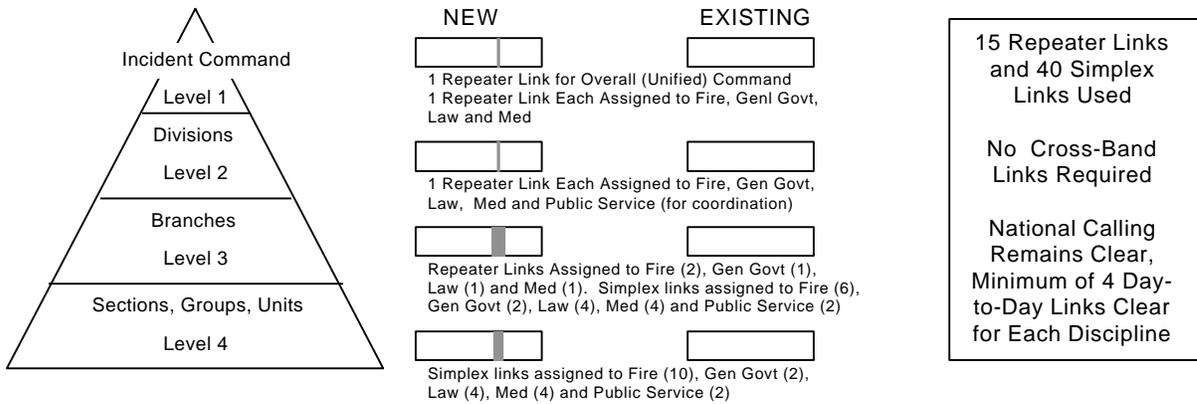
<i>Band</i>	<i>Shared</i>	<i>Crim Just</i>	<i>EMS</i>	<i>Fire</i>	<i>For Cons</i>	<i>Gen Govt</i>	<i>Hwy Main</i>	<i>Pub Serv</i>
New Band	N/A		6S* (7a)	6S* (7a)				

Table A-2.7: Urban Search & Rescue/Disaster Medical Assistance Teams

- (7a) Based on the individual incident, DMAT channels can be used simplex or paired for repeater operation.
- (7b) Based on the individual incident, USART channels can be used simplex or paired for repeater operation.

## APPENDIX A Interoperability Link Implementation Option Matrices

### Interoperability for A Major Wildland Fire



Command Level 1: Nat Tac #R1 serves as Unified Command Net for all disciplines. Nat Tac #R2 is used for Fire Command, Nat Tac #R3 is used for Genl Govt Command, Nat Tac #R4 is used for Law Command, Nat Tac #R5 is used for Med Command.

Divisions Level #2: Nat Tac #R6 is used for Fire, Nat Tac #R7 is used for Gen Govt, Nat Tac #R8 is used for Law, Nat Tac #R9 is used for Med. SD/D-D Rpt is assigned to Public Service for coord.

Branches Level #3: Nat Tac #R10 and For Consv SD/D-D #R1 is used for Fire, GG SD/D-D #R1 is used for Genl Govt, Law SD/D-D #R1 is used for for Law, Med SD/D-D #R1 is used for Med. Nat Tac #S1 - S6 assigned to Fire, Nat Tac #S7 and S-8 assigned to Genl Govt, Nat Tac #S9 - S12 assigned to Law, Nat Tac #S13 - S16 assigned to Med, Nat Tac #17 - S18 assigned to Pub Serv.

Section/Group/Unit Level #4: Nat Tac #S19 - S24 & Fire SD/Tac #S1 - #S4 for Fire, Nat Tac #S25 - S26 for Genl Govt, Nat Tac #S27 - 28 & Law SD/Tac #S1 - S2 assigned to Law, Nat Tac #S29 - S30 & Med SD/Tac #S1 - S2 assigned to Med, Pub Serv SD/Tac #S1 - S2 assigned to Pub Serv.

15 Repeater Links and 40 Simplex Links Used

No Cross-Band Links Required

National Calling Remains Clear, Minimum of 4 Day-to-Day Links Clear for Each Discipline

This diagram depicts a typical assignment of Future Mutual Aid Spectrum Resources to a Major Wildland Fire Incident in Southern California

### Interoperability Links Applied to A Major Incident Using Incident Command System Protocols

Figure A-2

**APPENDIX B**  
**CURRENT INTEROPERABILITY FREQUENCIES**  
**FCC Part 90 (State/Local Government)**

A review of FCC Rules and Regulations indicates that the following intersystem/mutual aid operations are permitted. Only the standard channels (prior to refarming) are listed. Citations are from Pike and Fischer, Inc. Communications Regulation on CD ROM (2-96).

**B-1. FCC Part 90, Subpart B - Public Safety Radio Services:**

**1.1 FCC 90.19 Police Radio Service:**

39.46 and 45.86 MHz:

90.19(e)(11) This frequency is reserved for assignment to stations for intersystem operations only: provided, however, that licensees holding a valid authorization to use this frequency for local base or mobile operations as of June 1, 1956, may continue to be authorized for such use.

155.475 MHz:

90.19(e)(14) This frequency is available nationwide for use in police emergency communications networks operated under statewide law enforcement emergency communications plans. Operations authorized on this frequency which are not in accordance with this limitation may continue until January 1, 1985.

**1.2 FCC 90.21 Fire Radio Service:**

45.88, 154.265, 154.280 and 154.295 MHz:

90.21(c)(2) This frequency is reserved for assignment to stations in this service for intersystem operations only and these operations must be primarily base-mobile communications.

**1.3 FCC 90.27 Emergency Medical Radio Service:**

155.340 MHz:

90.27(c)(5) This frequency may be designated by common consent as an intersystem mutual assistance frequency under an area-wide medical communications plan.

460/465.525 and 460/465.550 MHz:

90.27(c)(10) This frequency is shared with the Police and Fire Radio Services. This frequency may be designated by common consent for intra-system and

inter-system mutual assistance purposes and is subject to the coordination requirements specified in §90.175 of this part.

#### **1.4 FCC Part 90, Subpart C - Special Emergency Radio Service:**

The following note should be removed from FCC rules as a result of the removal of 155.340 MHz from the Special Emergency Radio Service:

90.53(d)(3) The frequency 155.340 MHz may be assigned as an additional frequency when it is designated as a mutual assistance frequency as provided in §90.53(b)(10).

### **B-2. FCC Part 90, Subpart T - 220 - 222 MHz**

#### **2.1 FCC 90.715(a) Frequencies available to Public Safety eligibles [in part]:**

Channel	161	220.8025 MHz
	162	220.8075
	163	220.8125
	164	220.8175
	165	220.8225
	166	220.8275
	167	220.8325
	168	220.8375
	169	220.8425
	170	220.8475

#### **2.2 FCC 90.720 Channels available for public safety/mutual aid.**

(a) Part 90 licensees whose licenses reflect a two-letter radio service code beginning with the letter "P" (except for "PS") are authorized by this rule to use mobile and/or portable units on Channels 161-170 throughout the United States, its territories, and possessions to transmit: (1) communications relating to the immediate safety of life or (2) communications to facilitate interoperability between public safety entities.

(b) Any entity eligible to obtain a license under Subpart B of this part is also eligible to obtain a license for base/mobile operations on Channels 161-170. Base/mobile or base/portable communications on these channels that do not relate to the immediate safety of life or to communications interoperability between public safety entities may only be conducted on a secondary, non-interference basis to such communications.

**B-3. FCC Part 90, Subpart S - 800 MHz:****3.1 FCC 90.613(a) Frequencies available to eligibles [in part]:**

Channel	601	866.0125 MHz
	639	866.5125
	677	867.0125
	715	867.5125
	753	868.0125

**3.2 FCC 90.617(a)(1) General Geographic Requirements:**

Channel numbers 601-830 are also available to eligible applicants in the Public Safety Category in areas farther than 110 km (68.4 mi) from the U.S./Mexican border, and 140 km (87.0 mi) from the U.S./Canadian border. The assignment of these channels will be done in accordance with the policies defined in the Report and Order of Gen. Docket No. 87-112. (See §§90.16 and 90.34.) The following channels are available only for mutual aid purposes as defined in Gen. Docket No. 87-112: 601, 639, 677, 715, 753.

**3.3 FCC 90.619 Frequencies available in the U.S./Mexico & U.S./Canada border areas:**

(a) U.S./Mexico border area:

(2) Certain channels in the 821-824/866-869 MHz band are also available to eligible applicants in the Public Safety Category in areas within 110 kilometers (68.4 miles) of the U.S./Mexico border. These channels will be assigned according to the policies defined in the Report and Order of Gen. Docket No. 87-112 (see §§90.16 and 90.34). The following channels are available only for mutual aid purposes as defined in Gen. Docket No. 87-112: Channels 601, 639, 677, 715, and 753.

(b) U.S./Canada border area:

Specific provisions for use of the 821-824/866-869 MHz bands in the U.S./Canada border area are contained in paragraph (c) of this section

(c) Use of frequencies in the 821-824/866-869 MHz band (Channels 601-830) in the U.S./Canada border area. The following criteria shall govern the assignment of frequency pairs (channels) in the 821-824/866-869 MHz band for stations located in the U.S./Canada border area. They are available for assignments for conventional or trunked systems in accordance with applicable sections of this subpart and the Report and Order in Gen. Docket No. 87-112. They are not available for intercategory sharing.

(1) Channels 601-830, as listed in §90.613 Table of 806-824/851-869 MHz Channel Designations, are available to eligible applicants in the Public Safety Category for use in the U.S./Canada border area as shown in Table 25. Additionally, Channels 601, 639, 677, 715 and 753 are available in all regions only for mutual aid purposes as defined in Gen. Docket No. 87-112.

**APPENDIX C**

PSWAC/ISC 96-04-024/2

Revised 5/21/96

## **Metropolitan Washington Area Interoperability**

A Case Study Of The Spectrum Required To Facilitate Effective  
Inter-Jurisdiction and Inter-Agency Operations That Provide  
Public Safety Services During Major Emergency Events.

Prepared by: The Interoperability Subcommittee of the Public Safety Wireless  
Advisory Committee (PSWAC) and The Metropolitan Washington  
Council Of Governments.

## I. FORWARD

The Interoperability Sub Committee (ISC) of the Public Safety Wireless Advisory Committee (PSWAC) requested the assistance of the Metropolitan Washington Council of Governments (COG) to determine the spectrum requirements for wireless communications to successfully handle a disaster like the crash of Air Florida Flight 90 in today's environment. The request was officially made to the Police Chiefs Committee at their February 28, 1996 meeting. There were 40 representatives in attendance. The committee unanimously approved the request. Fire Service participation was accomplished by fax on February 28 by inviting COG's Fire Chiefs to send their communications representatives to the special meeting. A special joint meeting of the Police and Fire/EMS communications committees was called for March 8, 1996 to address the request. A follow up meeting was held on April 2, 1996 to review and edit a draft report covering the analysis, conclusions and recommendations. This final report is included in the ISC final report to the Advisory Committee and will be considered for adoption by the Police and Fire Chiefs Committees of the Council of Governments.

The Air Florida or the Fourteenth Street Bridge disaster occurred on January 13, 1982. This disaster represented many challenges to the in-place command and control and communications capabilities of the responding public safety agencies. The resulting overload condition severely hampered the responding agencies and prevented these agencies from providing their best service to those in need. One outcome of this disaster was formulation and adoption of The Greater Metropolitan Washington Area Police and Fire/Rescue Services Mutual Aid Operational Plan. This Mutual Aid Plan was adopted in December 1983 and was revised in September 1990. This Mutual Aid Plan incorporates the Incident Command System (ICS) developed by the US Fire Administration, the Federal Emergency Management Agency (FEMA), and the National Fire Protection Association (NFPA).

This paper will consider the original disaster looking for short comings in communications which hampered response and assistance. The report will then address the current communications capability in supporting the Mutual Aid Plan. Again the report will address the issues and problems in communications reported by the responders to recent disasters. The report also addresses the users' response to the question: "*If the Air Florida disaster occurred today what communications are required to make your Mutual Aid Plan viable? And, looking to the year 2010 what future communications needs do you anticipate to enhance interoperability and improve response and service in disaster incidents?*".

The following is a list of individuals who participated in the development of the case study:

METROPOLITAN WASHINGTON COG PARTICIPANTS		TABLE 1
NAME	ORGANIZATION/AGENCY	
Steve Souder	Arlington County (VA) ECC	
Ralph C. Henderson	Defense Protective Service	
Austin Story	Montgomery County Police - ECC	
Elwood R. Ey III	Montgomery County Fire/Rescue ECC	
Mark Deputy	Montgomery County Fire/Rescue ECC	
Bruce R. Blair	Montgomery County Police	
Ken Boyles	Central Intelligence Agency	
Tyrone Dindal	Central Intelligence Agency	
John Kurtin	Central Intelligence Agency	
Paul A. Nichols	Fairfax County Fire/Rescue	
Curt Andrich	Fairfax County Police	
Bruce Henry	Virginia State Police	
Mike Gallant	U.S. Park Police	
Phil Kramer	U.S. Park Police	
Henry Wood	Prince William Public Safety Center	
Steve Marzolf	Prince William Public Safety Center	
Gary E. DeBruler	MDW Provost Marshal Office US Army	
Douglas R. Champaigne	MDW Provost Marshall Office US Army	
Michael Gills	COG Public Safety	
Joe Zelinka	COG Public Safety	
Andrew L. Jackson, Jr.	DC Fire/EMS/Comm. Div	
M. R. Oluwa	DC Fire/EMS /Comm Div	
Paul Basak	U.S. Capitol Police	
Harold Pickering	DC Fire/EMS Department	
Joseph Lundholm	Montgomery County Police Dept. (Vol)	

## II. THE INCIDENT

On January 13, 1982 at approximately 3:45 in the afternoon Air Florida Flight 90 took off from Washington National airport and moments later crashed into commuter traffic on the northbound span of the Fourteenth Street Bridge. After striking the bridge, the 737 jetliner broke in two pieces and fell into the ice covered Potomac river near the Virginia side and quickly sank below the icy surface.

This tragic occurrence instantaneously created a multi-sector emergency response situation encompassing two geographic areas, both requiring emergency rescue and medical services. Each site represented a different set of circumstances that would require a different combination of equipment and personnel to be assembled from the resources available to the federal, state and local agencies in the surrounding area.

Helicopter, boats, life rafts and divers were needed to attempt a rescue of the aircraft passengers and crew members in the Potomac river. Rescue workers armed with tow trucks, hydraulic jacks, acetylene torches and related equipment were needed to rescue passengers from the crushed automobile wreckage on the bridge. Both sites needed emergency medical

services to stabilize and transport the rescued to nearby hospitals. Both sites needed a law enforcement response to assist in rescue efforts and provide traffic and crowd control.

The two sector aircraft and motor vehicle rescue operation quickly escalated to a multiple incident rescue operation a half hour later when a Metro subway train derailed in an underground tunnel near the Smithsonian station of the Metro subway rail system. Here, another group of rescue workers similar to those deployed on the bridge were needed to rescue passengers of the subway train wreckage.

To further complicate matters, massive traffic jams would impede the progress of the responding emergency personnel as they traveled toward the sites of the emergencies. The diminished road conditions coupled with the early release of Federal employees, due to the day-long snowstorm, produced traffic nightmares and grid-lock throughout the area.

### Public Safety Notification and Response

Public safety officials were notified of the air crash through two different means. The United States Park Police Communications Center received the initial call from a commuter on a mobile phone who advised that there was a plane crash in the Gravelly Point area (just north of the airport) of the Virginia shoreline of the Potomac River. The Park Police Communications Center called the control tower at National Airport and the FAA advised that they had no knowledge of an airplane crash. The District of Columbia Fire Department received notification from a commuter calling through the IMTS mobile telephone operator. The IMTS mobile operator connected him directly to the DC Fire Communications Center. The majority of the public safety agencies received notification when the FAA at National Airport broadcast an alert on the Washington Area Warning and Alerting System (WAWAS), a wireline network connected to the public safety agencies in the region sponsored by the Federal Emergency Management Agency (FEMA).

TABLE 2 lists the agencies that responded and their role in the emergency operations. It also shows the frequency band each agency was operating on at the time of the Fourteenth Street Bridge disaster. Helicopters were provided by the US Park Police. Divers were provided by Fairfax County, Virginia as well as the District of Columbia Harbor Patrol.

FOURTEENTH STREET BRIDGE RESPONDERS / ROLES TABLE 2

<u>Agency/Jurisdiction</u>	<u>Role Of Agency/Jurisdiction</u>
Arlington County, VA Police	Traffic Control
Arlington County, VA Fire / EMS	Emergency Medical / Rescue
District Of Columbia Fire / EMS	Emergency Medical / Rescue
District Of Columbia Police	Traffic Control/ Rescue
Fairfax County, VA Fire / EMS	Emergency Medical / Rescue
Federal Protective Service	Support (as requested)
Montgomery County, MD Fire / EMS	Emergency Medical
National Airport Fire	Rescue
National Airport Police	Traffic Control
Prince George's County, MD Fire / EMS	Emergency Medical / Rescue
RACES*	Comm Links (i.e., to morgue)
Red Cross	Support
U.S. Army MASH unit	M.A.S.H. Operations
United States Coast Guard	Rescue / Recovery
United States Navy	Recovery
United States Park Police	Traffic/Rescue
US Federal Aviation Administration	Notification / Alert
Virginia Department Of Transportation	Traffic Control Support
Virginia State Police	Traffic Control
WMATA Police	Traffic

\* Radio Amateur Civil Emergency Service

There were three basic types of problems encountered by responders to the Fourteenth Street Bridge disaster; 1) situational problems, 2) organizational problems and 3) communications problems.

**Situational Problems:**

Multiple Incidents. The Metro subway train crash siphoned off personnel and communications resources.

Traffic Gridlock. Bad weather and heavy traffic from early release of federal employees produced impeding traffic conditions.

Multiple Geographic Sectors. The fact that responders were needed on the bridge and at the river bank divided available personnel and created an increase in communications traffic.

Notification Delay. The driving snowstorm produced very low visibility at the time of the incident. This limited the number of people who could have witnessed and reported the incident to those in very close proximity of the accident. Most witnesses were in their cars and unable to report since cellular telephone service hadn't been implemented yet.

### Organizational Problems:

Lack Of Command & Control. At the time of the Fourteenth Street Bridge disaster there was not a formal Incident Command Structure (ICS) system in place. Command and Control protocol was inadequate. Likewise, communicating protocols and channel utilization procedures were inadequate.

Undetermined Controlling Jurisdiction. The fact that the incident involved both the bridge and the river made it difficult to determine jurisdictional authority.

### Communications Problems:

At the time of the Fourteenth Street Bridge disaster there were two mutual aid channels available to public safety agencies, one for fire and one for police. The Fire Mutual Aid Radio System (FMARS) channel operated on 154.280 MHz and was used for base-to-base, base-to-mobile and mobile-to-mobile communications. The Police Mutual Aid Radio System (PMARS) channel operated half-duplex on 458.550/453.550 MHz, available for base-to-base communications through a manual patch at the communications center. Interoperable communications during an incident like the Fourteenth Street Bridge disaster are conducted on the FMARS channel. The PMARS channel is used primarily for inter-jurisdictional vehicle pursuits and is spectrally inefficient in that it ties up three voice channels when in use.

The communications problems agencies encountered during the Fourteenth Street Bridge rescue operation principally centered around an inability to utilize the mutual aid channels. This was generally caused by either radio incompatibility or severe overloading of the single available mutual aid channel. Some agencies did not have the capability to access the mutual channels at all because their radios operated outside the frequency band of the FMARS channel. Even those agencies that operated radios compatible with the mutual aid channel sometimes could not communicate effectively because the single mutual aid channel was severely overloaded.

It should be pointed out that there is a peculiar irony in what has just been said. Some agencies could not access the already overloaded mutual aid channel. If these agencies were somehow able to access the mutual aid channel the result would likely have been an even more overloaded mutual aid channel.

Some of the specific communications problems encountered are listed below:

Inadequately Informed Responders. Due to lack of early situation reports and congested radio communications channels, responders were not informed about what to expect, where to go, etc., as they responded to the scene.

Functional Contention On Channels. Fire/EMS personnel had to compete for airtime with traffic and routing communications that were being carried out on the only common channel.

Telephone Overload. A heavy increase in wireline telephone calls blocked wireline telephone circuits. This further complicated communications because the telephone was a primary link between communications centers due to the congestion of the single mutual aid channel.

Dispatcher Overload. Use of only a single mutual aid channel resulted in too many communications to a single dispatch point and overload. Lack of channels did not allow distribution of communications.

Manual Patching. Some responders with radios that operated in a frequency band incompatible with the mutual aid channel were required to patch through the dispatcher to communicate with others on the mutual aid channel. This is a highly undesirable solution because it is extremely cumbersome and ties up the channel that is patched to the mutual aid channel.

Helicopter Communications. The lone helicopter involved in the initial rescue operations was equipped with a synthesized aircraft radio capable of "dialing up" on other agencies frequencies. The hindrance to interoperability was not hardware based but administrative procedures. At the time many agencies did not want any "outside" agencies operating on their systems. Discussions in the Council of Governments Police Communications subcommittee following the Air Florida incident highlighted concerns over the use of the FMARS channel and that helicopters operating in support of one jurisdiction on a medical evacuation were causing interference to ground units responding to other calls. The thrust of the discussions by some of the participants was that aero use of the FMARS channel be limited to ground use and in effect no airborne operation was authorized. It should be noted that much of the resistance has disappeared and there is now more interaction between helicopters and ground stations.

Hospital Communications. Due to inadequate radio communications, hospitals were not kept informed as to the number of casualties that would be transported to them and when they would arrive. Transporters were unsure of hospital capacities and therefore unsure of how to distribute transport of the casualties across the hospital network

TABLE 3 lists the agencies that responded and the frequency band which they operated on at that time. It clearly shows that many of the responding agencies could not communicate with other agencies at the scene because the radios they used were not compatible with the VHF FMARS mutual aid frequency.

Even in-band compatibility problems existed because crystal controlled radios with restrictive band splits were still in use during this time period. Fortunately, advances in wide band synthesizer technology have eliminated this problem.

FREQUENCY BAND OF 14th ST. BRIDGE RESPONDERS TABLE 3

Agency/Jurisdiction	Frequency Band (Mhz)
Arlington County, VA Police	450-470
Arlington County, VA Fire / EMS	150-162
District Of Columbia Fire	150-162
District Of Columbia EMS	30-50
District Of Columbia Police	450-470
Fairfax County, VA Fire / EMS	450-470
Federal Protective Service	406-420
Montgomery County, MD Fire / EMS	150-162
National Airport Fire	150-174
National Airport Police	150-174
Prince George's County, MD Fire / EMS	450-470
RACES*	140-150
Red Cross	30-50
U.S. Army MASH unit	225-400
United States Coast Guard	Maritime
United States Navy	225-400 MHz
United States Park Police	406-420 MHz
United States Park Police (helicopters)	UHF (tunable)
US Federal Aviation Administration	406-420
Virginia Department Of Transportation	30-50 MHz
Virginia State Police	150-174
WMATA Police	450-470
* Radio Amateur Civil Emergency Service	

### III. TODAY

In the aftermath of the Air Florida disaster the Public Safety Community generated numerous incident reports, participated on review boards, received extensive media coverage and took action to correct the problems that hampered their response and rescue efforts. Using the Metropolitan Washington Council of Governments (COG) as the catalyst a Metropolitan Emergency Response Task Force was created to make recommendations to strengthen the regional response capability. A report was approved by the COG Board of Directors on June 9, 1982.

The recommendations of the Task Force were used by the Police Chiefs Committee and the Fire Chiefs Committee to develop The Greater Metropolitan Washington Area Police and Fire/Rescue Services Mutual Aid Operational Plan (The Mutual Aid Plan). The Mutual Aid Plan was adopted in December 1983 and revised in September 1990. This Mutual Aid Plan focused on correcting the command and control deficiencies encountered during the disaster. The participating Police Chiefs and Fire Chiefs developed a detailed command and control system which would enable them to manage a disaster incident. The Mutual Aid Plan is governed by existing Police and Fire/Rescue Services mutual aid agreements and provides guidance to responding agencies. The Mutual Aid Plan incorporates the Incident Command System found in the Fire Service Major Incident Model and developed by the US Fire Administration, FEMA.

The communications problems which occurred during the Air Florida disaster were also addressed and a communications plan to support the command and control system in the Mutual Aid Plan was developed within the available resources. It was apparent that radio spectrum was not available to provide the needed channels/RF communication paths to support the command and control system. Two FMARS and one PMARS frequencies are available. FMARS is in the VHF Band and PMARS is in the UHF band. Spectrum in a common band is needed to provide interoperability without a multitude of radios and an overly complex operation. In a disaster situation communications must be an extension of that used in normal operations.

In reviewing the Mutual Aid Plan (MAP) the lack of wireless communications needed to support the command and control system is quite obvious. The efficiencies and ability to quickly respond which are the results of a properly executed command and control system cannot be achieved without information passing quickly and effortlessly between the responders and those directing the resources. A mutual aid plan detailing a command and control system places a greater demand on communications. Each functional element must have internal communications to direct their activity. This is not only to effectively carryout their mission but also for the safety of their team. The incident commander must have communications with each team to coordinate the response, to direct resources, to guard the safety of all responders and to maintain the command system.

The Mutual Aid Plan (MAP) has been employed numerous times in the past 12 years when the area public safety agencies were called on to respond to emergency incidents. Two of these incidents are listed below to illustrate the problems associated with communications to support the Mutual Aid Plan. In the March 28 meeting the participants were asked to provide the communications difficulties they have experienced in responding to other disaster situations.

1. Responding agencies in a disaster incident have equipment and systems operating in different bands. Additional equipment must be deployed at the scene to provide the interoperability to support the Mutual Aid Plan. Confusion and delays in implementing the Mutual Aid Plan are a result.
2. As response builds and tactical teams deployed the current designated mutual aid channels quickly become overloaded. Communications is disrupted as responders contend for the channels. Arriving responders communicating on the mutual aid channels disrupt communications within the tactical teams. The arriving responders are not efficiently and effectively assigned to an essential task. Delays are critical in the initial response.
3. The Incident Commander becomes an island if not kept abreast of the activity at the scene. The command and control system begins to unravel. Dispatchers become overloaded and unable to effectively control communications activity. Alternate means of communications are put in place such as runners, using channels from the agency's system where the incident occurred, etc. All of these stop gap measures reduce the effectiveness of the responders. Also, the agency who's channels are redirected to the incident may be at risk in meeting it's communications needs.

4. Should other mutual aid communications needs arise in the vicinity they would not be able to be met as mutual aid channels are not available. Should a second disaster occur no planned communications would be available to provide interoperability.

5. In past incidents, the use of mobile data and mobile computing to assist with command, control, database access, and secure communications has been extremely limited. The planned implementation of mobile computing and Automatic Vehicle Location systems, coupled with Geographic Information Systems, will increase the ability of incident managers to effectively control field resources. This will go a long way to help overcome the deficiencies noted above. Standards and application conventions will allow automated command and control systems to effectively replace the grease pencil acetate ICS documentation used today, thus ensuring functional and jurisdictional interoperability.

## COLONIAL PIPELINE SPILL

1. INCIDENT: MARCH 28, 1993
  - A. Colonial Pipeline Oil Spill at 1830 Town Center Parkway Fairfax County Fire and Rescue Dispatch Time 0910 hours
  - B. Colonial's thirty-six inch main transmission line broke, spewing #2 fuel oil about fifty feet into the air. Colonial initiated shut-down at approximately 0848 hours, immediately upon pressure drop.
  - C. Colonial personnel maintain 24 hour presence at the pipeline rupture area until the backfill operation is completed.
  - D. Colonial estimates that 407,436 gallons were spilled into the environment.
  - E. The main plume is being contained at the confluence of Sugarland Run and the Potomac by booms with product and containment water being recovered. Isolated sheen pockets have been noticed as far south on the Potomac as Quantico, Virginia.
2. INITIAL STRATEGIC OBJECTIVES
  1. Protect Public Water Systems
    - containment booms, Water Plant shutdown, product recovery and Government mobilization
  2. Protect Wetlands
    - animal rescue and shoreline assessment
  3. Protect Health and Safety Over Entire Spill Route
    - safety plan, atmospheric monitoring and drinking well water testing
  4. Protect Health and Safety in the Immediate Area
    - work area isolation
    - pipe removed
    - product removal
3. RESPONDING ORGANIZATIONS
  1. Fairfax County Fire and Rescue Department
  2. Fairfax County Police Department
  3. Fairfax County Health Department
  4. Fairfax County Animal Control
  5. Fairfax County Water Authority
  6. Fairfax County Department of Public Works

7. Fairfax County Attorney's Office
8. Herndon Police Department
9. Herndon Department of Public Works
10. Herndon Sewer and Water
11. Herndon Engineer
12. Loudoun County Fire and Rescue Department
13. Loudoun County Sheriff's Department
14. Loudoun County Animal Control
15. Loudoun County Health Department
16. Virginia Department of Waste Management
17. Virginia Department of Transportation
18. Virginia Department of Health
19. Virginia State Water Control Board
20. Virginia Department of Emergency Services
21. Virginia Department of Air Pollution
22. Maryland Department of Environment
23. Washington Suburban Sanitary Commission
24. City of Rockville, MD
25. D.C. Office of Emergency Preparedness
26. National Transportation Safety Board
27. U.S. Coast Guard
28. U.S. Environmental Protection Agency
29. DOT Office of Pipeline Safety
30. U.S. Navy
31. Department of Interior
32. U.S. Fish and Wildlife
33. Colonial Pipeline
34. Colonial Pipeline Contractors
35. Tri State Bird Rescue and Research
36. Virginia Power
37. Reston Hospital Center
38. Bell Atlantic
39. C & P Telephone
40. National Oceanic and Atmospheric Administration

#### 4. COMMUNICATIONS

A. Not enough communication with the forward command post. First morning overflights are important, conveying information from these overflights is imperative.

B. Issues with safety at the forward command area. Could not locate person in charge during early phase. Area seemed out of control initially.

C. More county communications required. Need photo identifications established early. Traffic control should be established immediately if

movement to new areas need to occur, the unified command should be notified first. Should have taken control of airspace by contacting Dulles Airport. Problems with availability of respirators for VDOT and Police.

- D. Initially confirmed lack of command for site safety at Potomac.
  - E. Problem maintaining open lane at work sites due to tanker truck traffic.
  - F. Lack of equipment can be caused by communication problems. Working on worldwide database to identify all response contractors and their resources.
  - G. Trouble with contractors arriving unprepared, probably due to a lack of communication.
- 
-

## **Radio Communication During Amtrak/MARC Train Accident**

At 1741 hrs. on February 16, 1996, the Montgomery County Emergency Communications Center (ECC) began receiving calls for a reported train accident on the tracks adjacent to the 1900 block of Lyttonsville Rd, in Silver Spring, MD. Silver Spring is located in the southeast quadrant of the County. It was clear from the beginning that a passenger train was involved in the accident and it was on fire.

The initial dispatch of units to the train accident was transmitted on Montgomery County Fire's main operational channel (154.160). Upon arrival of the initial engine units were directed to switch to the primary tactical channel (153.950) and a request was made for a 2nd alarm. The initial dispatch assignment included 1 unit from Prince Georges County. Since this unit is stationed close to the border it is equipped with an additional radio to operate on Montgomery County channels.

As the need for resources increased, an additional alarm was requested and included multiple units from Prince Georges County. A separate tactical channel (fire channel 3) was established. Some of the units that were dispatched to assist did not have Montgomery County or FMARS capabilities. Communications with these units was done by relaying information by direct telephone line to Prince Georges County and they would advise their units what to do.

### **Medical Sector**

The medical sector was assigned to use the channel designed as "EMS-1" (155.340) or fire channel 5. EMS-1 is normally used for hospital consultations. Use of this channel would allow the medical control officer to notify receiving hospitals to expect specific numbers of patients and what their injuries were. In addition, EMS sector personnel used Montgomery County's FEMA Urban Search And Rescue (USAR) team radio cache. These radios allowed EMS personnel to coordinate medical operations on a separate tactical channel.

### **Supplemental Resources**

The ECC Supervisor directed personnel to contact other jurisdictions to advise them of the situation and determine available resources. Fairfax County offered their Multi-casualty response unit and it was sent to Montgomery County Fire Station 10 to stage in the event the number of injuries began to increase. This unit did not have Montgomery County radio capabilities.

Prince Georges County also dispatched their 2 mobile communications units and numerous command officers to the scene to help alleviate the need to relay instructions by telephone.

### **Simultaneous Alarms**

Shortly after the 2nd alarm was transmitted for the train accident, the ECC received a report of a building fire in the east corridor of the county. This is the same general area as the train

incident. The dispatch assignment for the building fire included many units from Prince Georges County as well as Howard County. the mutual aid units from these jurisdictions did have Montgomery County radios.

As operations continued at the train incident, 10 units were dispatched to a multi-casualty motor vehicle accident, again in the same general area of the county.

### **Station Fill-ins**

The magnitude of this incident left much of the lower part of the county without fire and rescue protection. For this reason, the ECC supervisor relocated many units from other parts of the county into this area. Resources were certainly strained so the ECC Supervisor requested units to fill-in from Howard and Prince George counties and the District of Columbia. Again, most of the units did not have Montgomery County or FMARS radio capabilities.

### **Summary**

While most of the mutual-aid units that responded to the train accident in Silver Spring on February 16, 1996, had the capability to operate on Montgomery County channels, some did not. In addition, most of the mutual-aid units used for other incidents and station fill-ins did not have Montgomery County or FMARS radio capabilities. This is due mostly to the fact that the jurisdictions involved operate on different radio bands or the equipment that have is not capable of having additional radio frequencies added.

This incident did not escalate into a major disaster. Command was kept relatively modest. The fire & rescue operations were handled using 5 radio channels. Communications between other fire (mutual-aid) police and non public safety agencies were handled on additional 4 channels. Had spectrum been available to allow interoperability between all agencies involved, 9 channels would have been used for the train accident alone. In addition, 2 interoperability channels would have been used for the simultaneous incidents and station fill-ins.

### **Radio Channels used during Amtrak/MARC Train accident**

Fire Channel 1	Tactical - Main incident
Fire Channel 2	Main Dispatch, updates
Fire Channel 3	Tactical - Lyttonsville Rd sector
Fire Channel 5	EMS Control

FEMA Channel 4	EMS Tactical
Fire Channel 4	Tactical (HazMat, County Environmental Protection)
FMARS-1	Mutual-Aid, directions, dispatch, secondary incidents
Police Channel 3	Main Dispatch
Police Channel 6	Tactical

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**IV. TOMORROW**

The committee determined the spectrum needs to successfully implement the Mutual Aid Plan in order to respond to a disaster similar to Air Florida in today’s environment. These needs are given in the letter which follows.

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FAIRFAX COUNTY  
 FIRE AND RESCUE DEPARTMENT  
 4100 Chain Bridge Road  
 Fairfax, Virginia 22030

Glenn A. Gaines  
 Fire Chief

James Downes  
 U.S. Department of Treasury  
 Washington, D.C.

I have attached an assembly of materials related to EMS management of a major event. I tried several methods to assemble the information that you need to proceed, and it is difficult. Each incident is different, and there are so many variables that I cannot put together a typical event. I will use Air Florida, with the following understood.

1. I will include a survivability factor to illustrate the Medical Command tree.
2. Remember that there were two geographic sites for Air Florida, the river and the bridge. This would entail a separate sector of operations and EMS, so tactical channels would be doubled for extrication, and all of the EMS sectors.
3. Ideally, units with like responsibility would operate on one common channel. I made no attempt to try and describe the intricate "patching" network that would be required today to make this incident command system work with existing resources.
4. A note to qualify tactical channel assignments. When I identified a group for a tactical channel, that channel would be used to communicate with members of that work team. (For example, if the logistics supply group would receive orders from command to obtain a crane for rescue, the logistics group would work as a team to identify/locate one, have it dispatched to the incident, escorted by police through traffic, let through the security perimeter, and sent to command for Assignment. This requires coordination from several people and a tactical channel is necessary.

<u>Commander/Sector</u>	<u>type channel</u>	<u>Interfaces with</u>
Incident Commander I/C	repeated	Controlling Jurisdiction Dispatch, Operations command, EMS command, Liaison, Logistics
Liaison	repeated	I/C
Law Traffic	tactical	Liaison
Law Evacuation	tactical	Liaison
Law Security	tactical	Liaison
Investigations	tactical	Liaison
Federal agencies	tactical	Liaison
Safety		I/C Operations, EMS
Information		(monitor only)
Operations Commander:	repeated	I/C, EMS, Fire Suppression, Rescue, River, Hazmat, Logistics
Fire Operations:	repeated	Operations, EMS, HazMat, Logistics, River

Fire Suppression Sector	tactical	Operations, EMS, HazMat, Logistics, River
Extrication Sector	tactical	Operations, EMS, HazMat, Logistics, River
River Rescue Sector	tactical	Operations, EMS, HazMat, Logistics, River
Hazardous Materials		Operations, EMS, HazMat, Logistics, River
Entry	tactical	HazMat
Decontamination	tactical	HazMat
Access / Control	tactical	HazMat
Staging	tactical	Operations, EMS, Logistics
EMS Commander	repeated	I/C, Operations, Triage, Treatment, transport, Disposition, Logistics
Triage	Tactical	EMS command, triage, officers extrication, treatment
Treatment	Tactical	EMS command, triage, extrication, disposition
Transport (1)	Tactical	EMS command, disposition, staging, treatment
Disposition (1)	Tactical	hospital, treatment, air group, EMS command
Air Operations (1)	Tactical	air traffic control channel, disposition, hospital
Interhospital (1)	repeated	Communications between hospitals to balance patient load and ensure hospitals are prepared to handle appropriate patients.
Logistics		
Supply	Tactical	EMS command, Fire operations
Medical Support	tactical	EMS command, treatment, inter-hospital
Apparatus Support	Tactical	Operations, Fire operations, EMS command

(1) The number of sectors for fire suppression and rescue depends on the fire, number of attack teams, and complexity of fire operations. Air Florida being in a river without a fire involvement, minimized the need for suppression sectors. However, a land based crash could demand many additional sectors depending on location and number of buildings involved.

Participating COG Fire and Police Agencies involved:

Listing assembled during meeting. Ideally, all EMS units and Fire Units should operate on common frequencies.

Federal agencies

- NTSB    Law Investigations
- FAA:    Law Investigations
- USCG:   Fire Hazmat
- EPA:    Fire Hazmat

Communications Requirements

Total Tactical: 20 (excluding bridge sector)  
 Total repeated: 5

As a final note, we have identified a COG strike team to plan for the impact of a terrorist attack in the Washington, D.C. area. Using SARIN gas event in Tokyo as a model, and setting it at METRO Center, that gas would spread to several adjacent subway stations with thousands of victims. We can't begin to plan a communications network for an exercise of this magnitude, but it does identify that there will be several major events in close proximity. The ability to communicate will be drastically reduced if we do not seize the opportunity to create mutual aid channels for interoperability and develop disaster plans for their use.

This is my thought process using the incident command materials that I have attached. I could be available to discuss any of this further if necessary.

Sincerely

(signed) *Paul A. Nichols*

Communications  
Fairfax County Fire and Rescue  
4100 Chain Bridge Road  
Fairfax, VA 22030

## **UNIFIED COMMAND COMMAND - SINGLE AND UNIFIED**

Command is responsible for overall management of the incident. Command also includes certain staff functions. The Command function within the IMS may be conducted in two general ways.

- Single Command
- Unified Command

### Single Command - Incident Commander

Within a jurisdiction in which an incident occurs, and when there is no overlap of jurisdictional boundaries involved, a single incident Commander will be designated by the jurisdictional agency to have overall management responsibility for the incident.

The Incident Commander will prepare incident objectives which in turn will be the foundation upon which subsequent action planning will be based. The Incident Commander will approve the final action plan, and approve all requests for ordering and releasing of primary resources. The Incident Commander may have a deputy. The deputy should have the same qualifications as the Incident Commander, and may work directly with the Incident Commander, be a relief, or perform certain specific assigned tasks.

In an incident within a single jurisdiction, where the nature of the incident is primarily a responsibility of one agency; e.g., fire, the deputy may be from the same agency. In a multi-jurisdictional incident, or one which threatens to be multi-jurisdictional, the deputy role may be filled by an individual designed by the adjacent agency. More than one deputy could be involved. Another way of organizing to meet multi-jurisdictional situations are described under Unified Command.

This figure depicts an incident with Single Incident Command authority.

**Expanded Organization**  
Incident Management - Major Incident

***NOTE:*** *The electronic version of this figure was unavailable at the time this report was prepared. Readers can find the full text of this figure in FCC WT Docket No. 96-86, PSWAC/ISC Document No. 96-04-024/2.*

## Single/Unified Command Differences

The primary differences between the Single and Unified Command systems are:

- 1.) In a Single Command system, a single Incident Commander is solely responsible, within the confines of their authority, to establish objectives and overall management strategy associated with the incident. The Incident Commander is directly responsible for follow-through, to ensure that all functional area actions are directed toward accomplishment of the strategy. The implementation of planning required to effect operational control will be the responsibility of a single individual (Operations Section Chief) who will report directly to the Incident Commander.
- 2.) In a Unified Command system, the individuals designated by their jurisdictions, or by departments within a single jurisdiction, must jointly determine objectives, strategy and priorities. As a Single Command system, the Operations Section Chief will have responsibility for implementation of the plan. The determination of which agency or department the Operations Section Chief represents must be made by mutual agreement of the Unified Command. It may be done on the basis of greatest jurisdictional involvement, number of resources involved, by existing statutory authority, or by mutual knowledge of the individual's qualifications.

## V. Conclusions

The committee identified a need for 25 channels/RF communication paths to implement the Mutual Aid Plan in today's environment to respond to a disaster similar to Air Florida. This was qualified by factors unique to that disaster.

1. No fire was involved. Additional tactical channels/RF communication paths would be needed to support fire fighting activities. Experience shows that 12 channels/RF communications paths would be required.
2. The disaster area was small compared to that of a western wild fire, a riot, a natural disaster like a tornado or hurricane, etc. Additional personnel, the requirement for many more tactical teams, logistical demands, etc. would require many more tactical and functional communicational channels.
3. FEMA Urban Search And Rescue (USAR) teams were not required in this scenario. However, the Mutual Aid plan must include this specialty. Currently FEMA provides a cache of equipment and radio frequencies in the 406 - 420 MHz band for the US&R teams. This equipment is not compatible with the present mutual aid radio channels. The USAR special teams should be integrated into the Mutual Aid Plan employing compatible equipment and radio channels. An additional 10 channels/RF communication paths are required to support this function.

4. On January 13, 1982 a second disaster occurred involving a Metro subway train. Public Safety agencies from many entities were called on to assist the public. Interoperability is needed. Implementing a second Mutual Aid Plan at a near by location will require an equal number of channels/RF communication paths.
5. Public Safety response to this disaster was primarily a recovery mission. If rescue operations were needed the demand for additional channels/RF communications paths would be required to coordinate the rescue efforts.
6. The U.S. Public Health Service is currently coordinating the development of a Metropolitan Medical Strike Team (MMST) concept, similar to the USAR teams. The MMST's would react to a terrorist inspired event involving biological, chemical or nuclear/radiological agents. The MMST's communications needs will be similar to that of the USAR teams. It is important that a MMST operation be able to communicate and coordinate with local public safety agencies during operations in an event of this type.

## **VI. Recommendation**

In consideration of the above, the recommendation of this subcommittee is for 100 channels/RF communication paths, in contiguous spectrum and paired for repeater access, be reserved for public safety mutual aid operations, for use by any public safety agency anywhere in the nation.

These channels would be used for routine (day to day) mutual aid incident command and control operations, small and large, and for incident command and control of major disasters or major incidents to support multiple agency and multiple jurisdictional response to mitigate these type events.

This recommendation encompasses the current need for voice and data RF communications paths and includes future needs to support new and developing technologies, such as, but not limited to Global Positioning Satellite (GPS) vehicle and personnel location systems and Geographic Information Systems (GIS). The subcommittee recognizes the importance live video would be to those managing and coordinating the response. The spectrum to provide real time video is addressed by the Operational Requirements Subcommittee.

These RF communications paths would also serve to support the current Federal Emergency Management Agency (FEMA) Urban Search and Rescue (USAR) teams and the currently under development USPHS Metropolitan Medical Strike Teams (MMST).

It is further recommended that these RF communications paths be administered by the FCC authorized Public Safety Regional Plan Committee.

## **APPENDIX D**

### **ICS INTRODUCTION/OVERVIEW**

#### **D-1 BACKGROUND**

**1.1** The Incident Command System (ICS) has been developed to provide a common system which public safety agencies can utilize for response to local or wide area emergencies.

**1.2** The basic organizational structure of the ICS is based upon reviews of large incident responses in the past; organization needs were subsequently identified. Incident related management organizations in the past were organized informally as needs were identified. Under ICS the organization is pre-identified and is applicable to both small day-to-day situations as well as very large and complex incidents.

#### **D-2 ICS OPERATIONS REQUIREMENTS**

**2.1** The following are basic system design operating requirements for the Incident Command System:

**2.1.1** The System must provide for the following kinds of operation: (1) single jurisdiction/single agency, (2) single jurisdiction with multi-agency involvement, and (3) multi-jurisdiction/multi-agency involvement;

**2.1.2** The System's organizational structure must be able to adapt to any emergency or incident to which fire protection agencies would be expected to respond;

**2.1.3** The System must be applicable and acceptable to users throughout the county;

**2.1.4** The System should be readily adaptable to new technology;

**2.1.5** The System must be able to expand in a logical manner from an initial situation into a major incident;

**2.1.6** The System must have basic common elements in organization, terminology and procedures which allow for the maximum application and use of already developed qualifications and standards and ensure continuation of a total mobility concept;

**2.1.7** Implementation of the System should have the least possible disruption to existing systems;

**2.1.8** The System must be effective in fulfilling all of the above requirements and yet be simple enough to ensure low operational maintenance costs.

## D-3 COMPONENTS OF THE ICS

The Incident command System has a number of components. These components working together interactively provide the basis for an effective ICS concept of operation:

### 3.1 Common Terminology

**3.1.1** It is essential for any management system, and especially one which will be used in joint operations by many diverse users, that common terminology be established for the following elements:

*Organizational Functions:* A standard set of major functions and functional units has been predesignated and named for the ICS. Terminology for the organizational elements is standard and consistent.

*Resource Elements:* Resources refers to the combination of personnel and equipment used in tactical incidental operations; typically resources are grouped in units of 5. Common names have been established for all resources used within ICS. Any resource which varies in capability because of size or manpower (e.g., helicopters) is clearly types as to capability.

*Facilities:* Common identifiers are used for those facilities in and around the incident area which will be used during the course of the incident. These facilities include such things as the Command Post, Staging Area, etc.

### 3.2 Modular Organization

**3.2.1** The ICS organizational structure develops in a modular fashion based upon the kind and size of an incident. The organization's staff builds from the top down with responsibility and performance placed initially with the Incident Commander. As the need exists four separate Sections can be developed, each with several Units which may be established. The specific organization structure established for any given incident will be based upon the management needs of the incident. If an individual can simultaneously manage all major functional areas, no further organization is required. If one or more of the areas requires independent management, an individual is named to be responsible for that area.

**3.2.2** For ease of reference and understanding, personnel assigned to manage at each level of the organization will carry a distinctive organizational title:

Incident Command	Incident Commander
Command Staff	Officer
Section	Section Officer In-Charge
Group	Group Officer
Unit	Unit Leader

**3.2.3** In the ICS, the first management assignments by the Initial Attack Incident Commander normally be one or more Section Officers-In-Charge (OICs) to manage the major functional areas. Section OICs will further delegate management authority for their areas only as required. If the Section OIC sees the need, functional Units may be established within the Section. Similarly, each functional Unit Leader will further assign individual tasks within the Unit only as needed.

### **3.3 Unified Command Structure**

**3.3.1** The need for a unified command is brought about because:

**3.3.3.1** Many incidents have no regard for jurisdictional boundaries. Riots, fires, floods, hurricanes, earthquakes usually cause multi-jurisdictional major incident situations.

**3.3.3.2** Individual agency responsibility and authority is normally legally confined to a single jurisdiction.

**3.3.2** The concept of unified command simply means that all agencies who have a jurisdictional responsibility at a multi-jurisdictional incident contribute to the process of:

**3.3.2.1** Determining overall incident objectives.

**3.3.2.2** Selection of strategies.

**3.3.2.3** Ensuring that joint planning for tactical activities will be accomplished.

**3.3.2.4** Making maximum use of all assigned resources.

**3.3.3** The proper selection of participants to work within a unified command structure will depend upon:

**3.3.3.1** The location of the incident - which political jurisdictions are involved.

**3.3.3.2** The kind of incident - which functional agencies of the involved jurisdictions are required.

**3.3.4** A unified command structure could consist of a key responsible official from each jurisdiction in a multi-jurisdictional situation or it could consist of several functional departments within a single political jurisdiction.

**3.3.5** Common objectives and strategy on major multi-jurisdictional incidents should be written. The objectives and strategies then guide development of the

action plan. Under a unified command structure in the ICS, the implementation of the action plan will be done under the direction of a single individual, the Operations OIC.

**3.3.6** The Operations OIC will normally be from the agency which has the greatest jurisdictional involvement. Designation of the Operations OIC must be agreed upon by all agencies having jurisdictional and functional responsibility at the incident.

### **3.4 Consolidated Action Plan**

**3.4.1** Every incident needs some form of an action plan. For small incidents of short duration, the plan need not be written. The following are examples of when written action plans should be used:

**3.4.1.1** When resources from multiple agencies are being used.

**3.4.1.2** When several jurisdictions are involved.

**3.4.1.3** When the incident is of such duration that it will require changes in shifts of personnel and/or equipment.

**3.4.2** The Incident Commander will establish objectives and make strategy determinations for the incident based upon the requirements of the jurisdiction. In the case of a unified command, the incident objectives must adequately reflect the policy and needs of all the jurisdictional agencies.

**3.4.3** The action plan for the incident cover all tactical and support activities required for the operational period.

### **3.5 Manageable Span-of-Control**

**3.5.1** Safety factors as well as sound management planning will both influence and dictate span-of-control considerations. In general, within the ICS, the span-of-control of any individual with emergency management responsibility should range from three to seven units with a span-of-control of five being established as a general rule of thumb. Of course, there will always be exceptions (e.g., an individual Group Officer with responsibility of traffic control Supervision could have substantially more than five personnel).

**3.5.2** The kind of an incident, the nature of the task, hazard and safety factors all will influence span-of-control considerations. An important consideration in span-of-control is to anticipate change and prepare for it. This is especially true during rapid build-up of the organization when good management is made difficult because of too many reporting elements.

### **3.6 Designated Incident Facilities**

**3.6.1** There are several kinds and types of facilities which can be established in and around the incident area. The determination of kinds of facilities and their locations will be based upon the requirements of the incident and the direction of Incident Command. The following facilities are defined for possible use with the ICS:

*Command Post:* Designated as the CP, the Command Post will be the location from which all incident operations are directed. There normally should only be one Command Post for the incident. In a unified command structure where several agencies or jurisdictions are involved, the responsible individuals designated by their respective agencies would be co-located at the Command Post. The planning function is also performed at the Command Post, and normally the Communications Center would be established at this location. The Command Post may be co-located with the incident base if communications requirements can be met.

*Incident Base:* The Incident Base is the location at which primary support activities are performed. The Base will house all equipment and personnel support operations. The Incident Logistics Section, which is responsible for ordering all resources and supplies is also located at the Base. There should only be one Base established for each incident, and normally the Base will not be relocated.

*Staging Area:* Staging Areas are established for temporary location of available resources. Staging Areas will be established by the Operations OIC to locate resources not immediately assigned. A Staging Area can be anywhere in which personnel and equipment can be temporarily located awaiting assignment. Staging Areas may include temporary sanitation services and fueling. Feeding of personnel would be provided by mobile kitchens or sack lunches. Staging Areas should be highly mobile.

*Helibases:* Helibases are locations in and around the incident area at which helicopters may be parked, maintained, fueled, and loaded with personnel or equipment. More than one Helibase may be required on very large incidents.

*Helispots:* Helispots are more temporary and less used locations at which helicopters can land and take off.

### **3.7 Comprehensive Resource Management**

**3.7.1** Resources may be managed in three different ways, depending upon the needs of the incident:

*Single Resources:* Single resources are individual officers, volunteers, mutual aid helicopters, etc., that will be assigned as primary tactical Units. A single resource will be the equipment plus the required individuals to properly utilize it.

*Task Forces:* A Task Force is any combination of resources which can be temporarily assembled for a specific mission. All resource elements within a Task Force must have common communications and a Leader. Task Forces should be established to meet specific needs and should be demobilized as single resources.

*Tactical Units:* Tactical Units are a set number of resources of the same kind and type, which have an established minimum number of personnel. Tactical Units will always have a Leader and will have common communications among resource elements. An example of a Tactical Unit in the fire service is a Type 1 Engine Strike Team which would be composed of 5 identical engines Type 1 engines and a leader.

**3.7.2** The use of Task Forces is encouraged, wherever possible, to maximize the use of resources, reduce the management control of a large number of single resources, and reduce the communications load.

**3.7.3** In order to maintain an up-to-date and accurate picture of resource utilization, it is necessary that:

**3.7.3.1** All resources be assigned a current status condition.

**3.7.3.2** All changes in resource locations and status conditions be made promptly to the appropriate functional Unit.

**3.7.3.3** *Status Condition:* Three status conditions are established for use with tactical resources at the incident:

*Assigned* - Performing an active assignment.

*Available* - Ready for assignment.

*Out-of-Service* - Not ready for available or assigned status (for example, resources assigned to the Incident Base for rest and rehabilitation.)

## **D-4 ORGANIZATION AND OPERATIONS**

**4.1** The ICS organization has five major functional areas. The functional areas are:

### **4.1.1 Command**

### **4.1.2 Operations**

**4.1.3 Planning/Intelligence****4.1.4 Logistics****4.1.5 Finance****D-5 THE COMMUNICATIONS UNIT LEADER**

**5.1** The Communications Unit Leader, under direction and supervision of the Services Group Officer of Logistics Officer, is responsible for developing plans for the effective use of incident communications equipment and facilities, installing and testing communications equipment, supervision of the Incident Communications Center (not the Incident Dispatchers), and the maintenance and repair of communications equipment.

**5.1.1** Obtain briefing from Service Section Officer or Logistics Section Officer.

**5.1.2** Determine Unit personnel needs.

**5.1.3** Prepare and implement an Incident Radio Communications Plan.

**5.1.4** Ensure the Communications Center and equipment are working.

**5.1.5** Set up telephone and public address systems, as required.

**5.1.6** Establish appropriate communications distribution/maintenance locations.

**5.1.7** Ensure radio equipment from outside agencies is accounted for.

**5.1.8** Provide technical information as required on:

**5.1.8.1** Adequacy of communications systems currently in operation;

**5.1.8.2** Geographic limitations on communications systems;

**5.1.8.3** Equipment capabilities;

**5.1.8.4** Amount and types of equipment available;

**5.1.8.5** Anticipated problems with use of communications equipment.

**5.1.9** Maintain records on all communications equipment as appropriate.

**5.1.10** Recover equipment from relieved or released units.

**5.1.11** Maintain Unit Log.

## ATTACHMENT 1

Minority Report (Union Pacific Railroad)  
(PSWAC/ISC 95-12-059)**UNION PACIFIC RAILROAD COMPANY**INFORMATION  
TECHNOLOGIES1416 DODGE STREET  
OMAHA, NEBRASKA 68179Jim Downes,  
Chairperson, ISC  
PSWAC  
Via Fax

December 12, 1995

Dear Jim,

I was fortunate enough to receive your fax dated December 11, 1995 as I was leaving the building for the airport. I, once again, am on the road attending meeting for the railroad industry in Chicago as well as attending the PSWAC meeting in Washington D.C.

Your fax discusses the definitions of Public Safety/Public Service. I appreciate your "heads-up" call last week to alert me that the definitions that we had submitted were attachments and were not part of the actual text. After reviewing your fax, I was disappointed that the resulting definitions are very ambiguous in relation to the roll the railroad industry has with Public Safety.

You and I have served on many task forces and working groups together over the last several years. I understand that it can be very difficult to obtain consensus within a large group of people. I also realize that I was unable to attend the conference call last week which developed this version of text. That meeting would have given me the opportunity to defend our submission. In addition, a recent development is requiring that I attend a railroad industry meeting to discuss FCC related issues at 10:00 a.m. on December 14, 1995, which conflicts with your subcommittee meeting.

It is my intention to attend the opening portion of your meeting before I leave for my 10:00 a.m. meeting. If this issue is not discussed prior to my departure, I would like to submit the following comments on behalf of the railroad industry:

1. In general, the definitions lack clarity as to which radio users are considered to fall within the public safety definition. If possible, specific examples of public safety users would

be very beneficial. Obviously, we would like the railroad industry to be specifically identified as one of the examples.

2. If the subcommittee does not wish to identify any specific user as public safety, we would like to have clarification that the Federal Railroad Administration (FRA) qualifies as a Federal Government entity as identified throughout the definitions. In addition, the railroads, which are governed by the FRA, fall within one or more of the definitions as stated.

3. Finally, if specific users are not identified, we would like to have the statements in item 2 above, agreed to by the subcommittee and submitted into the minutes of the meeting as a point of record.

We appreciate the opportunity to be involved with this landmark event to draw attention to the needs of radio users associated with Public Safety. The Government found it necessary to establish a specific band of frequencies for the railroad industry many years ago based on the need for public safety. It is important that we reiterate that the railroad's use of radio spectrum for public safety has not diminished since then and, in fact, has become more prominent.

If you have any questions or comments, please leave a message at my office (402) 271-4883. I will be checking for messages periodically. I look forward to working with you on upcoming events.

Sincerely,



Edwin F. Kemp  
Director, Telecom Engineering  
Union Pacific Railroad

cc: Lynn Andrews, UPRR  
Roy Creath, UPRR  
Tom Keller, V.L.B.McP.&H

ATTACHMENT 2

Minority Report (Dr. Michael C. Trahos)  
(PSWAC/ISC 96-02-020)

Before the  
FEDERAL COMMUNICATIONS COMMISSION  
WIRELESS TELECOMMUNICATIONS BUREAU  
PRIVATE WIRELESS DIVISION  
Washington, D.C. 20554

In the Matter of	)	
	)	
Public Safety Wireless Advisory	)	WTB-1
Committee (PSWAC);	)	
Interoperability Subcommittee:	)	PSWAC/ISC 95-12-051/3
	)	
Definition of Public Safety/	)	
Public Services	)	

COMMENTS

Submitted by:

Dr. Michael C. Trahos, D.O., NCE, CET  
4600 King Street, Suite 4E  
Alexandria, Virginia 22302-1213

February 21, 1996

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Before the  
FEDERAL COMMUNICATIONS COMMISSION  
WIRELESS TELECOMMUNICATIONS BUREAU  
PRIVATE WIRELESS DIVISION  
Washington, D.C. 20554

In the Matter of	)	
	)	
Public Safety Wireless Advisory	)	WTB-1
Committee (PSWAC);	)	
Interoperability Subcommittee:	)	PSWAC/ISC 95-12-051/3
	)	
Definition of Public Safety/	)	
Public Services	)	

COMMENTS

Submitted by:

Dr. Michael C. Trahos, D.O., NCE, CET  
4600 King Street, Suite 4E  
Alexandria, Virginia 22302-1213

February 21, 1996

I. INTRODUCTION

1. Dr. Michael C. Trahos, D.O., NCE, CET (Commenter), pursuant to the Federal Communications Commission's (Commission) co-sponsored Public Safety Wireless Advisory Committee (PSWAC) (C-ID #2016) Charter (Attachment C), hereby submits these Comments in response to the PSWAC's Interoperability Subcommittee (ISC)/Steering Committee approved "Definition of Public Safety/Public Services" (Attachment A).<sup>1/</sup>

## II. COMMENTER QUALIFICATIONS

2. Commenter is a licensed and actively practicing General Medicine/Family Practice Physician and Surgeon. Commenter holds the academic faculty appointments of Clinical Professor of Medicine from Ross University School of Medicine and Clinical Instructor, Department of Family Medicine, Georgetown University School of Medicine. Commenter holds the current position of Chairman - Legislative Affairs Committee and was President (CY '94) of the Alexandria [Virginia] Medical Society (AMS), was Vice-Councilor (FY '95) - 8th U.S. Congressional District of the Medical Society of Virginia (MSV), is Chairman - Legislative Affairs Committee of the District of Columbia Osteopathic [Medical] Association, was Vice-President (Fys '89-90) of the Virginia [State] Osteopathic Medical Association (VOMA), is VOMA Virginia State Delegate to the [National] American Osteopathic [Medical] Association (AOA) House of Delegates and VOMA Federal Representative to the AOA Council on Federal Health Programs.

3. Commenter was selected/elected and currently serves as the "Medical Profession" Representative on the Technical Committee, Chairman - Legislative/Regulatory Affairs Committee and Special Emergency Radio Service Representative on the RPRC of the National Public Safety Planning Advisory Committee's (NPSPAC) Region-20 [State of Maryland, Washington, DC and Northern Virginia] Public Safety Plan Review Committee (RPRC), for the development and implementation of a Public Safety National/Regional Plan (General Docket No. 90-7) for the use of the 821-824/866-869 MHz bands by the Public Safety Services pursuant to the Report and Order in General Docket No. 87-112.

4. Commenter is a certified First Class Telecommunications Engineer, with expertise endorsements in Administrative/ Regulatory, Antenna Systems, Broadcast AM, Frequency Coordination and Land Mobile Systems, certified by the National Association of Radio and Telecommunications Engineers (NARTE), and possessor of a First Class Certificate of Competency, issued by the Association of Public-Safety Communications Officers (APCO). Commenter is a FELLOW of The Radio Club of America. Commenter has over twenty years experience in the telecommunications field with many of these years spent actively participating in Commission proceedings.

5. Commenter is licensed in the Amateur Radio Service (ARS), the Business Ratio Service (BRS), the General Mobile Radio Service (GMRS) and Special Emergency

Radio Service (SERS). Commenter has/is serving as a voluntary frequency/CTCSS/DCS GMRS coordinator for the Washington, D.C. Metropolitan area. It is with having the above extensive expertise in dealing with personal, business, medical and emergency/public assistance communications matters that this Commenter is qualified to make the following Comments.

### III.

### COMMENTS

6. Pursuant to the PSWAC Charter, the scope of activity and objectives of this Committee is to “provide advise and recommendations to the Chairman, Federal Communications Commission (FCC) and the Administrator, National Telecommunications and Information Administration (NTIA) on operational, technical, and spectrum requirements of Federal, state, and local public safety entities through the year 2010.”<sup>2/</sup> It is to further “[a]dvice the NTIA and FCC on options to provide for greater interoperability among Federal, State, and local public safety entities.”<sup>3/</sup>

7. On December 15, 1995, the PSWAC Steering Committee approved the ISC document entitled “Definition of Public Safety/Public Services”.<sup>4/</sup> In defining Public Safety/Public Services, the ISC has restricted the definition of Public Safety Services to those services only “rendered by or through Federal, State, or Local government entities” (Emphasis added) and Public Safety Services Provider/Support Provider to only those entities that are “properly authorized by the appropriate (Public Safety) governmental authority”<sup>5/</sup> (Emphasis added). These restrictive definitions fail to take into account recent Commission proceedings that further define Public Safety Services/Support Providers as those provided by entities not related to or requiring Public-Safety governmental authority authorization.

8. The issue of defining who is a “public safety authority”<sup>6/</sup> or public “safety-of-life” entity<sup>7/</sup> has been debated within Commission proceedings since 1987. It began with GN Docket No. 87-112 and has recently been concluded with the adoption of the Emergency Medical Radio Service (EMRS) Memorandum Opinion and Order in PR Docket No. 91-72 (EMRS M,O&O) on January 18, 1996.

9. Shortly after the adoption of the Report and Order in GN Docket Nos. 84-1231, 84-1233, and 84-1234<sup>8/</sup> which allocated the 821-824/866-869 MHz bands to Public Safety, the Commission adopted a Notice of Proposed Rule Making, GN Docket No. 87-112,

to establish service rules and technical standards for the use of these newly allocated bands (821 MHz Notice). In the 821 MHz Notice, the Commission proposed to define “public safety authorities” as being those entities licensed in the Public Safety Radio Services (PSRS) under 47 CFR Part 90, Subpart B and SERS under 47 CFR Part 90, Subpart C. After the extensive review of comments and replies regarding this issue, the Commission concluded that their proposed defining of “public safety authorities” as meaning PSRS and SERS eligibles was correct, sighting that PSRS and SERS are “both involved with public safety”, and issued the Report and Order in GN Docket No. 87-112 (821 MHz Order) adopting this definition.<sup>9/</sup>

10. Also in 1987, the Commission adopted a Notice of Proposed Rule Making, GN Docket No. 87-14, to reallocate the 220-222 MHz band from secondary ARS to primary narrowband commercial and public safety use.<sup>10/</sup> Shortly after the adoption of the Report and Order in GN Docket No. 87-14 reallocating this band<sup>11/</sup>, the Commission adopted a Notice of Proposed Rule Making, PR Docket No. 89-552, to provide for the use of this new band.<sup>12/</sup>

11. In the Report and Order to GN Docket No. 89-552, the Commission adopted a band plan for 220-222 MHz which included a 10 channel Public Safety/Mutual Aid set aside, but allowing only those public safety entities eligible under 47 CFR Part 90, Subpart B access to these frequencies.<sup>13/</sup> In response to a Petition for Reconsideration questioning the exclusion of select 47 CFR Part 90, Subpart C SERS eligibles from these new 220-222 MHz Public Safety/Mutual Aid channels<sup>14/</sup> (220 MHz Reconsideration), the Commission adopted a Memorandum Opinion and Order in PR Docket No. 89-552<sup>15/</sup> (220 MHz M,O&O) electing to defer this issue to a then recently enacted Notice of Proposed Rule Making, PR Docket No. 91-72, to create a new EMRS.<sup>16/</sup>

12. Upon adoption of the Report and Order in PR Docket No. 91-72 (EMRS Order), the Commission inadvertently omitted addressing the deferred 220 MHz Reconsideration issue, as noted in paragraph 11 *supra*, as stated would be done pursuant to the 220 MHz M,O&O. Upon release of the EMRS Order, a further Petition for Reconsideration<sup>17/</sup> (EMRS Reconsideration) was filed again raising the same issue addressed in the 220 MHz Reconsideration.

13. In comments filed in response to the EMRS Reconsideration, the International Municipal Signal Association/International Association of Fire Chiefs, Inc. (IMSA/IAFC) claimed that the purpose of the EMRS proceeding was to “disentangle emergency medical

communications from other SERS eligibles”, to “provide “Public Safety” recognition to this user community in recognition of its function and communications needs,” and to apparently “cure” a definable injustice to EMRS (47 CFR Part 90, Subpart B) eligibles.<sup>18/</sup> Upon adopting the EMRS Order, it was perceived that the Commission had appropriately redefined Public Safety authorities/safety-of-life eligibles as 47 CFR Part 90, Subpart B entities only and essentially deleting all non-EMRS SERS (47 CFR Part 90, Subpart C) entities from 821 MHz Order definition.

14. In reply to IMSA/IAFC’s comments, this Commenter presented substantive supportive arguments that non-EMRS eligible SERS entities, under 47 CFR Part 90 Subpart C [§§ 90.35 (physicians/hospitals), 90.37 (rescue organizations), 90.41 (disaster relief organizations), and 90.45 (beach patrols)], during emergencies and disasters do “perform the exact function and have interoperability communications needs equal to their EMRS counterparts.”<sup>19/</sup> In the EARS M,O&O, the Commission agreed with this Commenter’s assertions and appropriately amended 47 CFR 90.720 to reflect their inclusion because of the correct assessment that it would “serve the public interest by enhancing interoperability between many types of emergency providers in safety-of-life situations.”<sup>20/</sup>

#### IV.

#### CONCLUSION

15. With adoption of the EMRS M,O&O, the Commission has essentially refined the 821 MHz Order definition of Public Safety authorities/safety-of-life entities to now mean those eligible under 47 CFR Part 90 Subpart B (PSRS) and Subpart C (SERS under §§ 90.35, 90.37, 90.41 and 90.45). Nowhere in the Commission’s rules is it required that these entities be properly authorized by an appropriate governmental authority, whose primary mission is in providing public safety services, prior to performing their duties.

16. The PSWAC ISC definition of Public Safety Services is too restrictive. It fails to recognize that Public Safety/Safety-of-Life services are provided by entities not related to, or requiring prior specific authorization from, a governmental authority whose primary mission is in providing public safety services.

17. The PSWAC ISC definition also goes counter to the PSWAC Charter. The PSWAC Charter mandates the maximizing of interoperability between Federal, state, and local public safety entities. By defining Public Safety Services/Providers as those only related to or

authorized by a Public Safety governmental entity, interoperability communications becomes significantly restricted, hampers the prompt rendition and delivery of medical/emergency services and is therefore not in the public interest.

18. It is strongly recommended that the PSWAC ISC definition be modified to better conform with the PSWAC Charter and the Commission's definition of who constitutes a Public Safety/Safety-of-Life authority/entity by the removal from the definitions any reference to the requirement that such entities be "properly authorized by the appropriate governmental authority" whose primary mission is providing/to support public safety services (Attachment B). Only in this manner can the

PSWAC Charter mandate of maximizing interoperability communications between the many types of emergency providers in safety-of-life situations be achieved.

Respectfully submitted,

Dr. Michael C. Trahos, D.O., NCE, CET

FOOTNOTES

- <sup>1/</sup> DEFINITION OF PUBLIC SAFETY/PUBLIC SERVICES, PSWAC/ISC 95-12-051/3 12/14/95, ISC revised and approved 12/14/95, Steering Committee approved 12/15/95.
- <sup>2/</sup> CHARTER, Public Safety Wireless Advisory Committee, June 26, 1995, Section B.
- <sup>3/</sup> Ibid.
- <sup>4/</sup> DEFINITION OF PUBLIC SAFETY/PUBLIC SERVICES, PSWAC/ISC 95-12-051/3, December 14, 1995.
- <sup>5/</sup> Ibid.
- <sup>6/</sup> NOTICE OF PROPOSED RULE MAKING, GN Docket No. 87-112, 2 FCC Rcd at 2869, at paragraph 6.
- <sup>7/</sup> MEMORANDUM OPINION AND ORDER, PR Docket No. 91-72, FCC 96-11, at paragraph 19.
- <sup>8/</sup> REPORT AND ORDER, GN Docket Nos. 84-1231, 84-1233 & 84-1234, 2 FCC Red 1825 (1986).
- <sup>9/</sup> REPORT AND ORDER, GN Docket No. 87-112, FCC 87-359, at paragraphs 12 and 13.
- <sup>10/</sup> NOTICE OF PROPOSED RULE MAKING, GN Docket No. 87-14, FCC 87-45, at paragraph 10.
- <sup>11/</sup> REPORT AND ORDER, GN Docket No. 87-14, FCC 88-266, at paragraph 43.
- <sup>12/</sup> NOTICE OF PROPOSED RULE MAKING, PR Docket 89-552, FCC 89-327, in general.
- <sup>13/</sup> REPORT AND ORDER, PR Docket No. 89-552, FCC 91-74, at paragraph 24 - 28.
- <sup>14/</sup> PETITION FOR RECONSIDERATION, PR Docket No. 89-552, Dr. Michael S. Trahos, May 15, 1991; PUBLIC NOTICE, Report No. 1848, June 5, 1991.
- <sup>15/</sup> MEMORANDUM OPINION AND ORDER, PR Docket No. 89-552, FCC 92-261, at paragraph 38.

<sup>16/</sup> NOTICE OR PROPOSED RULE MAKING, PR Docket No. 91-72, 6 FCC Rcd 2017 (1991).

<sup>17/</sup> PETITION FOR RECONSIDERATION, PR Docket No. 91-72, Dr. Michael C. Trahos, April 2, 1993; PUBLIC NOTICE, Report No. 1936, April 27, 1993.

<sup>18/</sup> REPLY, PR Docket No. 91-72, IMSA/IAFC, June 4, 1993, at page 16.

<sup>19/</sup> REPLY COMMENTS, PR Docket No. 91-71, Dr. Michael C. Trahos, June 14, 1993.

<sup>20/</sup> MEMORANDUM OPINION AND ORDER, PR Docket No. 91-72, FCC 96-11, at paragraph 23.

## VI.

ATTACHMENT A

PSWAC/ISC 95-12-051/3 (12/14/95)  
Revised and approved by ISC (12/14/95)  
Approved by Steering Committee (12/15/95)

**DEFINITION OF PUBLIC SAFETY/PUBLIC SERVICES**

*Public Safety:* The public's right, exercised through Federal, State or Local government as prescribed by law, to protect and preserve life, property, and natural resources and to serve the public welfare.

*Public Safety Services:* Those services rendered by or through Federal, State, or Local government entities in support of public safety duties.

*Public Safety Services Provider:* Governmental and public entities or those non-governmental, private organizations, which are properly authorized by the appropriate governmental authority whose primary mission is providing public safety services.

*Public Safety Support Provider:* Governmental and public entities or those non-governmental, private organizations which provide essential public services that are properly authorized by the appropriate governmental authority whose mission is to support public safety services. This support may be provided either directly to the public or in support of public safety services providers.

*Public Services:* Those services provided by non-public safety entities that furnish, maintain, and protect the nation's basic infrastructures which are required to promote the public's safety and welfare.

VII.

ATTACHMENT B  
**PROPOSED**

**DEFINITION OF PUBLIC SAFETY/PUBLIC SERVICES**

Public Safety: The public's right, exercised through Federal, State or Local government as prescribed by law, to protect and preserve life, property, and natural resources and to serve the public welfare.

Public Safety Services: Those services tendered by or through Federal, State, or Local entities in support of public safety duties.

Public Safety Services Provider: Governmental and public entities or those non-governmental, private individuals or organizations, which are providing public services.

Public Safety Support Provider: Governmental and public entities or those non-governmental, private individuals or organizations which provide essential public services to support public safety services. This support may be provided either directly to the public or in support of public safety services providers.

Public Services: Those services provided by non-public safety entities that furnish, maintain, and protect the nation's basic infrastructure which are required to promote the public's safety and welfare.

## VIII.

ATTACHMENT C  
CHARTERA. Committee's Official Designation

Public Safety Wireless Advisory Committee.

The establishment of this Committee is in response to the provisions of Title VI of the Omnibus Budget Reconciliation Act of 1993 and, more specifically, to reflect the desires of the House Appropriations Committee's Subcommittee on Commerce, Justice, and State, the Judiciary and Related Agencies that the FCC and NTIA coordinate closely with the public safety community in planning for future spectrum needs.

B. Committee's Objectives and Scope of Activity

The function of the Advisory Committee is to provide advice and recommendations to the Chairman, Federal Communications Commission (FCC) and the Administrator, National Telecommunications and Information Administration (NTIA) on operational, technical, and spectrum requirements of Federal, state, and local public safety entities through the year 2010. In addition, it will serve to advise the FCC and NTIA of opportunities for improved spectrum utilization and efficiency and facilitate a negotiated rulemaking at the FCC regarding public safety spectrum, and the development and implementation of plans at NTIA regarding Federal public safety spectrum policy. Membership for the Committee will be solicited from public safety organizations, entities and manufacturers and members will serve as representatives of organizations and not as experts serving in an individual capacity. The Advisory Committee will:

- Advise the FCC and NTIA of specific operational wireless needs of the community including improvement of basic voice, data and E911 services, and the implementation of new wide-area, broadband telecommunications technologies for transmission of mugshots, fingerprints, video, and other high speed data.
- Advise the NTIA and FCC on options to provide for greater interoperability among Federal, state, and local public safety entities.
- Advise the FCC and NTIA on options to accommodate growth of basic and emerging services, including bandwidth vs. functional requirement trade-offs, technical options, and other options.
- Advise the NTIA and FCC on the total spectrum requirements for the operational needs referred to above including frequency band options, shared/joint spectrum use options, and other options.

C. Period of Time Necessary for the Committee to Carry Out its Purposes

The Committee will submit a report to the FCC and NTIA within the scope outlined in Part B above within 12 months of the first formal meeting. All business of the Committee will be completed within a two-year period.

D. Officials to Whom the Committee Resorts

Chairman, FCC  
Administrator, NTIA

E. Agencies Responsible for Providing Necessary Support to the Committee

The Federal Communications Commission

The National Telecommunications and Information Administration

F. Description of Duties for Which Committee is Responsible

The duties of the Committee will be to gather information and prepare technical analyses and recommendations concerning the matters listed in Part B above and provide them to the FCC and NTIA. The committee will function solely as an advisory body under the Federal Advisory Committee Act, 5 U.S.C. App2.

G. Estimated Annual Operating Costs in FTEs and Dollar

The estimated annual staff time is two FTEs for FCC and two FTEs for NTIA. The estimated annual operating costs for support services provided to the Committee are \$25,000.00, to be shared equally by NTIA and FCC.

H. Estimated Number and Frequency of Meetings

The Committee is expected to meet at least two times per year, and at such other intervals as the Committee decides.

I. Termination Date

The Committee would terminate no later than June 26, 1997.

J. Date Charter is Filed

June 26, 1995.

ATTACHMENT 3

PSWAC/ISC 95-10-030/2

**Public Safety  
Wireless Advisory Committee**

**Interoperability  
Subcommittee**

**Interoperability  
White Paper**

11 December, 1995

ericssonz

## **Introduction**

The Public Safety Wireless Advisory Committee (PSWAC) was formed on July 28, 1995, “to provide advice and recommendations to the Chairman, Federal Communications Commission (FCC) and the Administrator, National Telecommunications and Information Administration (NTIA) on operational, technical, and spectrum requirements of Federal, state, and local public safety entities through the year 2010. In addition, it will serve to advise the FCC and NTIA of opportunities for improved spectrum utilization and efficiency and facilitate a negotiated rulemaking at the FCC regarding public safety spectrum, and the development and implementation of plans at NTIA regarding Federal public safety spectrum policy.”<sup>1</sup> A key activity of PSWAC is to “advise the NTIA and FCC on options to provide for greater interoperability among Federal, state, and local public safety entities.”<sup>1</sup>

Indeed, interoperability is a formidable problem. It is a problem that is often associated with risk of life during natural disasters and national emergencies. The loss of a single life resulting from two different public safety agencies’ communications equipment inability to communicate is unacceptable! However, equally unacceptable is selecting an interoperability solution that cannot be implemented because it ignores practical considerations such as affordability.

The vast cornucopia of user needs and potential technological solutions quickly becomes overwhelming. The objective of this white paper is to review the fundamental user requirements for interoperability, identify candidate technical solutions, and recommend solutions that satisfy user needs for interoperability.

## **Interoperability Definition**

James E. Downes, Department of Treasury, chairman of the Interoperability Subcommittee provided two definitions of interoperability from the Federal Law Enforcement Wireless Users Group (FLEWUG) and FED-STD-1037B.<sup>2</sup> For the purpose of this white paper the following definitions are provided:

Interoperability - The ability of two or more public safety communications systems to interact with one another and exchange information according to a prescribed manner in order to achieve predictable results.

Public Safety - Individuals in Federal and non-Federal public safety agencies “generally made up of law enforcement/police services, fire and rescue services, emergency medical services, and emergency management services.”

<sup>1</sup> Charter Section of Handout at Public Safety Wireless Advisory Committee Round Table in Washington, DC on July 28, 1995

<sup>2</sup> PSWAC/ISC 95-09-003 dated September 28, 1995

**Interoperability Missions**

John Powell, representing the Association of Public Safety Communications Officials (APCO), described three types of public safety interoperability to AFCEA on September 19, 1995. (See Appendix A.) APCO’s three types of public safety interoperability missions and examples are summarized in the following table:

<b>Mission</b>	<b>Mutual Aid</b>	<b>Day-to-Day</b>	<b>Task Force</b>
<b>Definition (Requirements)</b>	Involves many agencies Little planning Small tactical talk groups Many incidents out of infrastructure coverage	Areas of concurrent jurisdiction Routine traffic Minimize dispatcher-to-dispatcher interaction	Layers of government (federal, state & local) Prior planning • Covert • Short range Roaming in and out of infrastructure coverage
<b>Examples</b>	Oklahoma City Amtrak Crash • Air Florida Crash • Hurricane Hugo • Wildland Fires • Polly Klaas	Polly Klaas  Urban Automobile Accident involving Police, Fire & EMS	Waco, Texas • World Leader Visit

It should be noted that John Powell’s conclusion that “infrastructure based interoperability is not efficient because it makes continuous use of an extra RF channel by each participant on a different band or system”<sup>3</sup> is incorrect. Powell’s argument contains two fallacies: 1) unless the two agencies of concurrent jurisdiction have a shared system (identical operating frequencies), an additional channel with the associated base station equipment is always required to provide interoperability, and 2) in the 866-869 MHz NSPSAC channels, agencies that are geographically adjacent are rarely (if ever) given the same frequency. Thus, different/additional frequencies are always required. The situation is also the same even when two agencies operate on systems that have identical protocols.

In order to ensure interoperability during a natural disaster, the following categories of radio users should be included:

1. Military - Military forces shall be considered a public safety agency when they assist state and local governments with emergency management activities related to natural disasters or during periods of civil unrest.
  
2. Utility Companies - Certain utility companies require interoperability with public safety agencies especially during natural disasters or during periods of civil unrest when gas lines, water lines, or electrical distribution pose a threat to the life and safety of individuals.

---

<sup>3</sup> Handout at September 19, 1995 AFCEA presentation.

3. Special Mobile Radio Services (SMRS) - Government agencies may mandate the use of SMRS resources during natural disasters to provide radio services and coverage in situations where otherwise the public safety communications infrastructure is jeopardized.

4. Third Party Provided Services - Some public safety users pay a third party for the communications services and therefore the communications system is not licensed in a public safety band. Consideration should be given to spectrum policy issues for these users.

5. Others - Interoperability with civil defense, railroads, flood control, public transportation, and district attorney offices should be an important consideration.

It should be noted that not all agencies have the same interoperability needs. For example, it is highly unlikely that volunteer firemen would be involved in many of the task force scenarios. However, the few task force scenarios that might involve volunteer firemen would have different interoperability requirements than a mutual aid scenario. An example of this is the Oklahoma City bombing disaster. Appendix C contains some excerpts of recent APCO Bulletin articles on the Oklahoma City bombing disaster. It suggests that communications architecture resembled a military-style hierarchy of communications links as represented in Figure 2.

The communications link between "Command & Control" and the first line of group leaders is separate from each agency's group communications link. In fact, separation of communication links is highly desirable because the vital "Command & Control" communications link would not want to be busy with group traffic. Capacity of any conventional communications link has a practical limit of approximately 50 users. Disaster relief also involves the Federal Emergency Management Agency (FEMA), whose role is to provide federal assistance and resources to state and local efforts.<sup>4</sup>

While some of these agencies are considered to be part of "public service" (instead of "public safety"), they are still critical user agencies who are called on during an emergency situation, and who require interoperability.

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<sup>4</sup> Federal Response Plan (For Public Law 93-288, as Amended), Basic Plan Paragraph II. A. 1. Page 4

Figure 2  
 Command & Control Hierarchy  
 Oklahoma City Example

**NOTE:** *The electronic version of this figure was unavailable at the time this report was prepared. Readers can find the full text of this figure in FCC WT Docket No. 96-86.*

It should be noted that there is a distinction between interoperability and interconnectivity: “Interoperability allows diverse systems operating on different frequencies to communicate with each other so users do not have to account for differences in products or services. Interoperability implies compatibility among systems at specified levels of interaction, including physical. This compatibility is achieved through specifications for the interfaces between systems.”<sup>5</sup> Interconnectivity is the technology required to provide interoperability; however, interoperability has many issues beyond technical interconnection.

**Interoperability Today**

John Powell’s interoperability presentation to AFCEA on September 19, 1995 (see Appendix A), also describes today’s solutions to interoperability. Solutions to the three types of public safety interoperability missions are summarized in the following table:

Mission	Mutual Aid	Day-to-Day	Task Force
<b>Definition (Requirements)</b>	Involves many agencies Little planning Small tactical talk groups Many incidents out of infrastructure coverage	Areas of concurrent jurisdiction Routine traffic Minimize dispatcher-to-dispatcher interaction	Layers of government (federal, state & local) Prior planning • Covert • Short range Roaming in and out of infrastructure coverage
<b>Examples</b>	Oklahoma City Amtrak Crash • Air Florida Crash • Hurricane Hugo • Wildland Fires • Polly Klaas	Polly Klaas  Urban Automobile Accident involving Police, Fire & EMS	Waco, Texas World Leader Visit
<b>Today’s Solution</b>	Portable-to-Portable Direct Talk	Multiple Radios for Different Bands Difficult Infrastructure Gateways	Portable-to-Portable Hand Out Unique Radio Equipment

For the mutual-aid scenario, a portable-to-portable direct-talk solution is entirely acceptable. The problem is that public safety communications operate on different, rather than contiguous

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<sup>5</sup> “In Pursuit of an Optimum: A Conceptual Model for Examining Public Sector Policy Support of Interoperability,” Lori Annette Perine, National Institute of Standards and Technology, August 1995.

frequency bands. Therefore, there is no guarantee that two different public safety agencies operate on the same frequency channels; this prohibits mutual aid operation. For the day-to-day scenario, the lack of common operating frequencies and incompatible communications infrastructure is solved by either 1) carrying multiple radios that are compatible with all the communications equipment in the jurisdiction of interest, or 2) provide “gateways” based on common channels to the communications infrastructure. For the task force scenario, unique covert requirements are provided by handing out unique radios.

The Polly Klaas case was used as an example of John Powell’s “Day-to-Day” public safety interoperability mission. John Powell defines the “Day-to-Day” interoperability mission as “areas of concurrent jurisdiction” while the Polly Klaas case clearly illustrates the failure of two *adjacent* counties to interoperate. A better example of interoperability in areas of concurrent jurisdiction would be an automobile accident where police, fire, and EMS agencies respond jointly. Interoperability in areas of concurrent jurisdiction is typically solved by the different agencies operating on a shared public safety radio system. The movement from agency specific conventional systems to shared trunked systems is prevalent today. For example, in Manatee, Florida, 30-40 public safety agencies operate on one system. Thus, the Polly Klaas example is more suitably classified under a Mutual Aid mission.

The real tragedy in the Polly Klaas case in terms of radio equipment was that the technology allowed the systems to interoperate between adjacent counties, however, interoperation was not part of routine procedures. Through the use of infrastructure gateways, different radio systems could have communicated. The point should be made that while technology is available for communication between dissimilar systems, not all agencies will want to interoperate. Stated another way, if a new common mutual aid channel is available in all new public safety radios, an agency may choose not to scan and monitor the new mutual aid channel. This amplifies a possible scenario in which new common mutual aid channels become available for new public safety radios. Following this logic, if an agency chooses not to scan and monitor the new mutual aid channel, then interoperability will not be achieved. Therefore, a mandated interoperability solution is impractical due to the diverse operations of public safety users.

### **User Requirements**

The system must provide for interoperability of communications between local, state and federal public safety agencies.

“Interoperability” is defined as the ability of two or more public safety communications systems to interact with one another and exchange information according to a prescribed manner in order to achieve predictable results.

The system must provide interoperability to licensees with minimal cost impact. The interoperability benefit of a solution must be balanced with the cost of implementation.

1. All radios must be capable of accessing current mutual aid channels designated within its frequency band of operation.

The imbedded base of equipment must be capable of interfacing with any newly-developed interoperability solution. Maximum reuse of existing equipment is critical because it speeds the realization of true interoperability and protects existing public safety investments.

Any interoperability solution must have a migration plan to meet all applicable FCC and NTIA rules and regulations.

2. Mobiles and portables must be able to communicate even when operating outside existing infrastructure.
3. Any advanced technology chosen for an interoperability solution should be public domain in order to allow multi-source, competitive procurements.

The primary control of the systems should remain with each distinct licensee.

Equipment size should be less than or equal to existing public safety equipment. All systems should provide simple and user-friendly functionality.

4. Portable radios shall be capable of operation for at least 8 hours on a 10-10-80 duty cycle or 16 hours on a 5-5-90 duty cycle.

### **User Desires**

Of course, there are unyielding requirements needed to provide interoperability. Users, however, also have specific needs and desires for their systems. The following list showcases these user desires.

1. There is a desire to minimize dispatcher-to-dispatcher interaction.

### **Potential Interoperability Solutions**

This paper addresses three possible solutions for achieving public safety interoperability: 1) move the operational frequency of all public service radios to a new common band, 2) establish new nationwide mutual aid channels within a common band, 3) utilize infrastructure gateways and cross band repeaters.

## **1. Move All Public Safety Communications to a New Band**

### *1.1 Overview*

Moving all public safety communications to a new band is the optimal technical solution; however, many barriers must be overcome before this becomes possible. While the Spectrum Subcommittee is actively working to identify spectrum, a frequency band adjacent to an existing public safety band would be optimal (e.g., 380-400 MHz new public safety band, 406-420 MHz federal public safety and 450-470 MHz non-federal public safety). This new common UHF band would have a subset of channels set aside for nationwide mutual aid use. It has been suggested that five mutual aid channels might be sufficient although ten mutual aid channels might better serve to meet interoperability requirements.<sup>6</sup> However, this approach could accommodate any number of mutual aid channels.

### *1.2 Technical Approach*

The advantages of this approach is that the radio terminal products (portables and mobiles) would operate in a single band avoiding the additional cost inherent in multi-band radio. Thus, a new common band radio could be programmed to scan and operate on *any* channel in the new common band. This approach would solve all of the user requirements defined in this paper.

### *1.3 Cost Analysis*

The cost of this approach could be minimal. The average life of a public safety communications system is approximately 15 years. This means that most of the current installed base will be obsolete by the PSWAC timeline of 2010. From a practical viewpoint, it may take longer than 15 years to migrate all public safety agencies to a new band since many agencies continue to use their communication equipment long after the average life (some agencies use systems as long as 30 years). Other challenging aspects of this plan are identifying 1) who will pay to clear a band that has billions of dollars of imbedded equipment, 2) who will administer a grant program transferring the monies raised by the auctions to public safety agencies, 3) where will the imbedded base of incumbents be relocated, 4) how will this be financially justified to Congress when other services will contribute auction monies to the U.S. Treasury, and 5) how will all public safety officials be convinced to join this migration.

## **2. Establish New Universal Mutual Aid Channels**

### *2.1 Overview*

This option assumes that public safety agencies would continue to operate on their current licenses and that new universal mutual channels be established. New universal mutual aid

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<sup>6</sup> Letter to FCC from Michael R. Granados, Sr., chairman IAFC Communications Committee dated September 2, 1995.

channels would allow any public safety agency needing interoperability a standard methodology for achieving this need. The command and control hierarchy of communications could be improved by scanning the new universal mutual aid band. The new universal mutual aid band *could operate on a new LMR Emergency Band, utilize existing cellular (PCS/ADC) networks, or could utilize Satellite systems.*

## *2.2 Technical Approaches*

The *new LMR Emergency Band* approach has the advantage of supporting direct talk. Public Safety agencies arriving on the scene of a disaster could talk to one another immediately. In-building coverage could be excellent and wide-area coverage could be extended by providing gateways into existing infrastructure networks. There may be a significant economic impact to the establishment of the *new LMR Emergency Band* depending on the approach used to access it.

The new universal mutual aid band could utilize *existing PCS/ADC networks*. This approach has this advantage: there is a significant commercial investment of infrastructure and services that could be utilized with little additional investment by the public safety community. This approach would utilize established commercial standards. Economical benefits include the use of extensive existing infrastructure, leveraging the benefits of a larger scale industry, and increased competition through cellular manufacturers. The disadvantages include slow access time, terrestrial infrastructure (vulnerable to natural disasters) that may not survive, coverage in rural area may be unacceptable, direct talk is not available, and interconnect-like services sometimes make group calls difficult.

The use of *Satellite Systems* to provide a new mutual aid band has a tremendous benefit in wide-area coverage. However, because of power limitations associated with in-building coverage, satellites may be unacceptable without the use of a terrestrial-based repeater. In addition, access time may be long, direct talk is not available, and interconnect-like services tend to make group calls difficult. Economical benefits of using existing satellite systems would be diminished over time by the usage fees for existing satellite systems.

Access to new common mutual aid channels could be accomplished by either using a *multi-band radio* or a *second dedicated emergency radio*. This approach could be implemented as soon as an agency begins to purchase new radio terminals that have a capability of accessing the new mutual aid channels.

A *multi-band radio* would transmit and receive on its normal operating frequency band and provide operation on mutual aid channels that are perhaps in another frequency band. This approach would add a separate transmit/receive (T/R) module to every public safety radio. This essentially adds another radio to the chassis of a public safety radio. The additional radio would share power, displays, keypad, and perhaps even the antenna. The advantage of this approach is that users could continue to operate on their existing communications systems. The disadvantages are that a new multi-band radio will be significantly more expensive, larger, and have shorter battery life than existing public safety equipment.

Instead of placing the burden of incorporating a second T/R module in every public safety radio, this approach would have a second *dedicated radio* specifically used for interoperability. Although this approach (multiple radio category) is not preferred by some users, it is very cost effective. A second dedicated radio would provide a method for agencies and specific users who need interoperability. It would be expected that every public safety agency would have a number of these new dedicated emergency radios. However, this approach would not require an agency to procure new expensive multi-band radios when the agency may not have a high need for interoperability.

### **3. Utilize Gateways & Cross-Band Repeaters**

One of today's solutions for interoperability is to modify existing infrastructure. This option would require that each of the fragmented public safety bands of operation establish nationwide mutual aid channels and gateways and then integrate these mutual aid channels into existing public safety infrastructure. All 800 MHz trunked public safety systems use this technique to accommodate interoperability with nationwide mutual aid channels.

Gateways achieve interoperability by incorporating a base station to translate dissimilar radio equipment into base-band analog voice and retransmit on the operating frequency and protocol of the home system. Gateways provide a system solution to interoperability yet require over-building the existing infrastructure. Gateways would probably be required to establish new universal mutual aid channels. This would provide interoperability over a large area but would not address the direct-talk requirement.

A FEMA vehicle equipped with cross-band repeaters could be an acceptable alternative for a direct-talk requirement. With as few as 100 FEMA vehicles, access to any disaster scene could be as little as 2 hours. A FEMA vehicle with cross-band repeaters could translate a fixed number of operating frequencies in all public safety operating bands, thus providing interoperability with the installed base of user equipment.

### **Economic Impact**

The interoperability solution needs to address all users, a large portion of which are small users. For non-federal public safety users, 10.9% (673,584) are volunteer firemen which equals 83% of all licensed fire transmitters. Also, 50% of all police departments have less than 10 officers. In fact "an examination of the present use by public safety reveals that the majority of licensees, particularly below 800 MHz, are individual agencies, utilizing one or two channels, often with a loading of less than 35 mobiles. (In fact, FCC records indicate of the Part 90 public safety licenses, more than 80% fall in this category.)"<sup>7</sup>

Intellectual Property Rights, or "IPRs," could potentially be a huge barrier to establishing an interoperability standard. An interoperability solution should be public domain. If

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<sup>7</sup> APCO Bulletin May 1994, TDMA-FDMA and Spectrum Efficiency by Art McDole, page 47

manufacturers want to build a public safety radio with FCC/NTIA mandated mutual aid channels, they should be able to do so without obtaining an IPR license from another manufacturer.

### **Cost - Benefit Analysis**

These three potential interoperability solutions are analyzed for estimated cost to the user community over a 15 year timeframe (PSWAC timeline is 2010). It should be noted that these are cost estimates and therefore are projections rather than hard numbers. These cost estimates are provided so that the different solutions can be compared on a relative basis.

#### **1. Moving All Public Safety to a New Band**

Assuming that the average communications equipment life is 15 years, the cost of procuring a communications system would be no additional burden to the user community. With an installed base estimated at \$30 billion (non-federal \$25 billion and federal \$5 billion), the cost to the user community is estimated at \$3 billion. Auctioning of spectrum vacated by public safety to help pay for this cost, however, is not taken into account in this projection.

#### **2. PCS/ADC Mutual Aid Channel with Dual Band Radios**

The estimated cost of adding one new mutual aid channel to the existing infrastructure is \$10,000 per base station x 230,000 Non-Federal licensed sites, or \$2.3 billion. In addition, the air time is estimated at \$.23 per minute x 100 minutes per year x 15 years x 6.2 million radio, or \$2.1 billion. The PCS/ADC capability is estimated to increase the cost of each public safety radio by \$200 x 6.2 million radios, or \$1.2 billion. The total estimated cost to the user community ultimately amounts to \$5.6 billion.

#### **3. Satellite Mutual Aid Channel with Dual Band Radios**

The estimated cost of adding one new mutual aid channel to the existing infrastructure is \$10,000 per base station x 230,000 Non-Federal licensed sites, or \$2.3 billion. In addition, the air time is estimated at \$.50 per minute x 100 minutes per year x 15 years x 6.2 million radios, or \$4.6 billion. However, this air time cost could be eliminated by the public safety community paying for a dedicated satellite which is estimated to cost \$1.5 billion for the payload and launch with \$10 million per year for administration, or \$150 million. Adding the satellite capability to the public safety radio is estimated to increase the cost of each public safety radio by \$300 x 6.2 million radios, or \$1.9 billion. The total estimated cost to the user community is \$5.9 billion.

#### **4. New LMR Mutual Aid Channel with Dual Band Radios**

The estimated cost of adding one new mutual aid channel to the existing infrastructure is \$10,000 per base station x 230,000 Non-Federal licensed sites, or \$2.3 billion. Adding the new LMR mutual aid channel capability to the public safety radio is estimated to increase the

cost of each public safety radio by \$150 x 6.2 million radios, or \$.9 billion. The total estimated cost to the user community is \$3.2 billion.

## **5. Dedicated Emergency Radio**

Estimated cost of adding one new mutual aid channel to the existing infrastructure is \$10,000 per base station x 230,000 Non-Federal licensed sites, or \$2.3 billion. Assuming that only half of the existing public safety users would need an emergency radio, the cost of a separate emergency radio is estimated at \$350 per radio x 3.1 million radio, or \$1.0 billion. The total estimated cost to the user community is \$3.3 billion.

## **6. Infrastructure Gateways & FEMA Cross-Band Repeaters**

Estimated cost of adding one new mutual aid channel to the existing infrastructure is \$10,000 per base station x 230,000 Non-Federal licensed sites, or \$2.3 billion. No modifications to the radio terminal products are required. Assuming 100 FEMA vehicles (2 for each state) outfitted with 10 cross-band repeaters, the cost would be \$10,000 per cross-band repeater x 10 per vehicle x 100 vehicles, or \$10 million. The total estimated cost to the user community is \$2.3 billion.

***NOTE: The electronic version of the figure in this position was unavailable at the time this report was prepared. Readers can find the full text of this figure in FCC WT Docket No. 96-86.***

## **User Data**

According to FCC data base, there are 6.15 million radios (transmitters) and 229,000 sites licensed for public safety use. There are approximately 80,000 Federal channel allocations. Both federal and non-federal public safety users operate on 9 fragmented frequency bands. See Appendix B for details.

The vast majority of the installed base of non-federal public safety radios are frequency synthesized analog radios.

The installed base of non-federal public safety communications equipment is estimated at \$25 billion and the federal public safety communications equipment is estimated at \$5 billion. The average life of a public safety radio terminal is 7 years and the life of radio infrastructure is 15 years.

## **Conclusions**

Interoperability is a problem often associated with risk of life and property during natural disasters and national emergencies. The loss of a single life resulting from two different public safety agencies' communications equipment not being capable of communicating is

unacceptable. However, equally unacceptable is to select an interoperability solution that cannot be implemented because it ignores practical considerations such as cost.

Three public safety missions have been identified to characterize interoperability: 1) Mutual Aid, 2) Day-to-Day, and 3) Task Force. Different public safety agencies have diverse interoperability needs. These requirements cover a vast range of capabilities from limited interoperability (i.e. volunteer fireman at an Amtrak accident) to encrypted covert interoperability (i.e. FBI at Waco, Texas).

Public safety users are diverse in their operational needs. From the FCC data base, there are 40,000 different public safety licensees, 6.15 million radios (transmitters) and 229,000 sites licensed for public safety use. There are approximately 80,000 Federal allocations. Both Federal and non-Federal public safety users operate on 9 non-contiguous frequency bands. The installed base of non-Federal public safety communications equipment is estimated at \$25 billion and the Federal public safety communications equipment is estimated at \$5 billion. The vast majority of the installed base of non-Federal public safety radios are frequency synthesized analog radios. The Federal users place a high value on encryption features. The lowest common denominator between existing and new public safety equipment is 25/30 KHz analog radios.

A significant consideration for all interoperability solutions must be cost. For any interoperability solution implemented nationwide, the cost will exceed several billion dollars since it is impacting an installed base of over \$30 billion.

Moving all Public Safety users to a new band appears to be optimal from a technical standpoint. This could be partially implemented by letting newly-procured public safety equipment operate in a new band. Auctioning vacated public safety spectrum could subsidize such a plan through federal grants. Shared systems (exclusive to public safety users) could be encouraged to provide a solution to day-to-day interoperability and maximize spectral use. It is desirable to locate this new public safety band contiguous to one of the nine existing public safety bands and to allocate at least 20 MHz of new spectrum for public safety.

Using satellites for mutual aid operation has a significant advantage over other potential solutions by providing wide area coverage. However, because of limited transmit power, there are concerns whether satellites can provide adequate in-building coverage.

Establishing a new common LMR mutual aid band does provide a level of interoperability. However, this is achieved at the expense of either procuring a second emergency radio or a dual band radio. Dual band technology, by its nature, will evolve slowly, reduce battery life, increase radio size and may remain cost prohibitive for many years.

The use of dedicated emergency radios appears to be a very attractive solution. Public safety agencies would only need to equip those individuals who require interoperability (i.e. the Oklahoma City bombing command and control hierarchy). The disadvantage is that some public safety users do not want to be burdened with a second radio.

The use of a mandated digital common air interface compatible with the highest tier federal encryption requirements would be achieved at the expense of the users who have limited interoperability needs and who are financially unable to procure such a high tier radio. Mandating and/or defining one interoperability solution severely penalizes users with limited resources and diverse interoperability needs.

Infrastructure-based interoperability solutions have demonstrated the capability to operate across bands and to connect dissimilar communications equipment. Establishing nationwide mutual aid channels in the nine public safety operating bands would provide an acceptable level of interoperability. FEMA vehicles equipped with a multitude of cross band repeaters could provide communications outside fixed terrestrial-based coverage areas.

### **Recommendations**

Many interoperability solutions may require over a decade to implement. Can public safety wait for an interoperability solution while human life and property are at risk? Obviously not. Therefore, it is recommended that the interoperability solution be divided into near-term and long-term solutions.

#### *Near-term Recommendation*

It is recommended 25/30 KHz analog mutual aid channels be established in each of the nine current public safety bands of operation. Interoperability can then be achieved in the near-term by reprogramming the large installed base of frequency synthesized analog radios to these new mutual aid channels. It is recommended that dedicated emergency radios be encouraged for agencies not owning frequency synthesized analog radios. It is further recommended that the agencies with the highest need for interoperability (typically the urban agencies) upgrade their infrastructure to provide cross band repeaters and gateways to provide users with interoperability in adjacent and concurrent jurisdictional areas. Alternatively, users with concurrent jurisdictional areas could investigate sharing operations on an existing trunked system. It is finally recommended that FEMA vehicles be fully equipped to provide cross band operation between these newly-established mutual aid channels for use in areas where existing infrastructure coverage is not available. These Interoperability recommendations will satisfy both the Mutual Aid and Day-to-Day public safety missions. It is recommended that the Task Force public safety mission accomplish interoperability the same way it is done today, namely, handing out mission specific radio equipment. This near-term solution could be implemented immediately.

#### *Long-term Recommendation*

*Primary* - The optimum long-term solution is to move public safety users to a new acceptable operating band adjacent to one of the existing nine public safety bands. Then 25/30 KHz analog channels would be established with at least 10 channels being allocated nationwide for mutual-aid use. The issue of auctioning vacated public safety spectrum, user incentives,

federal grants, and the administration of such a solution should be studied simultaneously. This solution is the only recommendation that would address all three of the defined public safety interoperability missions.

*Secondary* - It is recommended that a long-term backup solution be investigated given the uncertainty of the availability of acceptable spectrum. Although all of the solutions discussed in this report have significant merit, it is recommended that a further build out of infrastructure gateways to the new mutual aid channels be the primary back up solution. Infrastructure gateways would have a significant advantage over other potential solutions since gateways could be initiated immediately. It is recommended that Task Forces accomplish interoperability the way it is done today, namely handing out mission specific radio equipment. Dual band radio terminals are specifically not recommended since it would significantly increase the cost of radio terminals and penalize agencies with a large number of users who are ill positioned to afford such a solution.

The following table summarizes these recommendations.

<b>Mission</b>	<b>Mutual Aid</b>	<b>Day-to-Day</b>	<b>Task Force</b>
<b>Definition (Requirements)</b>	Involves many agencies Little planning Small tactical talk groups Many incidents out of infrastructure coverage	Areas of concurrent jurisdiction Routine traffic Minimize dispatcher-to-dispatcher interaction	Layers of government (federal, state & local) Prior planning <ul style="list-style-type: none"> <li>• Covert</li> <li>• Short range</li> </ul> Roaming in and out of infrastructure coverage
<b>Examples</b>	Oklahoma City Amtrak Crash <ul style="list-style-type: none"> <li>• Air Florida Crash</li> <li>• Hurricane Hugo</li> <li>• Wildland Fires</li> <li>• Polly Klaas</li> </ul>	Urban Automobile Accident involving Police, Fire, & EMS	Waco, Texas World Leader Visit
<b>Today's Solution</b>	Portable-to-Portable Direct Talk	Multiple Radios for Different Bands Difficult Infrastructure Gateways	Portable-to-Portable Hand Out Unique Radio Equipment
<b>Recommended Near-term Solution</b>	25/30 KHz Analog MA Channels in each PS Band FEMA Cross Band Repeaters Infrastructure Gateways & Cross Band Repeaters	25/30 KHz Analog MA Channels in each PS Band FEMA Cross Band Repeaters Infrastructure Gateways & Cross Band Repeaters or Shared Trunked Systems	Hand Out Unique Radio Equipment
<b>Recommended Long-term Solution</b>	Primary - Move PS to 20 MHz Band with 25/30 KHz Analog MA Channels Secondary - Continue building out Infrastructure Gateways and Cross Band Repeaters	Primary - Move PS to 20 MHz Band with 25/30 KHz Analog MA Channels Secondary - Continue building out Infrastructure Gateways and Cross Band Repeaters or Shared Trunked Systems	Primary - Move PS to 20 MHz Band with 25/30 KHz Analog MA Channels Secondary - Hand Out Unique Radio Equipment

**Appendix A**  
**Slides Presented by John Powell September 19, 1995**

**TYPES OF INTEROPERABILITY**

**Day-to-Day**

**1. Commonly used in areas of concurrent jurisdiction**

**Agencies need to monitor routine traffic**

**Minimizes need for dispatcher-to-dispatcher interaction**

**2. If agencies on different bands, may involve multiple radios in each vehicle.**

**Difficult for personnel using portable radios**

**3. Infrastructure based interoperability is not efficient due to continuous use of extra RF channel by each participant on a different band or system.**

**Mutual Aid**

- 1. Can involve many agencies with little opportunity for prior detailed planning (riots or wildland fires)**
- 2. Often requires assignment of several to many small groups, each on own talk group or frequency (tactical communications)**
- 3. Once on-scene, generally involves use of portable radios**
- 4. Many incidents are in rural areas out of infrastructure range.**

# **TYPES OF INTEROPERABILITY**

## **Task Force**

**Usually involves several layers of government  
(fed/state/local)**

**Opportunity for prior planning usually is present**

**Generally involves use of portable and/or covert  
equipment**

**Often requires extensive close-range communications**

**Nature of traffic is such that wide area broadcast is  
usually undesirable**

**May rove in and out of infrastructure coverage (metro to  
rural, in and out of buildings, etc.)**

**Often implemented by exchanging equipment.**

# **INTEROPERABILITY TECHNOLOGIES**

## **Conventional**

- 1. Use of simplex and/or repeater-based operations**
- 2. All subscriber units must be in same RF band**
- 3. Secure communications require equipment from same vendor,**

## **Analog Trunked**

- 1. Currently available only in 400 MHz band for federal agencies and 800 MHz band for state/local agencies**
- 2. Proprietary systems require subscriber equipment from same manufacturer (ora licensed second-source provider)**
- 3. Secure communications require equipment from same vendor.**

## **Project 25 Digital (Conventional or Trunked)**

- 1. Vendor independent (including secure mode)**
- 2. Infrastructure not required for conventional operation**
- 3. Some advanced features may be proprietary.**

# **INTEROPERABILITY TECHNOLOGIES**

## **Infrastructure-Based**

### **1. Necessary only in following cases:**

**Non-compatible (generally trunked or secure) systems**

- **Subscriber units on different RF bands**

### **2. Usually requires one RF channel on each participating system**

**Wastes spectrum for day-to-day operations**

### **3. Not usable when out of range of infrastructure (remote areas, etc.)**

### **4. All participating infrastructures must cover entire service area**

### **5. Provides control that may not be present with other technologies.**

## Appendix B

### FCC Public Safety License Data

Radio Service	Description	# Sites	# Licensed Transmitters
PS	Special Emergency	32,858	428,068
PO	Forestry	9,643	345,991
PP	Police	48,095	1,539,631
PL	Local Gov't	72,995	1,363,045
PH	Highway Maint.	14,551	331,785
PF	Fire	41,351	811,547
YP	800 MHz Trunked	3,628	483,232
GP	800 MHz Conventional	3,857	221,770
GF	NPSPAC Conventional	868	41,912
YF	NPSPAC Trunked	884	238,319
Total		228,690	5,805,300
Data Date		9/19/95	5/2/94
Corrected Total @ 6% annual growth		228,690	6,153,618

Public Safety installed base value is estimated at \$25 billion.

### Federal Government Law Enforcement License Data

It is estimated that the number of NTIA licensed transmitters is 80,000 which are operational in the UHF/VHF bands. The Federal Government installed base value is estimated at \$5 billion.

**NOTE:** *The electronic version of the figure in this position was unavailable at the time this report was prepared. Readers can find the full text of this figure in FCC WT Docket No. 96-86.*

## Appendix C

### Oklahoma City

“In fact, if it hadn’t been for two-way radio, getting a handle on the situation, particularly during the first critical few hours, would have been impossible. Two-way radio not only was the fastest and most efficient way to relay information back to dispatchers and request specific support, it was the only way. Phone lines were compromised or overloaded, and cellular telephone frequencies jammed. Our only challenge was the lack of radio interoperability among all the agencies involved. But, all the different radio systems and personnel on-site did create some communications challenges. ... But we still couldn’t communicate with most of the personnel from other agencies. The individual systems were incompatible. There was no common channel. The number of different public safety communications systems at the scene was substantial. ... Then within hours, came the Federal Emergency Management Agency (FEMA) search and rescue teams, mostly fire rescue, from cities ranging from Los Angeles, Miami, New York City, Phoenix and Seattle, to name a few. All of these teams, more than a dozen, each with about 60 personnel, brought their own communications systems. That only complicated the task of coordinating communications. ... To provide some inter-agency communication capability, he said the task force leader from each FEMA team used Motorola Saber portables that were reprogrammed to a common 450 MHz channel. ... If we had a highly classified message to send, Capt. Foley said, we should send it to the MDT in a vehicle and then notify the officer by two-way radio to check his terminal. ... We not only had to deal with our own communications systems issues, but also these additional agencies and their communications systems. At times it was frustrating. One example of that frustration was when Department of Public Safety staff had to resort to sending runners with messages.”<sup>8</sup>

“Interoperability on-site, it would seem, took some effort to organize, or was coincidental. One of the agencies on-site, the U.S. Marshal’s Office, already had its own 800 MHz system working through its own mobile command post, so that we were able to communicate with them immediately radio-to-radio. ... It is also of ultimate importance that the public safety community emphasize to the Federal Communications Commission that its access to frequencies previously and potentially allocated must be protected at any and all cost, Taxton said.”<sup>9</sup>

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<sup>8</sup> APCO Bulletin/ August 1995 “Oklahoma City - Two-Way Radio: ‘The ‘ Champion’ by Carl Oldberg

<sup>9</sup> APCO Bulletin/ August 1995 “Oklahoma Department of Public Safety” by Rick Arndt

ATTACHMENT 4

FOR AGENDA

PSWAC/ISC 96-02-018

Public Safety

Wireless Advisory Committee

**Mobile Satellite Systems**

Interoperability & Technology  
Subcommittees

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**ATTACHMENT 4**

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## Mobile Satellite Systems

To state the obvious, providing interoperability and introducing new technology are vexing and complex problems. This paper discusses each because both are required for real progress on the difficult issues facing the Public Safety Wireless Safety Advisory Committee [PSWAC].

Despite our current focus, interoperability was a historic problem long before the invention of radio. Coalition warfare became successful only after Bismarck and others invented a simple language of about 100 words to allow German tribes with different dialects to talk during battles. Even with no language barriers, communications during times of stress are always difficult. Lord Home became Great Britain's Prime Minister, but only after his ancestors changed the pronunciation of the family name to "Hume". During a critical battle, leaders attempted to rally their forces by shouting, "Home, Home, fight for Home". The troops mistook these urgings as instructions to go home and packed it in at a critical juncture. The Ericsson White Paper notes: "The real tragedy of the Polly Krause case in terms of radio equipment, was the technology allowed the system to interoperate between adjacent counties, however, interoperation was not part of routine procedures." This emphasizes the importance of developing and working with procedures and systems under normal circumstances that will serve us well during the stress of unusual events. This is not new. During the Titanic disaster, other ships that could have helped were not alerted because standardization on radio frequencies to be guarded had not occurred. Even SOS had not been designated as a universal call for help, and nearby ships sailed on unaware of the unfolding tragedy. The Titanic's loss caused the first Safety of Life at Sea Convention [SOLAS] that ultimately led to the formation of the International Maritime Organization [IMO] to provide international coordination of maritime telecommunications, training, operational procedures, standards, and the acceptance of new technology.

There is no similar national organization for the public safety community. One is needed to provide a continuous focus on all the issues important to success in the community. The Interagency Committee on Search and Rescue [ICSAR] coordinates activities of all Federal agencies involved in search and rescue, but its focus is well short of IMO's. ICSAR has commissioned a subcommittee to study the effective integration of mobile satellites into the distress and safety system. Another subgroup recently completed work on distress and alerting requirements for commercial mobile satellite systems. A matrix of their recommendations is included as Enclosure [2]. The PSWAC should invite the views of ICSAR concerning use of wireless systems for public safety.

Reaping new technology's advantages while not rendering obsolete billions of dollars of existing systems will be a challenge. These issues must be faced if we are to provide the public what it deserves -- the best safety system possible. Land mobile systems have been the subject of most interoperability and technology discussions thus far. While they will play a vital role in the future, attention should be given to Mobile Satellite Systems [MSS] and other emerging technologies. If interoperability among radio systems is to be possible during

emergencies many issues must be addressed such as frequency resources, standards, procedures, training, and a host of others.

Interoperability, used in the public safety wireless communication context, and public safety services have been defined. Please see Enclosure [1]. The fundamental requirement of interoperable systems is to exchange information with others when required in a form that is readily usable by all participants. "Where are you?", "What are you doing?", and "What do you need from me?" are typical questions.

In the past, most practical solutions involved exchanging equipment and, at times, operators among the various agencies. While this was cumbersome and wasteful, it often was the best solution possible. In the near term, with new technology, interoperability among different organizations deliberately separated during normal operations can be improved incrementally in many ways.

Success in the future will require an implementation framework describing end-state objectives in detail while providing concrete plans to insure incremental actions are in concert with and move toward the final desired outcome. It will also require an understanding that most useful progress occurs in incremental, not revolutionary, steps.

Dramatic advances in technology have been made in three areas to effective management of emergencies.

These are:

- \* the ability to communicate anywhere, any time;
- \* to know location precisely; and
- \* to overlay data base information to assist in response planning and execution.

One such application is integrating position with electronic map displays.

We need to experiment with these new technologies to learn what we don't know. We must incorporate these new capabilities into operations thus expanding the horizons of what we thought possible.

### **Satellite Systems In General**

Commercial Mobile Satellite Systems started in the 1970's when COMSAT offered service in the Atlantic for shipboard communications through its MARISAT system. This was subsumed into the International Maritime Satellite Organization [INMARSAT] when it was formed. In the early days, INMARSAT installations cost about \$50,000 each, and tariffs, were \$10 per minute. Both have been reduced significantly in recent years. INMARSAT became global and ultimately changed its name to International Mobile Satellite Organization [INMARSAT was retained]. It now offers worldwide aeronautical, land and maritime mobile telecommunications. Some interim operations have been allowed in the U.S., but with commencement of mobile satellite operations by the American Mobile Satellite Corporation

[AMSC], INMARSAT will not be allowed to provide land mobile communications in the U.S. because there is a domestic alternative with an exclusive license.

Recently, INMARSAT created another organization, ICO Global Communications to provide non geostationary mobile satellite communications from an Intermediate Circular Orbit [ICO]. ICO has received substantial investments and awarded satellite construction contracts to Hughes Space and Communications International. The system will include two orbits of five operational satellites in two different 40 degree planes with one in orbit spare satellite for each plane. Satellites will orbit at 10,355 kilometers. Licensing issues for service in the U.S. are not resolved.

In the U.S., three "Big LEOs" have been licensed by the FCC. Big LEO means satellites in low or medium earth orbit operating above 1 GHz and providing both voice and data. "Little LEOs" operate below 1 GHz and provide data service only. The three big LEO licensees are: Motorola's Iridium, Loral/Qualcomm's Globalstar, and Odyssey Telecommunications International, Inc.'s Odyssey where TRW Inc. and Teleglobe Inc. are the founding shareholders. Mobile Communications Holding, Inc.'s Ellipso has a pending application before the FCC to join the other three.

According to the literature, all the Big LEOs plan to offer service late in this century or early in the next with dual mode satellite\cellular telephones.

Currently, ORBCOMM is the only Little LEO in operation. It has two satellites in orbit, and beta testing is in progress. To provide continuous coverage over the U.S., 26 satellites are necessary. This constellation is planned for full deployment by the end of 1997.

As these systems are placed in operation and their user terminals tested in quantity, much more will be learned about their ability to support emergency communications.

### **The American Mobile Satellite System**

On 7 April 1995, the American Mobile Satellite Corporation [AMSC] launched its first satellite into geostationary orbit over the Equator south of Brownsville, TX. The era of affordable mobile satellite communications from terminals the size of a PC notebook computer was born. Coverage over CONUS, most of Alaska, Hawaii, the Caribbean, and to over two hundred miles offshore is provided. Voice, data, fax, and location services are possible through automatic connections to the public networks. AMSC provides not only exceptionally good communication during normal conditions, but also, as a backup system during emergencies when terrestrial systems may be destroyed or overloaded.

Frequencies are available and authorized. Simultaneous support for 2,000 voice channels [6 kHz each] is possible. Six spot beams are used so that some frequency re-use is possible. The system is completely digital thereby facilitating National Security Agency encryption systems, as well as, commercial voice privacy alternatives.

Public safety agencies and others may lease dedicated channel[s] for their exclusive use. Dispatch, push-to-talk, and “party line” talk group services are available. Dual mode satellite\cellular, satellite only, transportable and fixed site systems are available.

A Canadian counterpart with essentially duplicate coverage will be launched shortly. Capacity sharing and backup support agreements are in place so there will be no single point of failure in the space segment.

### **Interoperability Requirements**

The PSWAC has developed detailed interoperability requirements, and they are contained in Enclosure [1]. Most of these requirements can be satisfied by AMSC today; the challenge is to fully integrate it, and others to follow, into the public safety system. The preliminary draft of the PSWAC’s Technology Sub-Committee’s report says: “the fundamental service is the transmission of a speaker’s voice. Key attributes include its intelligibility, clarity, and all other attributes accompanying a speaker’s voice which convey significance [including inflection, emphasis, ability to recognize speaker, etc.]. Emphasis on this fundamental requirement should not be lost in all the “nice to have discussions”. Certainly, in the early hours of any emergency, the fundamental requirement is to talk to others.

### **Interoperability via the Publics Networks**

Interconnections to a common network can satisfy many interoperability requirements especially for interactions at the command post level. There, if systems can access the PSTN, information can be shared and made available to a wide audience of users without creating a new infrastructure. Satellite systems have particular advantage here when terrestrial systems are stressed. Their access to the PSTN is via a distant gateway station unlikely to be affected by a localized or even wide spread emergency.

### **Priority Access**

Priority access to terrestrial and satellite communications systems is essential for successful emergency managers needing communications support. Priority access to the Mobile Satellite System may be assured in several ways. Channel priorities may be implemented by techniques ranging from access to the next available channel to preempting existing users. Preemption is fraught with practical and public relations difficulties. A critical EKG transmission could be preempted inadvertently by an operator for another emergency. In the early years of operation where capacity limit problems are not expected, setting aside a few channels for emergencies is the desired approach. With these as an initial cushion, the highly dynamic nature of calls on and off the systems will allow timely access to channels as needed.

The AMSC System can accommodate up to eight levels of access priority when the full capability is implemented. Discussion of priority capabilities of the other MSS systems is beyond the scope of this paper.

Priority designations will be lost when communications enter the Public Switched Telephone Networks as they are currently configured unless dedicated lines are provided between gateway stations and public service agencies.

### **Other Services**

Interconnecting land, air, and maritime mobile users will be necessary to achieve complete interoperability. Many emergencies require response from all the services. Hurricanes, a major fire or collision at or near a port, oil and hazardous chemical spills are examples.

### **Operational Considerations**

It is a well-known tenet of emergency managers that systems used in everyday operation are most reliable during times of stress. If systems are not used frequently, they are unlikely to work when needed, and operators will not be proficient in their use. For these reasons, we should avoid "emergency use only" systems.

Loss of priority when mobile communications enter the public networks has been discussed. Overloaded telephone systems near a disaster are common. Access problems to gateway stations were highlighted during the Achille Laura fire and subsequent sinking off the coast of Somalia on 30 November 1994. Due to aggressive calling by the media and others, the Norwegian Rescue Coordination Center at Stavanger, Norway reported that it, "... lost contact with rescuing vessels for two hours as calls from media no others occupied INMARSAT lines." Stavanger was coordinating the rescue as was the associated rescue coordinating center for the INMARSAT coast earth station handling communications during this incident. Priority access via the PSTN or dedicated lines will be required for an effective emergency system. One such method is "GETS", the Government Emergency Telecommunications System.

### **Costs**

Previous papers have developed cost data on existing public radio systems and estimated the base installed amount is about \$30 billion [\$25 billion non-federal and \$5 billion federal]. Hope for monies from frequency auctions for migrating systems to the new order has been expressed by some. In the current budget environment, this is quite unlikely because any new sources of funding will attract dozens of suitors.

Previous papers gave estimates for satellite systems that are exceptionally high and incorrect. They assumed the public safety community would require dedicated satellites costing billions of dollars. Dedicated systems are unnecessary. Future public safety systems will rely on the public switched and data networks and commercial mobile satellite systems to avoid costly infrastructure investments. Even DOD is moving in this direction.

Public safety organizations cannot create the management structure, obtain regulatory approval and raise money for dedicated satellite systems; nor is it necessary. A better

approach is to follow and influence developments of those systems, use them, and factor requirements into existing and future systems.

Public safety organizations could make exceptional progress on interoperability with a modest investment in the AMSC system. Dual mode satellite\cellular radios cost about \$2500; per minute charges are \$1.49 or less including terrestrial long distance charges. Talk groups can be established for \$100 per month, and practically unlimited users may join them for \$70 per month. The \$70 per month allows dispatch and unlimited talk time for users.

An organization could buy 1000 radios for \$2.5 million and operate them in 100 talk groups, for about \$80,000 per month. Other studies have shown that up to 35 users per circuit can be accommodated; so 100 talk groups per 1000 users is conservative. With the AMSC System, a user may belong to 16 different talk groups. If this were implemented in the short term, there would be a giant leap toward interoperability. A state with such a system could deploy units gathered throughout the nation to respond with units to an Oklahoma City type disaster. Arriving units would be ready to communicate anywhere, anytime, provided there is a clear view to the south. Talk groups could be rearranged over the air in minutes without touching the installed equipment. The GPS interface could provide position locally or to transmit it to distant control stations for automatic tracking of responders. Differential GPS corrections are available via the AMSC system to provide accuracies better than 10 meters.

### **Summary**

We need to look at many alternatives to satisfy public safety telecommunications between now and 2010. Incremental progress will be the norm. As new systems become available they should be thoroughly tested in every day operations, and during the stress caused by catastrophic events to learn of their benefits, capabilities and limitations. Equipment, procedures and training play vital roles in successful operations. The AMSC System is currently being used and tested by dozens of public safety organizations. We expect they will find it a highly effective addition to their telecommunications capabilities.

### **Planning for the Unexpected**

We will need to account for unanticipated consequences as well. During a lull between campaigns, Napoleon's chief of staff organized a rabbit shoot to entertain his emperor. An elaborate lunch was provided in a park near Paris, and the leader dined in splendor while the rabbits were readied for their fate. Unfortunately, the logisticians produced not wild rabbits, but ones obtained from the local zoo. When released, they mistook the vicious hunter as the person who brought their daily ration of lettuce and charged toward him with enthusiasm. His officers, despite their success on the plains of Europe, were no match for the flanking maneuvers by the rabbits, and Napoleon was overrun.

He retreated to Paris in a bad mood. Success will require an ability to adapt to changing circumstances and a sense of humor.

**Enclosure [1]**

Public safety services include: law enforcement, fire prevention and suppression, emergency medical services, search and rescue services, emergency disaster management, public services and others supporting the public during emergency operations.

Previous papers have developed interoperability requirements as follows:

1. The systems must provide for interoperability among local, state and federal public safety agencies.
2. “Interoperability” is the ability of two more public safety communications systems to interact with one another and exchange information according to a prescribed manner to achieve predictable results.
3. The system must provide interoperability to licensees with minimal cost impact. The interoperability benefits of a solution must be balanced with the cost of implementation.
4. All radios must be capable of accessing current mutual aid channels designated within its frequency band of operation.
5. The imbedded base of equipment must be capable of interfacing with any newly developed interoperability solution. Maximum reuse of existing equipment is critical because it speeds the realization of true interoperability and protects existing public safety investment.
6. Any interoperability solutions must have a migration plan to meet all applicable FCC and NTIA rules and regulations.
7. Mobile and portable equipment must be able to communicate when operating outside existing infrastructures.
8. Any advanced technology chosen for an interoperability solution should be in the public domain in order to allow multi-source competitive procurement.
9. The primary control of the system should remain with the distinct licensee.
10. Equipment size should be less than or equal to existing public safety equipment. All systems should provide simple and user friendly functionality.
11. Portable radios will be capable of operation for at least 8 hours on a 10-10-80 duty cycle or 16 hours on a 5-5-90 duty cycle.

Enclosure [2]

1/17/96

**- DRAFT -**  
**SEARCH AND RESCUE AND DISASTER SUPPORT**  
**REQUIREMENTS MATRIX FOR**  
**COMMERCIAL MOBILE SATELLITE SERVICES (CMSS)**

REQUIREMENTS / USER TYPE	SERVICES			COMMENTS
	A PERSON PORTABLE	B VEHICLE MOBILE	C TRANSPORTABLE	
1. 2-WAY DATA	X	X	X	
2. 2-WAY VOICE	X	X	X	
3. FACSIMILE		X	X	
4. STILL IMAGES		X	X	E.G. DISASTER ASSESSMENT
5. PSTN COMPATIBLE	X	X	X	VIA GATEWAY
6. PSDN COMPATIBLE	X	X	X	VIA GATEWAY
7. POSITION AVAILABLE				
A. AT MOBILE	X	X	X	
B. AT RCC (See Note 1)	X	X	X	
8. POSITION ACCURACY 100 M OR BETTER	X	X	X	
9. SELECTIVE POLLING (SEE NOTE 2)	X	X		
12. LOCAL ALERTING (SEE NOTE 3)	X	X	X	FILLS SAME FUNCTION AS CURRENT GUARD CHANNEL (E.G. CHANNEL 16)
10. BROADCAST (SEE NOTE 4)		X	X	
11. SELECTIVE CONFERENCE (SEE NOTE 5)	X	X	X	
12. GLOBAL COVERAGE (SEE NOTE 6)		MARITINE AND AERONAUTICAL	X	
13. INTEROPERABLE (SEE NOTE 7)	X	X	X	
14. INTERNATIONALLY OPERABLE (NOTE 8)	VIA PSDN & PSTN	VIA PSDN & PSTN	X	
15. PRIORITY ACCESS	X	X	X	

NOTES:

1. FOR ELT/EPIRBs UPON INITIAL ALERT WITH AN UPDATE OF POSITION EVERY HOUR
2. THE ABILITY TO QUERY A UNIT FOR ITS POSITION
3. THE ABILITY FOR THE DISTRESS CALLS TO BE HEARD BY POTENTIAL RESPONDERS IN THE VICINITY OF THE DISTRESS
4. ONE WAY TRANSMISSION TO A SPECIFIED GEOGRAPHIC AREA
5. THE ABILITY TO SET UP PRIVATE COMMUNICATIONS WITH SELECTED PARTIES
6. ABILITY TO COMMUNICATE FROM ANY PLACE IN THE WORLD
7. ABILITY TO OPERATE WITH ANY OTHER EQUIPMENT WITHIN THE SYSTEM AND WITH EQUIPMENT IN OTHER SYSTEMS VIA PSDN OR PSTN
8. ABLE TO BE OPERATED IN VARIOUS COUNTRIES

ABBREVIATIONS:

- PSTN: PUBLIC SWITCHED TELEPHONE NETWORK
- PSDN: PUBLIC SWITCHED DATA NETWORK
- RCC: RESCUE COORDINATION CENTER

# Public Safety Wireless Advisory Committee

## Interoperability White Paper

*Submitted by Motorola Inc.  
Wednesday, April 3, 1996*

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### EXECUTIVE SUMMARY:

Interoperability between the wireless communications systems used by federal, state, and local public safety agencies is generally accepted to be not only desirable, but essential for the protection of life and property. Motorola believes that there are multiple levels of solutions that achieve interagency interoperability. Each of these has associated benefits, costs and limitations. The purpose of this white paper is to present these solution alternatives to the Interoperability Subcommittee for consideration, along with a discussion of cost and benefit relationships for these alternatives.

We categorize these solutions into infrastructure solutions and direct (unit to unit) solutions. Each category is further divided into "simple" solutions and "complex" solutions. Simple solutions present less technical difficulty. Complex solutions reach higher levels of technological difficulty. A console patch is an example of a simple infrastructure solution, while cross band connectivity and gateways are more complex. Likewise for direct solutions. Analog radios on mutual aid channels is a simple solution, while broad band, dual band and multi-band radios are more complex solutions. Common communication modes, defined as standards, can impact achievement of successful interoperability in all ranges of technical complexity. Motorola believes that the implementation of standards is best resolved by the public safety users.

These multi-level solutions are not mutually exclusive and the optimal solution may use various combinations as the need for interoperability escalates through different load levels. We define three mission load levels of interoperability and accompanying spectrum requirements as day-to-day, peak load, and disaster.

As research for this paper, we interviewed numerous public safety officials involved with major emergencies and disasters. We identified their specific interoperability issues as they related directly to the incident. The problems they encountered were similar for many of these cases.

Finally, interoperability cannot be resolved by technology alone. The most critical of these challenges is the need for additional frequency spectrum in public safety. Adequate spectrum was the most essential missing element in the communications systems that served these disasters. Public safety agencies are typically at full load capacity with their day-to-day mission level communications, even though their systems are designed around peak load requirements. Because disasters place significant interoperability demands on top of day-to-day and peak load levels, there are just not enough channels and communication paths to adequately permit interoperability for these emergencies.

### INTRODUCTION:

Technical solutions that can enable significant inter-agency interoperability currently exist, and more are under development. However, due to a wide range of factors, led by the lack of sufficient spectrum and other non-technical challenges, this capability is largely unavailable today.

The public safety community has long expressed concern that it does not have enough spectrum to develop adequate inter-agency interoperability solutions. For many agencies, the struggle to secure sufficient spectrum to effectively accomplish their own unique mission does not even permit them to consider interoperability needs. This is especially true in the fire services.

Each public safety organization has its own mission and area of responsibility. Organizational imperatives of control and security have created infrastructures, in some cases redundant, designed to meet the specific mission and control/security requirements of an individual agency. The public safety community currently uses a wide diversity of dispatch communication systems designed to meet these individual requirements, each of which consumes a unique geographical portion of the spectrum. This has created an enormous number of communications islands, operating in four different frequency bands between 30 MHz and 1 GHz, many with different manufacturers' proprietary technology. This, unfortunately, becomes most apparent during multi-agency response incidents and disasters, when communications interoperability is most critical.

Communications system planners are aware now more than ever of the essential need to design and develop interoperability solutions in their system designs. While recognition of this has been increasing throughout the public safety community, implementation of such capability has not kept pace.

This paper presents interoperability issues derived from real world applications and incidents. We address three mission load levels of interoperability and accompanying spectrum requirements, specific interoperability challenges, and multiple levels of solutions, including non-technical solutions. In the interest of space, relatively few examples of recent disasters have been cited directly. While no two specific incidents are ever alike, we did find common representative issues that emerged in all of the interviews conducted. A complete list of the officials interviewed, the agencies they represent, and their specific statements are detailed in the attachment. As is consistent with Motorola's approach in our PSWAC models and recommendations, the interoperability solutions described herein remain neutral on a preferred technology.

### **MISSION LOAD LEVELS:**

Public safety organizations and individuals regularly interact with each other in order to execute their respective missions. At a normal day-to-day communications level, a particular percent of communications is intra-agency dispatch with no need for interoperability. The remaining percent of communications requires inter-agency interoperability, such as a police pursuit across multiple communities. This is a "day-to-day" mission load level for spectrum and interoperability.

Communications needs have daily or routine peaks, often related to times when people are on the move (such as the rush hour or on holidays). A significantly higher level of spectrum and interoperability is normally required during such times. We refer to this mission load level as "peak load".

There are those situations that require extremely high levels of interoperability and spectrum, usually involving many agencies and levels of response. This is the “disaster” mission load level. It includes manmade as well as natural disasters. This level of radio traffic places demands on top of existing day-to-day and peak load requirements. The course of a disaster can progress rapidly from day-to-day, to peak load, to disaster mission load levels.

The above mission load levels build on John Powell’s interoperability presentation to the Armed Forces Communications and Electronics Association (AFCEA) on September 19, 1995, which addresses three types of interoperability: day-to-day, mutual aid and task force.

### **DISASTERS RESEARCHED:**

#### Southern California Kinnaloo Fires

In Southern California, channels are insufficient to meet the demands of a major emergency in the fire service. Over 100 personnel and 8 types of equipment resources are dispatched by the L.A. County Fire Department on the first alarm for a “brush fire”. The incident is dispatched on UHF, both voice and data. L.A. County has two VHF channels that are used in tactical situations. Fire ground communications switches to one of the VHF channels as soon as the first elements arrive on scene. This tactical radio channel quickly becomes overloaded as the number of firefighters and their geographical separation from the incident commander increases.

The second VHF tactical channel is used when additional alarms are called for or when there is an unrelated alarm in the vicinity (a rather common occurrence). The capacity of the VHF tactical channels is quickly outstripped when subsequent additional alarms are called for at either scene. In the Kinnaloo fire (Angeles National Forest / City of Pasadena), Capt. Robert Hewitt noted that the fire, fanned by high winds, rapidly went out of control and the response was elevated to a “Level 1” (general alarm). Many additional resources were dispatched to deal with the fire, with very limited additional radio channels. At peak, hundreds of pieces of fire equipment and thousands of fire fighters were working to bring the Kinnaloo fire under control. The incident commander had two VHF radio channels with which to coordinate their activities. Communications discipline completely broke down. Incident commanders, according to Capt. Hewitt, “improvised and did the best they could”.

In addition, the State of California licensed three VHF channels, referred to as “White One, White Two, and White Three”, for fire mutual aid state wide. All fire apparatus in the State is to be equipped with radios that operate on these frequencies. However, some fire departments are no longer equipped with VHF radios, and some others changed the names of the channels. This lack of standard procedures (nomenclature) further hampered over-the-air interoperability. (See Appendix A)

#### Oklahoma City Bombing

Teams from dozens of different agencies around the country (federal, state, and local) converged on the scene during the rescue efforts following the bombing of the federal office building in Oklahoma City. Interoperability between them was a challenge due to the number of agencies and different, often incompatible, radio systems involved. There was no common channel. In addition, more than a dozen Federal Emergency Management Agency (FEMA) teams arrived within hours from around the country, bringing with them their own communications systems. Task force leaders from each FEMA team used portables that were programmed to a common 450 MHz channel to provide some inter-agency interoperability. Runners were also used to provide interoperability. Personnel from various agencies were assigned to carry messages from one group's command post to another, where the message was relayed to the recipient. Mutual aid responders were issued Oklahoma City 800 MHz trunked radios in some cases. These individuals became "human repeaters", retransmitting messages as needed.

There was fear of a second explosive device in the hours just after the bombing. Warnings broadcast over non-encrypted radios to public safety personnel on scene were picked up by civilians using inexpensive scanners. The word spread very quickly and, instead of a calm orderly evacuation of the area, panic ensued. As a result of this incident, messages of a sensitive nature were transmitted as text to mobile data terminals (MDT's) for the duration of the crisis. The recipient was then called on the radio and instructed to go to the MDT to retrieve the message. (See Appendix B)

### Los Angeles Riots

Hundreds of police officers from around the State of California were brought into the city to assist the Los Angeles Police Department (LAPD) in restoring order during the riots following the Rodney King verdict. Although LAPD maintains a cache of radios to use in emergencies, it was not sufficient. Officers from outside the city were teamed with LAPD officers so that each team would have communications with LA Police Commanders. The California Highway Patrol (CHP) deployed some 2,600 officers in the city during this incident. They were equipped with VHF Low Band radios. One of their primary missions during this period was to protect LA Fire Department personnel and property, freeing the LAPD to deal with the rioters. In order to carry out this mission, CHP officers were paired with LAFD personnel to establish and maintain communications. Such teaming efforts significantly increased the human and equipment resources needed during this emergency. (See Appendix C)

### **INTEROPERABILITY CHALLENGES;**

Although there are many technical challenges to achieve communications interoperability, the following non-technical obstacles are the most significant challenges facing public safety:

### Spectrum Availability

The quality and quantity of communications, including inter-agency interoperability, available to the public safety community relate directly to the availability and efficient use of frequency spectrum. Adequate spectrum is the most essential element in a wireless system. The loading of public safety channels is generally very heavy and existing systems are often stretched to capacity. In most of the major metropolitan areas, additional channels for system expansion do not exist. During peak periods, police communications traffic is so heavy that it is difficult for field officers to access a channel to communicate with dispatchers or to request back up. Also, larger public safety agencies appear less inclined to allow other users access to their system in order to conserve already inadequate spectrum resources.

In all of the incidents described above, the lack of adequate spectrum would have hampered the use of additional interoperable equipment simply because the systems were already at capacity with the resident assets. The ability to provide simple interoperability by growing the system to fit the need is usually impaired by this lack of “disaster” mission load level of spectrum.

### Spectrum Dispersion

The current allocations for public safety land mobile radio (LMR) channels are scattered over four disparate and major segments of the frequency spectrum between 25 MHz and 1 GHz. (See Appendix D). There are public safety authorizations in VHF Low Band (30-50 MHz), VHF High Band (138-174 MHz), UHF (406-420, & 450-512 MHz), and 800 MHz (806-940 MHz). As a result, radios in one band can not currently interoperate with radios in another band without some other device or solution discussed in the following section. Consolidation of public safety radio channels in fewer bands would enhance the opportunities for inter-agency interoperability. Multiple agencies converging on a single incident with communications systems that do not share the same frequency face a much greater communications challenge than those who share common frequencies or even a common frequency band.

As addressed in Motorola’s Frequency Band Selection Analysis White Paper, submitted to PSWAC on February 21, 1996, there is no one band that provides the optimal fit for all the needs of public safety.

However, to promote the development of broad band radios needed for over-the-air interoperability, additional spectrum for public safety should be allocated to a band adjacent to existing public safety authorizations. For example: consideration should be given to (1) expanding LMR allocations in the UHF frequency range to 380 MHz - 520 MHz, and (2) reallocating existing television channels 60 through 69 out of 746 MHz - 806 MHz to enable use by LMR. Such adjacent reallocation would also promote rapid availability of equipment using existing technology, and provide economies of scale to manufacturers, resulting in lower priced communications equipment for the user. It would also promote narrow banding efforts by providing spectrum “green space” to which existing users can be migrated.

## Incident Command

Communications interoperability is not solely a question of technology. The public safety community must develop and implement a coordinated and cooperative approach for command and control of major public safety incidents involving multiple agencies. Some major metropolitan areas are standardizing Incident Command System (ICS) procedures which are both flexible and dynamic. The plan specifies command to ever higher ranking officials as the emergency escalates. It also designates span of control and organizational command structures as the number of agencies and units increase at the scene, thereby integrating them in an organized manner into the effort. From a communications standpoint, it calls for a trained Communications Unit Leader to be assigned command post responsibility for ensuring sufficient communications capabilities and resources. The ability to implement ICS plans is restricted by the amount of channels available. An increasing number of teams are created in the command structure as emergencies become wide area disasters. A corresponding increase in communications paths is required for these teams to effectively communicate. The Los Angeles County Fire ICS plan, for example, calls for a tactical channel to be made available for each supervisor and commander to provide each working team with a communications path. The issue of procedure, command and control, and jurisdictional barriers to interoperability are beyond the scope and expertise of what Motorola is able to address in this paper. However, we do recognize that these issues are real and can be as much a factor to achieving successful inter-agency communications. as the technical challenges. (See Appendix E)

## **INTEROPERABILITY SOLUTIONS:**

Technical solutions can be separated into infrastructure dependent interoperability and direct radio to radio interoperability, and each can then be categorized on a range from a “simple” to a “complex” solution. The following shows this range for currently achievable technology. These technical solutions are not mutually exclusive.

### 1. Infrastructure Solution Range:

Except for transportable/mobile cross band base stations and repeaters, these solutions are infrastructure dependent and can be limited or rendered inoperable by disaster damage to that infrastructure. Contingency plans using transportable/mobile cross band base stations/repeaters may help resolve such loss of infrastructure links.

#### A. Simple Solutions:

- Console patch: Routes audio from one radio network to another radio network, either as a permanent “wired” connection or through a dispatcher enabled switch. It provides lowest common denominator interoperability. Normally, this means conventional analog voice with no advanced features such as encryption, talk groups or trunking. Also, connecting two of the new digital radios systems (with digital vocoding technology) may result in actually degradation of voice quality. This is caused by the double vocoding effect, whereby original speech is vocoded,

restored to analog, patched, vocoded again, restored to analog again, and presented to the listener. This patch also requires system coverage overlap, and uses a channel resource on both systems to complete a single transaction.

### B. Complex Solutions:

- \* Cross band connectivity: Uses base stations or repeaters that are cross-connected allowing transmissions from one band or protocol to be retransmitted on another band or protocol. They can be fixed, transportable or mobile. If fixed, communications are limited to site coverage overlap. If transportable or mobile, they could be moved to a disaster scene, which does not have to be within infrastructure coverage. This interoperability solution also requires the use of two radio channels, one in each band, for each transmission.
  
- \* Gateways: Provides sophisticated system level interconnects which decodes one system's protocol and recodes the communication into another system's frequencies and protocol. Depending on the number of channels interconnected (in a trunked system, for example), the result can be full feature interoperability, including multi-talk groups, trunking and signaling features, and encryption. Gateways require system coverage overlap, and use a dedicated channel on both systems to complete a single transaction.

## 2. Direct Solution Range:

### A. Simple Solutions:

- \* Analog radios on mutual aid channels: Uses standard analog carrier squelch radios for over-the-air interoperability on common channels, which multiple agencies agree to use under a mutual aid agreement. For agencies that have systems in different frequency bands or protocols, this solution still requires public safety officers to carry a second emergency radio, either mobile or portable.

### B. Complex Solutions:

- \* Broad band radios: Requires development of next generation radios that will be capable of communicating across a wider range of the frequency band, such as 380 MHz to 520 MHz, or 746 MHz to 824 MHz. Reallocating public safety spectrum in bands adjacent to existing UHF bands or 800 MHz bands will provide interoperability to a greater number of agencies having systems within such new frequency range. These radios will most likely be larger, heavier, have shorter battery operating time and other reduced performance characteristics, which may also require incremental system infrastructure. They will not provide

interoperability with agencies that have systems in different frequency bands or protocols.

- \* Dual band / Multi-band radios: Requires development of next generation radios that will be capable of communicating across two or more frequency bands. Each additional frequency band interoperability will require an additional receive module to be built into every multi-band radio. If these radios are to interoperate across bands with current radios, they will require an additional transmit/receive module for each additional band. These radios will most likely be larger, heavier, require more battery power and have other reduced performance characteristics, which may also require incremental system infrastructure. The above challenges will be even greater than those for broad band radios. They will, however, allow public safety agencies to communicate on one radio across two or more frequency bands with other radios having the same protocol.

#### Land Mobile Radio Standards:

Spanning the above “simple” and “complex” interoperability solutions in the need for common communication modes defined as standards. Successful interoperability in all ranges of technical complexity will be promoted through such standards. However, existing communication system life cycles mean that interoperability will take years to achieve, even after such standards are resolved by the public safety users.

Also, multi-agency systems continue to emerge in the public safety market, providing individual agency autonomy via software partitioning, while providing interoperability to all agencies on that system. Standards for such system architecture will provide additional interoperability with incoming disaster response resources.

#### Low and Non-Technical Solutions:

The public safety community has also devised a variety of “low technical” and “non-technical” solutions to overcome interoperability issues of insufficient spectrum, different frequency bands, incompatible system protocols, and lack of inter-agency operating standards. These include the following:

1. Multiple radios:

Police and federal law enforcement vehicles often have multiple mobiles, while multiple portables are somewhat common in the fire service. This allows interoperability across bands or system protocols, but causes vehicle space problems or burdens public safety officials with additional weight to carry.

2. Emergency radio supply:

Larger agencies, such as New York City Police Department, have a supply or additional radios poised for emergency use, to provide interoperable communications coverage whenever incidents occur. Federal agencies, such as FEMA and the FBI, also often bring a supply of radios and distribute them to supporting public safety agencies to provide interoperability at declared emergencies.

3. Emergency Operations Centers / Mobile Command Centers :

Major city, county and Federal agencies often establish fixed or mobile command center to coordinate multi-agency responses at declared emergencies. Interoperability is achieved by operators relaying messages, often via wireline, from one agency's dispatch center to another agency's dispatch center for rebroadcast. Such relay operations not only require additional personnel, they also delay the communication process and introduce a greater possibility of human error in the message.

Standard Operating Procedures and Training :

Public safety agencies should develop and apply standard methods, practices, procedures, protocols and operations in such a manner that optimizes the use of inter-agency interoperability solutions. An optimal solution may use various combinations of direct radio to radio interoperability and infrastructure to infrastructure interoperability features. As missions progress from day-to-day load levels to disaster load levels, the needs for interoperability communication links escalate, usually well beyond the non-disaster, peak load level demand. Established procedures or protocols for the escalation process and the associated communications required, such as Incident Command System plans, are essential to minimize additional spectrum needs. These contingency plans are currently in place with many agencies and have proven successful in multiple incidents.

Agencies should also evaluate, update and expand radio communications training specific to interoperability modes and methods for their officials who use radios. Radio systems are becoming ever more sophisticated, incorporating software in the radios and computers in the infrastructure. Training all line personnel in the capabilities of this newer equipment is essential not only to proper use, but also effective interoperability with other radios and efficient use of spectrum resources.

**COST AND BENEFITS;**

Motorola's approach to evaluating the various costs and benefits associated with interoperability is to assess it in terms of relative comparisons and known relationships. There are far too many combinations of possible solutions and unknown factors (spectrum, engineering, market sizing, etc.) that would make it difficult to assign a believable dollar

estimate to any one universal approach or approaches. In addition, evaluating intangible benefits such as lives, resources and property must be considered in any cost/benefit equation. We would offer the following as a means of making a comparable cost/benefit evaluation for these solutions.

### Spectrum Dispersion Impact

The degree to which public safety spectrum is dispersed across the radio spectrum has a direct impact on both the cost of the radio system and interoperability. The cost of introducing new radios increases as the spectrum for public safety users becomes more diverse and segregated from other land mobile radio users. Public safety spectrum allocations that are both unscattered and adjacent to other commercial LMR bands enable manufacturers to take advantage of economies of scale, resulting in a lower radio price for the user. We estimate that the cost for non-adjacent bands could be greater than a factor of two. In addition, public safety spectrum dispersion directly affects an agency's ability to use existing infrastructure, with possible modifications.

### Infrastructure Solution Costs

Costs are dependent on their level of sophistication, and can be a very economic and effective use of existing system assets. The more automated the connectivity, the steeper the cost curve for implementing this solution. As a curve implies, the increase is projected to be non-linear, with cost increasing more rapidly to achieve the most sophisticated solutions. For example, a simple console patch may require the cost of a console and telephone circuit plus some dispatcher time. The cost of a gateway system depends on the number of communications paths to be interconnected, and the number of systems to be interconnected. A protocol translator is needed for each channel on each trunked system, and at least one channel on each conventional system, which are to be interconnected in a given geographic area to achieve full featured interoperability among multiple agencies. Because infrastructure connectivity is dependent on the presence of infrastructure, its interoperability value is limited to the system coverage overlap area and the survivability of such infrastructure in a disaster.

### Direct Solution Costs

These costs are dependent on the percent of interoperability required. To achieve interoperability, some federal, state and local public safety agencies have two mobile radios, plus one (or even two) portable radios for each vehicle and official. The incremental cost of this level of interoperability is roughly between 25% and 50% of their total system cost.

To provide dual band radios to agencies could mean a per unit cost which is greater than two single band radios. This is due to engineering developmental costs and manufacturing costs of scale. Depending on how close production volume approaches current levels, we estimate the cost of dual band radios will significantly exceed the cost of single band radios, and could be greater than a factor of two.

The cost of multi-band radios (more than two bands) will most likely be a multiple of the number of bands on which the radio is communicating. We do not currently foresee these radios becoming a commercial solution, thereby precluding economies of scale from being applicable.

Broad band radios could provide the lowest cost solution for direct interoperability within an expanded spectrum band, assuming that public safety spectrum is allocated adjacent to an existing band, such as the UHF band. Depending on how close production volume approaches current levels, we estimate the cost of broad band radios could be between one and a half and two times the cost of non-broad band radios.

The above radio cost factors should be multiplied by the percent of unit to unit interoperability needed by the agency. We anticipate that broad band and dual band radios will have reduced radio performance characteristics, given current technology limitations. These performance reductions, such as talk-in range, would require incremental system infrastructure cost to maintain existing performance levels. Such additional infrastructure costs need to be considered with the above calculated radio cost to approximate the cost of interoperability for a given agency.

### Benefits

The need for immediate, effective communications across agencies is evidenced by the fact that public safety response time is directly proportional to the ability to save both lives and property. As a result, interoperability solutions decisions should not only consider costs, but

also take into account the benefits attained through interoperability. Some of these are obvious, such as savings in suffering, lives and property, but often intangible. While it may be difficult to project potential dollar savings, quantifiable resource benefits for agencies can include:

- Spectrum resource efficiencies of using direct (unit to unit) interoperability solutions. Infrastructure solutions normally require use of two channels, one in each band, to complete a single transaction.
- Manpower resources are not used efficiently if public safety officials have to be “teamed” across agencies, have to act as runners, or have to repeat messages to provide interagency interoperability. This also applies to dispatcher time required to repeat messages.
- Tangible dollar savings are realized whenever property damages or losses are avoided as a result of greater communications interoperability.

## **CONCLUSION;**

Motorola believes that there is no one universal solution to achieving inter-agency interoperability for the public safety community. There are multiple levels of interoperability solutions which we have outlined in this white paper. These include both infrastructure and direct radio to radio solutions, which can be categorized on a range from simple solutions to complex solutions. We noted that these solutions are not mutually exclusive and the optimal solution may use various combinations as interoperability needs escalate from day-to-day, to peak load, to disaster load levels. What is universal is the essential need for interoperability between wireless communications systems of the public safety community.

The common and most significant challenge facing public safety toward achieving interoperability is the need for more frequency spectrum. Adequate spectrum is the most essential element of a wireless communications system and technical interoperability solutions are dependent on availability of adequate spectrum to permit implementation. To promote the development of radios needed for over-the-air interoperability, we encourage allocation of additional spectrum to a band adjacent to existing public safety authorizations. Consideration should be given to expanding LMR allocations to 380 MHz - 520 MHz range or to the 746 MHz - 806 MHz range. Such adjacent reallocation would also promote rapid availability of equipment using existing technology, and provide economies of scale to manufacturers, resulting in lower priced communications equipment for the user.



**The Role Of  
Commercial Wireless Services  
And Their Impact On Spectrum Requirements**

**Submitted by Motorola Inc. to the  
Public Safety Wireless Advisory Committee**

**Wednesday, May 29, 1996**

In an appearance before the US Senate Committee on Commerce, Science and Transportation, PSWAC Chair Phil Verveer stated that “Commercial mobile radio services can absorb some of public safety’s demands.” We agree with this general statement and believe it is consistent with the sentiment of the majority of the PSWAC committee. To help clarify the salient issues on this topic, this paper will expand upon this statement and offer a clear opinion of the extent to which public safety demands that “can” be absorbed by commercial mobile radio service *would* be absorbed and identified and size “some of public safety’s demands” that would be absorbed.

Commercial wireless services cannot be widely used to replace an entire public safety private system, or even a significant portion of one, because most public safety communications cannot be adequately served by commercial mobile radio services today or in the foreseeable future. Public safety requires a level of customized service that significantly exceeds, or is at least distinctly different than, that which is demanded by the principal users of commercial wireless services -- business/industrial users and individual consumers. Since commercial mobile radio services are fundamentally designed to meet the more modest needs of private sector customers and individual consumers they do not offer the type or level of service demanded by public safety. Also, it is unknown whether the providers of commercial wireless services would make the significant investment in improvements that would be required to adequately serve public safety.

For the public safety user, the major deficiencies of commercial wireless services center around their general inability to provide instant push-to-talk group dispatch, guaranteed access, priority access, security and remote location coverage. A public safety user operating over a wide area may have a communications footprint that would require piecing together service from multiple providers to form a commercial wireless “system” that meets their coverage requirements. Additionally, the multiple commercial wireless service providers may be using different technologies that are not interoperable with each other.

Public safety organizations engage in a wide variety of activities in their mission to protect life, property, and provide for the public safety. Like any other public or private sector organization, their activities range from those that are mission-critical and primary to the core activities of the organization to those that are of a more subordinate nature and therefore of a lower priority. The communications needed to support these activities are similarly wide ranging and carry differing operational requirements. The gap between what is required by public safety and what can be delivered by commercial wireless services is widest among mission-critical communications and narrowest among lower priority communications.

Public safety private systems are primarily designed to handle the higher priority mission-critical communications. A properly designed private system is designed to accommodate all mission-critical communications during peak load time periods. Any system designed for peak load capacity will, by definition, have excess capacity during off peak time periods.

Since the gap between what is required by public safety and what can be delivered by commercial wireless services is narrowest for lower priority communications, these applications are the strongest candidates for placement on commercial wireless services. However, if lower priority communications are retained on the private system the users can leverage their infrastructure investment and fill available system capacity. Lower priority communications can coexist on a private system designed for peak load mission-critical communications because the system manager has the ability to manage radio traffic to ensure that mission-critical communications get through during peak load periods while lower priority communications are postponed until capacity is available.

The protocol for managing communications traffic can be either technology-based or policy-based. Trunked systems provide a technology-based solution whereas conventional systems must rely on policy-based solutions. Trunked system priority access capabilities that can be used to assign priority to members of the system. These priority assignments can be used to queue channel requests and even displace low priority communications that are in process with high priority mission critical communications. Conventional systems cannot assign priority but can incorporate unit identification to allow monitoring of channel usage to ensure that priority based policies and procedures are followed by all users during peak load periods.

## CONCLUSIONS

Mission-critical communications can not be adequately served by commercial wireless services. Therefore, it is in the public interest for the FCC to allocate sufficient spectrum to allow public safety to design and build private systems that can handle all mission-critical communications during peak load time periods.

Many lower priority communications can be served by commercial wireless services. Therefore, the FCC should weigh the macro economic factor of alternative spectrum use when considering the prospect of allocating private spectrum for these types of communications by public safety agencies. The FCC should not allocate additional private

spectrum to public safety for low priority communications that can be adequately provided for by commercial wireless services.

Public safety should be allowed to choose whether low priority communications should be placed on commercial wireless services or remain on their private system. The budget pressures felt by public safety agencies are expected to continue through the time period under consideration here. Any opportunity to save money with a solution, private or commercial, that meets their requirements would be eagerly embraced. Decision makers at the state or local level are in the best position to weigh the economic and market factors affecting their situation and decide where to place their lower priority communications.

In public safety today, commercial wireless telephone interconnect and paging are widely used, primarily for connectivity with individuals or organizations outside the private system. This usage will continue into the future and it is widely believed to increase significantly. However, this wide spread supplemental or complementary usage is actually irrelevant to the determination of spectrum needs for public safety. It represents a usage that the planners of public safety systems have already identified as being outside the scope of their private system and was never intended to be included in PSWAC's quantification of incremental spectrum needs for public safety.

As we've discussed, the communications requirements of mission critical and lower priority communications are primarily differentiated by the extent to which guaranteed priority system access and security are required. One way to forecast the amount of public safety spectrum that would be absorbed by commercial wireless services would be to estimate the amount of lower priority communications and then estimate the amount of that which public safety private system planners would choose to have coexist, on a secondary basis, with mission-critical communications on the private system instead of moving them to commercial wireless services.

We believe that mission critical communications represent the majority of communications on a private system. We also believe that a majority of the lower priority communications can be retained, if desired, on a private system which is designed for mission critical peak loads by employing priority protocols that allow unrestricted lower priority communications during off peak periods but limits or eliminates them during peak periods. If we assume that mission critical communications represent two-thirds to three-fourths of all communications and that private systems can retain two-thirds to three fourths of lower priority communications, the percentage of all public safety communication that would move to commercial wireless service would be on the order of 6-11%.

It is difficult to accurately forecast commercial wireless service usage because it is difficult to predict the extent to which the providers of commercial wireless service will make the necessary and significant investments to further serve public safety. Even if long range strategic plans for public safety were being developed by some commercial wireless service providers, it would be unrealistic to expect them to jeopardize their business position by prematurely revealing their plans in order to aid PSWAC. Nevertheless, we believe the 6-11% percent range is of the right order of magnitude.

In his appearance before the US Senate Committee on Commerce, Science and Transportation, Mr. Verveer also stated that "...the advisory committee will attempt to factor the CMRS alternatives into its conclusion about the amount of additional spectrum public safety requires". Motorola recommends that after the advisory committee has concluded the amount of additional spectrum required by public safety it use a factor of 10% to reduce that amount to reflect the impact of commercial wireless services.

# **PUBLIC SAFETY INTEROPERABILITY SERVICE**

## **A NEW APPROACH TO MUTUAL AID AND INCIDENT COMMUNICATIONS**

### **WHITE PAPER**

**SUBMITTED TO THE INTEROPERABILITY SUBCOMMITTEE  
OF THE  
PUBLIC SAFETY WIRELESS COMMUNICATIONS ADVISORY COMMITTEE**

By

Ron Haraseth

State of Montana

July 1, 1996

## **PUBLIC SAFETY INTEROPERABILITY SERVICE**

### **A NEW APPROACH TO MUTUAL AID AND INCIDENT COMMUNICATIONS**

Interoperability has been identified as one of the critical elements of public safety communications and only follows basic dispatch service coverage and frequency congestion in importance. Long range planning that considered inter-disciplinary and inter-jurisdictional communications has thus far only existed in localized situations and at a national level only in a cursory manner with the creation of mutual aid channels in the 800 MHz NPSPAC channels.

Growth of the land mobile radio industry has progressed over a 60 year period. Original operations occurred at relatively low frequencies and progressed to the higher frequencies as technology and manufacturing procedures progressed. Public safety communications expanded into newer frequency bands as both capacity and feature requirements increased with passing time. The end result of this growth process has resulted in public safety operating in more than 5 discrete bands of frequencies such as the 30-50 MHz, 120-174 MHz, 380-500 MHz, portions of UHF TV (shared), and above 800 MHz. Along with this dispersion across multiple bands, both non-compatible operational and technical standards further complicated the situation within individual bands. The result is a chaotic mix of operations which often make interoperability at best, extremely difficult and expensive or in many instances impossible.

Much discussion has arisen during the Public Safety Wireless Advisory committee (PSWAC) meeting on solutions for interoperability. Discussion often revolves around technical solutions. These solutions have included moving all of public safety to a single band, using cross-band gateways and repeaters and others. Technical compatibility discussions have ranged from wide band analog to future use of digital narrow band techniques. None of these solutions can fully address the requirements of interoperability.

Common discrete frequencies are a must. A partial solution is linking frequencies in different bands. This solution is somewhat usable if and only if discrete frequencies in each and every identifiable band are reserved, named, and set aside exclusively for this purpose.

There is no interoperability in this scenario if direct infrastructure independent operation is required. It only serves the purpose of interoperability in a very limited and narrow operational area. Fully implementing such a scenario on a wide area basis is

unworkable. There are too many bands and combinations of frequencies to even consider such a solution acceptable.

Another major solution consisting of migrating all of public safety to a common band has been discussed. While definitely being utopian, it is flawed and not practical. There is good technical reasoning behind use of particular bands based on the differing specific characteristics for each of these bands and their suitability depending on the area of operation.

### **An Operational View**

All participants in any joint endeavor must speak the same language to be fully functional. In this case, we must speak the language of emergency response. This fits in with the operational aspects which have been discussed centering around using the Incident Command System (ICS) architecture to identify channels of operation along the same levels of function and command within ICS. ICS attempts to address the problem from an operational stand as opposed to a strictly technical approach.

At the very least, a strictly technical approach is doomed to failure no matter how many channels or gateways are provided if they do not conform to the manner in which they are used. It has often been repeated in the Department of Defense discussions that the military must train as they fight. The same is no less true for public safety responders.

Any incident includes the functions explained by ICS. Identifying functionality using the ICS structure standardizes operations allowing an understanding of the procedures by all involved. By operating under the assumptions in ICS, all parties are aware of their role and responsibilities within the overall event. Designating common names for common functions is the basic precept that makes ICS work. The same situation must take place in the communications structure of any incident. Channels must have designated names and associated usages so that all involved will understand where and in what manner they are to be used.

The basic command level and subsequent lower command levels must have pre-designated (and named) channels associated with those levels. Lower levels can be more flexible and dynamic. Understanding the operational characteristics does not complete the solution, but once they are defined, the correct technical solutions can then be applied.

A technical solution must be practical, relatively inexpensive, ubiquitous, and above all, attainable. A solution must be available both on the near term as well as the long term. It must work with existing systems without causing interference with standard dispatch systems or creating an undue hardship to implement.

### **PI Service Category**

The move of the entire public safety operating environment to a single band is not practical, and cross banding existing bands is far less than fully effective. The former being unworkable financially and later being extremely inefficient in terms of spectrum use. However, creating a single common Public Safety Interoperability service (which I will abbreviate as "PI") in one central band is very possible and very practical. This band would be dedicated exclusively for interoperation applications. This will not eliminate the need for dual band radios or two radio installations, but having a universal declared service gives an absolute common technical solution to the common operating requirements of a mutual aid incident. A field tactical vehicle (or hand-held) with the "PI" capability could interact with any other unit similarly equipped. This capability need not be linked in any way to the user's home system operation.

As an example, one unit's basic internal system dispatch operation could be in an 800 trunked environment while another unit could be operating in low band. If these field units' second band or second radio in each case were the common "PI" radio, they would technically be capable of true interoperability. Bringing a third unit into the picture more than clarifies the practicality of a common PI service band.

### **Operational Requirements - Unplanned/Planned Incidents**

We can learn much from the communications problems of historical incidents. Those that indicate failures in the communications link may not point directly to solutions. While some failures point to technical deficiencies, many have resulted from operational deficiencies. We also must review the aspects of these incidents that worked correctly and expand on those aspects. Similarly, we must avoid the known points of failure.

Planned incidents fall under the category of preplanned tactical events or locally restricted common action situations that can be anticipated accurately. These events are rarely

a problem technically regardless of what systems are involved. By their very nature and description they exist with pre-knowledge and the participants are prepared for the forthcoming actions. Planned incidents are not fully detailed here other than to indicate that they could be handled very easily under the following operational description for unplanned incidents.

By their very nature, unplanned incidents may happen any time and any place. These situations are difficult to plan for in any situation and even the best and thorough plans can not prepare for all of the possible unknowns.

### **“PI” System Operation**

Mutual aid operations that are unplanned are unique and go through several definable phases. The first phase is always the “first response” or “initial attack.” Some incidents may never escalate beyond this point. As a typical example, a public safety responder of any service traveling outside of their home coverage area often may be the first contact at a typical accident. Their conventional home dispatch system may be totally unusable. Under the PI scenario, a call on the PI radio to a monitoring station or another mobile in the area may be the one and only response required of the incident.

Other incidents may escalate requiring the same first responder to communicate to more units of various types. As long as the terminology and operating aspects of the PI capable radios are standardized, all units would be compatible. More developed incidents requiring the declaration of a planned operation under ICS would see the command shifted from the first responder to a more appropriate Incident Commander (IC). From this point on, any units entering the operation and conforming to the PI radio standard would be automatically capable of inclusion into the ICS command structure. Local units working as strike teams or individual resources lower in the ICS structure could use their own internal radio system for their level of operation or if mixed with dissimilar units, they could use assigned PI channels. In either case, communicating up the ICS chain of command would occur on the PI radio channel assigned for that purpose.

It is generally accepted that isolating a unique incident from routine daily radio traffic is to be preferred. A unique PI service would easily allow such an action.

Again this scenario is dependent upon standardized common assigned names associated with standardized associated channels used under standard operating procedures. This requirement, although it may seem extreme, is absolutely required for any successful multi-disciplinary incident. All aspects of a successful incident (not just radio operation), require the same standard procedure.

It is important for full universal utilization that a national standardized plan be devised and tied very closely to operating restrictions and requirements, This should be a basic requirement of any interoperability solution.

### The PI Solution

The above descriptions include the following basic requirements:

- \* Find a relatively free band of frequencies, preferably central to existing public safety bands. (220 MHZ?)
  
- \* Define specific frequencies and pairs of frequencies using developed ICS guidelines.
  
- \* Freely license these frequencies to all eligible public safety/service providers under operational as well as technical regulations.
  
- \* Restrict use to mutual aid interoperation.

The preceding requirements may seem somewhat simplistic, however there is a flexibility to the operational aspects of the PI solution that could allow for much higher levels of robust capabilities. **This would be a fresh and new service which could be implemented without regard to any backward compatibility requirements.** It need not be tied to existing technology and modulation schemes. This leads to a plethora of possibilities:

- \* Narrow channel bandwidth (or equivalent) should be specified for maximum spectrum efficiency.
  
- \* Digital modulation could be required for the same reason.
  
- \* Digital modulation leads to the fact that data transfer would be a natural possibility.
  
- \* Bandwidth on demand applications (or the equivalent) could also be implemented for the very same reason.
  
- \* Encryption could also be very easily adapted considering the possible digital nature of the service. Over the air rekeying (OTAR) should be a requirement.
  
- \* Although conventional mode infrastructure independent operation is basic and mandatory to support first response capabilities, trunking should be encouraged for escalated incidents. Trunking would have several advantages for implementation of escalated incidents or for systems embedded in local or regional systems. Caches could be developed that include base/controller equipment that would allow dynamic over the air reconfiguration of all units involved in the incident. This could be enhanced by requiring every radio manufactured to have an internal unique ID similar to the NAM in cellular radios. The ID should be easily read by units entering the incident either by physical connection, optical, or wireless. While such advanced types of operations would require knowledgeable and available communications unit leaders, this activity already takes place on large ICS incidents with existing programmable equipment.

Migration to this interoperability solution could take place as soon as rules and regulations were put into place. There are of course stumbling blocks such as adopting standards for a new operation, but these could also be looked upon as building stones. This solution would not require scrapping any existing system or worry about compatibility with existing systems and the associated costs.

**6.4 APPENDIX D - Spectrum Requirements Subcommittee Report**

**FINAL REPORT**

**SPECTRUM REQUIREMENTS SUBCOMMITTEE**

**PRESENTED TO**

**PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE**

**NATIONAL TELECOMMUNICATIONS AND**

**INFORMATION ADMINISTRATION**

**FEDERAL COMMUNICATIONS COMMISSION**

**FINAL REPORT**  
**SPECTRUM REQUIREMENTS SUBCOMMITTEE**  
**PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE**

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## **Spectrum Requirements Subcommittee**

### **1.0 Executive Summary.**

#### **Charter**

The mission of the Spectrum Requirements Subcommittee (SRS) is to examine the overall spectrum requirements of both Federal and non-Federal public safety agencies through the year 2010. To determine these spectrum requirements, the SRS has considered trends in demographics, crime, previous public safety spectrum studies, technology, and coupled these with the recommendations set forth in the Reports of the Operational Requirements, Technology, and Interoperability Subcommittees.

The SRS has attempted to develop a long-term spectrum plan for both the Federal and non-Federal public safety entities through the year 2010. This plan can be used by the FCC, National Telecommunications and Information Administration (NTIA), and others when addressing the spectrum requirements of the public safety community.

#### **Background**

Telecommunications constitutes one of today's prime "leverage technologies." Throughout business, industry, and government, the United States has increasingly relied on this technology to boost productivity, create new jobs and investment opportunities, and deliver more and better choices and services to the American public.

Radio-based communications are critical to the effective and efficient delivery of a wide range of important police, fire safety, emergency medical, and other public safety and related services. Although serious crime reported in 1994 and 1995 has declined, the demands for services continue to increase. Similarly, although the number of fires reported has declined slightly in recent years, the cost of fire losses has risen nearly 10 percent annually. Public concern regarding overall effectiveness of Federal, state, and local law enforcement and fire safety efforts is steadily increasing. Responding to these concerns, and ensuring that trends seen in recent years continue to show improvement, will require additional commitments by public safety professionals to improve their efforts. In most, if not all

instances, this has entailed greater investment in, and reliance on, radio-based telecommunications.

Public safety entities have requirements for spectrum to support their many and varied missions. These include immediate communications access to satisfy critical response times in the case of emergencies; the need for security, both in the physical integrity of the infrastructure and to ensure the privacy of the communications; control of the system to ensure priority access over the other non-emergency users; and custom coverage for the communications system. Leading the demand for additional spectrum to meet the requirements for enhanced public safety systems are high-technology mobile radio systems capable of transmitting, among other things, mugshots, fingerprints, building diagrams, and medical data.

For many years, mobile radio in general and public safety communications specifically, ranked relatively low in terms of the FCC priorities. The centrality of broadcasting, especially broadcast television, overwhelmed the radio frequency process and the regulatory environment. Consequently, less than 100 MHz of radio spectrum was allocated to all mobile radio applications. The non-Federal public safety community occupies slightly less than 30 MHz in the New York and Los Angeles areas, and slightly less than 24 MHz in the rest of the nation. Bands occupied by users are scattered across a wide range of frequencies.

In recent years, public safety communications groups have successfully urged that their requirements be seriously studied. Section 6002 of the Omnibus Budget Reconciliation Act of 1993 directed the FCC submit to Congress in February 1995 a review of the current and future state and local government public safety communications needs through the year 2010. The FCC was also directed to develop a plan to ensure adequate frequency spectrum would be available to meet those requirements. Subsequent actions by the Commerce Department's NTIA and the FCC led to the establishment of the Public Safety Wireless Advisory Committee (PSWAC).

Additional spectrum alone, however, is inadequate to meet the ever-increasing demands on public safety agencies. Long-term spectrum planning is also critical for the effective management of public safety spectrum allocations. The SRS notes that increased spectrum efficiency, increased interoperability, and the use of commercial services, where practicable, will play a major role in the satisfaction of future public safety radio communications requirements.

## **Demographics**

The subcommittee used projections for population, trends in crime, types of services provided by public safety agencies, and the usage rates of the services in the projections of spectrum requirements. To provide a better estimate of population density in the year 2010, the Rand McNally metric called Rannally Metropolitan Area (RMA) was used to estimate population changes. RMA's that approximate Metropolitan Statistical Areas (MSA's) comprise about 92 percent of the MSA population, while including only about 28 percent of the MSA area.

## **Current Spectrum Allocations and Usage**

Spectrum management authority in the United States is shared between the FCC and NTIA. The FCC allocates frequencies to be used by the private sector (including state and local governments) for public safety operations. NTIA authorizes frequencies to be used by Federal agencies that are, by definition, public safety agencies. The FCC has generally allocated approximately 23.2 MHz for public safety land mobile use, plus specific amounts of spectrum ranging from 6 to 18 MHz on a local basis in major metropolitan areas.

The Federal Government operates non-tactical land mobile systems generally in 7 frequency bands, but these operations are often shared with Federal fixed, hydrologic, and airborne operations.

## **Spectrum Management Options for Increased Efficiency**

There is a growing trend to consider public safety a synergy between Federal and non-Federal agencies. Federal law enforcement often must work with state and local police; the National Guard is called out by the controlling state to supplement the police when emergencies are declared. Several states are either considering or actually using shared Federal/state land mobile radio systems. The Subcommittee has found that shared Federal/state systems may offer advantages to both parties, and should be encouraged.

Federal use of the spectrum is authorized by NTIA via an entry in the Government Master File (GMF). These authorizations may be for a local area, for state-wide use, or even

for the United States and Possessions (US&P). Private licensing for public safety by the FCC is more local, but may include state-wide systems. The Subcommittee recommends that the FCC and NTIA establish a joint study group to further discuss and evaluate how their separate spectrum management processes can be improved to the benefit of the public safety community and the general public. This effort should be completed within 12 months of the completion of the PSWAC Report.

The Subcommittee further recommends the FCC and NTIA study and evaluate methods to improve the coordination between the national-level spectrum managers and the user communities. A short-term solution could be to have FCC and NTIA participation in the Public Safety Communications Council.

### Impact of New Technology and Commercial Services on Spectrum Requirements

The Technology Subcommittee provided technology estimates for the state-of-the-art of the average installed radio system in the year 2010. The Technology Subcommittee indicated that these estimates were aggressive. This implies that spectrum estimates based solely on new technology may be understated. This is balanced, however, by using one of the largest metropolitan areas in the public safety spectrum requirements example.

Privately-owned public safety systems are designed to handle high-priority, mission-critical radio communications. A properly designed system should be able to accommodate all mission-critical radio traffic during peak load periods, and have excess capacity during off-peak periods to service subordinate radio communications as well.

When subordinate communications are routinely postponed due to mission-critical operations, then outsourcing to commercial wireless providers becomes an alternative. Based on feedback from individual agencies to the Interoperability Subcommittee, and estimates by private network manufacturers, approximately 10 percent of the current applications running on private systems are candidates for outsourcing.

### Review of Previous Spectrum Management Studies

Within the last 12 years, several studies have been published that investigated the need for additional public safety spectrum. In 1985 the FCC released a staff report entitled *Report on Future Public Safety Telecommunications Requirements*. This report indicated that at least 12.5 MHz to 44.6 MHz of spectrum would be needed for public safety use in 21 major metropolitan areas by the year 2000. Eight years later, in 1993, the Coalition of Private Users of Emerging Multimedia Technologies (COPE) petitioned the FCC for 75 MHz to be used for developing advanced private land mobile radio systems, including public safety operations.

In 1994, the Association of Public Safety Communications Officials International, Inc. (APCO) filed a study with the FCC entitled *Public Safety Spectrum Needs Analysis and Recommendation*. This study concluded that an additional 18 MHz of spectrum was immediately needed “just to keep pace with the demand for basic voice and data communications.” APCO also concluded that an additional 25 MHz would be needed by 2000, and still another 50 MHz by 2010 to permit public safety agencies to implement a vast array of new telecommunications technologies.

In 1995, NTIA released a comprehensive study of future spectrum needs in the *NTIA Spectrum Requirements Study*. NTIA concluded, based on inputs from the private and Federal Government sectors, that 204 MHz of spectrum was needed for land mobile services in the next 10 years, which included 50 MHz for private land mobile radio services such as public safety.

The conclusion drawn from these various studies was that there is general agreement that additional spectrum for public safety services is needed, but the exact amount of spectrum and the specific frequency bands for operation was still unsettled.

## **Spectrum Need Projections**

The major output of the PSWAC process is the forecast of spectrum needs of the public safety community to the year 2010. The Spectrum Requirements Subcommittee intensely focused on the problem of spectrum requirements forecasting and to this end developed an equation, based in part on previous attempts to forecast spectrum needs by a mathematical method. Working Group 8 was chartered to evaluate a spectrum requirements model proposed to the Subcommittee by Motorola, Inc. This model was refined by the Working Group and used to define the future spectrum requirements.

The model uses as input parameters the basic building blocks of telecommunications system design, but is independent of any specific manufacturer's product. Certain technologies are assumed, based on inputs from the Technology Subcommittee.

Two major urban areas, the New York City and the Los Angeles metropolitan areas were chosen to represent high spectrum-use areas. It was reasoned that if these areas could be satisfied, all other areas in the nation would also have sufficient spectrum. Data corresponding to the NPSPAC Region 8 was used to approximate the New York City area.

Five general types of telecommunication services were analyzed for public safety use: voice, data, status/message, wide band data, and video. These services included advanced communications services such as slow scan and full motion video, data access and transfer, and image transmission (e.g., snapshot, mugshot, or fingerprint).

Erlang theory was incorporated into the model to assure effective channel usage at a design grade-of-service level of one per cent. The Erlang-C equation was used with a one per cent probability of queuing with a 19-channel server. Other significant parameters, such as future improvements in error correcting code rates and modulation efficiencies were used as agreed to by the Technology Subcommittee.

Table 1 summarizes the results of the spectrum needs modeling. The use of commercial services as an adjunct to privately-owned systems was considered. Commercial services are presently being used by public safety agencies. It was estimated that commercial services would be used to a degree that represented 10 per cent of allocated spectrum. As a consequence, the required spectrum as derived from the model is reduced by that 10 per cent. The final result is that 95 MHz will be needed for mobile public safety telecommunications by the year 2010. That is, voice requirements on a per-officer basis will increase until wide band data and video services are fully implemented. Long-term estimates show only a modest increase in the per-officer voice requirement. This implies that there will be an accelerated short-term need for voice operations, but this spectrum could be used for data or video at a later date as voice requirements track only the growth in user population. Further, it is stressed that the aggregate spectrum requirement is more important than its constituent parts. Table 1 below is shown mainly for illustrative purposes.

### **TABLE 1**

#### **Expected Land Mobile Spectrum Requirements for 2010**

<b>SERVICE</b>	<b>SPECTRUM (MHz)</b>
<b>Voice</b>	<b>32.3</b>
<b>Data</b>	<b>5.3</b>
<b>Status/Message</b>	<b>0.2</b>
<b>Wide Band Data</b>	<b>40.8</b>
<b>Video</b>	<b>50.7</b>
<b>SUBTOTAL</b>	<b>129.3</b>
<b>Present Allocation</b>	<b>(- 23.4)</b>
<b>Commercial Services</b>	<b>(- 10.6)</b>
<b>Net Need in 2010</b>	<b>95.3</b>

### **Spectrum Band Options**

National population growth has increased the demand for public safety services across the country. Modern public safety agencies, both Federal and non-Federal, depend heavily upon wireless telecommunications to accomplish their missions. However, radio spectrum allocated for public safety services has been fully assigned in many metropolitan areas of the United States. Generally, spectrum allocation to public safety services has not kept up with the demand in urban areas. Public safety agencies view this spectrum shortfall with alarm, since if not corrected, this shortfall may lead to a degradation of the quality of service rendered to the public.

Since there are no spectrum reserves from which to draw for public safety use, consideration must be given to selection of bands that may be made available in the future. Several parameters are important in considering which spectrum bands are suitable for public safety use. First, the spectrum used to support public safety must satisfy the requirements for land mobile voice, data, image, and video transmission and reception. Second, spectrum enhancing voice and data requirements should be near current public safety frequency bands, while applications using new or emerging technology may be in bands significantly removed from current bands.

Generally, frequency bands considered for new public safety requirements were (1) unused television channels, either in the VHF or UHF regions; (2) those frequency bands

transferred from Federal use to the FCC; (3) increased allocation in present VHF/UHF land mobile bands; and (4) other Federal bands not currently under consideration for transfer.

## **Conclusions and Recommendations**

### **Additional Spectrum**

The Spectrum Requirements Subcommittee concluded that immediate relief was needed for land mobile voice and data operations in major cities. In the short-term, voice and data operations require 25 MHz of new public safety allocations. By the year 2010, an additional 70 MHz will be needed for these applications, plus image and video requirements, for a total of 95 MHz.

Recognizing that the public safety telecommunications infrastructure (e.g., fixed microwave systems) are vital to the operation of area-wide systems, the Subcommittee recommends that 161 MHz of additional allocations be made for this use, as shown below.

It was noted that although landline technology, including fiber optics, offers increased telecommunications capacity and can be used to off-load communications from spectrum-dependent systems, certain areas of the country that are susceptible to earthquakes cannot rely on ground-dependent systems since these systems often fail during severe earth movements.

Federal Government users indicated that future Federal requirements could be satisfied in the currently allocated bands, provided that: (1) no more Federal allocations are lost through transfer to the FCC for commercial use; (2) the assumed spectrum-efficient technologies become available as needed; and (3) funds are provided by appropriations to implement the spectrum-efficient technologies into Federal radio systems.

The Subcommittee further concluded that spectrum should be requested near current public safety allocations, where feasible. Systems using new or emerging technology were not as sensitive to allocations, and could be located in bands removed from current public safety allocations.

The Subcommittee recommends that the FCC, in cooperation with NTIA, permit public safety services access to the following frequency bands, either by reallocation or by sharing. The frequency bands requested, in priority order are:

### **Voice, Data, and Video Requirements**

1. Immediate further sharing of TV channels in the 470-512 MHz band in all areas.
2. Reallocate all or part of TV channels in 746-806 MHz band.
3. Immediate allocation of the VHF and UHF channels in other services created by the FCC's Refarming Proceeding (including TV sharing bands).
4. Eventual reallocation of all TV sharing channels in the 470 to 512 MHz band.
5. Immediate new sharing of the 174-216 MHz VHF TV band primarily outside of urban areas and for statewide systems.
6. Reallocation of the 380-399.9 MHz band.
7. Sharing of the 380-399.98 MHz band with DOD on a mutually agreeable basis to minimize interference to public safety operations.
8. Hold a portion of the 174-216 MHz band in reserve to meet future public safety needs, or needs not met by this effort.

### **Wide Band Data and Video Requirements**

1. Allocations in the 1710-1755 MHz band.

### **Short-Range Video Requirements**

1. Allocations in the 4635-4685 MHz band.

### **Fixed Service Requirements**

1. Allocations in the 4635-4685 MHz band.
2. Allocations in the 1990-2110 MHz band.
3. Allocations in the 3700-4200 MHz band.

### **Intelligent Transportation Systems**

1. Allocations in the 5850-5925 MHz band.

### **Interoperability**

In addition to the spectrum requirements stated above, the Subcommittee recommends that channels be made available in a band below 512 MHz for nationwide interoperation among state, local and Federal public safety agencies. Specific details on spectrum requirements for interoperability are contained in the Report of the Interoperability Subcommittee.

### **System Sharing**

The Subcommittee recommends that state and local agencies consider system sharing arrangements with Federal agencies within their jurisdiction. The Subcommittee further recommends that the FCC and NTIA encourage sharing arrangements, and amend applicable rules to permit flexible licensing and authorizations for shared systems using either Federal or FCC-controlled land mobile spectrum.

## **2.0.0 Spectrum Subcommittee's Charter Overview.**

**2.0.1** The primary mission of the Spectrum Requirements Subcommittee (SRS) is to examine the overall spectrum requirements of both Federal and non-Federal public safety agencies through the year 2010. To determine these spectrum requirements, the SRS has considered several factors, including population growth characteristics of the country and crime statistics. Additionally, the SRS has also taken into consideration previous public safety spectrum requirement studies coupled with the recommendations set forth in the Reports of the Operational and Interoperability Subcommittees.

**2.0.2** As the demand for new commercial and noncommercial communications services increases, the amount of spectrum available for these competing services decreases. Importantly, therefore, the SRS has been asked to examine the impact of technology, the use of commercial services, and spectrum management options on the need for spectrum for public safety communication requirements.

**2.0.3** The SRS also has the task of analyzing spectrum that is suitable for both Federal and non-Federal use by public safety entities to more fully meet existing communications requirements as well as new communication tools like transmitting fingerprints, mugshots, building diagrams, full motion picture, and a host of other high speed data applications. Factors such as existing Government and non-Government use of the bands, adjacent channel uses, and the propagation characteristics of the bands have been analyzed to determine the suitability of the bands for public safety use and for what potential services the identified bands can be used.

### **2.1.0 Report Scope.**

**2.1.1** The SRS has attempted to develop a long-term spectrum plan for both Federal and non-Federal public safety entities through the year 2010. This plan, hopefully, can be used by the Congress of the United States, the FCC, and NTIA to assist them when addressing the spectrum requirements of critical public safety services through 2010.

**2.1.2** Public safety entities have unique requirements for spectrum to support their many and varied missions. Leading the demand for additional spectrum to meet the requirements for enhanced public safety systems are high-technology mobile radio systems capable of transmitting — among other things — mugshots, fingerprints, building diagrams, and medical emergency data. The continued ability of public safety agencies to meet their responsibilities of serving the public welfare depends in large measure on the effective allocation of spectrum to meet these ever-growing communication requirements.

**2.1.3** The SRS, to address the issue of spectrum planning for public safety, has reviewed the usage of current public safety allocations. It is clear that additional efficiencies may be gained in spectrum allocations below 512 MHz by the deployment of newer, advanced technologies in these bands. Because, however, these bands are highly fragmented, public safety licensees will continue to suffer severe spectrum shortages to meet existing and new communication requirements, including interoperability needs, unless spectrum relief is afforded and soon.

### **3.0.0 Background.**

**3.0.1** Telecommunications constitutes one of today's prime "leverage technologies." Throughout business, industry, and Government, the United States has increasingly relied on this technology to boost productivity, create new jobs and investment opportunities, and deliver more and better choices and services to the American public.

**3.0.2** Telecommunications and information technology, linked together, thus constitute one of the most powerful and useful tools available to public policy makers today. They represent solutions to an array of challenges, and admit to widespread ubiquitous application. This is particularly true of wireless, radio-based communications that traditionally have proven one of the chief sources of productivity and efficiency gains.

**3.0.3** Radio-based communications are also increasingly critical to the effective and efficient delivery of a wide range of important police, fire safety, emergency medical, and other public safety and related services. The costs of such services also represent a growing part of most state and local government budgets.

**3.0.4** It is true that serious crime reported to U.S. law enforcement authorities has been declining. It declined by 2 percent in 1995 compared with 1994, according to the Federal Bureau of Investigation (FBI). This decline continued the trend from 1993, when overall crime was down 3 percent from the previous year. There were Crime Index decreases in all the nation's cities except those with populations of under 25,000 and 500,000 to 999,999. The greatest decline (6 percent) was recorded in cities with a population of one million or more. Rural law enforcement agencies reported a 3 percent increase. See FBI, Uniform Crime Reports, 1995 Preliminary Annual Release. Although the serious crime reported has declined, the demands for services continue to increase.

**3.0.5** Public concern regarding the overall effectiveness of Federal, state, and local law enforcement efforts nevertheless is steadily increasing. Responding to these concerns, and ensuring that trends seen in recent years continue to show improvement, has required additional commitment by law enforcement professionals to improve their efforts. In most, if not all instances, this has entailed greater investment in and reliance upon radio-based telecommunications.

**3.0.6** Fire safety is another field where government faces important challenges. In general, the number of fires reported to U.S. fire departments has declined slightly in recent years. Total as well as per capita fire losses have risen by nearly 10 percent annually, however, according to the most recent official statistics. In 1991, for example, total U.S. fire losses amounted to some \$11.3 billion — \$48.24 per capita. See 1994 U.S. Statistical Abstract at Table 348.

**3.0.7** Response times are absolutely critical in fire safety, both to minimize property losses and, what is more important, potential loss of life. Average departmental response times also have a direct bearing on the casualty loss insurance premiums paid by property owners. Obviously, the more effective and efficient the wireless communications available to fire professionals, the greater the public welfare gains.

**3.0.8** Response times are also clearly critical in the case of emergency medical services and, again, are essentially dependent upon the quality of the radio-based communications available to emergency medical service teams. Even fractions of a minute translate into significant additional lives saved, and often substantial reductions in subsequent medical treatment costs. Demand for emergency medical services, moreover, typically is a function of the age and thus the vulnerability of the population. At present, about one-third of Americans are aged 50 to 62, and the fastest growing part of the population are the elderly. How well emergency medical services are able to meet the needs of these communities obviously has a direct and immediate impact on their overall quality of life.

**3.0.9** For many years, mobile radio in general and public safety communications specifically, ranked relatively low in terms of the FCC priorities. The centrality of broadcasting, especially broadcast television, overwhelmed the radio frequency process and the regulatory environment. Consequently, less than 100 MHz of radio spectrum was allocated to all mobile radio applications, and uses were scattered across a wide range of frequencies, thus necessitating multiple or expensive multi-frequency transceivers. Television broadcasters currently have more than 400 MHz of spectrum.

**3.0.10** This scarcity of available frequencies limited the contribution that mobile radio services could make. It also had some beneficial consequences, however. In order to multiply the effective communications capacity of scarce channels, the public safety agencies had to find ways to use the frequencies more efficiently, usually by splitting their channels. On the Federal Government side of the radio frequency management equation, difficulties accommodating Federal public safety spectrum requirements have not been as apparent. This is the result of better cooperation among the Federal agencies and NTIA than exists between public safety and private sector users (through the FCC), prompt implementation of narrowband channeling (12.5 kHz), periodic re-evaluation of frequency assignments, and stringent receiver standards. All these factors allow Federal agencies to better meet their increasing spectrum requirements in their limited spectrum resources.

**3.0.11** Mobile radio, particularly in the public safety arena, is an area where spectrum scarcity and relatively few equipment buyers (and suppliers) shaped the market.

**3.0.12** From the inception of mobile radio services in the 1930's, however, Government policy has generally sought to promote competitive marketplace solutions. Advances and public dividends are a function of Government consistently striving to reduce rules and regulations, and actively seeking to foster actual and potential, private sector competition.

**3.0.13** Obviously, not all issues and choices can be — or, indeed, should be — made solely on the basis of competitive and de-regulatory considerations.

**3.0.14** If, however, there is a single lesson to be gleaned from America's positive experience in communications over the past two decades, it is that less almost always has meant more. Fewer Government rules, more reliance on individual decision making, and more confidence in the ability of competitive private enterprise to evolve sound marketplace solutions have all fostered competition. That competition, in turn, has spurred innovation and greater customer responsiveness. The result has been significant unarguable national gains. The Government's role during these changes was to ensure that interference potential between the many divergent spectrum users was reduced.

**3.0.15** Fundamentally at issue today are how much competition, choice, and individual decision making makes sense in public safety communications. Congress recently overhauled much of the 1934 Communications Act, as amended, 47 U.S.C. Sec. 151 et seq. The Telecommunications Act of 1996, Public Law No. 104-104, 110 Stat. 56, approved February 8, 1996, directs major, pro-competitive, and deregulatory change throughout the regulated

telephone, television, radio broadcast, and cable television sectors. That legislation rests on the assumption that competitive markets will achieve solutions as effective, if not more effective, than those which Government might otherwise mandate and impose.

**3.0.16** One major area of communications, a critical area of communications, was not directly affected by that landmark legislation — public safety communications. This is not to say public safety communications issues and choices are not critical, however.

**3.0.17** The preamble to the 1934 Act ranks “promoting safety of life and property” second only to fulfilling national defense requirements. Certainly Congress will expect any regulatory action in this area to be fully consistent with the overall pro-competitive, pro-choice, pro-“devolution” thrust of the major legislation it just passed.

**3.0.18** In recent years, public safety communications groups have successfully urged their requirements be seriously studied. Section 6002 of the Omnibus Budget Reconciliation Act of 1993 directed the FCC, in February 1995, submit to Congress a review of current and future state and local government public safety communications needs through the year 2010. The FCC was also directed to develop a plan to ensure adequate frequency spectrum would be available to meet those requirements.

**3.0.19** In March 1995, Congressman Harold Rogers, Chairman of the House Appropriations Subcommittee on Commerce, Justice, State, and the Judiciary, expressed concern that the Commission’s response to the 1993 Act requirement had been inadequate. Chairman Rogers requested the issue of the amount of spectrum available for Federal as well as state and local public safety communications be carefully and systematically addressed. Subsequently, the Commerce Department’s NTIA, which is responsible for managing the use of spectrum by Federal agencies pursuant to Section 305 of the Communications Act, and the FCC jointly established the Public Safety Wireless Advisory Committee (PSWAC).

**3.0.20** The PSWAC membership is drawn from all parts of the public safety communications field, including users, regulators, national associations, equipment suppliers, and members of the public. Participating on the subcommittees and steering committee are officials of many Federal agencies as well.

**3.0.21** Public safety communications is a generic term. It encompasses the wireless systems used by Federal, state, and local users. They include law enforcement, fire safety, emergency medical service, emergency preparedness, disaster relief, and other important subject areas.

**3.0.22** Traditionally, Federal radio frequency management in this field has apportioned spectrum — radio channels — on a relatively rigid and inflexible basis. Channels have been earmarked for discrete, individual services. The channels apportioned to fire safety systems, for example, have not generally been available for local law enforcement use. Likewise, channels used by public utilities, road crews, and those used to support Federal law enforcement have been essentially “off-limits” to state and local public safety agencies.

**3.0.23** Government policy has done little to date to change the inefficiencies brought about by the separate and distinct frequency management systems employed by both the Federal and non-Federal users. Likewise, Government policy has done little to encourage the development of interconnected, “public” or common-user radio networks. Consequently, the proliferation of radio systems too often necessitates multiple transceivers in public safety vehicles. Partly as a function of the relatively inefficient way in which spectrum resources have been allocated, urban police vehicles, for example, too often display “more antennas than an old Soviet trawler,” as one critic put it.

**3.0.24** Moreover, there has been a trend toward more and more customized, user-specific, public safety communications systems. Customization has helped public safety communications users more closely tailor their systems to specific needs. Customization may also be a function of the limited spectrum available to public safety agencies, and the tradition of licensing public safety agencies separately. But, that very customization that may optimize achievement of some missions has come at a significant cost.

**3.0.25** Public safety communication devices have not decreased in cost over the years. Thirty years ago, a 100-watt mobile radio would use standard squelch, had one channel, and cost more than \$1,000. Today that same radio would cost less than \$500. But today, public safety agencies don’t buy that type of radio. Today’s radio uses some form of squelch control. It has several channels and it is common to have either a scan feature or a second channel monitor to increase the efficiency of the public safety personnel. Enhanced scrambling is often requested. The radio is all solid state, uses less vehicle power, and is much smaller to fit in the reduced size of vehicle trunks. These features are required to meet the challenges of “Working Smarter” and meeting the ever increasing demands for service. All these features distort the cost picture. The bottom line is demand for features has increased, not the basic cost of the radio.

**3.0.26** Moreover, serious network interconnection and interoperability issues have arisen and persisted. Such issues typically arise when state or local public safety communications users endeavor to communicate with nearby jurisdictions or Federal users, usually in a disaster context (e.g., an airplane crash). In part, this incompatibility is a function of the different frequencies used by public safety and, in part, it may be a function of differing regulatory schemes. Federal spectrum users are authorized by NTIA; non-Federal users are authorized by the FCC. Each group of users may employ different frequencies and there is little, if any, coordination between the licensing agencies. However, it is important to note that if separate agencies used the same frequency all the time, channel loading could be increased to the point the channel would be unusable for both parties. Increased emphasis on better cross-banding and cross-patch services would facilitate interoperability between distinct users when required.

**3.0.27** Public safety communications has encountered legitimate criticism in recent years. Questions have been raised regarding the cost-effectiveness of various systems and planned systems. Some of this criticism is no different from that which other government institutions have encountered in recent years, and reflects a growing concern on the part of taxpayers and elected officials that they get a fair value for their money.

**3.0.28** Public safety communicators thus confront a diversity of institutional and regulatory pressures. Public safety communications operations are not immune from budget cutting. No longer are public safety operations, including law enforcement, necessarily deemed “sacred cows” that are immune from budget cutting. Indeed, both at the Federal and state and local levels, there have been reductions in public safety and law enforcement funds.

**3.0.29** What this has meant is growing pressure on public safety communications managers to use their radio channels more efficiently. In this regard, that same familiar convergence of modern communications and computer technology that has reshaped so much of the U.S. wireline telecommunications industry is also reshaping the way public safety and other wireless communications is undertaken today.

**3.0.30** The central reality of this convergence process is the supplanting of traditional analog communications techniques with digital systems tied into computers, a transition that holds much radio spectrum management promise. Digital technology facilitates use of far narrower channels or more capacity: a given bandwidth can handle substantially greater use. In short, digital today means substantially more efficient spectrum use — a clear plus from an overall frequency management perspective, given escalating demand today for spectrum generally and more complex public safety communications requirements. However, without establishing common interface standards for digital services, the interoperability problems that currently exist will worsen.

**3.0.31** An NTIA Report, entitled *U.S. National Spectrum Requirements: Projections and Trends* (April 1995) (hereinafter called *NTIA Spectrum Requirements Study*) found additional spectrum was needed to satisfy users requirements in a variety of different radio services, including public safety. As noted in the NTIA Report, all the identified services are important to the nation and it is difficult to determine which services deserve spectrum and how much. Congress, however, has repeatedly mandated that the FCC must give “top priority” to the needs of those users who “protect the safety of life and property.”

**3.0.32** The SRS has found that forecasting the demand for spectrum for public safety has been difficult at best. It is clear, however, that increasing demands are being placed on public safety entities at all levels, especially in major metropolitan areas, for more and better services. The SRS has concluded that additional spectrum must be set aside for public safety entities at the Federal, State and local levels to support law enforcement, fire, emergency medical, forestry-conservation, highway maintenance and other public safety services.

**3.0.33** Additional spectrum, standing alone, however is not enough to meet ever increasing demands on public safety agencies. Long-term spectrum planning is also critical for the effective management of radio spectrum allocated for public safety use, including more efficient use of current spectrum allocations. Accordingly, in this Report, the SRS has identified a number of spectrum management options that, if implemented, will improve spectrum by Federal and non-Federal public safety entities. The SRS believes the use of future commercial services by public safety agencies will play a major role in public safety agencies using their allocations more efficiently and effectively for critical public safety communications requirements.

#### **4.0 Current Spectrum Allocations and Usage.**

**4.1 Introduction.** Spectrum management authority in the United States is shared between the FCC and the President. The Communications Act of 1934 established the Commission and gave it authority to assign frequencies to radio stations, except for Federal Government owned or operated radio stations. Section 305 of the Act preserves for the President the authority to assign those frequencies. These powers are currently delegated to the Assistant Secretary of Commerce for Communications and Information who is also the Administrator of the NTIA. The FCC is composed of five members, who are appointed by the President with the advice and consent of the Senate. The Interdepartment Radio Advisory Committee (IRAC), which is composed of twenty Federal departments and agencies, serves in an advisory capacity to the NTIA’s management of the electromagnetic spectrum. The Act provides for the function of developing classes of radio service, allocating frequency bands to the various services, and authorizing frequency use. However, the Act does not mandate

specific allocations of bands for exclusive Federal or non-Federal use; all such allocations stem from agreements between NTIA and the FCC.

Use of the radio spectrum is vital to the security and welfare of the Nation. Sufficient mobile communication capacity for agencies charged with protecting the public welfare is of critical importance.

#### 4.2 Non-Federal Public Safety Allocation and Usage.

<b>CURRENTLY ALLOCATED PUBLIC SAFETY LAND MOBILE SPECTRUM</b>		
<b>Non-Federal Government</b>		
<b>Frequency Band (MHz)</b>	<b>Number of Channels</b>	<b>MHz (Approximate)</b>
25-50	315	6.3
150-174	242	3.6
220-222	10	0.1
450-470	74	3.7
806-821/851-866	70	3.5
821-824/866-869	230	6
<b>TOTAL*</b>	<b>941</b>	<b>23.2</b>

\*Various amounts of spectrum have also been allocated in the 470-512 MHz band in 11 markets: Boston, Chicago, Dallas, Houston, Los Angeles, Miami, New York, Philadelphia, Pittsburgh, San Francisco, and Washington, D.C.; ranging from 6 to 18 MHz. (In Los Angeles, 6.5 MHz is allocated.)

### 4.3 Federal Spectrum Allocation and Usage.

<b>LAND MOBILE SPECTRUM</b>		
<b>Federal Government</b>		
Frequency Band (MHz)	Uses	Remarks
30-50	Dispatch	Conventional
138-144	Dispatch	Military
148-149.9	Dispatch	Military
150.05-150.8	Dispatch	Military
162-174	Dispatch	Conventional and trunked
220-222	Dispatch	Conventional
406.1-420	Dispatch	Conventional and trunked

These bands support many Federal land mobile functions, of which public safety (law enforcement, fire, medical, etc.) is only a part.

### 5.0 Demographics. Impact on Need for Additional Spectrum.

**5.1 Introduction.** Section 9 defines the spectrum needs of public safety based upon the population of public safety users and their radio units in a particular geographical area. The number of users depends upon the total citizen population of the geographical area. As the Census Bureau tracks residential populations and their data are readily available, Census

Bureau data will be used to estimate the total citizen populations for population centers of about 50,000 inhabitants and greater and relate citizen populations with public safety users.

**5.2 Current U.S. Demographic Characteristics.** A statistical description used by the Office of Management and Budget (OMB) provides an understanding of how to classify urban and rural. OMB divides the United States into county-based Metropolitan Statistical Areas (MSAs) and nonmetropolitan areas. A county is included in an MSA if:

- 1) it contains a city with a population of at least 50,000; or
- 2) it contains an urbanized area<sup>1</sup> with a population of at least 50,000 and a total metropolitan population of at least 100,000;  
or
- 3) it has strong economic and social ties to a central county containing the main city or urbanized area.

For example, the Colorado Springs, Colorado MSA includes a single county with a single large city. The Indianapolis, Indiana MSA includes a single large city located in Marion County, but it also includes eight surrounding counties that are relatively densely populated. The Las Vegas, Nevada MSA includes a single large city located in Clark County, but it also includes sparsely populated Nye County. Ten counties in the state of Iowa are included in MSAs, but the remaining 89 counties are considered nonmetropolitan.

According to 1994 population estimates, approximately 80% of the total U.S. population of 259.6 million people live in MSAs (Rand McNally, 1995). The remaining 20%, 52.4 million people, live in nonmetropolitan counties. Nonmetropolitan counties, however, comprise approximately 80% of the land area in the country (U.S. Bureau of the Census, 1994).

Some counties included in MSAs contain portions that are sparsely populated and located a considerable distance from the nearest city. Estimating spectrum needs on a large population spread over a large MSA land area could give wrong results compared with estimating the needs of the same population over a much smaller land area associated with a densely populated metropolitan center. To provide a better estimate of spectrum needs, a

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<sup>1</sup> According to the Census Bureau, an urbanized area consists of a central city and the contiguous, closely settled area outside the city(ies) political boundaries.

metric other than that defined by an MSA is needed which ties population more closely to the land area where the population resides.

Attempts have been made by non-OMB demographers to more clearly separate urban and rural areas. One such definition by Rand McNally, called Ranally Metropolitan Areas (RMAs), includes only sub-counties in their definition and by their estimate, "RMAs that approximate MSAs comprise about 92% of the MSA population although only about 28% of the MSA area." Currently Rand McNally has defined 452 RMAs with populations of about 50,000 and greater.

Appendix A gives the data available from Rand McNally's Ranally Metropolitan Area population data. Each RMA is identified by the major city within the RMA and population values are given for the RMA's metropolitan area, the RMA's central city(ies), and the suburban area associated with the RMA. The land areas in square miles are provided for the metropolitan and central city of each RMA. Population figures are listed from the April 1, 1990 Census and estimated populations are for January 1, 1994. The percent change over the four-year period is given for the metropolitan area, the suburbs, and the central city(ies) of each RMA.

**5.3 Projected Demographic Data.** Population projections are made for 2010 by using the historical population change from 1990 to 1994 listed for each RMA. In some cases the population changes from 1990 to 1994 were of greater percentage for cities than those for their metropolitan area. Projecting the growth of the city versus the metropolitan area in some cases resulted in a city population greater than the metropolitan population. In Appendix A, the 2010 population estimates were first based upon the metropolitan projection and the associated city population projection was constrained to not exceed the metropolitan projection.

## **6.0 Spectrum Management Options for Increased And/or More Effective Use of Current and Future Spectrum Allocations.**

**6.1** There is growing pressure on Federal and non-Federal public safety communications managers to use their radio channels more efficiently. As demonstrated elsewhere in this Report, there is a need for additional spectrum to support public safety agencies at all levels. There is also a need for better long-term planning and better management of the radio spectrum allocated for public safety use.

**6.2** The Spectrum Requirements Subcommittee observes that the Transition Subcommittee Report discusses several spectrum management proposals that may lead to more effective and efficient use of spectrum allocated for public safety uses. These include transitioning to exclusive licensing, encouraging spectrum sharing between public safety agencies, developing regional plans to manage spectrum allocations, privatizing licensing functions currently performed by the FCC, increasing the use of electronic filing and processing of public safety applications, and increasing the role of States in the spectrum management process. The SRS also believes these proposals can lead to better management and use of public safety spectrum allocations. The SRS thus recommends the FCC and NTIA fully evaluate the Transition Subcommittee's suggestions and implement those they determine will improve the management of the radio spectrum within their respective jurisdictions.

**6.3** The SRS further recommends the FCC and NTIA undertake joint planning efforts to improve management of spectrum allocated for public safety purposes and to assure it is used efficiently. For decades, use of spectrum by Federal Departments and Agencies has been managed by the President and his designee; the use of spectrum by non-Federal public safety agencies has been managed by the FCC. These separate systems have, in the past, served their constituencies well.

**6.4** As the demand for scarce spectrum has grown, however, Government policy has done little to change the inefficiencies brought about by the separate and distinct frequency management systems employed by NTIA and the FCC. The SRS therefore also recommends the NTIA and FCC establish a joint study group to further discuss and evaluate how their separate and distinct spectrum management systems can be improved to the benefit of public safety agencies and, ultimately, the public-at-large. The SRS believes this joint spectrum planning effort should be undertaken and completed within twelve months of the date of completion of the PSWAC Report.

**6.5** Similarly, it may be advisable to establish an advisory process between Federal and non-Federal public safety users to evaluate and consider the wide variety of issues that face public safety agencies at all levels of operation. Increasingly, there are requirements for communication between different Federal and non-Federal public safety agencies. Moreover, substantial efficiency gains could be achieved by sharing spectrum and infrastructure by Federal and non-Federal agencies. The SRS notes, for instance, the State of Wisconsin and the Department of Defense are currently planning the development of a joint, multi-agency VHF trunking system that has the potential for dramatic improvement over the systems currently in use. More such efforts should be encouraged and there should be put in place a mechanism where such sharing can occur with the minimum of Government "red-tape."

**6.6** The SRS also recommends the FCC and NTIA study and evaluate methods to consider the multiplicity of operational and licensing issues that confront Federal and non-Federal public safety agencies on a day-to-day basis. Here again, the objective should be to improve the coordination between the Federal managers and the user community. In the short-term, improvements in coordination between the FCC and NTIA and various user groups could be accomplished by placing FCC/NTIA representatives on the Public Safety Communications Council, a private organization whose membership is composed of various public safety user groups.

## **7.0 Impact of New Technology and Commercial Services On the Spectrum Needs of Public Safety Communications.**

**7.1 Introduction.** In this section, we will investigate the magnitude of the impact of technology and the use of commercial services on the spectrum need computed in Section 9.0. It will be shown the parameters used for the spectrum computation herein are very aggressive, and, in fact, that a paradigm shift will be necessary to effect the projections made.

**7.2 Technology Subcommittee Input.** The Technology Subcommittee provided the expected state-of-the-art for the average installed system in 2010 as part of the basis for generating spectrum estimates. The Technology Subcommittee has stressed these technology estimates are quite aggressive - **thus any spectrum estimate based upon them will be correspondingly conservative.**

**7.2.1 An Example.** The technology forecast provided estimates that the public safety voice radio system in use in the year 2010 would require **an average of 4 kHz** of spectrum per active conversation.<sup>2</sup> Realistically, this high level of efficiency could only be achieved by universal replacement of existing equipment and the widespread deployment of public safety systems more spectrum efficient than any on the market today.

**7.2.2 Impact of Projection.** To put this requirement in perspective, assume that the older one-fourth of installed equipment in 2010 operates with a spectrum efficiency of 12.5 kHz per speech path (the level required for new type acceptances today under the FCC's refarming rules, but not yet in significant use in public safety). Then, if the forecasts of the Technology

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<sup>2</sup> The value of 4 kHz per voice channel is based on an offered load of 6 kb/s for digitized voice today, and by the year 2010, an improvement in coding of 2:1, the use of error correcting code and overhead that requires double the offered load, and a transmitted rate (or modulation efficiency) of 1.5 b/s/Hz.

Subcommittee are to be met, the other three-quarters of equipment must operate with a spectrum efficiency of 1.17 kHz per speech path (roughly twenty times more efficient than today's typical practice). This discussion considers one specific technological element, voice transmission. The forecasts were similarly aggressive in other areas such as data modulation, video coding improvement, etc.

### **7.3 Use of Commercial Services: Impact on Spectrum Needs of Federal/Non-Federal Public Safety Agencies.**

**7.3.1** Since most commercial mobile radio services are fundamentally designed to meet the needs of private sector customers and/or individual consumers, they do not all offer levels of customized service required for certain applications in the public safety environment.

Those requirements include the need for instant push-to-talk group dispatch, priority access, and security. Agencies that are concerned about inter-jurisdictional communications need to ensure that if they use commercial services, they are able to work with vendors that provide interoperability with other vendors and/or have plans to interface with private systems, ensuring ubiquitous coverage to the largest degree possible.

Public safety organizations engage in a wide variety of activities in their mission to protect life, property and to provide for public safety. Like any other public or private sector organization, their activities range from those that are mission-critical to those that are more subordinate in nature. The communications needed to support these activities are similarly wide-ranging, and offer differing operational capabilities. The gap between what is required by public safety and what can be delivered by commercial wireless services is widest among mission-critical communications like "shoot, don't shoot" scenarios, and narrowest among subordinate applications, like routine background checks.

Public safety private systems are primarily designed to handle high priority, mission-critical communications. A properly designed private system should be able to accommodate all mission-critical communications during peak load periods, and have excess capacity during off-peak load periods to accommodate subordinate communication applications as well.

If subordinate communication applications can be retained on private systems, agencies can leverage their infrastructure investment and fill available system capacity. On some networks,

the system manager is able to control radio traffic to ensure that mission-critical communications get through during peak load periods, while subordinate types of communications are postponed until capacity is available. When subordinate communications become postponed on a regular basis however, alternatives should be considered.

Since private systems provide what is required by public safety agencies for mission critical applications, subordinate applications become the strongest candidates for outsourcing to commercial wireless services. When agencies migrate applications to commercial services, an examination regarding the cost/benefits of outsourcing should be conducted. Outsourcing makes sense when the benefits versus the cost of commercial services reach a “break-even” or positive gain over using a private network. If subordinate communications are continuously postponed or unavailable due to priority preemption, user productivity and responsiveness can suffer. Costs associated with time loss and the inability to accomplish desired results may be many times the cost of outsourcing. A migration plan to commercial services is best suited for agencies consistently nearing or exceeding capacity beyond peak traffic hours. An outsourcing “back-up” plan should be sufficient when extenuating circumstances require occasional additional capacity.

Based on feedback received from individual agencies to the Interoperability Subcommittee, and estimates by private network manufacturers, 10% of the current applications running on private networks are candidates for outsourcing (Appendix B). Whether that outsourcing is required for occasional preemption or whether the need is for all subordinate communications has not been explored. However, growing demand for private spectrum to support customized applications specific to public safety will encourage agencies to explore commercial options for subordinate applications as private spectrum fills.

### **7.3.2 Spectrum Relief**

**7.3.2.1** Public safety agencies are increasingly finding new roles for commercial services which did not previously exist, yet substantially lighten the load for dispatchers, by directing routine traffic to alternate, commercial spectrum.

**7.3.2.2** The Alexandria, Virginia, Police Department (PD) provides a good example of how moving to a commercial data service can relieve an overcrowded voice channel. According to PSWAC/ISC 96-04-036, notes from a meeting at the Alexandria Police Department Headquarters, a cellular digital packet data (CDPD) system is under current evaluation as part

of a pilot test. A CDPD network will be used to support laptop/notebook computers with wireless modems for data transfer. According to the report:

*“The Alexandria PD representative stated that the system initially will be used to request tag checks, wants and warrants, which are currently handled on a voice channel through the central dispatcher, who then accesses the data base in Richmond. The Alexandria PD currently operates on one dispatch channel and it routinely becomes overloaded during peak traffic periods. This creates delays of up to fifteen (15) minutes to get a routine license check called in to dispatch, and depending on the dispatchers’ traffic load, the response back to the officer does not conduct a query due to the time required to get on the channel. They feel the use of CDPD, will help to minimize both problems, first it should reduce the voice traffic by at least 30%, while reducing the response time of such data queries, and second, the officers will accomplish more queries, which they feel will increase the capability to recover stolen vehicles and apprehend offenders. The response time experienced during the test has been two (2) to three (3) seconds from the time an officer inputs the data until the time he/she receives the response.”*

additionally,

*“Officers will eventually utilize the system to provide incident reports from the scene, which will relieve some of the officers’ administrative burden, as well as possibly further reduce voice traffic by as much as another 15-30%.”*

**7.3.2.3** Groton, Connecticut Police Department uses CDPD with mobile data computers for messaging and to query the National Crime Information Center. Public safety officials can wirelessly exchange forms or messages from their vehicles or desktops within seconds. Previously, if an officer needed certain information, he/she had to call into the dispatch operation to get someone to pull the data and then relay it verbally. This was a slow process and discouraged people from asking for what they needed.

## **8.0 Review of Previous Spectrum Management Studies.**

**8.0.1** As previously observed, long-term spectrum planning is critical if the spectrum requirement needs of Federal and non-Federal public safety entities are to be met now and in the foreseeable future. Forecasting the spectrum requirement needs of public safety agencies

has been undertaken on several previous occasions. In August of 1985, for instance, the FCC released a staff *Report on Future Public Safety Telecommunications Requirements* indicating at least 12.5 MHz to 44.6 MHz of spectrum would be needed for public safety use in twenty-one major metropolitan areas by the year 2000.

**8.0.2** In December of 1993, the Coalition of Private Users of Emerging Multimedia Technologies (COPE) submitted a petition to the FCC requesting an allocation of 75 MHz for the development of advanced private land mobile radio systems. This spectrum request was to meet the unique needs of the private land mobile radio users for advanced wireless imaging and decision processing/remote file access capabilities. COPE's request was for an allocation of spectrum below 3 GHz, in the vicinity of the 2 GHz band.

**8.0.3** In August of 1994, the Association of Public Safety Communications Officials International, Inc. (APCO) also filed with the FCC a study, entitled *Public Safety Spectrum Needs Analysis and Recommendation*, concerning the specific spectrum needs of non-Federal public safety agencies. APCO found that an additional 12 MHz of spectrum is required in metropolitan areas, with another 6 MHz of spectrum required nationwide, "just to keep pace with the demand for basic voice and data communications." APCO also maintained that at least 25 MHz of additional spectrum would be needed by the year 2000, and another 50 MHz by the year 2010, to permit law enforcement and other public safety agencies to implement a vast array of new telecommunications technologies.

**8.0.4** The *NTIA Spectrum Requirements Study*, as previously observed, also found that eight land mobile radio services, including public safety, would need access to additional spectrum to satisfy user requirements to the year 2004. More specifically, the *NTIA Spectrum Requirements Study* found that 204 MHz of spectrum is required for land mobile services in the next ten years, including 50 MHz for new advanced private land mobile radio services like public safety.

**8.0.5** The general consensus gleaned from these studies is that there is now and will continue to be insufficient mobile communications capacity (i.e., spectrum) for public safety agencies to meet their critical and essential responsibilities to protect the public welfare.

## **9.0 Spectrum Need Projections.**

**9.1 Introduction.** The projection of the amount of spectrum needed by the public safety community through the year 2010 has been a cooperative effort in PSWAC with each Subcommittee contributing to the process in the area of their special interest. Careful consideration was given by each Subcommittee to the state of the art at this time, and projections were made, where possible based on past history, to provide the best estimate possible of the growth of wireless technology in the public safety community.

Section 9.3 provides the input of the SRS to the model, and then the model that was used to make the projection is described. Section 9.2 describes the input of each of the other Subcommittees as it relates to this projection. This information is then summarized in Section 11.0 where the conclusions of the analysis are presented.

## **9.2 Subcommittee Inputs.**

**9.2.1 Operational Requirements Subcommittee.** In Annex B of their Report, the Operational Requirements Subcommittee provided the population (POP) of public safety personnel and the percentage of the identified population that will use a particular type of radio communication (PEN).

**9.2.2 Technology Subcommittee.** In Appendix C of their Report, the Technology Subcommittee provided RF transmission rates (RATE); error control and overhead (ERR); source content (SRC); channel occupancy (LOAD); and coding improvements (COD).

**9.2.3 Interoperability Subcommittee.** The Interoperability Subcommittee provided the number and use of channels required for Federal, state, and local interoperability communications.

## **9.3 Spectrum Requirements Subcommittee Analysis of Spectrum Required.**

**9.3.1 Description of Model Used.** Working Group 8 (WG-8) of the SRS was chartered to evaluate a model proposed by Motorola in its White Paper first submitted on February 2, 1996, and to make any changes that would prove necessary. The resulting model was then to

be used, with input from all Subcommittees, to project the spectrum need of the public safety community through the year 2010. The model that has evolved is fully described in the White Paper included as Appendix C. Select portions will be described here to provide a working knowledge of the model.

An engineering methodology for projecting spectrum needs that is independent of any manufacturer's product was incorporated into the model. This is only reasonable, since the products that will be available by the year 2010 have probably not been invented at this time.

A methodical approach is used to project the trends of key technologies that relate to spectrum need. The relationships between operational need and required spectrum are described in terms of technical parameters in a mathematical equation, the model. That model is used to predict future spectrum requirements. This methodology is derived from that in the Coalition of Private Users of Emerging Multimedia Technologies (COPE) petition<sup>3</sup> and has been successfully employed in the work of others.<sup>4</sup>

The steps to be used in the development of the model, and the resulting parameters, are:

**9.3.1.1 Identify Geographical Area.** Identify the geographical area over which the model will be applied and the population of public safety personnel who will use the services to which the model applies. Any major metropolitan area will serve the needs of this analysis. A larger area will involve the selection of a larger geographical reuse parameter, described in Appendix C. A smaller area will have a proportionally smaller reuse parameter. Thus, the selection of a particular geographical area does not limit the generality of this process. The geographical area that will be used is the greater metropolitan area of Los Angeles, California.

**9.3.1.2 Identify Advanced Services.** Identify the advanced services that will be used by the public safety community through the year 2010.

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<sup>3</sup> Coalition of Private Users of Emerging Multimedia Technologies (COPE), FCC Petition for Rule Making, Spectrum Allocations for Advanced Private Land Mobile Communications Services, filed 12/23/93. COPE represents many private users of land mobile radio, including public safety organizations such as APCO and the PSCC.

<sup>4</sup> Joint Comments of Advanced Mobilecom Technologies, Inc. and Digital Spread Spectrum Technologies, Inc. to the FCC in General Docket No. 90-314 in the matter of Amendment of the Commission's Rules to Establish New Personal Communications Services, dated January 29, 1993.

The detailed advanced services which have been considered are:

- . voice dispatch
- . telephone interconnect
- . transaction processing
- . facsimile
- . snapshot
- . decision processing/remote file access
- . slow scan video
- . full motion video

These services have been summarized into the following five for purposes of detailed computation:

- . Voice
- . Data
- . Status/Message
- . Wide Band Data
- . Video

**9.3.1.3 Identify Technical Parameters.** Identify a self-consistent set of technical parameters that can relate the spectrally efficient usage of the advanced services to the spectrum required. The chosen parameters are:

- . Population (POP) of public safety personnel
- . Penetration (PEN) of service into the population, (%)

- . Average offered load (ERL) per officer, Erlangs
- . Source (SRC) content today, kbits/sec
- . Expected coding (COD) improvement factor
- . RF transmission rate (RATE), bits/sec/Hz
- . Error (ERR) control and overhead, % of transmission
- . Average busy hour channel loading (LOAD) factor determined from Erlang theory, %
- . Geographic reuse (REUS) factor
- . Spectrum used today

**9.3.1.4 Quantify Technical Parameters.** Quantify these technical parameters with the best information that is available at the present time. A Unified Traffic Model has been used to quantify the offered load. A detailed description is contained in Appendix D. The category of Special Data described therein has been broken into two categories for this report, Wide Band Data and Video, and the offered load has been refined downward based upon more recent information that has been obtained through the Focus Groups process (Appendix E). Other parameters have been quantified by reference to the curve trends in Appendix C, and others by reference to handbooks and reports as described in the various Subcommittee reports contained herein. The state of the art technologies in the year 2010 have been quantified, as described above. However radio equipment has a useful life that is often in excess of 10 years, some of it 15 years and longer. So, by the year 2010, there will be a distribution of equipment on the street with a range of spectral efficiencies. It is also reported that some agencies warehouse old equipment that is in operating condition for use under extreme conditions when there are unusual concentrations of personnel. Thus, the parameters which are used in the model represent an integration of the parameters that are projected to be in use in equipment in the 2010 time frame.

As described previously, the geographical area chosen for this analysis was the greater Los Angeles metropolitan area. However, it was not possible to conduct a detailed analysis of the population of public safety personnel in the allotted time. However, an analysis of a comparable area around New York City, NPSPAC Region 8, was available and is contained in Annex B of the Operational Requirements Subcommittee Report. This material provides the population of citizens in the area as well as the public safety users divided into the services of Police, Fire, Emergency Medical Services (EMS), and General Government. The population of citizens was available for the Los Angeles area (most of NPSPAC Region 5); therefore, the public safety population was assumed to be the ratio of citizens in Los Angeles to the citizens in New York City multiplied by the public safety personnel in New York City.

The penetration of the radio services being considered into the total population of potential users was also not available for the Los Angeles area. Again, a detailed analysis was available from New York City, and is contained in Annex B of the Operational Requirements Subcommittee Report. That penetration was used directly as input to the model.

**Table 9.1A**  
**Parameters That Apply to All Users**

SERVICE	SOURCE CONTENT, kb/s	CODING IMPROVEMENT	TRANSMISSION RATE, b/s/Hz	CHANNEL LOADING	REUSE FACTOR	ERROR CODE & OVERHEAD, %
Voice	6	2	1.5	54.5	2.5	50
Data	6	1	1.5	54.5	2.5	50
Status/ Message	6	2	1.5	54.5	2.5	50
Wideband Data	384	3	3.5	54.5	4	50
Video	384	3	3.5	54.5	4	50

**Table 9.1B****Parameters That Apply to Separate Functions**

<b>SERVICE</b>	<b>OFFERED LOAD IN ERLANGS</b>	<b>POPULATION, THOUSANDS</b>	<b>PENETRATION IN PERCENT</b>
<b>POLICE</b>			
VOICE	0.0538	89.4	65
DATA	0.0087	89.4	35
STATUS/MESSAGE	0.0004	89.4	31
WIDEBAND DATA	0.0140	89.4	23
VIDEO	0.0240	89.4	14
<b>FIRE</b>			
VOICE	0.0484	164.7	51
DATA	0.0087	164.7	27
STATUS/MESSAGE	0.0004	164.7	31
WIDEBAND DATA	0.0140	164.7	28
VIDEO	0.0240	164.7	20
<b>EMS</b>			
VOICE	0.0484	55.8	47
DATA	0.0087	55.8	45
STATUS/MESSAGE	0.0004	55.8	34
WIDEBAND DATA	0.0140	55.8	31
VIDEO	0.0240	55.8	17
<b>GENERAL GOVT.</b>			
VOICE	0.0430	269.8	22
DATA	0.0087	269.8	1
STATUS/MESSAGE	0.0004	269.8	16
WIDEBAND DATA	0.0140	269.8	1
VIDEO	0.0240	269.8	3

**9.3.1.5 Assumptions.** In any model such as this spectrum need projection, there are assumptions that are necessary, if only because the future is not assured. In the paragraphs to follow, we will first list the assumptions that apply to the model in general, followed by those that relate to specific parameters. In the latter case, the source of the data that allowed quantification of the model will also be indicated.

**9.3.1.5.1 Global Assumptions.**

1) It is assumed there are delays between the availability from manufacturers of more spectrally efficient radios and the actual implementation and use of these radios in the marketplace that result in the distribution of voice and data radios in the year 2010.

2) The applications used on networked desktop computers will be required in wireless form by public safety officers in the future.

3) Historical trends of semiconductors, data compression, and wireless technology will continue the established trends reported in the Technology Subcommittee Report through the year 2010.

4) Spectrum will be made available in a timely manner so that volume sales of wireless advanced services will bring the cost down to within the budget constraints of most public safety users.

5) The requirement for presently unidentified future services will have a negligible impact on spectrum need through the year 2010.

**9.3.1.5.2 Parametric Assumptions.**

1) OFFERED LOAD, ERLANGS. The traffic profiles for a “hypothetical Law Enforcement/Public Safety organization employing both digital voice and digital multimedia services” are quantified for both present and future uses in the Immigration and Naturalization Service (INS) White Paper in Appendix D. This data is developed

from an aggregation of existing Federal, state, and local law enforcement information and was logically extrapolated into the future. Wide band data and video are assumed based on current estimates of potential utilization should spectrum be made available. The future usage was further refined by the SRS based on input from the Focus Groups as reported in Appendix E and the Operational Requirements Subcommittee.

2) POPULATION. The population of public safety users was obtained from a detailed study of NPSPAC Region 8 which contains the City of New York. The study is contained in Annex B of the Operational Requirements Subcommittee (ORS) Report. It is assumed therein that the population of public safety personnel per citizen will follow the population density of citizens over time.

A similar study was started for NPSPAC Region 5 which contains Los Angeles. However, there was not sufficient time to complete that study for this final Report. It is assumed the distribution of public safety users will be similar to that of the New York area, so the detailed public safety demographics of New York were scaled to the total population of Los Angeles in 2010.

3) PENETRATION. The penetration of the services that have been identified for the public safety officers in the year 2010 was also determined in a study of NPSPAC Region 8. The study is contained in Annex B of the ORS Report. The penetration was determined by conducting interviews with a sample of communications officers representing over 47 percent of the public safety users. It is assumed the rest of the New York area users follow the distribution of the sample. Again, a study was started in the Los Angeles area, but it was not available in time for this Report. The New York penetration was used, and it is assumed the penetration into Los Angeles will follow that of New York.

4) SOURCE LOADING. The data rate for voice, data and status message is taken from the INS White Paper in Appendix D where it is assumed to be 750 B/s (6 kb/s). This is not inconsistent with the values proposed in the Motorola White Paper in Appendix C. The data rate for wide band data and video is taken from the Motorola White Paper where the status of the state of the art is reviewed and the average at this time is determined. These values were then confirmed by the Technology Subcommittee.

5) CODING IMPROVEMENT FACTOR. The Motorola White Paper was referenced for this parameter as well as the Technology Subcommittee report for the state of the art

that will be available in the 2010 time frame. The value used for the computation is an assumed value based upon the SRS estimate of the average coding improvement that will be in use in 2010 for each offered service. This value was then confirmed by the Technology Subcommittee.

6) TRANSMITTED RATE (MODULATION EFFICIENCY). The Motorola White Paper contains data of the historical transmitted rate and a projection of the rate that will be available in the year 2010 based upon an upper limit imposed by signal to noise considerations. The Technology and Spectrum Requirements Subcommittees estimated the average that will be in use in 2010 assuming continued mixed use of older with newer equipment through that time. The video and wide band data average modulation efficiency for 2010 is much higher than that for traditional functions. Since there is little use of those functions now, there will be a much smaller percentage of older technology in use at that time.

7) CHANNEL LOADING. The percent of time which any individual channel is loaded is computed based on the number of servers available to the user group on the system, the average message length, and the delay permitted on the system. A grade of service of 1 percent blockage and an average number of servers of 19 was assumed with erlang C traffic theory. This permitted the computation of the average channel loading for use in this spectrum model. This technique is recommended in the INS White Paper and supported by the Spectrum Requirements Subcommittee as well as the Motorola White Paper on the model.

8) CHANNEL REUSE FACTOR. The factors used in the model for services offered today are based on a study of the reuse in NPSPAC Region 5 today contained in Appendix F. It is assumed there will be little change in the future because the limitation is based on the operational requirement that many users listen to most messages. The factors used for wide band data and video are based on information obtained in the Focus Groups (Appendix E) and the extrapolation of existing usage.

9) ERROR CODING AND OVERHEAD. The technology improvements projected in the other parameters of the model make every bit of data more important than it has been in the past. The state of the art was shown in the Motorola White Paper on the model to be about 50%, and the Technology and Spectrum Requirements Subcommittees agree that a projection of improvement is not warranted. It is therefore assumed there will be little change by 2010 in this parameter.

**9.3.1.6 Compute Spectrum Need.** Compute the spectrum need for each of the advanced services to obtain the total spectral need for public safety through the year 2010.

The equation (the MODEL) used to compute the spectrum need for each service in the year 2010 is as follows:

$$\text{MHz} = \frac{10000 * \text{ERL} * \text{POP} * \text{PEN} * \text{SRC}}{\text{COD} * \text{RATE} * \text{LOAD} * \text{REUS} * (100 - \text{ERR})}$$

The total spectrum need for voice, data, and video by the state and local public safety community is 129.3 MHz through the year 2010 (Appendix G). As indicated in Appendix I, an additional 161 MHz of spectrum is needed to meet state and local public safety microwave requirements. Also, the total spectrum need does not include the channels required for Federal, state, and local interoperable operations. The study indicated that existing Federal spectrum will meet the Federal public safety requirements provided: a) no more Federal spectrum is reallocated to the FCC for commercial use; b) the assumed spectrum-efficient technologies become available; and c) funds are provided by appropriations to implement the spectrum-efficient technologies. As shown in Section 4.2, there is presently 23.2 MHz allocated to the non-Federal public safety community nationwide. Two major manufacturers have stated they will no longer supply equipment in the frequency band from 25-50 MHz, and it is therefore assumed that the 6.3 MHz of spectrum in this band will not be in use in the major metropolitan areas in the 2010 time frame. However, there is existing use of TV channels 14-20 in the major metropolitan areas, and it is assumed the 6.5 MHz in use in Los Angeles will be in use at that time. Therefore, there is 23.2+6.5-6.3=23.4 MHz which must be subtracted from the total need.

In addition, some of the need can be satisfied by using commercial services. For instance, some of the requirement for telephone interconnect may best be served by the cellular services. Local paging networks are also a prime candidate; e.g., in the volunteer fire service for calling the volunteer officers in for service. It has been projected in Section 7.3 that 10% of the spectrum need in 2010 may be satisfied by such commercial services. This is an additional 10.6 MHz that must be subtracted from the total. Therefore, the net spectrum needed for voice, data, and video by the public safety community in the year 2010 is 129.3-23.4-10.6=95.3 MHz.

**9.3.1.7 Partial Spectrum Computations.** It would be a mistake to attempt to partition the spectrum into blocks for each service or for each category based on the computation made herein. There is an error associated with each computation because of the associated assumptions. In some cases, the amount of spectrum computed will be too large; in others, it will be too small. But, by the central limit theorem, the total will be close to the correct value. Therefore, the total is more accurate than any of the parts.

In addition, consider the need for police communications compared to firefighters and the Emergency Medical Service (EMS). In Los Angeles, there are large summer brush and forest fires. The crime statistics for Los Angeles are, however, relatively lower than the rest of the nation. There is, therefore, a proportionally higher need for communications for firefighters in Los Angeles. In New York, the opposite is true. The crime statistics are relatively high, but the size of typical fires is relatively small. So, in New York, the relative need for communications for police is higher.

In summary, the total computed spectrum need is relatively accurate, and can be used for spectrum planning purposes. Further, there are different spectral requirements for like public safety departments in various areas of the nation. Much more effort would be necessary to carefully quantify the input parameters and regional uses before attempting to plan based upon the separate portions that make up the whole. Therefore, the recommended approach is to use technical flexibility and sharing of frequencies between the various public safety services.

**9.3.1.8 Validate the Model.** This model has been validated by some members of WG-8 by using it to obtain the results derived in the joint comments of Advanced Mobilecom Technologies, Inc. and Digital Spread Spectrum Technologies, Inc., (footnote 4). Further validation has been accomplished by independent review by other members of the working group. Finally, validation is provided by comparison to other projections of spectrum need for the public safety community that are shown in Section 8.0 of this Subcommittee report. Since the projection contained herein is consistent with those other projections, it is the considered opinion of WG-8 the model used herein is a valid model for the projection of the spectrum need of the public safety community through the year 2010.

**9.3.1.9 Effect of Mandates and Incentives on Spectrum Need.** It was indicated in Section 7.2 that the spectrum need computed by the model herein is based upon very aggressive projections of technology parameters. However, equipment that is manufactured for the public safety market is designed to meet stringent quality standards. Some of it, therefore, lasts for years after new equipment is available which is more spectrally efficient.

Effective January 1, 1995, NTIA mandated that all new Federal radio systems operating in the 162-174 MHz and 406.1-420 MHz bands must be capable of operating within a 12.5 kHz channel; effective January 1, 1998, new systems in the 138-150.8 MHz band must operate within a 12.5 kHz channel. After January 1, 2005, all systems in the 162-174 MHz band must be capable of operating within a 12.5 kHz channel. This date was extended to January 1, 2008, for all systems in the 138-150.8 MHz and 406.1-420 MHz bands. Time Division Multiple Access (TDMA) systems, with at least 1 voice channel per 12.5 kHz, will be allowed and can be accommodated on adjacent 12.5 kHz channels.

At the present time, the FCC will not accept equipment for type acceptance if the equivalent channel width per voice path is greater than 12.5 kHz, and in the year 2005, that requirement is reduced to 6.25 kHz. However, the FCC does not require that 25 kHz equipment be removed from service as long as the original specifications are met. It will be shown below, that there must be incentives or regulatory mandates which form the basis for removing old equipment from the major metropolitan areas in a timely manner, or the spectrum need will be much greater than that computed in Section 9.3.1.6.

As described in Sections 7.2.1 and 7.2.2, the average voice path in 2010 will have a bandwidth projected to be 4 kHz wide. This will accommodate all voice users in the 32.3 MHz of spectrum computed in Appendix G. In this example, we continue to assume that one fourth or 25 percent of the equipment in use then will occupy a voice path bandwidth of 12.5 kHz. If, however, an additional 3.5 percent of users have 25 kHz equipment, no amount of spectrum will remain for other users, no matter how spectrally efficient ( $25\% * 12.5/4.0 + 3.5\% * 25/4 = 100\%$ ). If the remaining 71.5 percent of the users have an average voice path occupying only 4.0 kHz, it will require an additional 23.1 MHz of spectrum ( $0.715 * 32.3 = 23.1$ ).

Therefore, it is concluded that regulatory mandates and incentives must be implemented to assure that the public safety users of wireless communications in the major metropolitan areas adopt spectrum efficient technology at an accelerated rate. Even a small number of public safety users that continue to operate equipment that is two generations old will consume the allocated bandwidth, leaving others with no means to satisfy their requirements.

**9.3.2 Time Line.** The net spectrum need for the state and local public safety community through the year 2010 has been developed in the document and shown to be 95 MHz. In this section, we will provide a time line which can be used to schedule the allocation of this spectrum in a timely manner.

**9.3.2.1 Need by the Year 2000.** In 1985, it was projected by the FCC as reported in Section 8.0.1 herein, that between 12.5 and 44.6 MHz of spectrum would be needed by the year 2000. In 1993, COPE, as reported in Section 8.0.2, requested 75 MHz for all the private services be allocated by the year 2000. Using the ratio of existing spectrum allocated of 1/3 for public safety, that results in a need of 25 MHz for the public safety community in that time frame. In Section 8.0.3, it is reported that APCO, in 1994, found that 12 MHz was needed for voice and at least 25 MHz more would be needed for advanced services by the year 2000.

Considering the range above, it is concluded from these studies that approximately 25 MHz should be allocated by the year 2000. We now turn our attention to the source for this spectrum.

**9.3.2.2 Source of Spectrum for the Year 2000.** At the present time, there is a move to implement Advanced Television (ATV) services in the United States. The new standard, replacing the existing National Television Systems Committee (NTSC) standard, uses a new digital modulation format. This format, and the implementation of improved TV receivers, allows the removal of the UHF TV taboos that have long required the wasteful allocation of only every sixth UHF TV channel in any individual metropolitan area. Thus, it will be possible to actually reduce the spectrum used for TV transmissions and have the same or more TV stations on the air.

It has been suggested that 24 MHz, or 4 TV channels, of a portion of the spectrum presently occupied by UHF TV channels 60-69 may be available for public safety use. The FCC is encouraged to proceed with the reallocation of this spectrum at this time, as this is directly in line with the projections of need above.

**9.3.2.3 Ongoing Need After 2000.** It was projected in Section 9.3.1.6 that a total of 95 MHz would be needed for public safety by the year 2010. Should 24 MHz be allocated at this time, there remains a need for an additional 71 MHz. A timely allocation of the additional need would include about half of that, or 35 MHz, prior to 2005 and the remaining portion, 36 MHz before the year 2010.

This delayed allocation plan permits the FCC to assure that the spectrum is provided for in a timely manner.

## **10.0 Spectrum Band Options.**

**10.1 Introduction.** As our nation grows, the demand for public safety services also increases. Modern public safety organizations, both Federal and non-Federal, depend heavily upon wireless communications to accomplish their missions. However, radio spectrum allocated for public safety services has been fully assigned in many metropolitan areas of the United States. The allocation of spectrum for public safety use in these urban areas has not kept pace with the growth of public safety services. This spectrum shortage, if not corrected, may eventually degrade the quality of services rendered to the public.

Although there are no spectrum reserves from which to draw for public safety use, NTIA is in the process of transferring 235 MHz of spectrum (Table 10.1) to the FCC for sharing and/or reallocation. Not all of this spectrum is suitable for public safety use; however, certain of the frequency bands hold promise for advanced-technology applications.

**Table 10.1**

<b>Bands Identified for Reallocation (MHz)</b>	<b>Reallocation Status<sup>a</sup></b>	<b>Reallocation Schedule</b>
1390 - 1400	Exclusive	January 1999
1427 - 1432	Exclusive	January 1999
1670 - 1675	Mixed	January 1999
1710 - 1755	Mixed	January 1999/January 2004 <sup>b</sup>
2300 - 2310	Exclusive	Reallocation Complete
2390 - 2417	Exclusive	Reallocation Complete
2417 - 2450	Mixed	Reallocation Complete
3650 - 3700	Mixed	January 1999
4635 - 4660	Exclusive	January 1997
4660 - 4685	Exclusive	Reallocation Complete

**a** Some Federal stations will continue operation.

**b** Earlier availability date applies only to the 25 largest U.S. cities and is further subject to timely reimbursement of Federal costs, including reimbursement directly from the private sector.

The Subcommittee Working Group on spectrum band options examined the frequency spectrum from 138 MHz to 6000 MHz for applicability to public safety use, both from a technical and availability standpoint. Spectrum subject to FCC competitive bidding actions was eliminated from consideration. Spectrum above 2000 MHz was excluded from consideration for land mobile communications based upon known problems of implementation, propagation (Appendix J, Frequency Band Selection Analysis), and equipment availability. The Working Group focused on the remaining spectrum, with particular interest on current public safety spectrum, and the spectrum being transferred from NTIA.

## **10.2 Spectrum Band Choices**

**10.2.1 VHF Low Band (30 - 50 MHz).** Portions of this band are currently allocated for public safety use. This band is good for wide area coverage from mobiles to dispatch centers

in open terrain. Portable radios operate poorly due to antenna limitations. The band is also subject to “skip” interference between widely separated systems. Other problems with the band are high ambient noise levels, particularly on highways and near industrial areas. Mobile relay systems are also difficult to implement. Equipment availability is an increasing problem in this band.<sup>5</sup>

The California Highway Patrol operates a statewide radio system in this band and in comments received<sup>6</sup> support migrating all public safety systems to the UHF band. Other comments from the American Association of State Highway and Transportation Officials expressed the desire to continue operating in this band. This Subcommittee recommends no new allocations be made in this band due to the band deficiencies. New spectrum is needed in the VHF and UHF bands for those agencies needing to relocate. The current public safety allocations should remain for those agencies continuing to operate in this band.

**10.2.2 VHF High Band (138 to 174 MHz).** There are allocations in this band for both Federal and Non-Federal public safety users. This band has good wide area mobile coverage. Comments from the State of Michigan<sup>7</sup> demonstrate the need to use this band for cost-effective wide-area systems. Federal agencies also require continued access to portions of this band for this very reason. For urban environments where good building penetration is a concern, this band is not as effective as higher bands (See Appendix J). The Subcommittee recommends retaining all current allocations in this band. New allocations to public safety can be made in this band by assigning the new channels from other services created by the FCC refarming proceeding. With the new Personal Communications Systems (PCS) and Enhanced Specialized Mobile Radio (ESMR) systems, there are viable alternatives for the non-public safety users to migrate to PCS and/or ESMR systems to accommodate growth requirements. Also some VHF channels allocated for the Public Mobile Service may be available for reallocation to public safety in some areas.

The 138 to 144 MHz subband is currently allocated primarily to operations by the military services. Sharing of this band with public safety is possible. Comments from the Department of Defense (DOD) indicate possible sharing with public safety on a case-by-case basis (Appendix H). Due to DOD’s diverse uses of this band, a standard sharing agreement, like that used for TV sharing with land mobile, is not practical. The

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<sup>5</sup> Letters to California Highway Patrol from Ericsson and Motorola stating they will no longer manufacture equipment for this band.

<sup>6</sup> Letter dated February 6, 1996 (PSWAC/SRS-15/1).

<sup>7</sup> Letters dated January 23, 1996 (PSWAC/SRS-16/1) and January 25, 1996 (PSWAC/SRS-17/1).

Subcommittee recommends that NTIA implement a standard procedure for public safety agencies to request sharing with DOD in this band.

**10.2.3 VHF Television (174 to 216 MHz).** This band has the same propagation characteristics as the 138 to 174 MHz band. It is an excellent candidate band for additional allocations from a technical viewpoint. Although building penetration for portables is a concern, properly designed systems can provide the necessary coverage. The main problem with this band is availability for use. The broadcast industry must implement the Advanced Television (ATV) systems nationwide and phase out broadcasting in this spectrum to clear the band.<sup>8</sup> However, the assignments of TV channels are such that adjacent channels are not assigned in an area. Because of this, either channels 7, 9, 11, and 13 or 8, 10, and 12 are not used in an area.

This band should be considered for future public safety allocations and for immediate sharing with public safety, in the manner similar to the TV sharing in the 470 to 512 MHz band. The Subcommittee recommends that incentives to speed the clearing of this band be created by the FCC. The sharing of this band would meet needs in non-urban areas and for statewide systems. The spectrum requirements of public safety cannot be precisely known. The impact of new technologies can only be estimated at this time. This band is a good choice for reserves to meet public safety needs greater than estimated in this report. The Subcommittee recommends a portion of this band, not required for current needs, be held in reserve for a later review of public safety spectrum needs.

**10.2.4 UHF (380 to 806 MHz).** This band includes several sub-bands which will be discussed individually. This band has very good technical characteristics for public safety use. Many comments were received supporting the consolidation of all public safety services in this band. Although one band for public safety would be highly desirable for interoperability, the wide area coverage attributes of the VHF band are needed. This band is recommended for additional public safety voice and narrowband data allocations.

**10.2.4.1 UHF (380 - 399.9 MHz).** This portion of the 380 to 512 MHz band is currently allocated exclusively for military fixed, mobile, and mobile-satellite services. This band is part of a larger allocation for military operations, 225 to 328.6 MHz and 335.4-399.9 MHz. The 328.6-335.4 MHz band is allocated exclusively for the aeronautical radionavigation service. Comments received from the Office of the Assistant Secretary of Defense (OASD)<sup>9</sup> and the United States Coast Guard<sup>10</sup> strongly defend the need of this band for DOD use and Coast Guard use. Additional DOD comments concerning use of this band are contained in

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<sup>8</sup> Land Mobile Spectrum Planning Options, NTIA Special Publication 95-34. October 1995. PP. 3-8 & 9.

<sup>9</sup> OASD Comments on the PSWAC Draft Report (PSWAC/SRS-20/1), Commander Gross (OASD) briefing, April 13, 1996, at SRS meeting, and OASD letter, dated May 9, 1996 (PSWAC/SRS-21/1).

<sup>10</sup> U.S. Coast Guard letter dated April 8, 1996 (PSWAC/SRS-22/1).

Appendices H and K. Use of this spectrum is critical to the national defense and supports a wide variety of uses. For example, there are over 30,000 HAVEQUICK radios that must use this spectrum to help defeat enemy jammers and other threats. Many high powered military satellites and transportable US Army radios use this spectrum. This spectrum is used in peacetime by the military to train forces. Also, during disaster relief operations (e.g., Hurricane Andrew, Los Angeles earthquake, etc.) the Air Force uses this spectrum to help coordinate the operations of cargo aircraft that must bring in relief supplies. The military also has many high-powered jammers in this spectrum to teach tactical forces how to operate under simulated enemy electronic attacks. In addition, there would be high costs associated with the reallocation of this band, resulting from the necessary redesign and reprogramming of existing military equipment.

This portion of the spectrum is desirable for use by public safety voice and narrowband data systems. No detailed investigation has been done on the use of this band segment. European public safety sharing proposals for small segments of this 20 MHz have been negotiated with the North Atlantic Treaty Organization (NATO) for use in emergencies. A similar sharing arrangement may be sought in the United States. The Subcommittee recommends discussions be initiated with the DOD and U.S. Coast Guard to ascertain the feasibility of reallocation and/or sharing.

**10.2.4.2 UHF (450 - 470 MHz).** This band segment is used by numerous private radio services. Reallocation of existing users to other bands would be difficult and time-consuming. There is, however, potential to reallocate the narrowband channels in other services created by the FCC's refarming proceeding. These offset channels are not licensed at this time. With the installation of new PCS and ESMR systems, there are viable alternatives for the non-public safety users to migrate to PCS and/or ESMR systems to accommodate growth requirements. Also channels allocated to the Public Mobile Service could possibly be reallocated to public safety in many areas. The FCC should develop incentives to speed migration of existing users to narrowband systems (12.5 kHz channels and less) to allow rapid access by public safety users.

**10.2.4.3 UHF Television (TV) Sharing (470 to 806 Mhz).** Portions of this band are allocated for land mobile use in thirteen urban areas.<sup>11</sup> In these areas, additional allocations to public safety could be made by relocating non-public safety users to PCS or ESMR systems. This band can be used more efficiently by requiring the use of trunked systems on the same basis as the 800 MHz band. The spectrum made available in other services by the FCC refarming effort should be allocated to public safety use. The Subcommittee also recommends additional public safety allocations in this band in all areas. These allocations will need to be coordinated to clear broadcast operations as the Advanced Television service is implemented. Additional allocations on a sharing basis can be made and utilized immediately.

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<sup>11</sup> See CFR 47 Part 90 Subpart L.

The TV broadcast channels 60 to 69 (746-806 MHz) have light use throughout the United States. This spectrum is adjacent to the existing land mobile use in the 800 MHz band and would be suitable for all categories of use.

Except for regulatory roadblocks, this spectrum can provide the quickest spectrum relief for frequency impacted areas.

**10.2.5 UHF (800 MHz Band).** This band has excellent propagation properties for urban areas where building penetration is required. The band is undergoing many regulatory changes due to the Specialized Mobile Radio (SMR) allocations which are affecting all users. The FCC has distributed a docket concerning auctioning of the SMR bands and relocating existing users. Because of these changes, the Subcommittee does not recommend any new allocations in this band.

**10.2.6 1990 to 2110 MHz Band.** This spectrum was reallocated for emerging technologies and has not been designated for a specific use. The Subcommittee notes this band could be used by public safety for either microwave or wide band data/video use.

**10.2.7 Spectrum Being Made Available By the Federal Government.** These bands have been identified for sharing and/or reallocation by the Federal Government (Table 10.1). This discussion will focus on only those bands that have potential for public safety use.

**10.2.7.1 (1710 to 1755 MHz).** This band is scheduled for transfer to the FCC for mixed use January 1, 2004. It is suitable for wide-area wide band data and video use. The band can also be used for voice and narrowband data if required. It is in the same range as the PCS allocations and will benefit from PCS technologies. The Subcommittee recommends this as the primary band for wide band data and video (using a compressed digital format) systems. This will require equipment development by manufacturers, but equipment should be available in advance of the 2004 release date. In some areas of the country, continued Federal use is authorized. Provided proper coordination in these areas is performed between the public safety community and the existing Federal users, it should not prevent either group from meeting their critical mission requirements. The Subcommittee requests NTIA research the possibilities of sharing in this band prior to January 1, 2004, and determine the specific needs required to speed the clearing of the band.

**10.2.7.2 (4635 to 4685 MHz).** Although the band is not suitable for wide-area voice or data systems, it is useful for short-range mobile video systems, both compressed digital and uncompressed analog formats. This band is also suitable for point-to-point (fixed) microwave applications. The band will support low capacity (one or two T1 circuits), the capacity most needed to link remote radio sites to dispatch centers. The Subcommittee recommends this band for both the above uses.

**10.2.7.3 (5850 to 5925 MHz).** Although not a part of the spectrum being transferred from the Federal Government, the NTIA<sup>12</sup> recommends this band for Intelligent Transportation Systems (ITS) use, which has public safety-related requirements. The Subcommittee believes ITS systems should be developed in their own band allocations. However, it is anticipated that public safety and public service agencies will be able to request frequency assignments in this band for safety-related ITS applications. Therefore, the Subcommittee supports the NTIA recommendation.

**10.3 International and Border Issues.** Care must be taken to consider any international, and particularly cross-border, implications. In a number of the bands, the United States has made agreements and/or commitments with Canada, Mexico, NATO, other nations, and the International Telecommunication Union. Any of these proposed reallocations must be examined in light of these agreements. The Subcommittee recommends the FCC and NTIA consider these issues when determining the spectrum band options to meet the spectrum requirements of public safety. To aid interoperability, agreements with Canada and Mexico will be needed to resolve potential border interference issues. Immediately upon reallocation of new spectrum, discussions should be initiated with Canada and Mexico to develop appropriate Frequency Coordination Agreements.

**10.4 Summary and Conclusions.** There is no spectrum being held in reserve from which new allocations can be made to public safety. The bands below 2 GHz are most suitable for public safety land mobile use. To the extent possible, public safety voice systems should be consolidated into the VHF high band and UHF (380 to 512 MHz) bands. Some users in the 30 to 50 MHz band need to migrate to higher bands and will require spectrum for this migration. The 1710 to 1755 MHz band is best suited for new wide band data and video systems (new technologies). Public safety spectrum needs will come from a variety of the bands discussed in this section.

There are needs for additional spectrum for public safety fixed service (microwave) systems. The Subcommittee has not determined any suitable spectrum beyond the 4635 to 4685 MHz band. The only other option identified is to further split the 3710 to 4190 MHz band into 10 MHz bandwidth channels. More examination of the technical parameters for interference between systems should be undertaken to determine if modifications can be made to allow for more reuse of existing spectrum. The shortage of microwave spectrum will be a continuing problem for public safety microwave systems.

As there are many competing interests for spectrum, many options are presented in this section. There is an approximate 315 MHz of spectrum, not including new channels from refarming, identified to fully meet the public safety needs. The Subcommittee offers these options to the FCC and NTIA so the needs of public safety for spectrum are fully met. To assist the FCC and NTIA in the regulatory changes required, the Subcommittee recommends the following priority listing for each type of use. The Subcommittee

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<sup>12</sup> Land Mobile Spectrum Planning Options, NTIA Special Publication 95-34. October 1995. PP. 3-8 & 9.

recommends spectrum to meet the voice system needs by using spectrum at 800 MHz and below.

**For voice systems, narrowband data, wide band data, and video:**

1. Immediate further sharing of the 470 to 512 MHz (TV band) in all areas.
2. Reallocate all or part of the 746 to 806 MHz (TV channels 60 to 69) for public safety use.
3. Immediate allocation of the channels in other services created in the FCC's refarming proceeding at both VHF and UHF (including TV sharing bands.)
4. Eventual reallocation of all TV sharing 470 to 512 MHz channels to public safety.
5. Immediate new sharing of the VHF TV band (174-216 MHz) (primarily outside of urban areas and for statewide systems).
6. Reallocation of the 380 to 399.9 MHz band to public safety.
7. Sharing of the 380 to 399.9 MHz band with DOD on a mutually agreeable basis to minimize interference to public safety to nuisance levels.
8. Hold a portion of the 174 to 216 MHz (TV band) in reserve to meet future public safety needs or needs not met by this effort.

**For wide band data and video systems:**

1. Make allocations from the 1710 to 1755 MHz band.

**For short range video systems:**

1. Make allocations from the 4635 to 4685 MHz band.

**For fixed microwave systems:**

1. Make allocations in the 4635 to 4685 MHz band.
2. Make allocations in the 1990 to 2110 MHz band.

**For Intelligent Transportation System:**

1. Make allocations in the 5850 to 5925 MHz band.

**11.0 Conclusions and Recommendations.**

**11.1 Conclusions.**

**11.1.1** State and local public safety agencies require additional spectrum to satisfy voice, data, video, and fixed service requirements, especially in major metropolitan areas. An additional 25 MHz of spectrum is needed immediately to satisfy existing voice and data requirements. A total amount of 95 MHz is required by the year 2010. The additional spectrum is required for additional voice and data use, plus use of new technologies such as

wide band data and video. An additional 161 MHz of spectrum is required to meet fixed service needs.

**11.1.2** The existing Federal Government spectrum allocations will satisfy Federal public safety/public service requirements through the year 2010 provided: **a) no additional spectrum is transferred to the FCC for commercial use; b) the assumed spectrum-efficient technologies become available; and c) funds are provided through appropriations to implement the new spectrum-efficient technologies.**

**11.1.3** Public safety agencies will continue to use commercial services to decrease the demands on private systems. It is estimated that commercial services will satisfy 10% of the spectrum need by 2010.

**11.1.4** Additional spectrum is required for Federal, state, and local interoperability communications.

**11.1.5** The implementation of Shared Federal, state, and local public safety systems will provide both fiscal and spectrum efficiencies, plus enhance interoperability requirements.

**11.2 Recommendations.** It is recommended an additional 25 MHz of spectrum be immediately authorized to meet existing voice, data, and video requirements. Another 35 MHz should be reallocated by 2005 and the remaining 35 MHz prior to 2010. It is recommended the following frequency bands be analyzed to determine the feasibility of authorizing public safety use.

**11.2.1 Voice, Data, and Video.** Some of this spectrum need can be provided by increasing the sharing of the TV spectrum in the 470-512 MHz band in all areas of the country. Other options include: a) reallocation of spectrum between 746 to 806 MHz (TV channels 60-69), b) immediate reallocation of the VHF and UHF channels in other services created by the FCC's Refarming Proceeding, c) new sharing in the 174-216 MHz TV band, and d) sharing with the military in the 380 to 399.9 MHz band.

**11.2.2 Wide Band Data and Video.** For Wide Band data and video requirements, reallocate the 1710 to 1755 MHz band for public safety use when it is transferred from NTIA.

**11.2.3 Short-Range Video.** Make allocations in the 4635 to 4685 MHz band.

**11.2.4 Fixed Service.** Make allocations in the 4635 to 4685 MHz, 1990 to 2110 MHz, and the 3700 to 4200 MHz bands.

**11.2.5 Intelligent Transportation Systems.** Make allocations in the 5850 to 5925 MHz band.

**11.2.6 Interoperability Spectrum.** Allocate channels below 512 MHz for Federal, state, and local public safety interoperable operations, as indicated in the Interoperability Subcommittee Report.

**11.2.7 Shared Systems.** It is further recommended the FCC and NTIA revise applicable frequency licensing/assignment rules to encourage sharing arrangements between Federal, state, and local agencies.

**APPENDIX A**

**Table 5.1. Ranally Metropolitan Areas and Projected 2010 Populations (with permission from Rand McNally to use their entire table with PSWAC estimates for year 2010)**

Rank	Metro and City Name	RMA	1990 Metro Pop.	Est. 1994 Metro Pop.	% Chg. Pop.	Est. 2010 Metro Pop.	Est. 1994 City Pop.	% Chg. Pop.	City Pop.	Metro Area sq mi	City Area sq mi	Metro Density Pop/sq mi	City Density Pop/sq mi
1	New York, NY-NJ-CT	N. Y.	17,310,800	17,552,300	1.4	18,522,556	7,648,300	0.7	7,915,991	6,286	333	2,947	23,772
1	A New York, NY						7,385,400	0.9	7,717,743		309		24,977
1	B Newark, NJ						262,900	-4.5	203,748		24		8,489
2	Los Angeles, CA	L.A.	11,705,000	12,253,600	4.7	14,455,675	3,495,800	0.3	3,548,237	2,595	469	5,571	7,566
3	Chicago, IL-IN-WI	CHI	7,835,300	8,096,600	3.3	9,128,125	2,762,000	-0.8	2,651,520	3,699	227	2,468	11,681
4	Philadelphia-, PA-NJ-DE-MD	PHIL-	5,529,600	5,645,300	2.1	6,110,208	1,719,500	-1.5	1,590,538	3,796	154	1,610	10,328
4	A Philadelphia, PA						1,558,400	-1.7	1,425,936		135		10,562
4	B Trenton, NJ						88,200	-0.6	85,554		8		10,694
4	C Wilmington, DE						72,900	2.0	80,190		11		7,290
5	San Francisco-, CA	SF-O	5,390,900	5,644,900	4.7	6,657,762	1,934,800	3.0	2,225,020	2,047	275	3,252	8,091
5	A San Francisco, CA						736,600	1.7	799,211		47		17,004
5	B Oakland, CA						377,600	1.5	405,920		56		7,249
5	C San Jose, CA						820,800	4.9	1,021,896		172		5,941
6	Detroit, MI-CAN	DET	4,348,100	4,401,500	1.2	4,608,986	1,106,200	-2.8	951,332	3,278	165	1,406	5,766
6	A Detroit, MI						995,700	-3.1	841,367		139		6,053
6	B Ann Arbor, MI						110,500	0.8	114,920		26		4,420
6	C incl. Windsor, CAN		4,619,100	4,679,500	1.3	4,919,342				3,611		1,362	
7	Boston, MA-NH	BOS	4,171,800	4,175,500	0.1	4,192,659	893,300	-4.0	714,640	3,106	132	1,350	5,414
7	A Boston, MA						555,500	-3.3	463,843		48		9,663
7	B Brockton, MA						87,000	-6.3	59,595		22		2,709
7	C Lowell, MA						98,100	-5.1	73,085		14		5,220
7	D Lawrence, MA						62,600	-10.8	28,796		7		4,114
7	E Haverhill, MA						52,800	2.7	59,928		33		1,816
7	F Salem, MA						37,300	-2.1	33,384		8		4,173
8	Washington, DC-MD-VA	WASH	3,808,700	4,007,800	5.2	4,798,962	574,500	-5.3	422,258	2,701	61	1,777	6,922
9	Dallas-TX	D-FW	3,606,600	3,924,800	8.8	5,193,504	1,512,900	4.0	1,815,480	2,842	623	1,827	2,914
9	A Dallas, TX						1,045,900	3.9	1,249,851		342		3,655
9	B Fort Worth, TX										281		
10	Miami-, FL	MIA	3,456,600	3,629,900	5.0	4,320,750	510,900	0.6	526,227	1,073	67	4,027	7,854
10	A Miami, FL						362,800	1.2	384,568		36		10,682
10	B Ft. Lauderdale						148,100	-0.9	141,436		31		4,562
11	Houston, TX	HOU	3,327,800	3,604,200	8.3	4,708,837	1,703,200	4.5	2,086,420	2,679	543	1,758	3,842
12	Atlanta, GA	ATL	2,621,100	2,924,600	11.6	4,141,338	403,200	2.3	449,568	3,132	132	1,322	3,406
13	Seattle-, WA	SEAT-	2,565,600	2,760,900	7.6	3,540,528	709,800	2.4	794,976	2,647	132	1,338	6,023

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13	A Seattle, WA						521,300	1.0	547,365		84		6,516
13	B Tacoma, WA						188,500	6.7	251,648		48		5,243
14	Minneapolis-,MN-WI	MPLS-	2,332,100	2,470,200	5.9	3,020,070	633,900	-1.0	602,205	2,391	108	1,263	5,576
14	A Minneapolis, MN						365,500	-0.8	350,880		55		6,380
14	B St. Paul, MN						268,400	-1.4	249,612		53		4,710
15	St. Louis, MO-IL	ST.L	2,238,700	2,350,700	5.0	2,798,375	378,200	-4.7	289,323	2,267	62	1,234	4,667
16	Phoenix, AZ	PHOE	2,124,900	2,323,900	9.4	3,123,603	1,055,100	6.7	1,408,559	2,071	422	1,508	3,338
17	San Diego, CA-MEX.	SDGO	2,158,900	2,296,100	6.4	2,849,748	1,168,300	5.2	1,472,058	995	324	2,864	4,543
17	incl. Tijuana, MEX		2,893,900	3,156,100	9.1	4,210,625							
18	Cleveland, OH	CLEV	2,142,100	2,164,800	1.1	2,259,916	500,400	-1.0	475,380	1,985	77	1,138	6,174
19	Baltimore, MD	BAL	2,045,800	2,096,200	2.5	2,301,525	718,900	-2.3	636,227	1,506	81	1,528	7,855
20	Pittsburgh, PA	PGH	2,062,000	2,052,200	-0.5	2,010,450	362,300	-2.1	324,259	2,608	56	771	5,790
21	Denver, CO	DEN	1,617,900	1,775,200	9.7	2,402,582	498,000	6.5	659,850	1,267	153	1,896	4,313
22	Cincinnati, OH-KY-IN	CIN	1,547,700	1,598,100	3.3	1,803,071	363,600	-0.1	361,782	1,860	78	969	4,638
23	Portland, OR-WA	POR	1,391,700	1,519,200	9.2	2,031,882	458,400	4.8	568,416	1,379	127	1,473	4,476
24	Kansas city, MO-KS	K.C.	1,388,600	1,449,200	4.4	1,694,092	432,500	-0.6	419,525	1,842	313	920	1,340
25	Milwaukee, WI	MILW	1,407,200	1,438,400	2.2	1,561,992	620,400	-1.2	583,176	1,362	96	1,147	6,075
26	Riverside-, CA	RIV-	1,205,800	1,373,000	13.9	2,043,831	421,700	7.9	588,272	689	134	2,966	4,390
26	A Riverside, CA						242,400	7.0	327,240		78		4,195
26	B San Bernardino, CA						179,300	9.2	261,778		56		4,675
27	Sacramento, CA	SAC	1,168,100	1,272,600	8.9	1,687,905	391,600	6.0	509,080	714	96	2,364	5,303
28	San Antonio, TX	SANT	1,158,000	1,251,300	8.1	1,626,990	998,900	6.7	1,333,532	730	336	2,229	3,969
29	Indianapolis, IN	IND	1,154,500	1,219,400	5.6	1,477,760	760,700	4.0	912,840	1,620	362	912	2,522
30	New Orleans, LA	N.O.	1,147,300	1,171,600	2.1	1,267,767	494,800	-0.4	484,904	755	181	1,679	2,679
31	Columbus, OH	COL	1,085,700	1,145,800	5.5	1,384,268	649,700	2.7	737,410	1,211	192	1,143	3,841
32	Buffalo, NY-CAN	BUF	1,097,600	1,095,900	-0.2	1,086,624	317,500	-3.2	266,700	1,066	41	1,019	6,505
32	incl. St. Catherines- Niagara Falls, CAN		1,474,900	1,481,900	0.4	1,504,398				1,607			936
33	Hartford-, CT	H-NB	1,085,900	1,082,800	-0.3	1,069,612	198,500	-7.8	121,085	1,431	30	747	4,036
33	A Hartford, CT						127,100	-9.0	69,905		17		4,112
33	B New Britain, CT						71,400	-5.4	52,122		13		4,009
34	St. Petersburg-, FL	ST.PET-	1,031,500	1,060,600	2.8	1,175,910	335,700	-0.5	327,308	397	84	2,962	3,897
34	A St. Petersburg, FL						236,600	-0.8	227,136		59		3,850
34	B Clearwater, FL						99,100	0.3	100,587		25		4,023
35	Norfolk-, VA ++	NORF-	962,300	1,024,500	6.5	1,275,048	362,400	-0.7	349,716	1,076	87	1,185	4,020
35	A Norfolk, VA						258,600	-1.0	245,670		54		4,549
35	B Portsmouth, VA						103,800	-0.1	103,281		33		3,130
36	Memphis, TN-AR-MS	MEM	951,500	995,700	4.6	1,170,345	626,700	2.7	711,305	1,272	263	920	2,705
37	Orlando, FL	ORL	900,400	988,500	9.8	1,341,596	181,000	9.9	270,595	629	70	2,133	3,866
38	Providence-, RI-MA	PROV-	979,300	983,900	0.5	1,003,783	240,000	-2.5	210,000	908	55	1,105	3,818
38	A Providence, RI						153,700	-4.4	119,886		19		6,310

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38	B Warwick, RI						86,300	1.1	91,047		36		2,529
39	Louisville, KY-IN	LOU	887,600	911,300	2.7	1,007,426	271,800	1.0	285,390	996	62	1,011	4,603
40	Oklahoma City, OK	O. C.	850,900	886,800	4.2	1,029,589	457,800	2.9	524,181	1,426	608	722	862
41	Las Vegas, NV	LASV	720,900	882,500	22.4	1,528,308	317,900	23.1	685,075	515	85	2,968	8,060
42	Honolulu, HI	HON	836,200	876,500	4.8	1,036,888	373,200	2.2	414,252	600	83	1,728	4,991
43	Salt Lake City , UT	S.L.C.	801,000	872,300	8.9	1,157,445	169,700	6.1	221,459	418	109	2,769	2,032
44	Rochester, NY	ROCH	838,000	851,200	1.6	905,040	233,300	0.7	241,466	1,390	36	651	6,707
45	Jacksonville, FL	JAX	777,100	829,300	6.7	1,037,429	673,600	6.0	875,680	963	759	1,077	1,154
46	Richmond, VA	RICH	785,300	825,100	5.1	985,552	200,700	-1.2	188,658	1,030	60	957	3,144
47	Tampa, FL	TAM	780,500	819,400	5.0	975,625	287,900	2.8	328,206	591	109	1,651	3,011
48	Dayton, OH	DAY	780,000	800,600	2.6	881,400	185,000	1.6	199,800	1,100	56	801	3,568
49	Nashville, TN	NASH	749,500	793,100	5.8	966,855	502,800	2.9	575,706	1,464	398	660	1,446
50	Albany, NY	A-S-T	756,200	772,800	2.2	839,382	218,300	-1.2	205,202	1,357	42	619	4,886
50	A Albany, NY						99,300	-1.8	90,363		21		4,303
50	B Schenectady, NY						65,200	-6.0	45,640		11		4,149
50	C Troy, NY						53,800	-9.0	29,590		10		2,959
51	Birmingham, AL	BIR	722,700	742,800	2.8	823,878	264,700	-0.5	258,083	1,180	149	698	1,732
52	Austin, TX	AUS	631,100	701,800	11.2	984,516	518,300	11.3	811,140	510	220	1,930	3,687
53	Akron, OH	AKR	666,400	685,300	2.8	759,696	223,700	0.3	227,056	825	63	921	3,604
54	Charlotte , NC-SC	CHRLT	598,400	659,000	10.1	900,592	462,700	16.9	853,682	984	194	915	4,400
55	Tucson, AZ	TUC	608,200	659,000	8.4	863,644	435,400	7.4	596,498	778	159	1,110	3,752
56	El Paso, TX-NM-MEX	ELP	592,100	653,000	10.3	897,032	561,700	9.0	814,465	377	245	2,379	3,324
56	Ciudad Juarez, MEX.		1,387,100	1,563,000	13.5	2,323,393				437		5,317	
57	Tulsa, OK	TUL	615,600	646,200	5.0	769,500	379,300	3.3	441,885	1,089	184	707	2,402
58	Knoxville, TN	KNOX	600,800	629,100	4.7	741,988	167,600	1.5	180,170	1,802	84	412	2,145
59	Toledo, OH-MI	TOL	591,700	600,100	1.4	633,119	331,600	-0.4	324,968	942	81	672	4,012
60	Grand Rapids, MI	GDR	570,200	598,300	4.9	709,899	193,800	2.4	217,056	1,058	44	671	4,933
61	Albuquerque, NM	ALBU	542,800	595,000	9.6	803,344	416,500	8.3	589,348	477	134	1,684	4,398
62	Omaha, NE-IA	OMA	571,100	594,600	4.1	688,176	345,100	2.8	393,414	446	103	1,543	3,820
63	Allentown- PA-NJ	AL-B	559,700	575,000	2.7	635,260	181,700	2.9	208,047	790	37	804	5,623
63	A Allentown, PA						108,000	2.8	123,120		18		6,840
63	B Bethlehem, PA						73,700	3.2	85,492		19		4,500
64	Fresno, CA	FRES	515,000	573,500	11.4	808,550	397,400	12.2	639,814	456	99	1,773	6,463
65	West Palm Beach, FL	WPB	488,400	536,200	9.8	727,716	69,300	2.5	77,963	337	53	2,159	1,471
66	Syracuse, NY	SYR	529,500	535,800	1.2	561,270	160,800	-1.9	145,524	1,084	25	518	5,821

## **APPENDIX B**

**The Role Of  
Commercial Wireless Services  
And Their Impact On Spectrum Requirements**

**Submitted by Motorola Inc. to the**

**Public Safety Wireless Advisory Committee**

**Wednesday, May 29, 1996**

In an appearance before the US Senate Committee on Commerce, Science and Transportation, PSWAC Chair Phil Verveer stated that “Commercial mobile radio services can absorb some of public safety’s demands.” We agree with this general statement and believe it is consistent with the sentiment of the majority of the PSWAC committee. To help clarify the salient issues on this topic, this paper will expand upon this statement and offer a clear opinion of the extent to which public safety demands that “can” be absorbed by commercial mobile radio service *would* be absorbed and identify and size “some of public safety’s demands” that would be absorbed.

Commercial wireless services cannot be widely used to replace an entire public safety private system, or even a significant portion of one, because most public safety communications cannot be adequately served by commercial mobile radio services today or in the foreseeable future. Public safety requires a level of customized service that significantly exceeds, or is at least distinctly different than, that which is demanded by the principal users of commercial wireless services — business/industrial users and individual consumers. Since commercial mobile radio services are fundamentally designed to meet the more modest needs of private sector customers and individual consumers they do not offer the type or level of service demanded by public safety. Also, it is unknown whether the providers of commercial wireless services would make the significant investment in improvements that would be required to adequately serve public safety.

For the public safety user, the major deficiencies of commercial wireless services center around their general inability to provide instant push-to-talk group dispatch, guaranteed access, priority access, security and remote location coverage. A public safety user operating over a wide area may have a communications footprint that would require piecing together service from multiple providers to form a commercial wireless “system” that meets their coverage requirements. Additionally, the multiple commercial wireless service providers may be using different technologies that are not interoperable with each other.

Public safety organizations engage in a wide variety of activities in their mission to protect life, property, and provide for the public safety. Like any other public or private sector organization, their activities range from those that are mission-critical and primary to the core activities of the organization to those that are of a more subordinate nature and therefore of a lower priority. The communications needed to support these activities are similarly wide ranging and carry differing operational requirements. The gap between what is required by public safety and what can be delivered by commercial wireless services is widest among mission-critical communications and narrowest among lower priority communications.

Public safety private systems are primarily designed to handle the higher priority mission-critical communications. A properly designed private system is designed to accommodate all mission-critical communications during peak load time periods. Any system designed for peak load capacity will, by definition, have excess capacity during off peak time periods.

Since the gap between what is required by public safety and what can be delivered by commercial wireless services is narrowest for lower priority communications, these applications are the strongest candidates for placement on commercial wireless services. However, if lower priority communications are retained on the private system the users can leverage their infrastructure investment and fill available system capacity. Lower priority communications can coexist on a private system designed for peak load mission-critical communications because the system manager has the ability to manage radio traffic to ensure that mission-critical communications get through during peak load periods while lower priority communications are postponed until capacity is available.

The protocol for managing communications traffic can be either technology-based or policy-based. Trunked systems provide a technology-based solution whereas conventional systems must rely on policy-based solutions. Trunked system priority access capabilities that can be used to assign priority to members of the system. These priority assignments can be used to queue channel requests and even displace low priority communications that are in process with high priority mission critical communications. Conventional systems cannot assign priority but can incorporate unit identification to allow monitoring of channel usage to ensure that priority based policies and procedures are followed by all users during peak load periods.

### CONCLUSIONS

Mission-critical communications can not be adequately served by commercial wireless services. Therefore, it is in the public interest for the FCC to allocate sufficient spectrum to allow public safety to design and build private systems that can handle all mission-critical communications during peak load time periods.

Many lower priority communications can be served by commercial wireless services. Therefore, the FCC should weigh the macro economic factor of alternative spectrum use when considering the prospect of allocating private spectrum for these types of communications by public safety agencies. The FCC should not allocate additional private spectrum to public safety for low priority communications that can be adequately provided for by commercial wireless services.

Public safety should be allowed to choose whether low priority communications should be placed on commercial wireless services or remain on their private system. The budget pressures felt by public safety agencies are expected to continue through the time period under consideration here. Any opportunity to save money with a solution, private or commercial, that meets their requirements would be eagerly embraced. Decision makers at the state or local level are in the best position to weigh the economic and market factors affecting their situation and decide where to place their lower priority communications.

In public safety today, commercial wireless telephone interconnect and paging are widely used, primarily for connectivity with individuals or organizations outside the private system. This usage will continue into the future and it is widely believed to increase significantly.

However, this wide spread supplemental or complementary usage is actually irrelevant to the determination of spectrum needs for public safety. It represents a usage that the planners of public safety systems have already identified as being outside the scope of their private system and was never intended to be included in PSWAC's quantification of incremental spectrum needs for public safety.

As we've discussed, the communications requirements of mission critical and lower priority communications are primarily differentiated by the extent to which guaranteed priority system access and security are required. One way to forecast the amount of public safety spectrum that would be absorbed by commercial wireless services would be to estimate the amount of lower priority communications and then estimate the amount of that which public safety private system planners would choose to have coexist, on a secondary basis, with mission-critical communications on the private system instead of moving them to commercial wireless services.

We believe that mission critical communications represent the majority of communications on a private system. We also believe that a majority of the lower priority communications can be retained, if desired, on a private system which is designed for mission critical peak loads by employing priority protocols that allow unrestricted lower priority communications during off peak periods but limits or eliminates them during peak periods. If we assume that mission critical communications represent two-thirds to three-fourths of all communications and that private systems can retain two-thirds to three fourths of lower priority communications, the percentage of all public safety communication that would move to commercial wireless service would be on the order of 6-11%.

It is difficult to accurately forecast commercial wireless service usage because it is difficult predict the extent to which the providers of commercial wireless service will make the necessary and significant investments to further serve public safety. Even if long range strategic plans for public safety were being developed by some commercial wireless service providers, it would be unrealistic to expect them to jeopardize their business position by prematurely revealing their plans in order to aid PSWAC. Nevertheless, we believe the 6-11% percent range is of the right order of magnitude.

In his appearance before the US Senate Committee on Commerce, Science and Transportation, Mr. Verveer also stated that "...the advisory committee will attempt to factor the CMRS alternatives into its conclusion about the amount of additional spectrum public safety requires". Motorola recommends that after the advisory committee has concluded the amount of additional spectrum required by public safety it use a factor of 10% to reduce that amount to reflect the impact of commercial wireless services.

**APPENDIX C**

**PUBLIC SAFETY  
WIRELESS ADVISORY COMMITTEE  
MODEL FOR PREDICTION OF  
SPECTRUM NEED  
THROUGH THE YEAR 2010**

**A  
WHITE PAPER**

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**MOTOROLA**

**DRAFT v1.1**

**February 2, 1996**

**EXECUTIVE SUMMARY**

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**PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE**

September 11, 1996

The present service requirements of the public safety community that relate to wireless communications have been identified and projected through the year 2010. Future service requirements have also been identified that are made possible by advances in semiconductor and computer technology that will add to the efficiency and safety of public safety officers as well as the communities which they serve. All of these service requirements include voice, data, image and video. For each of these, the average number, duration, and message load offered, as they relate to the use of wireless communications now and in the future, have been quantified.

The technological parameters that relate the service requirements to spectrum need include RF transmission rate, digital coding, channel occupancy, and error control. The historical rate of change in these have been determined, and then projections were made into the future. A geographical model of Los Angeles which contained 390 thousand public safety officers with advanced services radios was then identified as shown below. The spectrum need for each was also determined as shown, and this is the basis that shows that 84 MHz of RF spectral bandwidth should be provided for public safety applications through the year 2010.

<b>Spectrum Requirements 1996 through 2010</b>		
<b>SERVICE</b>	<b>THOUSANDS OF USERS</b>	<b>SPECTRUM BANDWIDTH MHZ</b>
VOICE	273	20
TRANSACTION PROCESSING	195	5
FACSIMILE	117	9
SNAPSHOT	156	19
DECISION PROCESSING/ REMOTE FILE TRANSFER	117	14
SLOW VIDEO	27	6
FULL MOTION VIDEO	3	9
COMPUTATION TOLERANCE	NA	2
TOTAL		84

## I. INTRODUCTION

The goal of the Public Safety Wireless Advisory Committee is primarily to advise the FCC and NTIA on the “operational, technical, and spectrum requirements of federal, state, and local public safety entities through the year 2010.”<sup>1</sup> The objective is to bring about significant enhancement to the effectiveness and efficiency of public safety communications. Wireless communications have been well used by public safety in the past, and with proper planning, even better use can be made in the future.

This paper will examine the implications of semiconductor advances on computing and telecommunications, and the wireless offering of related services that will impact the public safety community.<sup>2</sup> The present state of semiconductor technology is reviewed in Appendix A, and the cost impact on one market is illustrated. The operational requirements of public safety will be reviewed and projected through the year 2010.

It is the function of this paper to present the best intellectually supportable forecast for the spectrum needed by public safety by 2010. A model will be used that is based on a projection of the current state of digital compression and wireless radio delivery technologies that apply to public safety needs. From that, a forecast is made for the amount of spectrum which will be needed for specific advanced telecommunication services through the year 2010.

## II. SPECTRUM PREDICTION MODEL

We are herein proposing an engineering methodology for projecting spectrum needs. We will show a methodical approach to projecting the trends of key technologies, and how that approach can be employed to predict future spectrum requirements. The relationships between need and required spectrum can be described in terms of technical parameters. Mathematical equations can then be used to project the bandwidth of spectrum required. This methodology has been previously employed in the COPE<sup>3</sup> petition, and we use this as a starting point. The steps to be used are:

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<sup>1</sup> FCC/NTIA Report No WT 95-22, Wireless Telecom Action, September 8, 1995.

<sup>2</sup> This paper draws heavily from a paper by Allen Davidson and Larry Marturano titled Impact of digital techniques on future LM spectrum requirements, IEEE Vehicular Technology Society News, May, 1993. New material given in this paper and some material deemed of importance will be referenced herein. The reader is referred to the predecessor paper for complete citations.

<sup>3</sup> Coalition of Private Users of Emerging Multimedia Technologies (COPE), FCC Petition for Rule Making, Spectrum Allocations for Advanced Private Land Mobile Communications Services, filed 12/23/93. COPE represents many private users of land mobile radio, including public safety organizations such as the Association of Public Safety Communications Officials, International (APCO) and the Public Safety Communications Council (PSCC).

- 1) Identify the geographical area over which the model will be applied and the population of officers who will use the services to which the model applies. We will use the greater Los Angeles area herein.
- 2) Identify the advanced services that will be used by the public safety community through the year 2010.
- 3) Identify a self consistent set of technical parameters that can relate the usage of the advanced services to the spectrum required in a spectrally efficient manner.
- 4) Quantify those technical parameters for each of the advanced services.
- 5) Compute the spectrum need for each of the advanced services and sum them to obtain the total spectral need for public safety through the year 2010.

Each of these will be discussed in turn in the sections to follow. The application of semiconductor technology to radio communications has resulted in certain technology trends that can be useful in these discussions. Several of these trends are presented in Appendix B.

### **A. Metropolitan Area and Population (POP)**

Above we identified the greater metropolitan area of LA as the area which will be used for the computation.<sup>4</sup> The population of public safety users there has been evaluated by the Association of Public Safety Communications Officials (APCO).<sup>5</sup> They show that there were an estimated 78,000 mobile and portable radios in the Los Angeles area in the year 1985, and that this number was estimated to grow to 155,000 by the year 2000.

However, the actual growth in the number of licensed mobile and portable radios in the public safety service between 1985 and 1990 as published by the FCC was much greater than had been estimated in 1985. The actual growth rate by the year 1990, 11.6 percent, produced 135,000 mobiles and portables. Using a much more conservative growth rate of 6.0 percent from 1990 to 2000 and 5.0 percent from 2000 to 2010 they projected that the population of public safety units will be 390,000 by the year 2010.

We will use this estimate as the population for our computation herein; it will be abbreviated POP in the equations to follow. This number may appear to be somewhat large for the population of resident public safety officers in the greater metropolitan area of Los Angeles. However, when one considers the case of a large emergency, where virtually all of the normal activities continue, and there is a large influx of additional resources which must interpolate with the resident population, the number seems very reasonable.

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<sup>4</sup> It would have been possible to use the areas around New York or Chicago as these are crowded users of the spectrum and would also have provided a valid result.

<sup>5</sup> The impact of Advanced Technologies on Public Safety Spectrum Requirements, prepared by APC O Spectrum Needs Task Force, July 1994

## B. Advanced Services

The advanced services which will be available to the public safety community by the year 2010 are:

Table 1  
Advanced Services

- voice dispatch (to support other services)
- telephone interconnect
- transaction processing
- facsimile
- snapshot
- decision processing/remote file access
- slow video
- full motion video

Each of these are described in detail in Appendix C and will not be described further here. The land line services that are driving the need for these advanced services in the public safety environment are also described in Appendix C. Further, some examples are given there of the first steps being taken to bring them into the wireless world.

## C. Technical Parameters

A set of parameters that apply to the model at hand are given below, and each of them will be described further in the paragraphs to follow.

Table 2  
Parameters Used in Model

- penetration of each service into the target population (%)
- source content (kbytes or kbits/sec)
- expected coding improvement (factor)
- average duration of message (sec)
- calls per hour (number)
- RF transmission rate (bits/sec/Hz)
- error control (% of transmission)
- average busy hour channel loading factor (related to blocking, %)
- geographic reuse factor (factor)

### 1. Service Penetration Into Target Population (PEN)

The penetration of each of the services into the population of public safety users is represented by the shortened form PEN in the equations to follow. It is a dimensionless quantity that may be expressed as a percentage, and as the penetration into any service increases, the amount of spectrum needed will also increase.

Each of the above identified services will not be used by all of the population of 390 thousand users of the advanced services identified above. For example, transaction processing functions will probably be used frequently by a traffic officers as they request data on license numbers. But they will probably not use telephone interconnect in their regular duties. An officer on foot may frequently receive mug shots of individuals who are wanted for some reason. But they will not usually need to transmit or receive long files such as locations of gas lines or power lines such as a firefighter is interested in.

The estimation of the penetration should also take into account that out of the ordinary emergencies require services that may not be used on an every day basis. Thus, adequate penetration should provide for the unusual. The penetration that will be used in the sample computation to follow is given in Table 3.

Table 3  
Penetration of Services Into the User Population

<u>SERVICE</u>	<u>PENETRATION, %</u>
Voice	50
Transaction Processing	50
FAX	30
Snapshot	40
Remote File Access	30
Slow Video	7
Full Motion Video	0.7

## 2. Source Content (SRC)

The content of the source message to be transmitted is represented by the shortened form SRS in the equations to follow. It is given in two forms, depending on the service being discussed. Those services which have a stringent latency requirement, which include voice, telephone interconnect, slow video, and full motion video, are expressed in bits per second.

The data services which include transaction processing, snapshot, facsimile and decision processing are given in kbytes. In order to determine the number of bits per second required of these services, we multiply by 8 to determine the number of bits, and then divide by the average duration of the message which is described in 5 below.

The magnitude of the source content is that content which is contained in the state of the art message today, including any coding improvement that has been done. Advances in coding are addressed in the next parameter. The content of the advanced features is discussed in Appendix C, and are summarized in Table 4.

## 3. Coding Improvement (COD)

The coding improvement is a dimensionless factor that describes the anticipated improvement in coding that will take place between the years 1996 and the year 2010. The shortened term

COD is used in the equations to follow. This too is described in Appendix C and in Table 4 below.

<b>Table 4 Source Content, Compression Ratio, and Future Content</b>			
<b>ADVANCED SERVICE</b>	<b>CONTENT</b>	<b>IMPROVEMENT</b>	<b>FUTURE SOURCE CONTENT</b>
Decision Processing/ Remote File Transfer	200 kbyte	2 to 1	100 kbyte
4 Page FAX	92 kbyte	3 to 1	31 kbyte*
SNAPSHOT, including			
Fingerprint Inbound	3 kbyte	1 to 1	3 kbyte
Fingerprint Outbound	6.25 kbyte	1 to 1	6.25 kbyte
Mug Shot Outbound	2.5 kbyte	1 to 1	2.5 kbyte
EMS Picture	103 kbyte	2 to 1	51 kbyte
Slow Video	384 kbps	3 to 1	128 kbps
Full Motion Video	1.5 kbps	3 to 1	500 kbps

**4. Duration of Message (DUR)**

The needs of each mobile officer who uses the services in question will now be predicted. The length, or duration, of the messages on the RF link will be called the DUR in the equations to follow.

Table 5 summarizes the number of seconds that each transmission will take on average. In the case of voice dispatch, the length of the message on private trunked systems averages about 24 seconds and on community repeaters it averages about 17 seconds.<sup>6</sup> On public safety systems the length is frequently less because of the strict discipline enforced on those systems. Telephone interconnect calls are usually much longer, and in the public safety environment, where there may be a hostage situation, the length can become hours. However, the average call length for the composite voice application which is used in conjunction with the advanced services is taken as 24 seconds.

The length for the video applications is estimated based on the information that might be obtained from the periodic observation of a fire or a crowd. The estimated times for the data applications are taken from those applications in use on wire based computers today.

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<sup>6</sup> Garry C. Hess, Land-Mobile Radio System Engineering, Artech House, Boston - London, 1993, pp.249-253.

<b>Table 5</b>	
<b>Length of Messages on Advanced Systems</b>	
<b>SERVICE</b>	<b>AVERAGE MESSAGE LENGTH SEC.</b>
VOICE	24
TRANSACTION PROCESSING	1
FACSIMILE	15
SNAPSHOT	20
DECISION PROCESSING/ REMOTE FILE TRANSFER	15
SLOW VIDEO	210
FULL MOTION VIDEO	210

## 5. Messages Per Hour (MPH)

Service usage will be quantified in terms of the numbers of requests for service per user in the busy hour, and this parameter will be called MPH in the equations to follow. The proposed usage model is summarized in Table 6. These have been gleaned from many sources over time. Where possible, wireless data has been used, but where none is available, data from wireline use has been extrapolated. The use of traditional voice and data services as well as newer advanced services have been included. Also, full motion video is expected to be viable by the 2000 time frame, and it is expected to find more use as it is placed in the hands of the users.

<b>Table 6</b>	
<b>Advanced Service Usage Rates Per Hour</b>	
<b>SERVICE</b>	<b>AVERAGE REQUEST RATE PER HOUR</b>
VOICE	3
TRANSACTION PROCESSING	6
FACSIMILE	0.5
SNAPSHOT	1

<b>Table 6</b>	
<b>Advanced Service Usage Rates Per Hour</b>	
<b>SERVICE</b>	<b>AVERAGE REQUEST RATE PER HOUR</b>
DECISION PROCESSING/ REMOTE FILE TRANSFER	0.5
SLOW VIDEO	0.1
FULL MOTION VIDEO	0.4

## **6. RF Transmission Rate (RATE)**

The word RATE will be used to designate the RF transmission rate in the equations to follow. The historical transmission rate is discussed in Appendix B. The leading edge technology in use was projected there to be 3.5 in the year 2000 and 5.0 in the year 2010. Assuming a 15 year life, the systems in use in the year 2010 will be the accumulation of systems sold starting with those purchased today and including those that will be sold in the year 2010. Those sold today include some which are at the level of about 2.5 b/s/Hz on Figure B2 and some that are less than 1.0 b/s/Hz. Those sold in the year 2010 will likewise have a range of values.

By using crude integration, we arrive at a values of 1.5 b/s/Hz that can provide all of the advanced features in a reasonable bandwidth for all applications except video. For slow and full motion video we use 3.5 b/s/Hz.

## **7. Error Control and Overhead (ERR)**

In the equations to follow, we will use COD to represent the subject parameter, and it will be expressed in the average percent of transmitted bit rate that is dedicated to this function.

Coding of the information bits allows more and more compression to take place. However, each bit then becomes more important, and the error correcting function then becomes more important. In addition, over time, linear modulation schemes are being used with higher transmission rates. Because of the multipath propagation environment, it becomes necessary to provide synchronization and equalization functions that also use some capacity.

State of the art systems in operation today use up to 55 percent of their transmitted bit rate for error correction and overhead. Because increased emphasis will be given in the future, we will project that this parameter will only improve to 50 percent for all of the services by the year 2010.

## 8. Channel Loading (LOAD)

Channel loading is the portion of time the channel has RF transmitted over it expressed in percent of the total time the channel is available. It is represented by the term LOAD, and is a complex subject that is a function of many parameters. These parameters include the kind and urgency of the message, the number of users of the channel, how many servers are available for the channel, and the length of message and number of them per hour offered by the users.

An example of a situation where a lightly loaded channel is necessary is when a group of scattered police officers are waiting to simultaneously close in on a suspect with a hostage. They operate on a single channel, and It is imperative that when the word go is uttered they all move with the greatest of speed. The channel in use must be **very** lightly loaded, LOAD less than 5 percent, to assure that the short message will not be blocked.

An example of a situation where a heavily loaded channel can be used involves trunked systems that carry routine messages. Data requests for license plate checks can wait two or three seconds as the officer writes a ticket. A dispatcher request for present location usually takes a few seconds for a voice reply as the officer reaches for the radio to reply. That too will not suffer greatly if two or three seconds of blockage occur. LOAD can be 20 to 25 percent on a single channel system and as much as 70 to 80 percent on 20 channel trunked systems and meet this criteria.

Finally, there are messages that can wait for a few minutes before delivery to the intended party. These may include a FAX sent to an individual driving a car (we recommend that they keep their eyes on the road as opposed to reading a FAX), and E-Mail message, or a long file which is to be used at some time in the future. Single channel systems can be loaded up to 50 percent and 20 channel systems up to 95 percent and provide this service. Table 7 summarizes the estimated average channel loading that will be attained by the year 2010 for all of the public safety services being considered herein.

<b>Table 7</b>	
<b>Assumed Public Safety Channel Loading in the Year 2010</b>	
<b>SERVICE</b>	<b>AVERAGE CHANNEL LOADING, %</b>
VOICE	40
TRANSACTION PROCESSING	50
FACSIMILE	60
SNAPSHOT	60
DECISION PROCESSING/ REMOTE FILE TRANSFER	60

<b>Table 7</b>	
<b>Assumed Public Safety Channel Loading in the Year 2010</b>	
<b>SERVICE</b>	<b>AVERAGE CHANNEL LOADING, %</b>
SLOW VIDEO	50
FULL MOTION VIDEO	50

## 9. Geographic Reuse (REUS)

This parameter is a dimensionless factor which will be called REUS in the material to follow. There are three states for REUS, it may be greater than, equal to, or less than 1.0. We will look at each of these in turn.

"Talk around" is a function that is used on systems with two frequency repeaters with no additional infrastructure. Mobile or portable radios disable their repeater function and use their radio in a single frequency simplex mode, public safety unit direct to unit. They use the base talk out frequency, but because they are so close together, their signal dominates the signal received at the base. Many individuals can simultaneously use this function in the same geographic region, in addition to those using the repeater. Thus, the reuse factor is greater than 1.0. REUS can perhaps be as high as 5 or 10 depending on the number of officers simultaneously using this function.

A second way that REUS can be greater than 1.0 is by the use of a cellular like system. Here, the same channel is used more than once in the same geographic area. That channel traditionally used Frequency Division Multiple Access (FDMA), but Code Division Multiple Access (CDMA) has been implemented in the past few years. Cellular FDMA has demonstrated REUS factors of 4 to 6 in a given geographic area while CDMA proponents claim REUS equivalent factors of 10.<sup>7</sup> This technology is not yet been proven in fully loaded service, so it is premature to conclude what this technology is capable of at this time.

Two frequency repeaters with high base antennas which cover wide geographic areas are the technology that provides a REUS factor of 1.0. These can either be conventional or trunked repeaters; it makes no difference to the REUS factor.

Finally, REUS factors less than 1.0 are provided by simulcast systems that use multiple transmitters on the same RF frequency that broadcast the same message content. This also applies to multiple transmitters on different frequencies that broadcast the same message.

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<sup>7</sup> When CDMA was new, advocates claimed REUS factors of 20 would be possible. However, at the December 13 PSWAC Technology Subcommittee meeting, representatives of CUALCOMM, Inc. and Airtouch Cellular stated that a factor of 10 is possible. We note that the trend of claims is decreasing. It is probably necessary to wait until fully loaded systems are in place demonstrating this capability before REUS for CDMA will be known.

These frequently take the form of state wide systems. Because the frequency can not be reused in the next geographic area, REUS will be less than unity. The value of REUS will be the ratio of the area covered by one high site repeater to the area covered by the multisite system. So, if the system covers the area which two high repeater sites normally covers, REUS = 0.5. If it covers the area of four sites it will be 0.25, and so on.

The amount of reuse that can occur is dependent on the advanced service being considered because the area of needed coverage varies. The value of REUS that will be used in the analysis to follow is given in Table 8 for each service.

<b>Table 8</b>	
<b>Public Safety Spectrum Reuse Factor by 2010</b>	
<b>SERVICE</b>	<b>AVERAGE REUSE FACTOR</b>
VOICE	2
TRANSACTION PROCESSING	3
FACSIMILE	3
SNAPSHOT	3
DECISION PROCESSING/ REMOTE FILE TRANSFER	4
SLOW VIDEO	4
FULL MOTION VIDEO	1

**D. Spectrum Computation**

At this point, the technological capabilities related to providing voice, transaction processing, FAX, snapshot, decision processing and file transfer, slow and full motion video have been characterized. The parameters that relate to the use of them by the public safety community have also been quantified. The spectrum needed to provide these services through the year 2010 must now be determined.

**1. Model Equations**

The equation that relates all of the user service capabilities and technical parameters to spectrum need is given in (1), where FREQ is the frequency in MHz and K is a normalization parameter used to accommodate the units and the type of service being analyzed.

$$\text{FREQ} = \text{K} \frac{\text{POP X PEN X SRC X DUR X MPH}}{\text{COD X RATE X LOAD X REUS X ERR}} \tag{1}$$

For two frequency repeater operation, there is a factor of 2 included in K because two bandwidths are used that are separated by the inbound and outbound frequency. We will assume that the slow and full motion video services are single frequency simplex, and therefore only transmitted one way. So the factor of 2 only applies to the other services

In order to express the answer in MHz, and with the units described above, the additional factor of 1/3600 must be used because the service requests are expressed in terms of number per hour, and all other parameters involve seconds.

Finally, the voice and video services source content were described in terms of kb/sec while the data related services were described in terms of kbytes. In order to quantify the spectral need, we will assume that the transmitted rate just meets the time required to get the message through. So, for the data related services there is an additional factor of 8/DUR required. The constant K is summarized in Table 9.

<b>Table 9</b>	
<b>Normalization Factor K for Each Service</b>	
<b>SERVICE</b>	<b>K</b>
VOICE	2/36.00
TRANSACTION PROCESSING	16/(36.00*DUR)
FACSIMILE	16/(36.00*DUR)
SNAPSHOT	16/(36.00*DUR)
DECISION PROCESSING/ REMOTE FILE TRANSFER	16/(36.00*DUR)
SLOW VIDEO	1/36
FULL MOTION VIDEO	1/36

## **2. Spectrum Needs: 1996-2010**

The predicted public safety radio needs given above, coupled with the technological capabilities to meet these needs, described earlier, allow a calculation of the spectrum that will be required for advanced communication services as the year 2000 approaches. The results are presented in Table 10. An estimate of the spectrum needs for voice services is also included, based upon expected efficiency improvements in the current land mobile allocation, and the needs of advanced services users for traditional voice services. The number of users within the geographic area that need the spectrum are also listed. These spectrum requirements are expected to increase through the year 2010 as the penetration for these services increase and there is a greater dependence on multimedia information.

<b>Table 10</b>		
<b>Spectrum Requirements 1996 through 2010</b>		
<b>SERVICE</b>	<b>THOUSANDS OF USERS</b>	<b>SPECTRUM BANDWIDTH, MHZ</b>
VOICE	273	20
TRANSACTION PROCESSING	195	5
FACSIMILE	117	9
SNAPSHOT	156	19
DECISION PROCESSING/ REMOTE FILE TRANSFER	117	14
SLOW VIDEO	27	6
FULL MOTION VIDEO	3	9
<b>TOTAL</b>		<b>82</b>

### **3. Tolerances in Parameters Used and Result**

The parameters that were used in the computation above all require judgment in their selection and in the levels to which they were quantified. Additional time could be used to reduce the tolerance in each of the parameters, however, with the limited time available they are the best that could be done. It is believed that the computation involved in each of the bandwidths required for each service in Table 10 can have a one standard deviation error of 30%. Assuming that the errors are normally distributed, the probable error in the total is the square root of the sum of the squares of the separate errors. The first standard deviation error in total is therefore 2 MHz. So, in order to accommodate this error, it is recommended that a total of 84 MHz be made available to the public safety community by the year 2010.

### **4. Prediction Reliability**

This vision of the future is a prediction and, like any other prediction, is subject to some debate. Although the details of the vision just described may unfold somewhat differently as time goes on (e.g. in the case of full motion video as a land mobile service), the nature of the vision should be accurate. The "details" of the vision will be driven by a combination of innovative technologies and innovative users.

This model and its reliability represent a comprehensive and scientific approach that has been assembled through the cooperation of the wireless communications industry and public safety user experts. The resulting conclusions and forecasts provide the FCC and NTIA with a firm foundation for allocating adequate spectrum for public safety.

There is a need to revisit the prediction periodically because there are many factors which can hasten or delay the use of these advanced services. Perhaps the largest factor influencing the speed at which these innovative technologies can be introduced will be the availability of adequate spectrum. This prediction is made on the basis that some spectrum be allocated within the next year, and also that a plan be put in place for reaching the required bandwidth. It is recommended that the prediction be revisited at 5 year intervals to determine if changes have occurred that would call for a revision of the spectrum need. Historically, such predictions have fallen short in stating the need. With periodic reexamination of the need, the safety, effectiveness and efficiency of the public safety community can be maintained at the necessary level.

### **III. CONCLUSION**

Advances in semiconductor technology are one of the major enablers for the introduction of advanced telecommunications and computing applications and services. The introduction of these services in the home or office environment tends to increase the demand for ubiquitous wireless access to these same services shortly thereafter. We have also seen how the same semiconductor technology which creates the demand for these services in the wireline environment provides solutions for wireless access, by making advanced spectrally efficient modulation and source encoding techniques economically viable for mass production. These advances have been utilized by public safety mobile radio equipment manufacturers and service providers to pace the past user demand for new wireless services.

However, due to expected proliferation of advanced digital services through the year 2010, it is expected that the increase in demand will overtake the additional capacity offered by technological improvements. In order for these advanced telecommunications services, like file transfer, fax, imaging and video, to be offered to the public safety community, it is necessary that adequate spectrum be provided to make up for the shortfall between the anticipated demand and the expected advances in efficiency of presently allocated spectrum. The total spectrum that should be provided for public safety through the year 2010 is 84 MHz.

**APPENDIX D**

**Public Safety Wireless Communications User Traffic Profiles  
and  
Grade-Of-Service Recommendations**

**13 March 1996  
Revision-0**

**Submitted to:**

**PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE  
(PSWAC)**

**Submitted By:**

**United States Department of Justice  
Immigration and Naturalization Service  
Headquarters Radio Systems Section**

**Prepared by:**

**Dr. Gregory M. Stone  
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## **ABSTRACT**

This paper presents a structured approach and methodology recommended for the modeling and simulations of conventional (including those with composite control) and trounced public safety wireless communications systems based upon traffic engineering principles. These recommendations include: the provision of standard public safety user traffic profiles; adoption of the Poisson and Erlang-C traffic and delay equations; establishment of a recommended grade of service, priority and response times for public safety wireless communications.

## **ACKNOWLEDGMENTS**

The traffic profiles presented in this paper owe their origin to the significant works of Mr. Mark Racek and Mr. Ed Kelly of Ericsson and Mr. Keith Barnes of the E.F. Johnson Company. We continue to acknowledge the receipt of valuable comments and suggestions from a number of individuals and entities. We are appreciative of the contributions to this process provided by Mr. Paul Derynck of the Calgary Police Service and APCO Canada, as well as those from EEG, Motorola and GEC-Marconi. In addition, Mr. Richard Roley from the State of Georgia and Mr. R.E. Ginman Head of Radio Frequency and Communications Planning Unit, of the United Kingdom's Home Office provided valuable data from existing systems that were considered in the construction of these metrics. Using the Ericsson and EFJ materials as a point-of-departure, we have made substantive changes, especially in the numerical offered load values.

## **1. INTRODUCTION**

The impetus behind the development of a standard or baseline traffic profile was to assist the global PSWAC effort through providing a set of modeling and simulation constraints concerning public safety offered load that may be of use in determining comparative performance between current and future technology implementations.

Since the initiation of this traffic profile and grade-of-service (GOS) recommendation process, considerable evolution of the standard profiles has occurred, most as a result of reconciling philosophical differences between how a metric should be constructed and some by assimilating additional real world data.

To facilitate document utility, we have segregated the presentation of "SPECIAL" data (defined as data with file sizes of 30 kiloBytes or larger (KB)) requirements from the aggregate offered load metric standard. Notwithstanding this segregation, we have become more confident that SPECIAL data and imaging usage will predominate in the future. These forecasts are indeed problematic as no currently available commercial wireless technology implementation can support the information transfer intensive requirements imposed by SPECIAL data.

Our basis for these statements is straightforward. There is historical precedent that when query type wireless data is used in public safety, certain types of voice traffic tend to decrease. In addition, as most query types of data are of a relative small file size in the order of a few hundred Bytes, the transfer times needed are modest even at relatively low information transfer rates. Public safety users are accustomed to fairly rapid response times for both voice and data services. Systems are hopefully designed to support typical voice traffic profiles. When data services that involve large file sizes are attempted, both the information transport and processing and turnaround times tend to become significant. If a system is sized to accommodate a certain quantity of five second messages and the traffic usage is characterized by transmissions of 30-60 seconds or more, the overall performance of the system quickly becomes degraded. Likewise, operational users of the systems are not accustomed to long transmission or turnaround delays; in fact, public safety operations are generally intolerant of such delays.

SPECIAL data will not be able to be accommodated on a wholesale basis until its transfer times are comparable to query type data in most systems or in a worst case, comparable to the typical voice transmission length in those lightly loaded systems. This is an important point that is often overlooked in the current euphoria over technology. Of course, should dramatic advancements in compression techniques make SPECIAL data more manageable, current and emerging state-of-common usage systems can then be effectively exploited for this type of teleservice.

Given the operational requirements of the vast majority of public safety user agencies, we assert the primary usages of current public safety systems will be to transport voice, status/message and file query data. In this regard the metrics presented have been further refined to focus on these primary services.

In an attempt to understand the broad applicability and utility of this profile, we have created sub-categories such as voice and data for hazardous materials and for EMS communications. Also identified in a separate sub-category is a very common communications mode that is often overlooked: car-to-car or unit-to-unit traffic. Many federal, state, and local law enforcement and Public Safety operations including Fire Ground, etc. make extensive use of this tactical unit-to-unit communications modality.

Heeding the advice of many commentators on our previous traffic profile work, we have avoided the double counting aspect of this tactical unit-to-unit operational modality. This issue arose as most of the unit-to-unit traffic is typically "off-infrastructure" on a simplex channel not going through a mobile relay. Occasional unit-to-unit communications, which use a mobile relay, can be accommodated through the remaining categories.

It is our intent to present a universal traffic profile and metric amalgamation. From a user needs and requirements point-of-view, we believe that the traffic profile should be broadly applicable to both conventional and trunked environments and scaleable to address small and large system usages.

In this regard, we are unable to subscribe to the notion that specifics given for control traffic loading and usage are user requirements or are representative of a user offered load. We therefore do not include values which are illustrative and applicable to a particular trunking technology implementation solution. Thus, how much trunking control load is imposed in a particular system implementation to service the user profile we have advanced here-in is NOT addressed. In this regard, it is our position that control channel load is the effect caused by a certain user loading and will vary depending upon the specific technical solution applied.

Likewise, we have not included any references to implementation solutions such as transmission or message trunking or any reference to fringe area retransmission or retry factors. Nor have we included any multi-site load factors as they appear to assume that the average user may be generalized to a multi-site system. In addition, the selection of multi-site factor(s) is technology solution dependent and this is not representative of a user defined load.

Furthermore, the fact that we have presented a unified metric means that we are generalizing that all Public Safety users employ voice, data and status. This assertion is somewhat is problematic to us as our experience has shown that there is a very wide diversity in data and status usage amongst public safety users.

We have therefore chosen to present the offered data in both aggregate total offered load and in decomposed format segregating the voice, data and status loading. In the future, we believe that most but not all Public Safety users will employ some form of data, be it status and or messaging. Thus for simulation purposes we strongly recommend employing the unified aggregate load figures for projected future usage.

The traffic profiles provided represent discrete and composite values for both current and projected future usages for a hypothetical Law Enforcement/Public Safety organization employing both digital voice and digital multimedia services. The current traffic profile was developed from an aggregation of federal, state and local law enforcement data. The future profile was based upon the current aggregation along with projections of future data usage. The assumptions and predicates for these profiles are declared. These composite traffic profiles are presented to serve as a comparative baseline to assess the performance of advanced digital trunked systems in law enforcement/public safety usage. This composite traffic profile is not meant to serve as an absolute design criteria for any specific user agency or activity.

We acknowledge the need however, for a standard traffic profile. The traffic profiles offered in this document may be used for system modeling, simulation and design purposes for both current and projected usages. However, it is incumbent upon all designers and system operators to regularly collect and analyze the actual usage statistics of their respective systems. Certain user agencies may find our profiles are too conservative, while others may find we have underestimated the real load. Over time, on a continual and regular basis, the specific system performance must be evaluated. If excessive blocking and access delays occur, steps must be taken to correct for these occurrences. Likewise, if the grade-of-service is significantly better than the design objective, additional officer traffic may likely be accommodated.

We advocate a technically sound common sense approach to system optimization be institutionalized in both trunked and conventional environments. Recognizing that past statistical trends may be useful for certain forecasting where the operational imperatives remain constant. Unfortunately, natural and manmade disasters will impose severe demands on any conventional or trunked system in a fashion that is radically different from “routine” emergency peak loading. Proactive planning, and not our traffic profiles is needed to assure system availability in times of catastrophic events.

### **TRANSACTION CLASSIFICATION DEFINITIONS:**

The traffic profiles tables provided in the attachments tabulate the types of transactions supported by public safety wireless communications systems. General categories such as Teleservice, are employed to define the types of information being transported. These transactions are grouped into the following three categories:

**Digital Voice:** Those actions that relate to the use of system resources needed to handle calls related to information transfer via voice and contribute to the aggregate communications system channel information transfer rate and load. Voice traffic is generally passed via a working channel that is either dedicated for voice transport or is shared with supervisory and/or status/message data.

**Data:** Those actions that relate to the use of system resources needed to handle calls related to information transfer via non-voice means and contribute to the aggregate communications system channel information transfer rate and load. Data traffic is generally passed via a working channel that is either dedicated for message data transport or is shared with supervisory data and/or voice traffic. Data traffic may be transported through both circuit switched and packet mechanisms. It is assumed for this analysis that all data are packetized, confirmed delivery except for slow scan imagery, which is presumed to be circuit switched. SPECIAL DATA has been segregated from the projected future offered load and presented separately. Its impact is NOT considered in the recommended future projected load values.

**Status/Message:** Those actions that relate to the use of system resources needed to handle the transfer of information which indicates status change, or provide for equally short message data, of the subscriber or infrastructure. This occurs without producing any specific response either through non-voice means, but contributes to the aggregate communications system channel information transfer rate and load. Status/message traffic may be passed on a working channel or may be passed on a control channel depending upon the specific system implementation. It is anticipated that most if not all Status/Message traffic will be conveyed via packet means.

Activities in each of the three categories contribute to the total user-defined load of a system. The characterization of the traffic load thus must consider certain elements which are:

**Number of Transmissions:** The number of transmissions per activity. An activity that is completed is a "message." Some number  $n$  of transmissions would comprise a complete "message". In this case we are not using the term "message" but rather are identifying the number of transmissions required to effect a specified activity. This number of transmissions is referred to as  $Tn$ .

**Duration of Transmissions:** In addition to the number of transmissions  $Tn$ , the duration of the transmission is also a load determining element. Duration of the transmission is defined in seconds and is represented by the term  $Td$ .

**Number of Calls per Average Busy Hour:** In addition to the two elements addressed, the third load determining element is the number of transmissions the Public Safety officer is involved in per hour that results in the associated transmissions. This element is expressed by the term  $M$ .

From this information the offered load, in Erlangs ( $E$ ) can be determined and is calculated by the following expression:

$$\text{Offered Load in Erlangs} = (Tn \times Td \times M)/3600.$$

## 2. PUBLIC SAFETY OFFICER TRAFFIC PROFILE SUMMARY:

Our data indicate that the busy hour itself is highly variant. Thus, we have elected to recommend that an average busy hour load factor be employed that is approximately four times (4X) as busy as the average non-busy hour. Thus the Average Busy Hour appears to effectively consider routine peak traffic loads. Of course, emergency loading is not considered in this analysis. Typically under emergency conditions, loading may increase by a factor of ten or more.

The summary of offered traffic load per Public Safety officer is as follows:

### Present Requirements Summary (Average Busy Hour):

Transaction Type	Inbound Erlangs	Outbound Erlangs
Voice (Digital)	0.0073484	0.0462886
Data	0.0004856	0.0013018
Status/Message	0.0000357	0.0000232

Present Busy Hour Traffic Load Per Officer: 0.0554832

**Present Requirements Summary (Average non-Busy Hour "25% of Busy Hour"):**

Transaction Type	Inbound Erlangs	Outbound Erlangs
Voice (Digital)	0.0018371	0.0115722
Data	0.0001214	0.0003254
Status/Message	0.0000089	0.0000058

Present Average Hour Traffic Load Per Officer: 0.0138708

**Future Requirements Summary (Average Busy Hour):**

Transaction Type	Inbound Erlangs	Outbound Erlangs
Voice (Digital)	0.0073284	0.0463105
Data	0.0030201	0.0057000
Status/Message	0.0001540	0.0002223

Future Busy Hour Traffic Load Per Officer: 0.0627354

**Future Requirements Summary (Average non-Busy Hour):**

Transaction Type	Inbound Erlangs	Outbound Erlangs
Voice (Digital)	0.0018321	0.0115776
Data	0.0007550	0.0014250
Status/Message	0.0000385	0.0000556

Future Average Hour Traffic Load Per Officer: 0.0156838

**SPECIAL DATA Future Requirements Summary (Average Busy Hour):**

Inbound Erlangs	Outbound Erlangs
0.0268314	0.0266667

Future SPECIAL Data Traffic Load Per Officer: 0.053498

**SPECIAL DATA Future Requirements Summary (Average non-Busy Hour):**

Inbound Erlangs	Outbound Erlangs
0.0067078	0.0066667

Future SPECIAL Data Traffic Load Per Officer: 0.0133745

What do these data indicate? Firstly, that the use of data in the future will significantly impact system design and use. Secondly, consider the practical translation of the above. If one Erlang is equivalent to 3600 seconds, then in a one hour period a Public Safety officer would use his/her communications equipment (transmit and receive) for the following durations:

**Present Busy Hour (0.0554832 Erlangs or 200 seconds)**

200 seconds or 3.3 minutes of airtime per officer per busy hour

(If a 5 second average voice transmission is assumed, with a typical message being comprised of three five (5) second transmissions, then 3.3 minutes equates into 13 messages per hour excluding multimedia data usage.)

**Present Non-Busy Hour (0.0138708 Erlangs or 50 seconds)**

50 seconds per officer of airtime per officer per non-busy hour

(If a 5 second average voice transmission is assumed, with a typical message being comprised of three five (5) second transmissions, then 50 seconds equates into 3.3 messages per hour excluding multimedia data usage.)

**Future Busy Hour (0.0627354 Erlangs or 226 seconds)**

226 seconds or 3.7 minutes of airtime per officer per busy hour

(If a 5 second average voice transmission is assumed, with a typical message being comprised of three five (5) second transmissions, then seconds equates into 15 messages per hour excluding multimedia usage.)

**Future Non-Busy Hour (0.0156838 Erlangs or 56.5 seconds)**

56 seconds of airtime per officer per non-busy hour

(If a 5 second average voice transmission is assumed, with a typical message being comprised of three five (5) second transmissions, then 56 seconds equates into 3.7 messages per hour excluding multimedia usage.)

**SPECIAL DATA: Future non-Busy Hour (0.0133745 Erlangs or 48 Seconds)****SPECIAL DATA: Future Average Busy Hour (0.053498 Erlangs or 193 Seconds)****3. GRADE OF SERVICE (GOS), PRIORITY and RESPONSE TIME:****Grade of Service:**

We are recommending that the GOS employed for the standard evaluation of Public Safety trunked and conventional system performance be one call for service per one hundred attempts during the average busy hour, is blocked and that the blocked call be held in queue for a period not to exceed five seconds. This results in a GOS being defined as P.01 for the average busy hour.

We are additionally recommending that the Erlang-C traffic equation be employed in determining the Service Grade in conjunction with an assumption that the call arrival rate follows a Poisson distribution.

However, notwithstanding this recommendation, it is important to note that today's public safety trunked systems typically operate with a Busy Hour Grade of Service of P.1, meaning that during a busy hour typically 90% of the calls get through with no delay and 10% being delayed for five seconds or less.

What we are recommending is a transition from a GOS of P.1 to P.01. It is our opinion that average busy hour blocking should not impact more than one call per hundred.

**Priority:**

In addition, we recommend that only two priority types be recognized for baseline comparative purposes: Routine and Emergency.

We suggest that during normal usage ALL Public Safety officers be treated with equal routine operational priority. The only time routine operations priority would be overridden is during an "EMERGENCY". Emergency priority, in our view, results in the ability to "seize" system resources under all circumstances.

**Response Time:**

In the case of packetized Data and Status/message transmission the notion of GOS is problematic. We believe that Data and Status/message performance is best reflected in terms of a statistically expressed response time. In this regard, we propose that all Data and Status/message messages be received 99% of the time at the following response times assuming a information transport rate of 750 B/s:

**SPECIAL DATA**

Large Data Message (30 KBytes)	40,000 ms
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**NON-SPECIAL DATA**

Moderate Data Message (5 KBytes)	6,666 ms
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Small Data Message (2.4 KBytes)	3,200 ms
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Status/Message	600 ms
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Note: For bearer service, circuit switched data usages, the GOS metric would be applicable as the channel resource is seized until the transaction is completed.

The response times are consistent with a current public safety state-of-common usage technology which has a total payload information transfer rate of approximately 6,000 bits-per-second (b/s) or 750 Bytes-per-second (B/s) including all overhead and turn-around times for half duplex acknowledgment and represent(s) a significant i.e., two fold (2x) improvement in information transfer either in terms of duration (half the time) or content (twice the data) as compared to current 4800 b/s analog systems nominal payload data rates. Compared to those analog systems operating at a 9600 b/s gross rate, the information transport rate of 6,000 b/s (750 B/s) is comparable if not better than that achieved in current analog practice.

**4. TRAFFIC MODEL RECOMMENDATION:**

Public safety communications traffic loading is typified by large peak-to-mean variations. Typically we have found that average busy hour traffic is at least four (4) times the average non busy hour.

In addition, as stated, it is unacceptable for Public Safety users to be denied service. If system resources are busy, all Public Safety users must be held in queue and assigned a resource as it becomes available. The exception is in an emergency where we recommend that an emergency call seize whatever system resource is needed. This recommendation is discussed further under our coverage on priority usage.

We therefore recommend that the GOS for a Public Safety trunked system be determined through the use of the Erlang-C delay model which is based upon the following predicates:

- The offered load follows a Poisson arrival process
- Service times are exponential
- The load source is infinite
- A FIFO queue is utilized
- A single server queue is employed, calls are directed to the first available server or trunk
- No calls leave the queue
- An infinite queue is available
- Average busy hour to non-busy hour ratio of 4-1

The Poisson traffic equation is expressed as follows:

$$P = e^{-y} \sum_{x=n}^{\infty} (y^x/x!)$$

where:

P = probability of blocking

n = number of trunks or channels

y = traffic offered in Erlangs

The Erlang-C delay model is expressed as follows:

$$w = \frac{t(y)^{n+1}P_0}{y(n-1)!(n-y)^2}$$

where:

$$P_0 = \frac{1}{\sum_{x=0}^{n-1} \frac{1}{x!} (y)^x + \frac{1}{n!} (y)^n \left( \frac{n}{n-y} \right)}$$

w = mean wait time in queue in seconds

n = number of trunks or channels

y = Traffic offered in Erlangs

t = mean message duration in seconds which is the reciprocal of the mean message servicing rate

## 5. IMPACT ON PART 90 LOADING REQUIREMENTS

A word of caution is in order concerning the use of traffic profiles in general: The adoption of any traffic profile for the evaluation of conventional or trunked systems may be in direct conflict with FCC Rules and Regulations. Part 90 specifies conventional and trunked loading as a function of the number of licensed units assigned to a given channel. Thus if 100 units are required per channel, a twenty channel trunked system must have 2000 subscriber sets licensed to it.

We have attempted to present a comparison of our future traffic loading findings and the loading requirements enumerated in Part 90. In this regard, we have assumed a GOS of P.1 (10% blocking) in the average busy hour. Using a baseline 20 channel trunked system that employs one channel for control, we have used the Poisson Traffic table to infer the offered load of 2000 units on 19 trunks (channels) at a GOS of P.1. Nineteen (19) trunks at a P.1 GOS can support 13.65 Erlangs of traffic. Distributed across 2000 units, each unit has an inferred load of approximately .0068 Erlangs.

We believe that in the Public Safety environment, officer safety and mission effective communications demand that sound traffic engineering principles and practices be followed in the design of either a trunked or conventional voice or data or combined system(s). In the United States there is precedent for this in terms of the Part 22 Common Carrier trunked system loading and engineering standards. This recommendation is applicable BOTH to conventional (i.e., non-trunked) and trunked systems.

**6. HYPOTHETICAL SYSTEM EXAMPLE OF PROPOSED FUTURE USAGE**

Let us consider a hypothetical system that has traffic characterized by our proposed future usage metrics. Let us further assess the performance of the system in context of the P.01 (one call per 100 is blocked) GOS recommendation.

Consider the following configuration:

Number of channels (including control)	20
Number of Trunks	19
Erlangs Supported on 19 trunks	10.35
Recommended GOS	P.01
Future Average Busy Hour Load per user	0.0627354E
Future Average Hour Load per user	0.0156838E

The question then is how many users can the system support using these parameters?

Referring to a traffic table one finds that 19 trunks at a GOS of P.01 can handle 10.35 Erlangs of traffic. Given our assumption that each user generates 0.0627354 Erlangs per hour, a total of  $(10.35/0.0627354)$  165 users can be supported. At a reduced GOS of P.1 (10 out of 100 calls will be blocked), 19 trunks supports 13.65 Erlangs of traffic which supports 218 users. This analysis reveals an apparent inconsistency with Part 90 which requires that 20 channels (irrespective of control channel usage) have 2000 licensed users.

The values are depicted in the following table:

**FUTURE USAGE (AVERAGE BUSY HOUR)**

<b><u>GOS</u></b>	<b><u>#Units Supported</u></b>	<b><u>Assumed Offered Load/Unit</u></b>	<b><u>Airtime Per Unit Per Hour</u></b>
P.01	165	0.0627354	226 Seconds (3.8 Min.)
P.1	218	0.0627354	226 Seconds (3.8 Min.)

In the case of Average Hour (NONBUSY) the number of units supported are as follows:

**FUTURE USAGE (AVERAGE HOUR)**

<b><u>GOS</u></b>	<b><u>#Units Supported</u></b>	<b><u>Assumed Offered Load/Unit</u></b>	<b><u>Airtime Per Unit Per Hour</u></b>
P.01	660	0.0156838	56 Seconds
P.1	870	0.0156838	56 Seconds

As one can see these values are less than the loading prescribed in Part 90 assuming that the quantity of licensed units and units actually in service at a given point-in-time, are the same. The following table summarizes the Part 90 offered load for both P.01 and P.1 GOS, during the Average BUSY Hour:

**FCC PART 90 LOADING**  
(Hypothetical 20 Channel Trunked System)

<b><u>GOS</u></b>	<b><u>#Units Supported</u></b>	<b><u>Assumed Offered Load/Unit</u></b>	<b><u>Airtime/Unit/Hour</u></b>
P.01	2000	0.0052 E	18.7 Seconds
P.1	2000	0.0068 E	24.5 Seconds

Thus, the Part 90 inferred offered load appears to be significantly less than our present day busy-hour and projected future non-busy and busy hour metrics.

In an attempt to evaluate the Part 90 inferred offered load of 0.0068E or 24.5 seconds with our projected average busy hour offered load metric of 0.0138708E or 50 seconds, we looked for obvious areas of usage that did not exist with the Part 90 standards were developed. We focused on three areas: Tactical Voice, Data and Status:

If we back-out the contribution of Tactical VOICE, DATA and STATUS from our future projected offered load metrics we see that the 0.0138708E offered load reduces by (0.010416675E tactical VOICE, 0.00032545E extracting the DATA, and by 0.0000058E extracting the STATUS for a total reduction in offered load of 0.010747925E) resulting in an adjusted voice only system load of 0.003122875E (11.24 seconds). This value is much less than the Part 90 inferred value of .0068E (24.5 Seconds) based upon "current" non-busy hour usage.

However, during a present day busy hour, the traffic increased by a factor of four (4) resulting in a corrected load of 0.0124915E (45 Seconds) (excluding the tactical voice, data and status messages).

In the future, the situation appears to be more complicated where both non-busy and busy hour loads are anticipated to be significantly greater characterized by extensive combined digital voice, data and status traffic. In addition, the tactical voice modality is a current reality which is likely to proliferate in the future.

Notwithstanding these facts, one may conclude that the loading values established in Part 90 based upon a non-busy hour GOS of P.1 (10% blocking) was reasonable when considering traditional dispatch voice traffic during the non-busy hour.

It is important to keep in mind the fact that although examples provided are illustrative of trunked systems, the same issues face designers, operators and users of conventional or composite conventional systems. Each trunk (functional channel) can support only a certain traffic load for a prescribed grade-of-service. Proper system engineering demands that user loading be considered in all types of systems (trunked, composite conventional, conventional) and for all types of usage (digital voice, data and status).

## **7. NOTES TO PROPOSED TRAFFIC PROFILE METRICS**

The following are notes applicable to the traffic profile metrics attached to this document as Appendix A:

### **Note 1:**

These values represent an amalgamation of state, local, federal, and international data. In those areas where no information different from the initial Ericsson proposal was available, the Ericsson data remain.

Future projections were based upon logical extrapolations of current usage.

### **Note 2:**

These values are representative of an amalgamation of state, local, federal, and international data. In those areas where no information different from the initial Ericsson proposal was available, the Ericsson data remain.

Future projections were based upon logical extrapolations of current usages. Certain new services considered NCIC-2000 type technologies and large file size multimedia, information transfer rate intensive technologies.

### **Note 3:**

The emerging use of SPECIAL DATA presents major concern, as seen above, SPECIAL DATA will likely increase the offered load by 48 seconds per user in the average hour and by

193 seconds in the busy hour. Clearly these increases in offered load are NOT supportable by currently deployed technology.

As technological advancements occur in compression methodologies that permit large data messages and slow scan imagery to be transmitted in shorter times, the impact on system loading will be dramatically decreased. However, it is important to note that new technologies such as the wireless transmission of telephoto (mug shot), fingerprint and imagery, employing today's compression techniques, will require significant transmission times. If user operational requirements PROJECT significant usage of these large data files sharing with tactical voice may result in unacceptably long delays.

We recommend that SPECIAL DATA be transported by means of technologies and systems specifically engineered to handle its information transfer rate intensive nature in a fashion that provides response time equivalency to today's status, message and database query usages. This is because operational users have certain expectations as to how long data queries should take. To foster user acceptance and to constrain system loading, we assert multimedia transmission and transport times should be comparable to those of current data usages. Thus, information transfer rates in the high kb/s to low Mb/s range will likely be required depending upon the compressed file size in order to provide response times comparable to current status message data usage.

## **APPENDIX A**

### **Aggregated Public Safety Communications User**

#### **TRAFFIC PROFILES**

**25 MAY 1995**  
**(reprinted 13 March 1996)**

<b>PUBLIC SAFETY OFFICER</b> AVERAGE BUSY HOUR TRAFFIC PROFILE PRESENT REQUIREMENTS SUMMARY	Inbound Erlangs	Outbound Erlangs
<b>VOICE</b>	0.0073484	0.0462886
<b>DATA</b>	0.0004856	0.0013018
<b>STATUS</b>	0.0000357	0.0000232
<b>Resulting Subscriber Busy Hour Traffic Loading</b>	0.0078696	0.0476136
	<b>TOTAL</b>	0.0554832

<b>PUBLIC SAFETY OFFICER</b> AVERAGE BUSY HOUR TRAFFIC PROFILE FUTURE REQUIREMENTS SUMMARY	Inbound Erlangs	Outbound Erlangs
<b>VOICE</b>	0.0073284	0.0463105
<b>DATA</b>	0.0030201	0.0057000
<b>STATUS</b>	0.0001540	0.0002223
<b>Resulting Subscriber Busy Hour Traffic Loading</b>	0.0105026	0.0522328
	<b>TOTAL</b>	0.0627354

<b>PUBLIC SAFETY OFFICER</b> AVERAGE HOUR TRAFFIC PROFILE PRESENT REQUIREMENTS SUMMARY	Inbound Erlangs	Outbound Erlangs
<b>VOICE</b>	0.0018371	0.0115722
<b>DATA</b>	0.0001214	0.0003254
<b>STATUS</b>	0.0000089	0.0000058
<b>Resulting Subscriber Average Hour Traffic Loading</b>	0.0019674	0.0119034
	<b>TOTAL</b>	0.0138708

<b>PUBLIC SAFETY OFFICER</b> AVERAGE HOUR TRAFFIC PROFILE FUTURE REQUIREMENTS SUMMARY	Inbound Erlangs	Outbound Erlangs
<b>VOICE</b>	0.0018321	0.0115776
<b>DATA</b>	0.0007550	0.0014250
<b>STATUS</b>	0.0000385	0.0000556
<b>Resulting Subscriber Average Hour Traffic Loading</b>	0.0026256	0.0130582
	<b>TOTAL</b>	0.0156838

<b>PUBLIC SAFETY OFFICER</b> AVERAGE BUSY HOUR TRAFFIC PROFILE	Inbound	Outbound
FUTURE REQUIREMENTS SUMMARY (SPECIAL DATA)	Erlangs	Erlangs
<b>SPECIAL DATA</b>	0.0268314	0.0266667
<b>Resulting Subscriber Busy Hour Traffic Loading</b>	0.0268314	0.0266667
	<b>TOTAL</b>	0.053498

<b>PUBLIC SAFETY OFFICER</b> AVERAGE HOUR TRAFFIC PROFILE	Inbound	Outbound
FUTURE REQUIREMENTS SUMMARY (SPECIAL DATA)	Erlangs	Erlangs
<b>SPECIAL DATA</b>	0.0067078	0.0066667
<b>Resulting Subscriber Busy Hour Traffic Loading</b>	0.0067078	0.0066667
	<b>TOTAL</b>	0.0133745

Public Safety Officer Busy Hour Traffic Profile FUTURE REQUIREMENTS		Traffic Channel Loading							
TELESERVICES	OPERATIONS	INBOUND				OUTBOUND			
		Tn	Td	M	OFFERED LOAD (erlangs)	Tn	Td	M	OFFERED LOAD (erlangs)
VOICE (Note 1)	Group								
	Special Info/Assign	2	2.00	1.260	0.0014000	2	2.00	1.385	0.0015385
	Medical Detail	2	2.00	0.009	0.0000104	2	2.00	0.009	0.0000104
	Bomb/Explosive Alert	2	2.00	0.009	0.0000104	2	2.00	0.009	0.0000104
	Conduct Investigation	2	2.00	0.210	0.0002333	2	2.00	0.231	0.0002564
	Individual								
	Special Info/Assign	2	4.80	0.840	0.0022400	2	2.50	0.923	0.0012821
	Medical Detail	2	2.50	0.019	0.0000259	2	1.25	0.021	0.0000142
	Conduct Investigation	2	4.80	0.105	0.0002800	2	2.50	0.115	0.0001603
	Traffic Report	2	2.50	0.210	0.0002917	2	1.25	0.210	0.0001458
	Bomb/Explosive Alert	2	2.50	0.005	0.0000065	2	1.25	0.005	0.0000032
	Emergency	2	2.50	0.009	0.0000130	2	1.25	0.009	0.0000065
	Vehicle Report	2	6.00	0.525	0.0017500	2	2.50	0.525	0.0007292
	Persons Report	2	6.00	0.315	0.0010500	2	2.50	0.315	0.0004375
	Broadcast								
	Special Info/Assign	1	3.00	0.009	0.0000078	1	6.00	0.009	0.0000156
	Emergency	1	3.00	0.004	0.0000029	1	6.00	0.004	0.0000058
	Bomb/Explosive Alert	1	3.00	0.005	0.0000039	1	1.00	0.005	0.0000013
	Hazardous Material	2	2.00	0.0004	4.44E-07	2	2.00	0.004	0.0000044
	EMS Control and General	2	10.00	0.0004	2.22E-06	2	10.00	0.004	0.0000222
	PSTN								
	Special Info/Assign	2	10.00	0.0000100	0.0000001	2	12.00	0.0000100	0.0000001
	Unit-to-Unit Tactical	0	0.00	0.000	0	3	20.00	2.500	0.041667

<b>Public Safety Officer</b> Busy Hour Traffic Profile FUTURE REQUIREMENTS									
<b>TELESERVICES</b>	<b>OPERATIONS</b>	<b>Traffic Channel Loading</b>							
		<b>INBOUND</b>				<b>OUTBOUND</b>			
		Tn	Td	M	OFFERED LOAD (erlangs)	Tn	Td	M	OFFERED LOAD (erlangs)
<b>Total Contributions</b>		33	70.60	3.535	0.0073284	36	80.00	6.283	0.0463105
<b>DATA (Note 2)</b>									
Hazardous Material		1	1.00	0.004	0.0000011	1	1.00	0.004	0.0000011
EMS Control and General	Public Safety Reports	1	5.00	0.004	0.0000056	1	5.00	0.004	0.0000056
	Missing	1	0.80	0.068	0.0000150	1	2.40	0.068	0.0000450
	Unidentified	1	0.80	0.270	0.0000600	2	2.40	0.270	0.0003600
Stolen Articles	License Plate	1	0.80	0.135	0.0000300	2	2.40	0.135	0.0001800
	Serial Number	1	0.80	0.036	0.0000081	2	2.40	0.036	0.0000486
	Identification Number	1	0.80	0.090	0.0000201	1	2.40	0.090	0.0000603
Alarm Compliance	Burglary	1	0.80	0.036	0.0000081	1	2.40	0.036	0.0000243
	Ringling	1	0.80	0.018	0.0000039	1	2.40	0.018	0.0000117
	Vandalism	1	0.80	0.068	0.0000150	1	2.40	0.068	0.0000450
	Robbery	1	0.80	0.068	0.0000150	1	2.40	0.068	0.0000450
For Information (FI)	Suspicious Persons	1	2.40	4.000	0.0026667	1	4.00	4.000	0.0044444
Addr/Tel Info (ATI)	Suspicious Persons	1	1.60	0.386	0.0001716	1	4.00	0.386	0.0004290
Voiceless Dispatch	(see voice)								
<b>Total Contributions</b>		13	17.20	5.183	0.0030201	16	35.60	5.183	0.0057000

<b>Public Safety Officer</b> Busy Hour Traffic Profile FUTURE REQUIREMENTS									
<b>TELESERVICES</b>	<b>OPERATIONS</b>	<b>Traffic Channel Loading</b>							
		<b>INBOUND</b>				<b>OUTBOUND</b>			
		Tn	Td	M	OFFERED LOAD (erlangs)	Tn	Td	M	OFFERED LOAD (erlangs)

STATUS	Special Info/Enroutes	1	0.03	6.000	0.0000500	1	0.03	3.000	0.0000250
	Network Management	1	0.80	0.420	0.0000933	1	1.60	0.420	0.0001867
SYSTEM CONTROL									
	Security Registration								
	Authentication	1	1.03	0.009	0.0000027	1	1.03	0.009	0.0000027
	Corroboration	1	3.09	0.009	0.0000080	1	3.09	0.009	0.0000080
Total Contributions		4	4.95	6.439	0.0001540	4	5.75	3.439	0.0002223

<b>TELESERVICES</b>	<b>OPERATIONS</b>	<b>INBOUND</b>				<b>OUTBOUND</b>			
		Tn	Td	M	OFFERED LOAD (erlangs)	Tn	Td	M	OFFERED LOAD (erlangs)
<b>SPECIAL DATA</b>									
	Slow Scan	1	100.00	0.060	0.001667	1	100.00	0.060	0.0016667
	Images Mugshot	1	30.0	1.000	0.0083333	1	30.0	1.000	0.0083333
	Fingerprint	1	30.0	1.000	0.0083333	1	30.0	1.000	0.0083333
	Object ID	1	30.0	1.000	0.0083333	1	30.0	1.000	0.0083333
Total Contributions		4	190.00	3.060	0.0268314	4	190.00	3.060	0.0266667

<b>Public Safety Officer</b>									
<b>Busy Hour Traffic Profile</b>									
<b>PRESENT REQUIREMENTS</b>									
<b>TELESERVICES</b>	<b>OPERATIONS</b>	<b>Traffic Channel Loading</b>							
		<b>INBOUND</b>				<b>OUTBOUND</b>			
		<b>Tn</b>	<b>Td</b>	<b>M</b>	<b>OFFERED LOAD (erlangs)</b>	<b>Tn</b>	<b>Td</b>	<b>M</b>	<b>OFFERED LOAD (erlangs)</b>
VOICE (Note 1)									
Group	Special Info/Assign	2	2.00	1.260	0.0014000	2	2.00	1.385	0.0015385
	Medical Detail	2	2.00	0.009	0.0000104	2	2.00	0.009	0.0000104
	Bomb/Explosive Alert	2	2.00	0.009	0.0000104	2	2.00	0.009	0.0000104
	Conduct Investigation	2	2.00	0.210	0.0002333	2	2.00	0.231	0.0002564
Individual	Special Info/Assign	2	4.80	0.840	0.0022400	2	2.50	0.923	0.0012821
	Medical Detail	2	2.50	0.019	0.0000259	2	1.25	0.021	0.0000142
	Conduct Investigation	2	4.80	0.105	0.0002800	2	2.50	0.115	0.0001603
	Traffic Report	2	2.50	0.210	0.0002917	2	1.25	0.210	0.0001458
	Bomb/Explosive Alert	2	2.50	0.005	0.0000065	2	1.25	0.005	0.0000032
	Emergency	2	2.50	0.009	0.0000130	2	1.25	0.009	0.0000065
	Vehicle Report	2	6.00	0.525	0.0017500	2	2.50	0.525	0.0007292
	Persons Report	2	6.00	0.315	0.0010500	2	2.50	0.315	0.0004375
Broadcast	Special Info/Assign	1	3.00	0.009	0.0000078	1	1.00	0.009	0.0000026
	Emergency	1	3.00	0.004	0.0000029	1	1.00	0.004	0.0000010
	Bomb/Explosive Alert	1	3.00	0.005	0.0000039	1	1.00	0.005	0.0000013
Hazardous Material		2	2.00	0.0004	4.444E-07	2	2.00	0.0004	4.444E-07
EMS Control and General	Public Safety Reports	2	10.00	0.004	2.222E-05	2	10.00	0.004	2.222E-05
PSTN	Special Info/Assign	2	7.20	0.0000100	0.0000000	1	7.20	0.0000100	0.0000000

<b>Public Safety Officer</b>									
Busy Hour Traffic Profile									
PRESENT REQUIREMENTS									
TELESERVICES	OPERATIONS	Traffic Channel Loading							
		INBOUND				OUTBOUND			
		Tn	Td	M	OFFERED LOAD (erlangs)	Tn	Td	M	OFFERED LOAD (erlangs)
Unit-to-Unit Tactical		0	0.00	0.000	0	3	20.00	2.500	0.0416667
Total Contributions		33	67.80	3.538	0.0073484	35	65.20	6.279	0.0462886
DATA (Note 2)									
Hazardous Material		1	1.00	0.004	0.0000011	1	1.00	0.004	0.0000011
EMS Control and Public Safety Reports General		1	5.00	0.004	0.0000056	1	5.00	0.004	0.0000056
	Missing	1	0.80	0.050	0.0000111	1	2.40	0.050	0.0000333
	Unidentified	1	0.80	0.200	0.0000444	2	2.40	0.200	0.0002667
Stolen Articles	License Plate	1	0.80	0.100	0.0000222	2	2.40	0.100	0.0001333
	Serial Number	1	0.80	0.027	0.0000060	2	2.40	0.027	0.0000360
	Identification Number	1	0.80	0.067	0.0000149	1	2.40	0.067	0.0000447
Alarm Compliance	Burglary	1	0.80	0.027	0.0000060	1	2.40	0.027	0.0000180
	Ringling	1	0.80	0.013	0.0000029	1	2.40	0.013	0.0000087
	Vandalism	1	0.80	0.050	0.0000111	1	2.40	0.050	0.0000333
	Robbery	1	0.80	0.050	0.0000111	1	2.40	0.050	0.0000333
For Information (FI)	Suspicious Persons	1	2.40	0.333	0.0002220	1	4.00	0.333	0.0003700
Addr/Tel Info (ATI)	Suspicious Persons	1	1.60	0.286	0.0001271	1	4.00	0.286	0.0003178
	Voiceless Dispatch (see voice)								
Total Contributions		13	17.20	1.211	0.0004856	16	35.60	1.211	0.0013018

Public Safety Officer Busy Hour Traffic Profile PRESENT REQUIREMENTS									
TELESERVICES	OPERATIONS	Traffic Channel Loading							
		INBOUND				OUTBOUND			
		Tn	Td	M	OFFERED LOAD (erlangs)	Tn	Td	M	OFFERED LOAD (erlangs)
STATUS	Special Info/Enroutes	1	0.03	3.000	0.0000250	1	0.03	1.500	0.0000125
SYSTEM CONTROL									
	Security Registration								
	Authentication	1	1.03	0.009	0.0000027	1	1.03	0.009	0.0000027
	Corroboration	1	3.09	0.009	0.0000080	1	3.09	0.009	0.0000080
Total Contributions		3	4.15	3.019	0.0000357	3	4.15	1.519	0.0000232

**APPENDIX E**

Focus Groups Report  
Future Data Applications for Public Safety Communications  
(D.S. Howard & Associates)

**NOTE:** *The electronic version of this document was unavailable at the time this report was prepared. Readers can find the full text of this document in FCC WT Docket No. 96-86.*

## APPENDIX F LOS ANGELES AREA FREQUENCY REUSE

For this paper, the Los Angeles area is the 5 county region of Los Angeles, Orange, Ventura, Riverside, and San Bernardino Counties. The defined area is based upon the local experience showing frequency assignments in Los Angeles County impact the assignments in the surrounding counties. This does not imply that a frequency assignment cannot be reused within the area, only that assignments must be coordinated as a total area.

The Association of Public-Safety Officials-International (APCO) local frequency advisors maintain a database of frequency assignments to agencies in this region. This database tracks each public safety agency licensed on a frequency. This database was used for 150 MHz and 450 MHz band reuse. The NPSPAC Region 5 frequency assignment list, excluding mutual aid channels, was used for reuse factors for the NPSPAC 800 MHz assignments.

The assignments (or licenses) at 150 MHz and 450 MHz are typically made to smaller agencies. The NPSPAC assignments are typically made on a county-wide basis for regional multi-agency systems. This indicates the smallest reuse on the NPSPAC frequencies, although a frequency may be reused more than once in a regional system. At 150 MHz, the assignments are on an individual frequency basis. At 450 MHz and 800 MHz, the assignments are for a channel (two paired frequencies). The complete listing of assignments was used for the NPSPAC reuse factors and a sampling of frequencies was used at 150 MHz and 450 MHz.

The average reuse is listed below:

	<b>Assignments</b>	<b>Frequencies</b>	<b>Average Reuse</b>
150 MHz	81	24	3.4
450 MHz	31	11	2.8
800 MHz	300	216	1.39

The reuse pattern is explained by the history of frequency assignments in the area. The 150 MHz band was the primary band for most users. The 450 MHz band and later TV sharing bands were allocated and the larger agencies tended to migrate to these bands. Some smaller agencies also operate in the UHF bands. The 800 MHz bands are licensed almost entirely to large agencies with many systems serving several agencies or departments as consolidated systems. These reuse figures reflect this history with many geographically small users at 150 MHz, fewer medium-sized users at 450 MHz, and a few large users at 800 MHz.

These assignments are for voice dispatch systems and a few mobile data systems. Mobile data systems, while only a minority of the assignments and primarily used by larger agencies, are configured to cover the same geographical areas as a voice system for any particular agency. Mobile data systems can handle more units on a channel than voice. Geographically larger mobile data systems have some reuse because the channel can send data to different units (one to one, rather than the one to many configuration for voice) from separate sites simultaneously. Other services, such as snapshot and slow scan video are extensions of the current mobile data systems. They can operate on existing mobile data systems, possibly

needing higher data rates. The reuse of frequencies for these services may be greater than for voice systems.

Full motion video systems require more bandwidth for the higher data rates required. The hold times are longer than voice systems. These factors differ from voice systems but do not influence the reuse of frequencies designated for video systems. As a new service, video systems should follow the implementation history of mobile data systems with implementation by larger agencies first. Considering the infrastructure costs, there will be incentives for smaller agencies to join large regional systems. This argues for a reuse pattern similar to other large mobile data systems.

The last issue is the reuse spread of 1.39 for 800 MHz to 3.4 for 150 MHz. Public safety agencies operating in the 150 MHz band are typically small single users, such as a city fire department or a special district. The band still has many simplex systems with mobile only frequencies. Many users would like to upgrade to mobile relay systems. The 450 MHz band is a mix of medium and large agencies. This mix is the prime reason for lower reuse in this band than 150 MHz. Both bands are quite crowded with interference problems between users. The 800 MHz band is typically assigned for large county-wide systems. There is some reuse within the systems and not reflected in the assignment list.

What should the reuse factor be in the spectrum prediction model? For voice systems, a middle factor using the 450 MHz band is reasonable. It should be reduced to account for the crowding in the band. A factor of 2.5 is proposed for voice systems. This same factor will apply to slow data (including status/message). These categories are typically configured the same as voice systems.

A reuse factor for high speed data systems (special data) is more difficult to determine. If it is assumed there is some inherent additional reuse in high speed data systems due to the one to one communications rather than the one to many found in the voice systems, a factor higher than 2.5 is appropriate. A factor of 3.4 could be used which reflects the highest reuse found in today's systems. However, these high speed data systems are not installed today so there can be better planning for reuse to reflect the one to one nature of the communications. In urban areas, it is probable that higher frequencies will be used to build these systems, allowing smaller footprints and thus higher reuse. However, this reuse will not approach cellular system reuse factors. Public safety systems are designed to cover operational areas of the agencies. Another critical distinction between cellular systems and public safety data systems is the significantly higher user density of cellular systems; this, in turn, supports much smaller cell sizes. This does not imply that public safety high speed data systems can alternatively be carried on the cellular network. Given all these factors, a reuse factor of 4.0 is proposed as reasonable for high speed data.

**APPENDIX G**

**SPECTRUM COMPUTATION FOR NON-FEDERAL PUBLIC SAFETY**

**FREQ. MHz = ERL\*(10000\*POP\*PEN\*SRC)/(COD\*RATE\*LOAD\*REUS\*[100-ERR])**

**SPECTRUM COMPUTATION FOR POLICE THROUGH THE YEAR 2010**

	Avg ERL/User	POP in thou.	PEN,%	Computed Net Pop, thous.	SRC, kb/s	COD	RATE b/s/Hz	LOAD,%	REUS	ERR,%	Computed MHz in 2010
Voice	0.0538	89.4	65	58.11	6	2	1.5	54.5	2.5	50	9.2
Data	0.0087	89.4	35	31.29	6	1	1.5	54.5	2.5	50	1.6
Stat/Messg	0.0004	89.4	31	27.71	6	2	1.5	54.5	2.5	50	0.0
W.B. Data	0.0140	89.4	23	20.56	384	3	3.5	54.5	4	50	9.7
Video	0.0240	89.4	14	12.52	384	3	3.5	54.5	4	50	10.1

**SPECTRUM COMPUTATION FOR FIRE THROUGH THE YEAR 2010**

	Avg ERL/User	POP in thou.	PEN,%	Computed Net Pop,thous.	SRC, kb/s	COD	RATE b/s/Hz	LOAD,%	REUS	ERR,%	Computed MHz in 2010
Voice	0.0484	164.7	51	84.00	6	2	1.5	54.5	2.5	50	11.9
Data	0.0087	164.7	27	44.47	6	1	1.5	54.5	2.5	50	2.3
Stat/Messg	0.0004	164.7	31	51.06	6	2	1.5	54.5	2.5	50	0.1
W.B. Data	0.0140	164.7	28	46.12	384	3	3.5	54.5	4	50	21.7
Video	0.0240	164.7	20	32.94	384	3	3.5	54.5	4	50	26.5

**SPECTRUM COMPUTATION FOR EMS THROUGH THE YEAR 2010**

	Avg ERL/User	POP in thou.	PEN,%	Computed Net Pop,thous.	SRC,kb/s	COD	RATE b/s/Hz	LOAD,%	REUS	ERR,%	Computed MHz in 2010
Voice	0.0484	55.8	47	26.23	6	2	1.5	54.5	2.5	50	3.7
Data	0.0087	55.8	45	25.11	6	1	1.5	54.5	2.5	50	1.3
Stat/Messg	0.0004	55.8	34	18.97	6	2	1.5	54.5	2.5	50	0.0
W.B. Data	0.0140	55.8	31	17.30	384	3	3.5	54.5	4	50	8.1
Video	0.0240	55.8	17	9.49	384	3	3.5	54.5	4	50	7.6

SPECTRUM COMPUTATION FOR GENERAL GOVERNMENT THROUGH THE YEAR 2010

	Avg ERL/User	POP in thou.	PEN,%	Computed Net Pop,thous.	SRC,kb/s	COD	RATE b/s/Hz	LOAD,%	REUS	ERR,%	Computed MHz in 2010
Voice	0.0430	269.8	22	59.36	6	2	1.5	54.5	2.5	50	7.5
Data	0.0087	269.8	1	2.70	6	1	1.5	54.5	2.5	50	0.1
Stat/Messg	0.0004	269.8	16	43.17	6	2	1.5	54.5	2.5	50	0.1
W.B. Data	0.0140	269.8	1	2.70	384	3	3.5	54.5	4	50	1.3
Video	0.0240	269.8	3	8.09	384	3	3.5	54.5	4	50	6.5

**SPECTRUM COMPUTATION FOR PUBLIC SAFETY THROUGH THE YEAR 2010**

	<b>POLICE</b>	<b>FIRE</b>	<b>EMS</b>	<b>GEN. GOVT</b>	<b>TOTAL</b>
<b>Voice</b>	<b>9.2</b>	<b>11.9</b>	<b>3.7</b>	<b>7.5</b>	<b>32.3</b>
<b>Data</b>	<b>1.6</b>	<b>2.3</b>	<b>1.3</b>	<b>0.1</b>	<b>5.3</b>
<b>Stat/Message</b>	<b>0.0</b>	<b>0.1</b>	<b>0.0</b>	<b>0.1</b>	<b>0.2</b>
<b>W.B. Data</b>	<b>9.7</b>	<b>21.7</b>	<b>8.1</b>	<b>1.3</b>	<b>40.8</b>
<b>Video</b>	<b>10.1</b>	<b>26.5</b>	<b>7.6</b>	<b>6.5</b>	<b>50.7</b>
<b>TOTAL</b>	<b>30.6</b>	<b>62.5</b>	<b>20.7</b>	<b>15.5</b>	<b>129.3</b>
<b>EXISTING SPECTRUM USED IN 2010</b>					<b>-23.4</b>
<b>SPECTRUM PROVIDED BY COMMERCIAL SERVICES</b>					<b>-10.6</b>
<b>NET SPECTRUM NEED BY 2010</b>					<b>95.3</b>

**APPENDIX H**

Department of Defense Comments  
(Office of the Assistant Secretary of Defense Letter - July 18, 1996)

***NOTE: The electronic version of this document was  
unavailable at the time this report was prepared.  
Readers can find the full text of this document in  
FCC WT Docket No. 96-86.***

## **APPENDIX I**

### **PUBLIC SAFETY FIXED SERVICE SPECTRUM REQUIREMENTS**

To determine the amount of additional spectrum required by public safety for fixed services through the year 2010, an analysis was completed using the Los Angeles area. The State of California, the County of Los Angeles, and the City of Los Angeles each submitted microwave growth requirement through the year 2010. The results are representative of metropolitan areas as the requirements were based upon population, terrain, density, and extensive need for wireless carrier systems. The following discussion relates to identified needs in the Los Angeles area only.

Projections from the agencies listed above are based on past growth and projected future growth. This analysis includes considerations for new technology. New applications will certainly add to growth projections in the near future. Because there is no specific way to quantify the effect of new applications, spectrum for non-identified purposes is not included.

Based on growth projections, the State of California identifies a need for 68 new digital microwave links. Also, 31 links for the County of Los Angeles, 27 links for Los Angeles City, and 20 links to serve the more than 100 incorporated cities within a 30-mile radius of the Los Angeles Civic Center were identified. In a heavily populated area such as Los Angeles, there is a large capacity (i.e., channel) requirement.

Listed below are the link and band requirements. These requirements were used to calculate the microwave spectrum requirements.

<u><b>AGENCY</b></u>	<u><b>CAPACITY</b></u>
California State	20 DS3
Los Angeles County	31 DS3
Los Angeles City	26 DS3
	11 OC3
100+ Los Angeles Cities	56 DS1
	21 DS2
	6 DS3
	3 OC3

### **PATH LENGTH**

<u><b>CALIFORNIA STATE</b></u>	<u><b>20 DS3</b></u>
--------------------------------	----------------------

11%= 2 links <16 KM ≤18 GHz ≥ 6 GHz  
 18 links >16 KM ≤ 6 GHz

**LA COUNTY**

**31 DS3**

6 links <16 KM ≤18 GHz  
 25 links >16 KM ≤ 6 GHz

**100 LA CITIES**

56 DS1	<16 KM	≤18 GHz
21 DS2	<u>11</u>	<18 GHz
6 DS3	<u>11</u>	≤19 GHz
3 OC3s	<u>11</u>	<11 GHz

**LA CITY**

**26 DS3**

60%	16 links	≤16 KM	≤ 6 GHz
40%	10 links	≤16 KM	≤18 GHz

(11 OC3)

6 links	≥16 KM	≤ 6 GHz
5 links	≤16 KM	<20 DS3

**BANDS**

	2-8 GHz	10-18 GHz
(a) <b>LA CITY</b>	16 DS3 6 OC3	10 DS3 5 OC3
(b) <b>LA CITIES</b>		3 OC3} 6 DS3} 21 DS2} 20 DS3 56 DS1}
(c) <b>CAL STATE</b>	18 DS3	2 DS3
(d) <b>LA COUNTY</b>	25 DS3	6 DS3

A 30-mile radius from the Los Angeles Civic Center was used in calculating the reuse factor. This area was selected as it is the most congested within the greater Los Angeles area, and will continue to have the highest channel loading requirements. Using the FCC's third party database, an inventory of all 6500 MHz to 6900 MHz microwave systems within a 30-mile

radius of the Civic Center was completed. This analysis was made to determine what a realistic reuse factor is, based upon real data.

$$\text{Spectrum} = \frac{\text{Links} * \text{BW} * 2}{\text{Reuse Factor}}$$

Using data from the existing 6 GHz (heavily congested) data base for Los Angeles, the reuse factor is 11.8(x12) for this calculation.

**NON-FEDERAL PUBLIC SAFETY SPECTRUM REQUIREMENTS**

2-8 GHz  
 65 DS3 Spectrum =  $\frac{65 * 20}{12} = 108.3 \text{ MHz}$

A higher reuse factor for bands ranging from 10-18 GHz was chosen because the higher frequencies had shorter propagation (even though the lower portion of this range, 11-12 GHz, travels over 30 miles). A factor of 20 was considered reasonable.

10-18 GHz                      Spectrum =  $\frac{53 * 20}{20} = 53 \text{ MHz}$

This analysis indicates a total of 161.3 MHz (108.3 MHz + 53 MHz) is required through the year 2010. This recommendation should accommodate other metropolitan areas; less populated areas should require somewhat less additional microwave spectrum.

**EXISTING MICROWAVE ALLOCATION SHARED/PUBLIC SAFETY**

<b><u>BAND (MHz)</u></b>	<b><u>SHARED BANDWIDTH AVAILABLE</u></b>	<b><u>PUBLIC SAFETY LICENSES</u></b>	<b><u>PUBLIC SAFETY BANDWIDTH</u></b>
900	13 MHz	$\frac{3}{31} = 10\%$	1.3 MHz
2130-2150	20 MHz	$\frac{19}{57} = 33\%$	6.6 MHz
2180-2200	20 MHz	$\frac{18}{55} = 33\%$	6.6 MHz
3720-4100	380 MHz	$\frac{0}{7} = 0\%$	0
5927-6425	498 MHz	$\frac{18}{233} = 8\%$	40 MHz
6525-6875	350 MHz	$\frac{245}{408} = 60\%$	210 MHz
10550-10680	130 MHz	$\frac{45}{167} = 27\%$	35 MHz
10700-11700	1000 MHz	$\frac{23}{167} = 13\%$	130 MHz

17705-18120	450 MHz	179 68=52% 130	234 MHz
<b><u>BAND (MHz)</u></b>	<b><u>SHARED BANDWIDTH AVAILABLE</u></b>	<b><u>PUBLIC SAFETY LICENSES</u></b>	<b><u>PUBLIC SAFETY BANDWIDTH</u></b>
18762.5-18817.5	55 MHz	26=50% 52	26 MHz
19102.5-19157.5	55 MHz	20=48% 41	26 MHz

**Total Existing Public Safety Microwave Spectrum = 715 MHz**

To demonstrate that public safety users are aware of the need to conserve spectrum wherever possible, we compared the ratios of the existing microwave spectrum used by public safety to the spectrum now allocated for voice and data to the new requirements ratio of the same, i.e., present microwave spectrum used by public safety (715 MHz) divided by the present voice/data allocation (23 MHz) = 31.08. Future microwave spectrum required (161 MHz) divided by the future voice/data/video spectrum requirements (95 MHz) = 1.7.

The comparison of these ratios demonstrates the amount of microwave spectrum required for public safety through 2010 is ver conservative; 18 times less than that used by today.

All presently allocated links to which public safety has access are heavily used in the 30-mile radius of the Los Angeles area that was used for this case study. There is a growing demand for the microwave spectrum that is still available in the defined area, including numerous new users such as local and long distance PCS providers, telephone carriers, and cellular providers. It is becoming virtually impossible to license new microwave spectrum.

Another reason for the scarcity of microwave spectrum is that public safety has lost the use of the 1850-1990 MHz band to PCS and the 12.2-12.7 GHz band to Direct Broadcast Satellite systems, a loss of 190 MHz of spectrum. There is also a threat of losing an additional 40 MHz in the 2130-2150 MHz and 2180-2200 MHz bands. The common carrier bands that were made available to public safety to help with the spectrum losses to PCS are extremely congested and will soon be fully utilized as the users in the 1850-1990 MHz are forced to relocate.

This study and the requirements for the microwave spectrum for state and local public safety considered the use of fiber optics and commercial wire lines. These services are being used now and will continue to be used wherever it is practical and not cost-prohibitive. Use of fiber optic links to most mountain top locations where base stations and repeaters are located is cost-prohibitive, has serious right-of-way problems, and is susceptible to earthquakes to fires and flooding (especially in California). High reliability of links is essential to public safety; outages usually affect many circuits and cannot be tolerated.

As an example of fiber optics use, Los Angeles County is presently utilizing 48 DS3 and 12 OC3 fiber links. By the year 2010, they are planning to use 500 DS3 and 150 OC3 links. Agencies such as the City of Los Angeles, the State of California, and other cities presently use fiber and have similar plans for the future.

Assuming the use of commercial wirelines, fiber optics, and new technology, a very aggressive reduction of microwave usage by the year 2010 is projected. The following time frame for required 161 MHz of additional microwave spectrum is provided:

<u>TIME</u>	<u>ADDITIONAL SPECTRUM REQUIREMENTS</u>
Present through 1999	75 MHz
2000 - 2005	50 MHz
2006 - 2010	36 Mhz

**APPENDIX J**

White Paper:  
Frequency Band Selection Analysis  
(Motorola)

***NOTE: The electronic version of this document was  
unavailable at the time this report was prepared.  
Readers can find the full text of this document in  
FCC WT Docket No. 96-86.***

**APPENDIX K**

Department of Defense Comments  
(Letter dated July 29, 1996)

***NOTE: The electronic version of this document was  
unavailable at the time this report was prepared.  
Readers can find the full text of this document in  
FCC WT Docket No. 96-86.***

**6.5 APPENDIX E - Transition Subcommittee Report**  
**FINAL REPORT OF THE TRANSITION SUBCOMMITTEE**  
**Date: July 5, 1996**

1.0 Executive Summary.

Other PSWAC Subcommittees have made recommendations regarding the future operational requirements of public safety agencies, methods for achieving greater interoperability among agencies, the technologies that are and will be available to meet public safety requirements, and the amount of radio spectrum that will be necessary to accomplish these public safety goals. This Transition Subcommittee report examines and proposes procedures for public safety agencies to transition to new technologies and new spectrum in an efficient, cost effective manner that does not interfere with their mission critical operations.

Any significant transition will require public safety agencies to acquire new radio equipment and possibly modify their operations and spectrum management. The Transition Subcommittee proposes incentives for agencies to make those changes within a reasonable time frame, but with minimum disruption.

Public safety radio systems in frequencies below 512 MHz now operate in a shared frequency environment, though careful frequency coordination has allowed for a significant degree of de facto exclusivity to avoid harmful interference to vital emergency communications. The Subcommittee proposes that public safety licensees be granted formal, exclusive licenses for a Protective Service Area limited to the licensee's area of jurisdiction. With such exclusivity, licensees are more likely to expend resources to adopt new technologies.

The FCC has adopted "spectrum refarming" rules to encourage the use of narrowband radio equipment in bands below 512 MHz which, for example, allows current 25 kHz wide channels to be split into at least two 12.5 kHz channels, and eventually into four 6.25 kHz channels. The benefits of refarming, however, will not be realized until a substantial number of users acquire new radio systems capable of operating in the narrower channels.

To facilitate the transition to narrower channels, the Transition Subcommittee believes that current metropolitan area public safety users should be required to convert to more spectrum efficient equipment by the year 2005. This will allow users to realize the useful life of current equipment, without creating a situation in which one small agency prevents others from enjoying the benefits of spectrum efficient technology. The approach recommended by the Transition Subcommittee is also consistent with the migration plan adopted by NTIA for Federal Government users.

Coordinating use of new narrower channel operation will require adoption of technical standards for evaluating potential co-channel and adjacent channel interference. The Subcommittee urges the FCC to consider adoption of standards recently proposed in this regard by TIA TR8 Working Group 8.8.

The Transition Subcommittee believes that effective spectrum management of current operations below 512 MHz can best be accomplished through the current public safety radio services (Police, Fire, Local Government, Emergency Medical, Highway Maintenance, and Forestry Conservation). However, should the FCC proceed with its plan to consolidate these radio services, the Subcommittee believes that there should be a separate Public Safety Pool containing all of these services, with frequency coordination performed by the current public safety coordinators, each serving their own constituency.

The Transition Subcommittee also supports the use of intensive regional spectrum planning for congested metropolitan areas, and more generic planning approaches for rural areas. Another important method of achieving spectrum efficiency and interoperability is the creation of wide-area, multi-agency communications systems. While there should be encouragement and perhaps incentive for agencies to form such consolidated operations, shared systems will only succeed with the cooperation and consent of participating agencies. Therefore, system consolidation should be on a voluntary basis with appropriate recognition of the need to maintain local autonomy.

The Subcommittee also addressed the process of implementing new public safety spectrum allocations. How that transition will occur will depend upon factors such as which spectrum bands are targeted, the propagation characteristics of the bands, the type of technologies being implemented, the cost of the new operation, the types of infrastructure that will be required, whether the new spectrum will be shared by federal and non-federal users, and whether the new bands are encumbered by current non-public safety users.

A key issue in any transition will be how public safety agencies will raise sufficient funds to acquire new equipment. The Subcommittee explored several options, including traditional federal, state, and local funding, as well as more innovative funding mechanisms.

The Subcommittee also believes that there is a need for greater cooperation between federal and non-federal regulatory agencies to facilitate more efficient use of spectrum. FCC and NTIA rules need to be modified to facilitate sharing, and there needs to be a mechanism for greater information exchange between federal and non-federal users as to which bands and which locations are viable for spectrum sharing.

It is apparent that commercial services are likely to play an increasingly important role in the future. Nevertheless, the Subcommittee believes that the vast majority of public safety radio communications will necessarily remain on "private radio" systems owned and operated by public safety agencies. For most critical public safety communications, commercial services will not provide a sufficient level of coverage, reliability, restoration, priority access and security.

## 2.0 Transition Subcommittee Charter Overview.

2.0.1 The migration to new technologies and new spectrum allocations for public safety use involves a host of technical, licensing, interoperability, and funding issues. The Transition Subcommittee's charter is to examine these issues in an effort to provide the

Federal Communications Commission (FCC or Commission) and the Department of Commerce's National Telecommunications and Information Administration (NTIA) guidance on how to meet the public safety community's wireless communications needs.

2.0.2 More specifically, the Transition Subcommittee's primary mission is to establish a strategy that provides for the smooth and orderly transition to newer technologies and new spectrum allocated for use by non-Federal and Federal public safety entities. As public safety equipment becomes more outdated, non-Federal and Federal public safety entities must be in a position to migrate to newer and more efficient technologies, new frequency channelization schemes, and new spectrum allocations in a smooth and timely fashion. The Transition Subcommittee has thus been tasked with developing a plan for the migration to newer, more efficient technologies in both current and future spectrum allocated for use by non-Federal and Federal public safety agencies. To this end, the Transition Subcommittee considers: (i) whether the migration should be voluntary or mandatory; and, (ii) whether different migration timetables should be established for rural as opposed to urban areas.

2.0.3 The Transition Subcommittee has also been tasked to examine spectrum management options that may lead to more efficient use of current and future public safety spectrum allocations by both non-Federal and Federal public safety entities. The Transition Subcommittee examines the current non-Federal and Federal licensing processes to determine whether they can be modified and streamlined to reduce the paperwork burden on both the FCC and NTIA and public safety agencies. Additionally, the Transition Subcommittee examines whether non-Federal and Federal public safety agencies can more effectively and efficiently share spectrum allocations and otherwise improve the coordination between non-Federal and Federal public safety agencies.

2.0.4 The Transition Subcommittee has also been chartered to examine the various commercial wireless radio services that are available in the marketplace and how they may be more effectively used by public safety entities to ease the demand on the need for additional spectrum. The Transition Subcommittee further examines how public safety entities will migrate in a smooth and orderly manner to the recommended interoperability solution.

2.0.5 Migrating to new frequencies and to the use of new, more efficient technologies also raises a number of funding and regulatory issues. The Transition Subcommittee has been tasked with considering regulatory and statutory reform actions that may be required for an orderly and smooth transition to new spectrum allocations and more efficient radio technologies. With regard to the issue of funding, in this era of deficit reduction and balanced budgets, finding funding for migrating to new spectrum allocations and new, more modern radio equipment is difficult at best. Hence, the Transition Subcommittee is chartered with examining alternative approaches to obtain funding to assist in an orderly migration to new spectrum allocations and advanced technologies.

### 3.0 Background/Report Scope.

3.0.1 The Public Safety Wireless Advisory Committee (PSWAC or Advisory Committee) was established to ensure that the spectrum needs of this Nation's public safety agencies are adequately met through the year 2010. Today, many public safety agencies are facing shortages of spectrum to meet current voice and data communications needs. There is also clear documentation that the spectrum needs of the Nation's public safety agencies will fall far short of that necessary to implement new telecommunications technologies that will provide critical tools for the protection of life and property.

3.0.2 Because of the fear among public safety agencies that there may not be adequate spectrum available to meet their communications requirements, the PSWAC was established to provide the FCC and NTIA with advice on the operational, technical, and spectrum requirements of Federal, state and local public safety agencies through the year 2010. Based on its Charter, the Advisory Committee established five subcommittees to thoroughly examine the operational (i.e., communications) needs of public safety agencies at all levels (Operational Subcommittee), the interoperability requirements of public safety agencies (Interoperability Subcommittee), what current and new technologies are available to meet the communication needs of public safety agencies (Technology Subcommittee), what spectrum is available to meet the existing and future communications needs of public safety agencies (Spectrum Requirements Subcommittee), and how public safety agencies should migrate to new spectrum capacity and new technologies (Transition Subcommittee).

3.0.3 PSWAC's goal is to bring about significant enhancement to the effectiveness and efficiency of public safety communications at both the Federal and non-Federal level. Importantly, in recommending the optimal environment as part of longer-term spectrum planning for public safety agencies, the Advisory Committee's responsibilities also focus on how a smooth and orderly transition to new spectrum and technologies can evolve.

3.0.4 The Transition Subcommittee's primary mission is to establish a strategy that provides for the smooth and orderly transition to any new spectrum allocated for public safety use as the result of PSWAC deliberations. Section 1.0 of this Report provides an Executive Summary of the Transition Subcommittee's findings and recommendations.

3.0.5 Section 2.0 of this Report sets forth a summary of the Transition Subcommittee's Charter. Section 3.0 provides a brief discussion of the background leading to the establishment of the PSWAC and the scope of this Report.

3.0.6 Section 4.0 of this Report provides an overview of the FCC's *Refarming* proceeding and then goes on to discuss issues relating to channel exclusivity and the need for technical standards to govern the migration to the new channelization schemes developed for public safety spectrum below 512 MHz. Section 4.0 also discusses the issues relating to the consolidation of the public safety radio service pools and whether the migration to the newly established narrowband channels should be done on a voluntary or mandatory basis.

3.0.7 Section 5.0 of the Transition Subcommittee's Report discusses issues that relate to the more efficient use of current spectrum allocated to Federal public safety agencies, including plans for Federal users to migrate to narrower channels and more efficient mobile radio technologies.

3.0.8 Section 6.0 discusses the "meat" of this Report -- i.e., how public safety agencies should migrate to new spectrum allocated for the use of non-Federal and Federal public safety agencies. Section 7.0 of this Report discusses spectrum management options that may lead to the more efficient use of spectrum by public safety agencies. Section 7.0 provides an overview of current non-Federal and Federal licensing mechanisms, and then discusses new licensing alternatives that range from the manner in which licenses are issued, to privatizing the licensing process, to granting the States a more active role in administering spectrum allocated for public safety use. Section 7.0 also discusses methods to improve Federal licensing and issues relating to the joint licensing of Federal and non-Federal public safety agencies.

3.0.9 Other spectrum management issues discussed in Section 7.0 of the Transition Subcommittee's Report relate to the issue of multiple coordinators and the need to improve the electronic filing *and* processing of applications, particularly those filed with and processed by the FCC. Finally, section 7.0 discusses methods to improve the coordination between non-Federal and Federal public safety agencies.

3.0.10 Section 8.0 of this Report discusses the commercial mobile radio services that are available to public safety agencies and the potential impact use of such services may have on the need of public safety agencies for additional spectrum. Similarly, Section 9.0 of this Report discusses some of the special issues that surround the use of mobile video by public safety agencies. Section 10.0 of this Report then goes on to discuss how public safety agencies should migrate to the "interoperability" solutions recommended by the Interoperability Subcommittee.

3.0.11 In Section 11.0 of this Report, the Transition Subcommittee provides some insight into what Congress should consider doing to improve the ability of public safety agencies to fulfill their responsibilities to protect the public welfare. This section of the Report also discusses the administrative proceedings that will be required by the NTIA and FCC to allocate additional spectrum for public safety use, and to assist public safety agencies at all levels to achieve an orderly and smooth transition to newer technologies and new spectrum allocated for its use. Section 12.0 of this Report then provides an overall summary of the Transition Subcommittee's findings and recommendations.

#### 4.0 More Efficient Use of New Bandwidth in Existing Public Safety Bands Below 800 MHz Non-Federal.

4.0.1 There are, perhaps, three fundamental radio frequency management challenges confronting the public safety communications sector today. First, there is

insufficient radio spectrum allocated to these services to meet existing as well as future communications needs.

4.0.2 Second, the dispersion of public safety mobile communications land mobile “bands” across the radio frequency spectrum engenders special costs, technology challenges, and hampers operations.

4.0.3 Public safety communications are scattered across at least five main land mobile “bands” in the part of the radio frequency spectrum below 2 gigahertz (GHz). Current public safety radio transceivers cannot function across all public safety bands. This results in multiple units, often owned and operated by the same public safety entity. This diversity of bands increases the cost of public safety communications and impairs interoperability.

4.0.4 Whatever the reason, it is desirable from a public policy standpoint that the performance of the existing, embedded base of public safety communications equipment be substantially improved in areas of current spectrum shortage. Accomplishing this goal would entail significant new capital investment in more modern, more spectrum-efficient equipment.

4.0.5 Both the Federal Communications Commission and the National Telecommunications and Information Administration have undertaken proceedings to increase the efficient use of spectrum currently allocated and used by public safety agencies. The Communications Act of 1934, as amended, specifically directs the FCC to take action to improve the efficiency of spectrum use, to encourage competition, and to promote the introduction of new services and technologies. See 47 U.S.C. Sec. 332(a)(2) and (3); see also 47 U.S.C. Sec 7. Accordingly, the FCC, in 1995, following a lengthy and complex debate over proposals set forth in its so-called “refarming” proceeding, adopted new rules to govern the private land mobile radio bands below 512 MHz. See *Report and Order and Further Notice of Proposed Rule Making*, FCC 95-255 (June 23, 1995).

#### 4.1.0 Overview of Refarming.

4.1.1 The FCC’s new rules governing the spectrum below 512 MHz were designed to provide private land mobile radio users, including public safety users, additional channel capacity and to govern the migration of these users to more efficient technologies in these bands. The FCC sought to attain as its major policy goals (i) technical flexibility, (ii) rules that would enable users to make equipment investment decisions that best satisfy their needs, and finally, (iii) spectrum efficiency. From a public safety viewpoint, the major goal is to secure sufficient usable spectrum to fulfill their vital requirements. Rules, regulations and procedures must be employed to ensure this spectrum is used in an efficient manner.

4.1.2 To implement these policy goals, the FCC established a new channeling plan that permits the use of narrowband technologies. While the FCC’s new rules maintained the existing channel spacing in the 30-50 and 72-76 MHz bands, the agency stated that it would list channels every 7.5 kHz in the 150-174 MHz band and every 6.25 kHz in the 421-430, 450-470, and 470-512 MHz UHF bands. The FCC also provided that 12.5 kHz

technology could be licensed in the VHF and UHF bands as an interim measure to the migration to further narrowband technology.

4.1.3 In addition, the FCC established rules that would allow the use of wideband equipment that employs technology at least as spectrally efficient as narrowband equipment.

4.1.4 The FCC's new rules however did not require existing licensees to change out their radio systems by a date certain. Rather, the Federal Communications Commission stated that it would manage the migration to its new narrowband channeling plan through its equipment type acceptance process. The FCC, in this regard, adopted a spectrum efficiency standard of one voice channel per 12.5 kHz of channel bandwidth for equipment type accepted after January 1, 1996, and a spectrum efficiency standard of one voice channel per 6.25 kHz for equipment type accepted after January 1, 2005.

4.1.5 The FCC's new rules governing private radio spectrum allocations below 512 MHz also did not establish specific adjacent channel station separation requirements for the new channelization plan. Rather, the various frequency coordinators were given responsibility for determining separation distances needed in each case based upon the technical characteristics of the proposed and existing station(s).

4.1.6 The Commission's *Further Notice of Proposed Rule Making* in its *refarming* docket proposed to provide public safety agencies, as well as other private radio users that operate in the spectrum below 512 MHz, the option to obtain exclusive use of their channel assignments if they agree to convert to narrowband equipment by a certain date. With respect to the issue of exclusivity, the Commission sought comment on alternative ways to achieve the introduction of exclusivity in the public safety spectrum bands below 512 MHz, including introducing competitive bidding into these bands and the imposition of a user fee system. The Commission also sought additional comment on a modified version of its "Exclusive Use Overlay" proposal that would permit users to develop licensing arrangements with other users that would facilitate the deployment of efficient technologies in four refarmed bands (i.e., 150-174, 421-430, 450-470, and 470-512 MHz). The application of these options to the public safety service will be discussed in the following sections.

#### 4.2.0 Methods To Achieve Exclusivity.

4.2.1 An essential issue presented in the FCC's refarming proceeding is how public safety agencies can use their spectrum below 512 MHz more efficiently, and thus, gain additional capacity to meet their communications needs. Users of public safety spectrum below 512 MHz generally employ single-channel analog FM technology and use their channels in the conventional mode of operation. Offering users the option to convert to narrowband technology and to deploy other efficient technologies such as trunking and digital could lead to spectrum efficiency in these bands. These newer technologies, however, are generally incompatible with the use of other traditional technologies on the same channel in a shared spectrum environment. The needs of public safety for exclusivity and that of commercial users are dissimilar. Public safety requires exclusivity to ensure non-interference

to vital communications. Commercial systems are designed to produce revenue, either through a broad customer base or through effective operation of a business. Exclusive use of a portion of the spectrum can enhance this potential.

4.2.2 As noted, in its *Further Notice of Proposed Rule Making* in PR Docket No. 92-235, the FCC sought comment on mechanisms by which it could promote “more efficient and effective use of the PLMR bands below 800 MHz”. The Transmission Subcommittee observes that the FCC believes that spectrum efficiency in these bands can be promoted by converting them from a “shared” to an “exclusive” licensing environment that will allow users to more easily convert their channels to newer technologies. To further encourage the conversion to narrowband channels and newer technologies, the FCC would also permit users in this spectrum to sell any excess capacity that may be created by the deployment of advances in technology.

4.2.3 The requirement for spectrum efficient technology is clearly an incentive for exclusivity/protected service areas. However, the requirement to protect existing public safety users from harmful interference must also be recognized. Certainly, there is a valid reason for requiring new equipment on any newly allocated spectrum. There is also a need for an incentive to expedite the move to the new channels created by refarming. Finally, the need to encourage spectrum efficient equipment in the present spectrum not affected by refarming (30-50 MHz , 70-72 MHz, 800 MHz). The Transition Committee supports all reasonable requirements to move as rapidly as possible toward the use of more spectrum efficient technology in area where spectrum shortage is critical.

4.2.4 The Transition Subcommittee generally supports the concept of introducing channel exclusivity in these bands, but has reservations about allowing public safety to sell so-called “excess capacity”. Public safety agencies are licensed for the channels they need to carry out their public safety responsibilities and do not normally operate with excess capacity. The Transition Subcommittee recognizes, however, that once a system is converted to narrowband channels and/or newer technologies are implemented, some public safety and public service agencies may have some extra capacity. These agencies should be encouraged to share and combine their systems with other similar entities on a not for profit or cost recovery basis.

4.2.5 In all, the FCC proposed three options for transitioning to exclusivity. These are use of improved technology, auctions, and spectrum fees. As discussed below, the Transition Subcommittee does not agree that these are the only options which should be considered for transitioning to exclusivity. Furthermore, of the three options proposed by the FCC for transitioning to exclusivity on the bands below 800 MHz, the Transition Subcommittee believes that an appropriate licensing mechanism, as opposed to a regulatory scheme based on auctions or spectrum fees, is the preferable solution.

4.2.6 Clearly, the use of auctions is not an appropriate manner in which to transition to exclusivity for public safety for a variety of reasons. Commercial incentives for exclusivity clearly do not apply to public safety spectrum. Public safety entities rely on public funding to support their communications needs, and would not be able to compete fairly in an

auction market. Public safety does not have a commercial subscriber base which can be used to support bids for spectrum. The need for spectrum is based entirely on the geographic area served by the specific public safety entity, its demographics. Agencies with the greatest needs for spectrum may have the least ability to generate funds.

4.2.7 The use of spectrum fees is similarly unsuited for public safety agencies. As recognized by the FCC, at the present time it does not have the authority to impose spectrum fees under its current statutory authority. Spectrum user fees are not appropriate in services for the public safety radio services where the primary purpose is to protect safety of life, health, and property. User fees would be inappropriate and impose a financial burden on the public that need not be levied. Forcing state and local governments to pay for the use of a public resource also poses serious constitutional questions. Depending upon how such fees are structured, they could be tantamount to a tax on the use of the spectrum and, therefore, violate the constitutional principal that the federal government may not tax the states and vice versa.

4.2.8 An option that allows private radio users, including public safety agencies, to gain exclusive control would however contribute substantially to improving spectrum efficiency in the bands below 512 MHz. Existing licensees, in this regard, should be provided an appropriate licensing mechanism to gain exclusivity within their specific service area.

4.2.9 The term “exclusivity” does not imply that the sharing of channels among public safety users will be eliminated. Exclusivity in the case of public safety means that an agency must be protected from harmful interference. The public safety frequency coordinators have always gone to great efforts to make recommendations to minimize the possibility of interference. Public safety agencies are confined to jurisdictional and political boundaries which often results in independent operation of private systems for the various public safety departments within each entity.

4.2.10 There are several alternatives that have been proposed by which existing licensees that operate in the bands below 512 MHz can convert their shared licensed systems to exclusive licensed systems. The FCC’s *Initial Notice of Proposed Rule Making* in its *Refarming* proceeding, for example, proposed giving new applicants and existing public safety licensees the right to gain exclusivity through a plan it called Exclusive Use Overlay. The Land Mobile Communications Council (LMCC) has also proposed a method to gain exclusivity that permits licensees to file for a Protected Service Area, which is similar to a proposal submitted by the Association of Public-Safety Communications Officials - International (APCO) based on the political jurisdiction of a public safety agency. The Utility Telecommunications Council (UTC) submitted a plan that would allow licensees an opportunity to obtain exclusivity through an option it terms “shared exclusivity” Alternatively, a form of *de facto exclusivity* can be awarded through the existing frequency coordination process. Through existing frequency coordination procedures, the police, fire, and emergency medical services already essentially operate with a form of exclusivity – i.e. in the frequency coordination process, public safety users are provided the largest degree of channel exclusivity possible to prevent harmful interference and to ensure channel availability in times of emergency. Unlike the other concepts discussed above where the user would

obtain an exclusive license to use the assigned frequency against all other applicants, the term *de facto exclusivity* does not mean that the concept of sharing channels below 512 MHz is eliminated.

4.2.11 The Transition Subcommittee notes that the concept of exclusive licensing has a specific legal meaning as used in the FCC's Rules. Consequently, without formal recognition in the FCC's Rules that existing public safety shared spectrum users have the right to use their channels on an exclusive basis, the legal ability to protect the channels against all other users may be difficult to achieve. Thus, even though many public safety agencies may operate with a form of *de facto exclusivity*, this cloud of potential interference may be a factor that could prevent public safety agencies from implementing advanced technologies that are dependent upon channel exclusivity.

4.2.12 The Transition Subcommittee therefore concludes that an appropriate licensing mechanism that would permit public safety agencies to convert their shared system licenses to exclusive system licenses could encourage users to convert to narrowband channels and advances in technology. The Transition Subcommittee believes that the concept of permitting public safety agencies to file for a "Protected Service Area" (PSA) more closely describes public safety requirements than those proposed by the FCC and UTC. To this end, while public safety agencies should be permitted to continue to file under the existing concept of sharing spectrum in the bands below 512 MHz, those users that want to convert to exclusive licenses should also be permitted to do so if they can meet the following criteria:

- (i) That the area of coverage authorized by the license to the maximum extent possible coincide with the users' area of operation (PSA);
- (ii) That channel loading and utilization be used to determine the appropriate number of channels; and
- (iii) That, to achieve maximum spectrum efficiency, exclusivity can be based on sharing with other users provided that signals are kept below levels that would cause harmful interference.

4.2.13 The requirement for new spectrum efficient technology is clearly an incentive for exclusivity protected service areas. However, the requirement to protect existing public safety users from harmful interference clearly more important. Certainly, there is a valid reason for requiring new equipment on any newly allocated spectrum. There is also a need for an incentive to expedite the move to the new channels created by refarming. There is also the need to encourage spectrum efficient equipment in the present spectrum not affected by refarming. The Transition Subcommittee supports all reasonable requirements to move forward the use of more spectrum efficient technology in areas where spectrum shortage is critical.

4.2.14 The need for exclusivity is an element if the spectrum below 512 MHz is to be used more efficiently. The value of radio spectrum has seen explosive growth as the FCC has auctioned spectrum to commercial industry users. Inadequate spectrum availability

jeopardizes public safety's ability to safeguard the nation's well-being. Additional reliance on more spectrum efficient technologies is thus required if public safety agencies are to fulfill their responsibility to serve the public welfare.

4.2.15 The Transition Subcommittee believes that the concept of exclusivity/protective service area, is a critical element for public safety. Further, that increased spectrum efficiency is an absolute necessity. These requirements must be tempered with the reality of the difficulty that public safety entities have in obtaining adequate funding. This applies to day to day operations as well as funding for major system changes. The bottom line is recognition of the vital role played by public safety and the need for radio systems which can be operated without fear of harmful interference from other users. The effective role played by public safety frequency coordinators in this regard can be strengthened by a process which affords further protection through rules and regulations.

4.2.16 Accordingly, to achieve gains in spectrum efficiency in the bands below 512 MHz, the Transition Subcommittee believes that a form of exclusive licensing would facilitate public safety agencies to invest in more efficient technologies. Access to additional spectrum for public safety, as shown later in this Report, is critical. Likewise, administrative solutions that allow public safety entities to use their current spectrum allocations more efficiently will also maximize public safety's ability to protect lives and property.

**RECOMMENDATION:** The Transition Subcommittee recommends that all public safety licensees authorized to use channels in the shared bands below 512 MHz be given an opportunity to file for a protected service area which corresponds to their area of operation. Appropriate rules must be developed which would address requirements for the number of channels based on (1) number of units, (2) population served, (3) system design and (4) type of service.

For any new channels created by refarming, there should be a further requirement for spectrum efficient equipment. Channels in any newly allocated spectrum would require that all of the above apply, including the use of spectrum efficient equipment. The Transition Subcommittee also recommends that such public safety applicants *not* be required to upgrade their systems to narrower channels and new technologies at the time they file for exclusivity or PSA. Rather, as discussed below, applicants need not upgrade their systems until they seek additional channels that may be made available in the future. Frequency Coordinators should be given the authority to determine if the listed criteria was in accordance with the rules and to recommend system parameters which would limit radio coverage as necessary to comply with the protected area. Each applicant would be required to file the appropriate application/request with its coordinator setting forth its service parameters and justifying its area of operation. The coordinator would then certify the application to the FCC for the issuance of the appropriate license.

#### 4.3.0 Need for Technical Standards to Govern Migration.

4.3.1 The FCC's primary goal in its refarming proceeding is to increase spectrum efficiency by a factor of approximately four (4) relative to a standard 25 kHz or 30 kHz

analog channel. Even so, the FCC's refarming proceeding remains the subject of great debate, particularly over concerns about the potential difficulties in the implementation process.

4.3.2 Perhaps the most difficult issue presenting in the Report and Order is to develop a rational, systematic program for a migration to narrower channelization technologies that would adequately protect the interests of the thousands of licensed users currently operating in these bands and still achieve significant spectrum efficiency gains. Engineering knowledge teaches that the interference between systems operating at different bandwidth on the same channels is likely to be harmful. The Transition Subcommittee recognizes that the process of transforming current land mobile radio spectrum, including those channels used by public safety, from 25 kHz to 12.5 kHz and, ultimately, 6.25 kHz channels, will be a difficult and delicate transition.

4.3.3 Pursuant to the FCC's refarming plan, in certain bands, if an existing licensee of a 25 kHz system elects to convert to a 12.5 kHz operation, the licensee's new channel spacing will utilize the same center frequency as the existing transmitter. The portion of the 25 kHz channel that is "freed up" consequently comes in two segments of 6.25 kHz each that are located at the opposite edges of the 25 kHz channel. These freed up 6.25 kHz segments, however, become useful for other 12.5 kHz systems in the same geographic area only if they can be paired with adjacent 6.25 kHz segments that have been similarly freed up by other 25 kHz systems.

4.3.4 The conversion of a single 25 kHz system to a 12.5 kHz system, therefore, produces additional spectrum only if other adjacent channel users in the same area also convert. This is difficult to orchestrate because of the shared nature of the private land mobile radio bands below 512 MHz. Although there may be some potential for the use of the new 12.5 kHz adjacent channels by employing a certain amount of geographical separation, this will be limited and require careful coordination. Thus, unless there is a widespread effort to convert to narrower channelization, the improvement in spectrum efficiency may well be "illusory."

4.3.5 To achieve a graceful and meaningful transition the development of uniform technical guidelines that will permit frequency coordinators to coordinate 25 kHz spectrally efficient wideband technologies, as well as 6.25 and 12.5 kHz analog and digital systems, in the existing shared environment is critical. To this end, the Association of Public-Safety Communications Officials, International (APCO) and the Land Mobile Communications Council (LMCC) requested the technical assistance of the Telecommunications Industry Association (TIA) "in facilitating the accommodation of advanced technologies in a post refarming environment." In response to these requests, TIA prepared a *Report On The Technology Independent Methodology For The Modeling, Simulation and Empirical Verification Of Wireless Communications System Performance In Noise And Interference Limited Systems Operating On Frequencies Between 30 And 1500 MHz*, TIA TR8 Working Group 8.8 Technology Compatibility (5 April 1996)).

4.3.6 TIA Working Group 8.8's objective was to resolve procedural differences in measurement techniques and develop and issue procedures and practices for measurement of

compatibility's and/or incompatibilities and interference's between the various technologies offered to achieve the FCC's refarming objectives.

4.3.7 The result has thus far produced a document that describes a common methodology that can be used for modeling, simulating, predicting and empirically confirming performances of current generation systems as well as next generation bandwidth efficient systems operating in a post refarming environment. The document specifically defines system performance parameters and criteria and recommends an electromagnetic wave propagation model.

4.3.8 The TIA Working Group 8.8 product also defines a process and recommends data elements that can be used for spectrum management of various types of analog and digital systems. With regard to this aspect of Working Group 8.8's effort, the document attempts to catalog various current technology offerings and their respective modulation parameters and performance characteristics.

4.3.9 The Transition Subcommittee believes that it is essential that Working Group 8.8's working efforts be finalized as soon as possible and acknowledged by the FCC as the appropriate methods to coordinate and license various radio systems operating in the post refarming environment. For users to upgrade their systems to narrowband channels and advanced technologies, users must know the amount of protection their systems will be afforded from co-channel users. Otherwise, public safety users will be reluctant to seek funds to upgrade their systems to more efficiently use their current frequency assignments if their new systems employing advances in technology will be subject to harmful interference. See, *Laws of Physics Complicate the Spectrum Refarming Process*, Radio Resource Magazine, by Frederick J. Day).

**RECOMMENDATION:** The Transition Subcommittee recommends that the FCC issue a Public Notice seeking comment on TIA's TR8 Working Group 8.8 *Report On Technology Independent Methodology For The Modeling, Simulation and Empirical Verification Of Wireless Communications System Performance In Noise and Interference Limited Systems Operating On Frequencies Between 30 and 15 MHz* with the goal of acknowledging its use in determining the compatibility between different types of modulation systems in the post refarming environment. Appropriate technical standards accompanied by data elements for the automated processing of PLMR applications and licenses must be developed and placed in operation to assist users to achieve a graceful and meaningful transition.

#### 4.4.0 Consolidation of Radio Service Pools.

4.4.1 In the *Notice of Proposed Rule Making* in PR Docket No. 92-235 the FCC proposed to consolidate the various radio services in the bands below 800 MHz into three broad categories: (1) a Public Safety Radio Service, (2) a Non-Commercial Radio Service, and (3) a General Category Radio Service. The FCC also proposed to allow competitive coordination in each of these new radio services.

4.4.2 The FCC asked for further comment on this in its *Further Notice of Proposed Rule Making* in PR Docket 92-235 because of the wide divergence of opinion on how, if at all, the existing radio services should be consolidated. Hoping to form a consensus, the FCC asked the various user groups to work together to submit a proposal that would reflect the interests and needs of the PLMR community, including the various public safety communities. The FCC also asked how to create competition in the frequency coordination function.

4.4.3 The FCC's underlying reason behind its proposal to consolidate the various radio services "is to distribute assignments between low-use and high-use groups more evenly, to simplify interservice sharing procedures, to organize channel allocations that will enable licensees to more easily utilize advanced technologies, and to organize the services in such a manner to achieve more efficient and flexible spectrum use."

4.4.4 Since the issuance of the Further Notice of Proposed Rule Making in this proceeding, the various radio service groups have been unable to reach a consensus and have filed alternative proposals with the FCC. Indeed, the various private wireless radio groups have submitted no less than twenty (20) different sets of proposals in response the FCC's request for an industry consensus plan on radio service consolidation. Several radio services did not take any position on consolidation except to ask that their particular radio service not be included in any plan adopted by the Commission. The Transition Subcommittee supports a position that the public safety allocation of spectrum remain as currently established under the rules of the FCC, that separate service allocations be retained and that the current method of frequency coordination be retained with the present coordinators. The rules may be modified to identify the agencies to be accommodated frequency allocation and coordination through the public safety part of FCC rules and regulations. Essentially it includes all state and local government operations and some limited private sector operations.

4.4.5 The Transition Subcommittee supports a position that the public safety allocation of spectrum below 512 MHz remain as it is currently established under the rules of the FCC, that separate service allocations be retained and that the current method of frequency coordination be retained with the present coordinators. Recognizing that the FCC may consolidate the radio services, the FCC is encouraged to establish a public safety pool for new frequencies. Further that within the pool, specific coordinators be assigned groups of frequencies for assignment.

4.4.6 Federal government consolidations

4.4.7 It is important note that definitions established by PSWAC are identified as follows:

Public Safety: The public's right, exercised through Federal, State or Local government as prescribed by law, to protect and preserve life, property, and natural resources and to serve the public welfare.

**Public Safety Services:** Those services rendered by or through Federal, State, or Local government entities in support of public safety duties.

**Public Safety Services Provider:** Governmental and public entities or those non-governmental, private organizations, which are properly authorized by the appropriate governmental authority whose primary mission is providing Public Safety services.

**Public Safety Support Provider:** Governmental and public entities or those non-governmental, private organization which provide essential public services that are properly authorized by the appropriate governmental authority whose mission is to support public safety services. This support may be provided either directly to the public or in support of public safety services providers.

**Public Services:** Those services provided by nonpublic safety entities that furnish, maintain, and protect the nations basic infrastructures which are required to promote the public's safety and welfare.

4.4.8 Notwithstanding the controversy over the FCC's proposal to consolidate the various existing radio services, the Transition Subcommittee believes it is appropriate to consider some consolidation of public safety and public service. Such consolidation should not preclude the assignment of specific channels and blocks of channels to various public safety services as may be deemed necessary. Care must be taken with consolidation to preserve the existing channels which are dedicated for specific purposes such as mutual aid and wide area systems.

4.4.9 The Transition Subcommittee under that circumstance recommends that the current radio service pools be divided into three service categories. The Transition Subcommittee has ranked these service pools according to the relative criticality of these services to carry out the Congressional mandate to promote safety or life and property. The radio service pools recommended are listed in Appendix A.

4.4.10 The Transition Subcommittee's proposal is based on the definitions of Public Safety and Public Services quoted in 4.4.7 of this document that will be utilized to assess the current and future needs for public safety communications.

4.4.11 Based on these definitions, the Transition Subcommittee has included in the Public Safety category those radio services that have traditionally rendered law enforcement, fire control, emergency medical, special emergency, local government, highway maintenance, and forestry-conservation services. The Transition Subcommittee has similarly included in the Public Services category those services that provide support for the protection and restoration of the Nation's basic infrastructure that includes public utilities (e.g., electric, gas, and water services), and services that construct radio systems along extensive rights-of-way with unique operating areas that may extend over large geographic areas (such as the railroads and pipelines).

4.4.12 The Transition Subcommittee also believes that the FCC should rank the radio service categories according to the relative importance of the radio services to respond to emergency and life-and-death situations. To this end, the Transition Subcommittee's proposal parallels existing Federal government efforts to prioritize access to public communications services in times of national emergency. See *Report and Order* in General Docket No. 87-505, 3 FCC Rcd 6650 (1988); see also Appendix A, Part 64 of the FCC Rules, 47 C.F.R. Part 64. The *Telecommunications Service Priority System* (TSP) represents an effort to develop a unified national policy on the priorities for provisioning and/or restoring telecommunications circuits in the event of general service disruption. The TSP system generally ranks those service identified by the Transition Subcommittee in the proposed Public Safety and Public Services categories as essential telecommunications services. Accordingly, the Transition Subcommittee would rank Public Safety users first in the order of importance, then Public Services users, and finally, Business/Commercial users.

4.4.13 The Transition Subcommittee also believes that interservice sharing should only be permitted from a higher ranked service into a lower ranked service, but not *vice versa*. Hence, Public Safety users could secure access to channels in the Public Service or Business/Commercial category, and the Public Service users could secure access to channels in the Business/Commercial category, but the Business/Commercial users could not secure channels in either the Public Safety or Public Services categories. This method of interservice sharing will not only preserve public safety channels for their intended use, but also will lead to improvements in channel utilization and spectrum efficiency.

4.4.14 The Transition Subcommittee observes that the equipment and operational requirements of many public safety and public service radio users are identical. It is not uncommon, moreover, that public safety and public service radio users have the need to cover a rural, wide area.

4.4.15 In rural areas, public safety users may have more channels than they need, but no funds to construct a spectrum efficient system. On the other hand, public service companies, such as utilities, may not have sufficient channels or funds available to build out a modern, more efficient system. Combined systems may be built, provided the licenses must be held by the organization in the higher block. Thus public safety frequencies must be licensed to public safety agencies, but could be used in a combined system with public service or commercial systems.

4.4.16 Conversely, there may be instances where the public safety entity want to lease service from another public service such as a utility. The utility has the channels in the rural area and has constructed the system and would like to lease out capacity. The utility, however, may encounter difficulties doing this because of the prohibition of leasing out excess capacity on a for-profit basis and risk being classified as a Commercial Mobile Radio Services carrier.

4.4.17 As noted earlier, the Transition Subcommittee has serious reservations about private radio users, including public safety agencies, being permitted to sell excess capacity on their systems. The Transition Subcommittee also believes that public safety

spectrum should be protected from other users. Nonetheless, the Transition Subcommittee believes that the rules governing the use of radio spectrum should provide sufficient flexibility for public safety agencies to acquire service from public service radio providers either on a for-profit or cost shared basis. Spectrum efficiency can be promoted when public safety and public service users collaborate and share frequencies in some circumstances.

Recommendations: (1) That the FCC retain the current public safety allocation of spectrum established under the rules of the FCC, that separate service allocations be retained and that the current method of frequency coordination be retained with the present coordinators

(2) That, in the event the radio service pools governing spectrum below 512 MHz be consolidated, that three pools be established, namely: (i) Public Safety; (ii) Public Services; and (iii) Business/Commercial, however, public safety frequencies should be identified by service.

(3) That these radio service categories be ranked according to their relative importance in performing essential public safety responsibilities and preserving and restoring the Nation's infrastructure.

(4) That interservice sharing be authorized from the higher ranked categories to the lower rank categories, but not vice versa, except in situations where Public Safety and Public Services users collaborate to establish a "shared" system.

(5) That any public safety consolidated pool be serviced by the present authorized public safety coordinators serving their current constituency and that newly created frequencies be footnoted to the appropriate services.

#### 4.5.0 Migration Path to Narrowband Channelization.

4.5.1 As previously observed, the FCC did not establish specific dates for public safety entities to migrate to its new narrowband channelization plans for spectrum below 512 MHz. The Transition Subcommittee believes that this migration will be driven by the life cycle of presently employed equipment and the need for additional communications capacity by public safety agencies. As the equipment used by public safety entities becomes more outdated, and as they need additional channels to serve their needs, the Transition Subcommittee believes that they must be in a position to migrate to the new channelization plan established by the FCC and employ more advanced technologies.

4.5.2 The Transition Subcommittee strongly supports the goal of achieving a net gain in spectrum utilization by use of more efficient technologies in the presently overcrowded bands below 512 MHz. Indeed, the spectrum below 512 MHz is extremely congested in many urban areas of the country. Due to this congestion and other factors, current spectrum usage does not generally lend itself to the deployment of advanced wireless radio technologies.

4.5.3 A migration from 25/30 kHz wideband channels to more spectral efficient solutions like 12.5/6.25 kHz narrowband channels coupled with technologies like trunking can increase the system capacity of many public safety agencies. Exclusive use of channels is essential however if we are to expect public safety agencies to upgrade their current systems to narrowband channels and advances in technology.

4.5.4 Spectrum efficiency is, of course, a critical assessment criteria when migrating wideband systems. Increasingly, inadequate public safety communication spectrum must accommodate increases in personnel and support future applications like fingerprints, mug shots, slow and full motion video, and a host of other data transactions when responding to emergency situations. Migration to narrowband channels, standing alone, may provide some small gains in spectrum efficiency. Migration to narrowband channelization alone, however, will not increase the bandwidth to support these demands. In fact, some of these techniques will require much wider bands than presently used. Conversely, the Transition Subcommittee observes that a combination of narrowband technology and trunking technology can provide a significant improvement in spectrum efficiency in many instances.

4.5.5 The Transition Subcommittee fully supports the FCC's efforts to make more effective and efficient use of the public safety bands below 512 MHz. Clearly, spectrum efficiency gains will be significant over time. The conversion to narrowband channels and more efficient technologies, however, is expected to be an evolutionary rather than revolutionary process that will take many years to carry out and thus will have little immediate impact on the need for additional spectrum to meet the needs of the public safety community.

4.5.6 The Transition Subcommittee observes that the Commission has elected to manage the migration of the private land mobile radio bands below 512 MHz to advanced technologies through the type acceptance process, rather than require existing licensees to change out their systems by a date certain. It is suggested that unless a date certain is imposed it is unlikely that public safety agencies, particularly those in the urban areas, will reap any benefits of narrowband for many years to come.

4.5.7 The Transition Subcommittee believes that the Advisory Committee must be careful not to recommend, nor the FCC to mandate, any action that would impinge on the independent judgment and financial affairs of the wide variety of small, medium and large public safety entities that use radio spectrum. Their systems have been developed in full compliance with the Commission's rules governing private land mobile radio systems. To mandate migration to narrower channels and advances in technology before the users are ready and able to convert their existing systems would interject the hand of big government into planning activities and financial affairs of communities throughout the nation.

4.5.8 The Transition Subcommittee recognizes, however, that the efficient use of current spectrum allocations clearly has an impact on the amount of spectrum needed to meet existing and future needs of public safety community. If conversion to improved technology is dependent only upon type acceptance of equipment, it is probable that it will be a long drawn out process, and that significant benefits from the refarming process will be many years in coming. Thus, some compromise between forcing users to convert, by a date certain, with

adverse financial problems, and allowing them to continue to use wide band equipment indefinitely is in order.

4.5.9 The Transition Subcommittee notes, in this regard that there are possible approaches to this type of compromise. The first would be to establish dates certain by which all equipment would have to FCC requirements for spectrum efficiency. If not converted by that date the system would revert to secondary status. This would allow users in many rural and low density areas to extend the useful life of equipment. Urban areas, and other areas with high spectrum demands would be forced to convert or face the prospect of harmful interference or even loss of license. Dates for any mandated conversion could be different for rural and urban areas. The other approach, as new spectrum is allocated, is to require users to demonstrate how they are using existing spectrum efficiently before they receive any new allocations. In any event, all new spectrum should require the use of spectrum efficient technology and any users migrating would relinquish their existing spectrum as soon as the move was complete. A major concern in either alternative is that public safety systems are generally composed of units of various ages. Thus, any conversion, either voluntary or mandatory, could preclude full amortization of existing equipment.

**RECOMMENDATIONS:** (1) The Federal Communications Commission retain the mandated dates for type acceptance, and due to the extreme congestion and need for immediate relief, particularly in urban environments, conversion to meet FCC present requirements for spectrum efficiency (12.5 kHz) by January 1, 2005 in those areas. Rural areas, while also being required to convert, could be given somewhat longer periods of time. In each event, failure to meet the specified requirements by specified dates would result in reversion of authorization to secondary status.

(2) Agencies should be encouraged to convert to more spectrum efficient systems at the earliest possible date. This includes the potential for negotiating with others in near by areas to also convert.

(3) Encouragement for conversion should be provided in the form of funding assistance from federal or other resources.

## 5.0 More Efficient Use of Spectrum Assigned to Federal Public Safety Users.

5.0.1 NTIA, as noted earlier, is responsible for managing the Federal Government's use of the radio spectrum. Aside from the use of spectrum by the military, many Federal departments and agencies use the radio spectrum to support their unique missions. These missions include, but are not limited to, protecting the President and foreign officials, assuring the safety of the airways, water transportation, Federal Law enforcement, disaster relief, protection of natural resources, ensuring the security of power generation and nuclear material, and the efficient operation of the postal service.

5.0.2 Like spectrum use in the non-Federal sector, spectrum requirements of the Federal Government also tend to increase with population growth and are heaviest in areas of high population density.

5.0.3 The Federal Government, recognizing its growing spectrum requirements, has undertaken significant planning efforts in order to increase the spectral efficiency and capacity of their current spectrum allocations. The Federal Government's non-tactical land mobile operations are accommodated primarily in portions of the 30-50 MHz, 138-150.8 MHz, 162-174 MHz, 220-222 MHz, and 406.1-420 MHz bands. The 162-174 MHz and 406.1-420 MHz bands are the most widely used by Federal Departments and agencies.

5.0.4 As noted in an NTIA Special Publication,<sup>1</sup> the number of assignments in Federal land mobile bands has been increasing over the past few years, particularly in the 138-150.8 MHz, 162-174 MHz, and 406.1-420 MHz bands. There are forty-eight (48) Federal agencies that operate in the 162-174 MHz band and forty-seven (47) Federal agencies that operate in the 406.1-420 MHz band. The land mobile radio service is the dominant service used by Federal agencies in these bands, and trunking technology is primarily employed in the 406.1-420 MHz band.

5.0.5 The National Telecommunications and Information Administration (NTIA), its predecessor agencies, and its interagency advisory group, the Interdepartment Radio Advisory Committee (IRAC), have long sought to keep Federal government usage of the spectrum as efficient as both economic and mission requirements would permit. In 1992, completing a two-year effort, NTIA halved channel widths in the 162-174 MHz band, the band most heavily used for Federal non-military land mobile communications. This change accommodates expanding requirements of all agencies in this band by doubling the number of available channels and permitting the use of alternative communications technologies that can achieve equivalent spectrum efficiencies. Also in 1992, NTIA, working with the Federal Communications Commission (FCC), converted the 220-222 MHz band from the radio location service to the mobile service for Federal and non-Federal narrow band land mobile use. In addition, eight years ago NTIA urged industry to develop and market trunking communication systems in the bands available to Federal government users and urged the FCC to revise regulations that prohibited Federal government agencies from using commercially offered specialized mobile radio services.

5.06 Federal use of the mobile spectrum includes both traditional and specialized aeronautical-mobile, maritime-mobile, military tactical, and mobile satellite applications, which operate under rules and regulations established by international conferences. Any changes in the ways in which the frequencies allocated for these services are managed would require international agreement. Therefore, this plan is limited to policies and procedures for the regulation of the civil and military non-tactical use of those land mobile radio communication services that do not involve international matters by the agencies of the Federal government.

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<sup>1</sup> *U.S. National Spectrum Requirements: Projections and Trends*, 94-31 (March 1995)

5.0.7 NTIA's plan, mandated in the National Telecommunications and Information Administration Organization Act (NTIAOA), continues earlier NTIA efforts to help relieve demands by Federal government agencies for more spectrum to expand existing types of service. Under the NTIAOA, NTIA is to advance policies "[f]ostering national safety and security, . . . and the delivery of critical social services through telecommunications. . . . [f]ostering full and efficient use of the radio spectrum by the Federal Government, in a manner which encourages the most beneficial uses thereof in the public interest." The NTIAOA requires that "[i]n assigning frequencies for mobile radio services . . . , the Secretary of Commerce [acting through NTIA] shall promote efficient and cost-effective use of the spectrum to the maximum extent feasible," and "the Secretary of Commerce shall adopt and commence implementation of a plan for Federal agencies . . . to use . . . technologies that are at least as spectrum-efficient and cost-effective as readily available commercial mobile radio systems." Furthermore, the NTIAOA authorizes the Secretary "to withhold or refuse to assign frequencies for mobile radio services . . . in order to further the goal of making efficient and cost-effective use of the spectrum."

5.0.8 To meet the Congressionally set goals regarding mobile service operations of the Federal government and general policies regarding satisfying the national safety and security and the delivery of critical social services by the Federal government and encouraging beneficial uses of the spectrum by the Federal government, the objectives of this plan are to ensure that Federal agencies using land mobile radio technologies and services:

- use spectrum-efficient and cost-effective radio technologies to satisfy land mobile radio communication requirements, thereby minimizing both the amount of spectrum used and the long-term cost; and,
- use commercial sources or shared systems to provide land mobile radio communication services unless services or systems that can meet telecommunication mission requirements are not available or the available services or systems would cost more than alternatives.

5.0.9 In developing the plan, NTIA analyzed existing Federal government use of the spectrum for mobile services, the status of mobile communication technology, and existing NTIA and other agency policies regarding mobile services. Other Federal government regulations concerning acquisition of telecommunication resources were reviewed to determine appropriate types of regulation for Federal land mobile communication services and to ensure that NTIA regulations did not conflict with them.

5.0.10 NTIA reached several conclusions regarding how to continue expanding its efforts to use Federal government land mobile spectrum as efficiently as both economic and mission requirements will permit. Several of these would increase the number of channels available to the Federal government for land mobile communication without increasing the amount of spectrum dedicated to that use. Others would increase the number of users that can operate on each communication channel. In addition, NTIA reviewed its policies and procedures for managing Federal government use of land mobile radio communication

services and has developed findings concerning introduction of more spectrum-efficient technologies. These findings are:

- The doubling of Federal land mobile frequency assignments between 1980 and 1992 reflects the rapid growth in government demand for land mobile services over the same period. During the same period, the number of private sector frequency assignments tripled, reflecting similar but larger growth.
- Federal mission requirements often involve local, national and worldwide service areas that include remote, rural, suburban, and urban environments. These missions, which have been mandated by the Congress and the President, have few counterparts outside the Federal government, although, in some cases, state and local government missions are similar and result in similar uses of the radio spectrum.
- Federal land mobile radio systems use a wide range of equipment types in a variety of geographic environments for voice and data communications. Common types of equipment include base and repeater stations, mobile stations, and hand-held, portable stations. This equipment is generally the same "off-the-shelf" analog FM equipment used outside the Federal government, operating on different frequencies. Moreover, because the technology is the same, the spectrum-efficiency and cost-effectiveness of the radio technologies used by the Federal government usually are identical to that used in readily available commercial radio systems.
- NTIA has selected a 12.5 kHz channel width for rechanneling, which will double the number of basic channels available using currently available technology. This will also allow trunking systems to increase efficient use of the spectrum by a factor of 3-8 and systems using time division multiple access by a factor of 3-6, depending on the type of system. Federal agencies have already begun procurement of these new radios for the 162-174 MHz and 406.1-420 MHz bands.
- Under certain conditions, trunking systems are more efficient than conventional systems. When there are a large number of users with a high volume of short duration messages, a trunking system can significantly increase total traffic throughput on individual communication channels and still provide a high probability of immediate access to users. Agencies with large numbers of users spread throughout a contiguous geographic area, such as a military base, have found trunking systems to be especially useful. Wide area systems, which allow users to roam over large areas, such as a state or several counties, or between several areas are being implemented. In addition, systems operated by commercial vendors offering services on a for-fee-basis to all government agencies and systems jointly owned and operated by the user agencies have been successfully implemented.
- Government use of commercial Cellular systems and PCS will supplement the Federal land mobile service infrastructure, and appropriate plans are currently being formulated by the potential user agencies. The Federal government expects to use and own unlicensed PCS devices, such as wireless PBXs and wireless Local Area Networks. The Federal government

also expects to obtain PCS and cellular radio services from commercial service providers, as well as other services extending the public switched telephone network to mobile users.

## 6.0 Transition to New Frequency Bands

Overview of New Frequency Band(s) Recommended by Spectrum Subcommittee.  
(Explanation: One of the major endeavors of PSWAC is to determine whether the public safety community needs additional spectrum, and if so, how much and where that spectrum should come from. Once the Spectrum Requirements Subcommittee makes these determinations, the Transition Subcommittee must examine how the public safety community will migrate to the frequency band(s) identified. The purpose of this section is to examine the technical, licensing and other issues that the public safety community may encounter as they migrate to the new frequency bands). Information regarding this transition can be found in Appendix B.

## 7.0 Spectrum Management Options to Increase Spectrum Efficiency By Non-Federal Public Safety Agencies.

7.0.1 As discussed above, the Transition Subcommittee believes that *refarming* current spectrum allocations can provide some additional capacity to State and local governments to support their law enforcement, fire, emergency medical, forestry-conservation, highway maintenance and other public safety services. Additional spectrum capacity will also be required, particularly in major metropolitan areas, to keep pace with the ever growing demand for basic voice and data communications and to permit public safety to implement new telecommunications technologies that will provide State and local public safety entities with new tools for the protection of life and property.

7.0.2 Aside from issues relating to the more efficient use of current spectrum allocations *and* the critical need for additional spectrum for existing and new public safety communications services, the Transition Subcommittee believes that there are a variety of administrative undertakings the Federal Government can pursue to improve the overall efficiency of public safety's spectrum usage. These matters range from restudying the Federal Governments existing licensing mechanisms to improving the overall coordination of public safety issues between Federal and non-Federal public safety entities.

7.0.3 Indeed, while there have been changes in the regulatory procedures administered by the FCC over the years, in essence the licensing mechanisms followed by this agency have remained essentially the same since the statutory provisions set forth in the Communications Act of 1934 were adopted. The Transition Subcommittee believes that there are alternatives to the current regulatory process that could result in more expeditious licensing of public safety entities, better coordination between and among Federal and non-Federal public safety entities, and finally, more efficient use of spectrum allocated for public safety use. These alternatives range from streamlining current procedures to completely

revamping the way in which the Federal Government administers public safety spectrum management activities.

7.1.0 Current Non-Federal Licensing: An Overview.

7.1.1 The Communications Act of 1934, as amended, 47 U.S.C. Sec. 151 et seq., (Communications Act), provides for the regulation of interstate and foreign commerce in communication by wire or radio. The Communications Act requires Federal approval of any emission of radio transmissions by any person other than the Federal government. In essence, the Communications Act preempts the entire field of radio transmissions for exclusive Federal control, particularly in licensing the use of radio spectrum.

7.1.2 The Communications Act also retains Federal regulatory control of the radio spectrum to the exclusion of "private" interest. The Communications Act specifically states that its purpose is to maintain the control of the United States over all the channels of interstate and foreign radio transmissions. While the Communications Act provides for the use of radio channels by others under licenses granted by Federal authority, it does not provide for the ownership of such channels.

7.1.3 Indeed, the Communications Act makes it absolutely clear that no such license shall be construed to create any right, beyond the terms, conditions, and periods of the license. To make sure that Federal control is pre-dominant, the Communications Act provides that an applicant for a license must sign a waiver of any claim to the use of any particular frequency as against the regulatory power of the United States because of the previous use of the channel, whether by license or otherwise.

7.1.4 Private land mobile radio users, including public safety users, have thus had to seek authorization to use a particular frequency or channel by filing an application with the Federal Government's agent, the FCC. Once processed and approved, the FCC issues licenses for periods of up to ten (10) years, which periods may be renewed for successive terms of up to ten years.

7.2.0 New Licensing Alternatives: Non-Federal.

7.2.1 Private radio licensing statistics dwarf those of any other communications service regulated by the FCC. In 1994, total private radio stations licensed by the FCC exceeded 2.9 million (accounting for some 18.8 million transmitters). The FCC received nearly three-quarters of a million private radio authorization requests. There were more than a quarter of a million licensees in the six categories considered public safety. Some 50,651<sup>2</sup> public safety authorization requests were processed. By comparison, there were some 13,044 radio and television broadcast licensees, and the agency received fewer than 5,000 broadcast applications of all kinds that year. Id. at pp. 65-67.

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<sup>2</sup> See 1994 FCC ANNUAL REPORT at pp. 120-21 (1995).

Shared vs. Exclusive Licensing. Today, frequencies in the private land mobile radio bands at 25-50 MHz, 150-174 MHz, and 450-470 MHz are shared among different users in the same area. Frequencies, however, in the 470-512 MHz, 806-824/851-869 MHz, and 869-901/935-940 MHz bands are assigned on an “exclusive” basis determined by channel loading and mileage separation. The coordination process is also different for these frequency bands. In the bands above 470 MHz a frequency can be shared where loading is below that required or mileage separation exceeds the minimum. If the other criteria is met, the channel is protected for its licensed area of operation. In the bands below 470 MHz, the FCC’s application process only requires the identification of the “the most appropriate frequency.”

7.2.3 Hence, applicants are currently granted a license for a specific channel or group of channels on either a shared or exclusive basis. As previously discussed, licensing channels on a shared, non-exclusive basis tends to prevent the implementation of spectrum efficient technologies. This is primarily due to the likely crowding of the radio environment and the difficulty in getting all those that share a channel to upgrade their system to a more efficient technology.

7.2.4 Clear evidence of this difficulty is available in the older private land mobile radio bands where, as indicated, channels are assigned on a shared, non-exclusive basis. While the presumption that a shared radio market is inherently inefficient may be debated, the FCC’s refarming proceeding clearly indicates it is nearly impossible to implement advances in technology in the bands below 450 MHz because of the multiplicity of users in those bands. Where, on the other hand, channels are assigned on an exclusive basis, (e.g., in the MHz band), licensees have been more inclined to implement trunking and digital technologies.

7.2.5 Also as previously discussed, public safety licensees, should be given the option and tools to obtain exclusivity (PSA) on their channels below 512 MHz to permit and encourage the implementation of more efficient radio technologies. This must not be implemented by mandating the removal of any currently licensed systems operating on the requested frequencies.

7.2.6 Local, Area-wide or Statewide Licensing. Public safety entities are currently given authority by the FCC to serve their local areas. Spectrum efficiency may also be increased by greater sharing of the spectrum by a multiplicity of public safety users within a given area (e.g., all agencies within a township, city, or county). Today, many jurisdictions are combining resources to develop one advanced radio system to serve all the public safety agencies within the area.

7.2.7 Regional Plans Regional plans have demonstrated that they are useful tools, particularly in metropolitan areas where spectrum is scarce. Of a number of regional plans several regions have been extremely effective. The Los Angeles area, congested areas of Northern California, New York and several other metropolitan areas have demonstrated effectiveness of regional plans. However, in rural areas or areas of the country that do not have a critical spectrum shortage they have been of little use.

7.2.8 The Transition Subcommittee endorsed the idea of intensive regional planning for congested areas where there is a spectrum shortage and a simple generic plan for rural and

uncongested areas. The Transition Subcommittee would object strenuously, however, if agencies were held hostage to accomplish such planning endeavor as a condition of the release of any new spectrum. No other users of the spectrum are required to provide such planning as a condition of spectrum. It would be a discriminatory practice to require such of public safety.

### **Examples of Wide-Area Shared Systems**

The system described in the preceding paragraph has not yet been matched in fact. However, some systems have been proposed and are apparently moving towards implementation which seem to be driven by many of the same considerations as in the vision. We have included a brief description of a sampling of these systems for two reasons. First, they tend to validate the arguments describing a need for such shared systems. Second, they illustrate various approaches for achieving the fact of these systems. Possibly some synthesis of the approaches described here will offer the best of all organizations for these systems.

**State of Colorado** The State of Colorado is planning a statewide digital trunked radio system (DTRS), based on APCO-25 standards. Planning began in 1991 within the Division of Telecommunications, studying advanced designs for an improved statewide system for the State Patrol. Eventually, components of the Highway Maintenance and Natural Resources Departments were included. Beginning in 1992, an extended series of information meetings were undertaken to gather public support this system. A series of working committee meetings were set up to provide advice on the services and the administration of the system. These meetings included many public safety and municipal communication professionals, as well as industry, Federal agency, and FCC and NTIA personnel. This working committee issued a report in June 1995.

A 6-phase schedule of implementation has been proposed for DTRS, beginning with the Denver Metropolitan area in 1996. The system is expected to cost somewhere near \$120 million, not counting the microwave backbone which is already mostly in place. It is anticipated that the system will be built using the 800 MHz public safety bands. The state legislature would be expected to provide much of the funding, with some expenses recovered from monthly fees and some reimbursed construction costs. The Division of Telecommunications will own and operate DTRS, but local governments and Federal agencies have been invited to participate. A strong user's group is expected to be set up to help govern the system.

The implementation model assumes that several types of users will want to associate themselves more-or-less closely with the state network. The State Patrol, Highway Maintenance, Natural Resources, and Corrections will be full members, based on legislative fact.

**Client members** will be given service on DTRS, in exchange for the monthly subscription fee. Client members are typically small communities that have traditionally not built their own radio systems.

**Integrated members** will forego building their own radio systems, but will contract with the Division of Telecommunications to design and build a system for them, which will become part of the DTRS. Integrated members will probably pay a monthly service fee, as well as the incremental cost of building their part of the system. Typical Integrated members include small-to-medium size towns, whose communications needs are too large to piggy-back on the unmodified DTRS capabilities, but which have chosen not to build their own facility.

**Cooperating members** will build their own radio facilities to meet their own needs, but will design it to become part of the Colorado network. Cooperating members might include city/counties with a large population who are currently operating an extensive radio system. The Cooperating network might replace the DTRS Network in areas where the Cooperating network provides coverage. In exchange for providing services to all members of the Colorado network, the cooperating members might receive payment for services, as well as roaming rights on the remainder of the Colorado Network.

**Associated members**, like Cooperating members, build their own systems, but do not fully integrate them into the DTRS. Sharing between the Associated network and the DTRS is on a voluntary and limited basis, though an Associated network is fully capable of operating as part of the DTRS. An Air Force base might become an Associated member, maintaining full control over its own system, though finding it convenient to share limited roaming privileges with DTRS members. Some municipalities may initially join the DTRS as Associated members, using this status as a halfway point while deciding whether to become Cooperating members.

Finally, a limited number of **Commercial members** might be allowed, especially in areas of the state where other communications were not available. Commercial members might include guides in wilderness areas or ranchers in remote areas of the state. Commercial members would pay a monthly fee.

The Colorado DTRS is currently proceeding on schedule. Several municipalities are in conversation with the Division of Telecommunications regarding coordination of their municipal radio improvement plans with the DTRS.

The availability of a frequency band that could be used by Federal agencies and state agencies remains a problem, though the Division of Telecommunications has indicated that sufficient spectrum exists near 800 MHz to meet current needs. The FCC has indicated that the 800 MHz public safety bands could be used for this purpose.

**State of Michigan** The State of Michigan is building a statewide digital trunked radio system based on Motorola Astro technology. The system will include 168 sites, including upper and lower peninsulas, with an estimated cost of \$187 million. This will provide mobile coverage for 97% of the area of the state. Operation of the system is scheduled for October 1996. A total of 66 frequency pairs in the 821-824 MHz and 846-849 MHz band will be used in the system. The first implementation will include 1500 radios for State functions and 3000 radios for local government functions.

Users on this system include State Police, 911, and all other state public safety functions. Municipal governments are being invited to join. The City of Lansing (the state capitol) will be part of the system. Radio users will buy their own radio, pay a \$250 entrance fee, and pay \$300/year for service.

Some Federal law enforcement agencies have asked for some access to the system, though this is currently not intended to replace any existing Federal networks.

**Racom (Iowa and Surrounding States)** Racom is a commercial SMR company that has been supplying analog SMR services using 100 sites covering Iowa, much of southern Minnesota, and parts of Nebraska, South Dakota and Wisconsin. These older analog sites provide telephone interconnect and allow users operation on all sites in the system. Charges are \$10/month plus \$.25/minute airtime charges for telephone interconnect.

Recently Racom announced plans to build a multisite digital trunked radio system, eventually utilizing 200 sites over approximately the same multi-state geographical area. The new system will provide digital and analog voice and other digital services using Ericsson EDACS technology. The first part of the planned network is operational with 9 sites operating in Polk County (Des Moines area) which are providing services to the 300 radios of the Polk County Sheriffs Department. Cost to the Sheriffs Department is \$15/month/radio plus \$.30/minute air time for telephone interconnection.

The digital trunked service includes both business and law enforcement customers. Law enforcement radios have "ruthless preemption" privileges and can immediately preempt business user channels if law enforcement needs another channel. The wide area system is targeted toward the "high priority" market, including private and government public safety operations, utilities, and similar customers.

The frequencies for this operation come from the 800 MHz SMR frequencies. Although no encryption is in use at present, the Sheriffs department can encrypt transmissions whenever they feel that it is needed.

**State of Louisiana** The State of Louisiana is converting a large number of independent radio systems to a single 125-site trunked system based on Motorola SmartZone analog technology. This system will provide coverage to 95% of the state and will include all state communications functions. Frequencies will come mainly from the 821-824 MHz and 866-869 MHz public safety bands. It is anticipated that some municipal governments will also want to coordinate their radio systems with this network. Non-state users will be asked to pay \$200/year.

7.2.9 These multi-agency systems, whether done on a local, area-wide or statewide basis, have the clear potential of using the scarce public safety spectrum more efficiently. These systems however take the consent of all the agencies within the given area and, thus, should not be mandated by the government. Public safety is the responsibility of local, county, regional, state, and federal agencies and the public within those government jurisdictions must retain the ability to determine how they want their political bodies to

develop and administer communications systems for their benefit. To this end, and as a matter of policy, the government's rules should contain enough flexibility to allow the development of such systems that may include both public safety and related public service (e.g., utilities) entities. Sharing with related public service entities must be done in such a manner as to protect the public safety channels from primary use by public service. A further consideration in all such multi-agency systems is system design which maximizes the use of the spectrum by confining the area of operation of an appropriate number of channels to meet the needs in each specific area.

7.2.10 State Licensing. The Transition Subcommittee observes that in the past the FCC staff undertook a study, entitled *Possible State Roles In The Public Safety Radio Services* (July 1981) to examine whether that agency should create additional roles in which state and local governments could more actively participate in the management of the radio spectrum. The Transition Subcommittee further observes that U.S. Senator Larry Pressler has also suggested that the FCC should delegate to the various political jurisdictions responsibility for assigning and managing radio frequency spectrum allocated for public safety use within their respective borders.

7.2.11 The FCC currently licenses many thousand of individual public safety agencies for radio systems to serve their local areas. A spectrum management option of concern to public safety agencies, is to give the individual States so-called "block spectrum grants." Under this option, the Governor (or his/her appointee) of each State, or other appropriate official within jurisdictions such as the District of Columbia, the Virgin Islands, Puerto Rico, and Guam, would be given a license for all public safety spectrum with authority to sub-license blocks of frequencies to local public safety agencies within their jurisdictions. The task of coordinating between public safety uses, arbitrating among competing applications, and resolving disputes would be vested, in the first instance, in the Governor or his/her appointee or other appropriate official.

7.2.12 If the FCC were to adopt a block spectrum grant approach in the case of public safety licensure, one effect would be significantly to reduce current application processing time and, potentially, costs to users. On the surface it would appear that there are some benefits in that it could (1) encourage and facilitate the concept of state-wide public safety communications systems, shared with local government, (2) possibly relieve the FCC from licensing and allocation duties and (3) have the potential for improving interoperability within an individual state.

7.2.13 It is important not to confuse state licenses for operations for operations with other than state agencies on a shared basis. In discussions during Transition Subcommittee meetings regarding state wide and area wide system licensing and operation there is solid support. This is based on state and local governments having joint planning, ownership, and operation of such systems. Particularly in trunked mode of operation there could be great efficiency of use. The Transition Subcommittee supports such planning and priority licensing for shared state or area systems. Conversely, in our several discussions regarding states assuming licensing authority presently held by the FCC (State Block Grants) there has been little support for, and an overwhelming response opposed to such a concept. There was

only one person voicing support for state block grants from within the Subcommittee. The positive comment from the individual stated that states are closer to the users, have better knowledge of local needs and can aid in the resolution of interference issues. The individual further commented that empowering the states to manage this resource would result in faster processing of applications, reduce costs to users, more direct arbitration, more coordination with efficient use of the spectrum. Although these comments were appreciated by the Subcommittee, no specific were presented to support these assertions. Many have expressed opposition to this particular concept as noted in the following paragraph.

7.2.14 The idea of creating spectrum management roles for states and other United States political jurisdictions creates many complex issues that must be addressed before either the Congress or the FCC should proceed with this concept. Foremost among these issues is whether the states would be willing to accept the role of spectrum manager within their political boundaries and the extent to which such a role would affect the “balance of power” between the state and local governments within their boundaries. Another matter that must be thoroughly examined is how the various political jurisdictions would coordinate the multitude of frequency border frequency assignment issues and any disputes that may arise. Similarly, block grants to States may make even more complex the coordination problems that currently exist between Federal and non-Federal public safety agencies. Just a few concerns expressed are: (1) Requirements vary dramatically from state to state, reflecting size, population, geographical and demographic differences. Blocks would have to be adjusted accordingly. (2) Radio signals cannot be confined to state boundaries and coordination with adjacent states would become much more difficult, particularly if states were free to adopt their own rules and regulations. (3) Most states do not have an organization or structure for administering a program of allocating and managing frequencies. This would be costly and they may be reluctant to assume this responsibility. This could be interpreted as a federal mandate and would require funding. (4) Maintenance of a master data base to reflect the various state blocks and their individual uses would be extremely difficult to create and manage on an individual state basis. (5) Coordination and interoperability would be threatened by disparate use of frequencies by different services and by lack of a uniform state plan. (6) In most states local government, counties and cities would probably strongly object to state control of the spectrum, particularly in states with home rule.. While the FCC is not a user, in most instances the state is the largest user itself and it would be extremely difficult to maintain an objective position. (7) While the FCC presently provides the licensing service at no cost to the applicant, states would be forced to recover costs, probably through charges to users.

7.2.15 The Transition Subcommittee has received no support such a block grant operations. The opposite is true. Many expressions of opposition to such a program were discussed. The Transition Subcommittee therefore believes that this matter not be pursued.

7.2.16 Privatization v. Federal Licensing. As previously observed, the Communications Act preempts the field of radio transmissions for exclusive Federal control. In all cases where the Communication Act requires the operator to have a license, the Act anticipates that the licenses will be issued by the FCC. Section 307 of the Communications Act, for instance, states that “the Commission, if the public convenience, interest, or necessity will be served thereby ... shall grant to any applicant therefor a station license provided for by this Act.” Section 309 of the Act likewise provides that when entities need to operate radio

stations on a temporary basis, the Commission shall issue Special Temporary Authority. Thus, any effort to privatize the Commission's functions must first consider whether the delegation involves licensing activities and, if so, to determine ways to insure compliance with Section 307 and similar provisions of the Act.

7.2.17 Additionally, under Section 158 of the Act the Commission is responsible for accepting application fees. Hence, any process that involves the filing of application fees must take into account Section 158.

7.2.18 Nonetheless, it is the Transition Subcommittee's view that the FCC may be able to delegate many of its licensing functions without amending the Communications Act. The Act gives the Commission broad rule making powers and discretion to administer the Act. To this end, the Commission's rules provide that it alone will be responsible for the issuance of all licenses, modifications and renewals, as well as approval of assignments and transfers. Except in those areas where specifically prohibited by the Act, the Commission has the authority to change its rules and thus the manner in which it administers its licensing functions. This is particularly true in situations where the Commission has the final opportunity to review those matters delegated to others.

7.2.19 The Transition Subcommittee believes, therefore, that there are several options which the FCC may exercise in regard to their licensing functions. These include assigning more authority and responsibility to frequency coordinators who are both qualified and representative of the public safety users. Such responsibilities could include: Processing and granting non-mutually exclusive applications for public safety facilities, including but not necessarily limited to, applications for new and modified facilities, renewal applications, station cancellations, Special Temporary Authority requests, and other minor administrative matters (e.g., change of address). The Commission's rules already contain a "safety-value" provision to protect applicants. The Transition Subcommittee observes, in this regard, that an applicant dissatisfied with any action of a authorized coordinator could utilize the thirty-day petition for reconsideration period provided for in Section 1.108 of the Commission's rules.

7.2.20 Non-Federal Licensing Considerations. The non-federal public safety services currently function with authorized frequency coordinators. Inherent in the FCC's PR Docket 92-235 (Refarming) proposal to consolidate radio services is the issue of providing frequency coordination for a consolidated public safety service pool. Four organizations are currently authorized by the Commission to provide frequency coordination to non-federal public safety users: The Association of Public-Safety Communications Officials - International (APCO) coordinates for police and local government below 512 MHz, and all public safety users above 800 MHz; The International Municipal Signal Association (IMSA) is delegated coordination authority as an extension of the International Association of Fire Chiefs (IAFC) and coordinates for the fire service, emergency medical service, and special emergency service below 512 MHz; The Forestry Conservation Communications Association (FCCA) performs coordination for the forestry conservation service below 512 MHz; and the American Association of State Highway and Transportation Officials (AASHTO) coordinates for the highway maintenance service below 512 MHz. This structure has been built around the FCC's requirement that coordinators be "representative" of their affected user group.

In a pooled environment, each of the four current coordinators would be representative of their current constituency eligible for licensing within the public safety pool. Accordingly, each is qualified to continue coordinating for their current representative user group. Newly generated frequencies within the pool should be footnoted as to their appropriate service.

7.2.21 Electronic Filing and Processing of Applications. As currently structured, the private land mobile radio application process is still heavily paper dependent. The FCC, however, in an effort to eliminate cost and the delay in processing private radio applications, has begun to institute a procedure to file applications electronically. Today, automated data bases and computer software programs that perform all essential task are critical if the Governments wants to establish a modern application processing system. Electronic Data Interchange (EDI) is facilitating a faster and efficient licensing process. It is currently possible for an applicant to upload an application directly to a coordinator for processing. After the coordination process has been completed, an EDI generated application may be delivered electronically to the Commission. There is no reason that the process cannot be reversed and the license delivered to the applicant electronically through the coordinator. and can be transmitted to the applicant simultaneously after ensuring that all obstructions to the license process have been resolved. The licensing process is the final step of the coordination process. An original copy will then be mailed to the licensee if the applicant does not have the capability of receiving the license electronically. We must note that the FCC will remain the final authority in cases of arbitration. The FCC may choose to selectively check applications to ensure compliance to eligibility requirements, its rules and the integrity of the entire process.

RECOMMENDATION: The Transition Committee recommends that the matter of state block grants be studied in much more detail and that the governors of the states be questioned by Congress before any further effort to implement block grants to states is taken.

## 8.0 Spectrum Management Options For Improving Federal Licensing.

### 8.1.0 Current Federal Licensing: An Overview.

8.1.1 The functions relating to assigning frequencies to radio stations belonging to and operated by the United States, or to classes thereof, are conferred upon the President by the provisions of Section 305(a) of the Communications Act. These functions have been transferred to the Secretary of Commerce, which has assigned the responsibility for the performance of them to the Assistant Secretary of Commerce for Communications and Information (i.e., the Administrator, National Telecommunications and Information Administration (NTIA)).

8.1.2 The Interdepartment Radio Advisory Committee (IRAC) is the Federal organization that serves as the focal point for authorizing Federal agency use of the spectrum. Since its inception in 1922, the IRAC functions to assist the NTIA in assigning frequencies to U.S. Government radio stations and in developing and executing policies, programs,

procedures, and technical criteria pertaining to the allocation, management, and use of the spectrum.

8.1.3 The Interdepartment Radio Advisory Committee (IRAC) consists of a main committee, 4 subcommittees, a group for notifying frequencies to the ITU, and 12 ad hoc working groups that consider various aspects of spectrum management policy. The FAS also develops procedures for processing requests for frequency assignment. The Spectrum Planning Subcommittee (SPS) develops both recommendations to NTIA, on behalf of the IRAC, regarding agency requests for spectrum support for new systems and plans for use of the spectrum. The Technical Subcommittee (TSC) assists NTIA in developing policies, programs, procedures, and technical criteria regarding the allocation, management and use of the spectrum. The Radio Conference Subcommittee (RCS) prepares for ITU radio conferences, including the development of recommended U.S. Proposals and Positions. The International Notification Group (ING) prepares responses to the International Telecommunication Union (ITU) concerning questionnaires and other correspondence related to the notification of United States frequency assignments; and the Secretariat.

8.1.4 NTIA also represents the following Federal authorities in one or more of the IRAC subcommittees: Architect of the Capitol, Administrative Office of the U.S. Courts, Board for International Broadcasting, Commodity Futures Trading Commission, Central Intelligence Agency, Consumer Product Safety Commission, Equal Employment Opportunity Commission, Environmental Protection Agency, Federal Deposit Insurance Corporation, Federal Mediation & Conciliation Service, General Accounting Office, U.S. Government Printing Office, House of Representatives, Housing and Urban Development, International Trade Commission, Department of Labor, Library of Congress, National Archives and Records Administration, National Gallery of Art, Nuclear Regulatory Commission, Office of Personnel Management, U.S. Peace Corps, Securities and Exchange Commission, Social Security Administration, Department of State, Supreme Court, U.S. Capitol Police, U.S. Senate, and the Smithsonian Institute.

8.1.5 In recent years, however, legislation dictating the “retrocession” or privatization of radio frequency spectrum now apportioned to Federal use has necessitated greater inquiry on the part of NTIA into the basis for agency spectrum requests. Under that legislation, NTIA has undertaken to access both existing and planned Federal spectrum usage. See, e.g., *NTIA Spectrum Reallocation Final Report* (February 1995). NTIA’s assessment was premised in large part upon formal submissions by IRAC-Member departments and agencies, as well as the general public.

8.2.0 **Improvements in Federal Licensing.** Federal agency requirements for use of the spectrum continue to grow simultaneously with an explosive growth of private demand for many types of radio communication services, such as satellite mobile radios, cellular radios, position location and tracking systems, and others. With this rapid expansion of spectrum use and growing competition for scarce spectrum resources, it is of increasing importance that the federal spectrum management community employ efficient, automated techniques to 1) create applications for certification of spectrum support and for frequency assignment, 2) evaluate proposed spectrum use, 3) resolve spectrum requirement conflicts,

and 4) assess other spectrum supportability issues. By increasing the level of automation and with logical execution of the engineering analyses necessary, the Federal spectrum management community will be able to continue to accommodate additional users of the spectrum well into the next century.

8.2.1 NTIA and the Federal agencies have established general principles for spectrum management as embodied in the NTIA Manual of Regulations & Procedures for Radio Frequency Management. While adhering to these principles, different methods have developed in the various agencies for the selection of frequencies. These different methods may have been adequate in a time of plentiful spectrum. However, with increased spectrum congestion, it is necessary to adopt standard methods of frequency selection so that the benefits associated with more efficient spectrum use may be realized by all. In particular, standardized procedures are desirable to assess the electromagnetic compatibility of proposed systems with existing environments.

8.2.2 In April 1993 NTIA published a vision of Automated Data Processing (ADP) for Federal spectrum management support in which the appropriate individual in the Federal spectrum management community will have ready access to the latest spectrum environment information and the necessary computer programs to assist in the performance of their job functions, as well as the use of telecommunications to minimize the non-value-added time in the spectrum management process. To this end NTIA has introduced a number of improvements in the process and is currently developing more. One of these developments is the Joint Spectrum Management System (JSMS). The version of JSMS being distributed at the present time (April 1996) is the initial operating capability (IOC) and should be viewed as a work in progress.

This program represents a major Federal Government-wide effort to improvement the Federal spectrum licensing process, while improving spectrum efficiency and service to the user.

### 8.3.0 Non-Federal/Federal Licensing.

One major area of licensing that can be improved is the coordination between non-Federal and Federal public safety officials. As previously observed, Government policy to date has done little to change the inefficiencies brought about by the separate and distinct Federal and non-Federal licensing functions. There is growing pressure on public safety radio users at both the Federal and non-Federal level to use their spectrum more efficiently. In this regard, either better coordination between the Federal and non-Federal licensing agencies is needed or there should be a convergence of these functions under one regulatory umbrella.

8.3.2 Current NTIA and FCC regulations for sharing of frequencies between Federal, state and local users for coordinating law enforcement and emergency operations have been developed over many years, and are generally satisfactory for these purposes. However, the use of shared Federal, state, and local government systems would facilitate the close cooperation needed between police and emergency assistance personnel under some circumstances and allow the economic expansion of large wide area land mobile

communication systems needed by all three levels of government. A degree of regulatory flexibility in changing these rules could be exercised to enhance future sharing among Federal and non-federal public safety agencies and ease the coordination burden.

## 9.0 Overview of Commercial Services Available for Public Safety Use.

9.0.1 The need for additional spectrum for public safety use is clearly required over the long term. To this end, public safety users have requested the Federal Government on several occasions to grant them access to additional spectrum. As has been demonstrated elsewhere in this Report, the need for additional spectrum to meet the growing use of voice, data, images, and video in law enforcement and other areas of public safety (e.g., fire fighting) will continue to strain public safety spectrum allocations. Today, perhaps more than ever before, because of the emergence of competition in the commercial marketplace, the availability of a wide variety of commercial services may benefit the public safety user. Moreover, because of the amount of spectrum being “auctioned” to new competitors, which could result in up to ten (10) competing service providers in each market, it is likely that many areas will not have enough customers to support “commercial” services and, consequently, the economic challenges that may face these providers may ultimately result in additional service options for the public safety user.

### 9.1.0 Mobile Voice Services.

9.1.1 Cellular. There are three commercial mobile telephone services in the marketplace today. Cellular telephone service is the largest and most established. Cellular users can choose between two providers in each market. One of the providers, the wireline carrier, is a subsidiary of the local telephone company, and the other provider, or non-wireline carrier, is usually an independent operator. In recent years, however, some independent cellular providers have entered into agreements or been acquired by other telephone companies. Both the wireline and independent cellular providers have formed arrangements that allow users to make and receive calls from almost any place in the United States.

9.1.2 Public safety uses of cellular telephony as an adjunct to their own communications services take numerous forms. Temporary command centers are frequently established in emergency situations which require telephone service immediately in locations where regular phone lines and power have been lost. San Francisco’s public safety officials made extensive use of cellular telephones during the 1989 earthquake. Similarly, public safety officials in Florida used on cellular telephones to maintain communications during Hurricane Andrew and its aftermath as an adjunct to private systems.

9.1.3 Cellular telephones installed in police officers’ vehicles allow an officer to respond to a minor call for service over the phone instead of driving to the scene. This permits a patrol car to be more efficient and more responsive to the needs of the community it serves. And, calls for service that deal with in-progress crimes are dealt with much more efficiently when the officer can speak directly over the telephone to the reporting party or witness.

9.1.4 Other less direct use of cellular telephones by public safety officials have developed as well. Several communities, notably Houston, Boston and St. Augustine, have programs in place in which a victim of spouse abuse will be given a cellular phone that can be used to contact public safety officials if the abusive spouse becomes threatening. In other communities, citizens volunteers will be issued a municipally-owned cellular phone to report suspicious happenings in the neighborhood.

9.1.5 Specialized Mobile Radio Service. The Specialized Mobile Radio Service (SMR) was established in the early 1980's and provides dispatch services to many businesses ranging from taxicabs to public utilities to large corporations. Initially, SMR's provided dispatch communication services -- i.e., brief messages usually with a duration of less than a minute. While dispatch service is still the mainstay of SMR providers, some SMR carriers also provide interconnected mobile telephone service. Some SMR carriers are, moreover, redesigning their systems in a manner similar to cellular providers thus allowing them to use their spectrum allocations more efficiently and the ability to offer a wider array of mobile telephone service.

9.1.6 Personal Communications Services. The newcomer to the mobile telephone service market is the "personal communications services" provider. The FCC has allocated 120 MHz of spectrum for PCS, which has been divided among six licensees in each market. The three 30 MHz blocks are similar to the 25 MHz blocks assigned to cellular carriers. The three 10 MHz blocks can be used for niche services or aggregated with other PCS or cellular providers to provide some type of mobile service (i.e., either interconnected, dispatch, or both).

9.1.7 American Personal Communications' Sprint Spectrum service in the Washington, DC-Baltimore area is the only operating system providing service to paying subscribers. According to industry reports, the wide variety of features offered on the Sprint Spectrum service include caller ID, built-in answering-machine function and numeric paging, voice-mail, text messaging, call waiting, and call forwarding. (see Andy Kellett, *No More Talk About Talk - Broadband PCS Hitting The Airwaves*, RF design, January 1996).

9.1.8 Additionally, RF design reports that "many PCS systems may be adapted to act as a wireless PBX when within a building," and that "when two PCS phones are within the coverage of each others handset, the two phones can operate as walkie-talkies, completely bypassing the phone network (and tolls)."

9.1.9 PCS services are still in their infancy, and it is unclear how these services will develop. What is clear however is that the companies that have gained access to this spectrum are investing millions of dollars in licenses and hardware and, consequently, the competition for the mobile telephone user or market will be intense. This competition should promote lower prices and further innovation that could lead to a host of new services for all users, including public safety and related agencies.

9.1.10 Satellite Radio Systems. Geostationary satellite systems that also provide telephone service have been available for a number of years, and from the present until the year

2010 there will be several operational satellite systems with capabilities to serve non-Federal and Federal public safety agencies. By way of background, commercial satellite systems started in the 1970's when COMSAT offered service for shipboard communications through its MARISAT system. The space segment was subsequently subsumed into the International Maritime Satellite Organization, now called the International Mobile Satellite Organization, (INMARSAT). INMARSAT was initially established to provide communications to ships, but now offers worldwide aeronautical, land and maritime mobile communications services.

9.1.11 Initially, INMARSAT installations costs about \$50,000.00 each and tariffs were \$10.00 per minute. Both installation and per minute costs have been reduced significantly in recent years, however. Today, even though the telephone equipment is still somewhat bulky and expensive, INMARSAT can provide telephone service almost everywhere in the world and has been used for disaster relief and other purposes. Some interim operations have been allowed in the United States. But, because there is now a domestic alternative, INMARSAT will not be allowed to provide land mobile communications in the United States.

9.1.12 Domestically, the American Mobile Satellite Corporation (AMSC) has been provided an exclusive license to provide mobile satellite communications service in the United States. Because AMSC is now providing advanced mobile satellite service in the United States, INMARSAT will be allowed to offer such services only if they are unavailable through AMSC.

9.1.13 Furthermore, the next generation of mobile satellite services, or Low-Earth Orbiting and Medium-Earth Orbiting satellites, are scheduled to become operational in the late 1990s. In the United States, three big LEO's have been licensed by the FCC that will operate above 1 GHz and provide both voice and data communications services. According to the literature, all three big LEO's plan to offer service late in this century or early in the next with dual mode satellite/cellular telephones.

9.1.14 Currently, one Little LEO is licensed and in operation with two satellites in orbit. To provide continuous coverage over twenty-six satellites are necessary, and this constellation is planned for full deployment by the end of 1997.

9.1.15 Recently, INMARSAT created another organization, ICO Global Communications, which will provide non-geostationary mobile satellite communications from an Intermediate Circular Orbit. ICO has received substantial investments and awarded satellite construction contracts to several major corporations. Licensing issues in the United States have yet to be resolved.

9.1.16 The American Mobile Satellite Corporation (AMSC) also launched its first satellite into geostationary orbit in April of 1995 launching an ear of affordable mobile satellite communications. Coverage over the continental United States, most of Alaska, Hawaii, the Caribbean, and over 200 miles offshore is provided. Voice, data, fax and location services are possible through automatic connections to public networks.

9.1.17 Furthermore, the AMSC system is completely digital thereby facilitating National Security Agency encryption systems as well as commercial voice privacy alternatives.

9.1.18 All types of users, including Public Safety agencies, may lease dedicated channels for their exclusive use. Dispatch, push-to-talk, and party-line talk group services are available. Dual mode satellite/cellular, satellite only, transportable and fixed site systems are available to users.

9.1.19 Public Safety Requirements Review. The Transition Subcommittee has reviewed the materials from the Operational and Interoperability Requirements Subcommittees to compare public safety agency requirements against current and future mobile satellite systems and their ability to meet them. Based on this review, the following list of specific needs made be met in whole or in part by commercial mobile satellite systems: basic voice dispatch, air-ground communications, multiple levels of encryption, travel channels for dignitary protection, location data transmission, expandable to allow quick addition of capacity, channel priority assignment, transmission of reports and forms, electronic messaging, transmission to support remote device monitoring, EKG transmissions, access to distant gateway stations when local telephone systems are overloaded, long-range telecommunications, emergency broadcast, media support during incidents, public telephone system access, lightly loaded single channel backbone systems, still photograph transmission, transit management, electronic cargo clearance, and hazardous materials incident response, among others. Only experiment and use under the stress of operational events, of course, will determine the degree of satisfaction with commercial mobile satellite communications systems.

9.1.20 The Transition Subcommittee also notes that the current mobile satellite systems will have no capability to transmit full motion video. Building penetration will also be uncertain because of relatively low link margins. Portable-to-portable hand held transmissions via satellite may be possible with planned LEO satellites and the next generation of geostationary satellites.

#### 9.2.0 Wireless Data Services.

9.2.1 Wireless data services enable users to exchange electronic mail, send and retrieve documents, send and receive messages, and query data bases. These services use either terrestrial or satellite technologies, or both, to serve user needs, and are primarily designed to serve users who "are on the move." Wireless data services are increasingly being used by public safety agencies.

9.2.2 Paging Services. Paging services are the most basic form of wireless data delivery. Paging companies provide service at the local, regional, and national level, and offer a wide range of services -- e.g., tone-only, where the company transmits a signal alerting the user to call in for a message, and tone/voice or numeric pagers, where the user receives a voice message or phone number on his/her pager. Alphanumeric pagers, the most advanced pagers, can also receive short text messages, E-mail, voice mail notification, and information services like traffic alerts or stock quotes. It is also noteworthy, that the FCC has auctioned spectrum for further advances in paging services such as advanced digital and two-way

paging. This has allowed many paging companies to offer new enhanced informational services, including computing and other devices.

9.2.3 Two-Way Messaging Services. Similarly, two-way messaging services offer a wide array of interactive low-speed data applications. Many companies use these two-way services to send and receive e-mail messages and to gain access to company data networks.

9.2.4 Narrowband Personal Communications Services. As noted previously, the FCC has provided additional spectrum through its auction process for a host of narrowband wireless data services -- narrowband personal communications services. Narrowband personal communications services currently provide a family of advanced paging and messaging applications to individuals and businesses, including public safety. There will be approximately 3,554 narrowband PCS licensees that will provide traditional mobile data services such as fleet and courier dispatch, locator services, voice paging, acknowledgment paging, and two-way exchange of short messages.

9.2.5 Cellular Radio Services. Cellular telephone systems also are capable of sending data communications.

9.2.6 Broadcast stations are also developing methods to deliver data information services to the public using their existing facilities.

9.2.7 Satellite Data Systems. Satellite data systems are also used to transmit data and other types of information. Satellites can cover large areas, indeed the whole United States, which make them well suited for the transmission of data and information.

9.5.0 Issues and Implications Regarding the Use of Commercial Services By Public Safety.

9.5.1 Commercial wireless mobile voice and data services hold much promise for use by public safety agencies, whether constructed on their own facilities or purchased from a commercial provider. In the past, mobile data services have been hamstrung by the limited amount of spectrum available for their services, which has limited performance and capacity. Slow data speeds, in part due to the limited band width available for wireless data applications, has been a serious drawback, but additional spectrum and advances in technology (digital compression and transmission, for example) will help providers achieve higher throughput. Also, noise, interference, and attenuation are typical technical problems that confront all data service providers.

9.5.2 Nonetheless, the commercial voice and data wireless radio market offers public safety agencies a wide variety of adjunct services.

9.5.3 Today, when the necessary spectrum support is valued to the Government licensee at nearly zero, the opportunity costs tend to be obscured. Contracting out for

services thus is a means of ensuring accountability. It affords public officials, and taxpayers, a more accurate gauge of the true cost of spectrum-dependent undertakings. The final cost to Government, moreover, will always be less than the direct outlays because of the tax liabilities which private sector suppliers incur.

Contracting out for specialized communications services may be a way of reducing demands on governmental capital budgets. It must also be pointed out, that contracting increases the demand on operating budgets. The communications needs of the public safety community are significant, and in many instances, the public services involved are critical. Hence, not all mobile radio services offered by the private sector today, or even over the next few years, will meet all of the public safety needs.

9.5.4 A comparison must be made between commercial voice systems and public safety voice system. The typical public safety voice radio system is based on a “team” concept, with all players being ware of each others conversations and instantly in communications. The cellular system and PCS systems use a system that generally interfaces through the public switched network. SMR systems are normally shared between a number of various users. Thus the “fleet call” and “dispatch” approach required for most public safety communications can be provided by some, but not all, commercial services. However, many public safety radio systems regularly handle a communications significant volume of routine administrative type communications that could be handled by private sector alternatives.

9.5.5 It is in the area of “critical” communications however that commercial service providers today fail to fulfill the needs of police, fire safety and other public safety users. Traditionally, public safety agencies have been reluctant to subscribe to commercial mobile voice and data services for their primary public safety functions. When public safety agencies do contract with commercial wireless providers, an array of issues are raised ranging from control of the system to whether the commercial systems and their components are reliable, sturdy and capable of withstanding “hard use.” Security of the communications, in some instances, is also a critical factor<sup>3</sup>.

9.5.6 Indeed, it is safe to say that public safety entities will continue to need to operate and control their own communications systems for many years to come. Commercial systems like cellular and newer PCS systems will contribute to carrying out the functions and responsibilities of public safety agencies. They will facilitate routine administrative traffic and, as we observe above, they will also assist public safety agencies in the performance of their duties during both normal and abnormal situations.

9.5.7 However, while many commercial systems may facilitate public safety communications, generally they have not meet the overall communication needs and requirements of the public safety community. Public safety agencies, for instance, cannot wait for a normal dial tone or operate with the danger of jammed circuits during emergencies and

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<sup>3</sup> While the majority of participants in this subcommittee strongly agree with the content of this paragraph, it is noted that several commercial representatives in the group dissented.

other critical periods when instant communications is required. Moreover, public safety agencies must operate with high levels of reliability and interference-free protection, and must have signal quality coverage throughout their jurisdiction.

9.5.8 As noted, new communications technologies and applications are providing new tools for public safety agencies. Many of these technologies and applications may be provided by non-public safety entities. The Transition Subcommittee recognizes that, in the future, public safety agencies must be aware of the availability of such services. Moreover, in their procurement processes, public safety agencies should make efforts to determine whether providers of such services can meet their communication requirements, including considerations relating to control over the system, costs, reliability, coverage, security, and other considerations that now distinguish their own systems from those available in the commercial marketplace. Public safety systems, with sufficient capacity to accommodate peaks in service demand that occur during non-routine periods, to accommodate overall communication requirements.

10.0 Video/Data Services: Overview. (**Explanation:** Wideband systems pose special problems for licensing and spectrum management. Due to the technical nature of topic, it will be placed into appendix "C" at a later date)

11.0 Transition to Interoperability: Overview of Interoperability Subcommittee Recommendations. (**Explanation:** Questions relating to the need for interoperability, who should be able to talk to whom, and the solutions that are available to achieve interoperability fall within the purview of the Interoperability Subcommittee. How the public safety community migrates to the recommended interoperability solution falls within the purview of the Transition Subcommittee. This section is designed to explore transition/migration interoperability issues. This section will also explore interoperability issues that involve non-public safety entities (e.g., utilities).

Outline material follows:

11.1 Backward Interoperability

- (a) Issues Identified by Interop/Subcom.

11.2 Forward Interoperability

- (a) Issues Identified by Interop/Subcom.

11.3 Requirements of Interoperability For Other Entities (e.g., Utilities)

- (a) Definition of Procedures
- (b) Training
- (c) Funding
- (d) Access to PS spectrum
- (e) Backward/Forward Compatibility
- (f) Other

11.4 Infrastructure Dependent Issues

11.5 Infrastructure Independent Issues

11.7 Summary and Conclusions

12.0 Transition Timeline: Overview of Proceedings Necessary To New Spectrum and Technologies. (**Explanation:** Once all PSWAC recommendations are made, it will be necessary for the government to take specific actions to reallocate the spectrum and to adopt those rules that will implement those recommendations found to serve the overall public interest. This section will examine those actions PSWAC believes that they government may have to undertake and to develop some long term planning objectives (*i.e.*, a game plan) for the government and public safety community as it migrates to new spectrum allocations and technologies. These issues include, among others, rule making or other administrative actions that may be necessary to achieve the PSWAC goals and objectives.

Outline material follows:

12.1 Administrative Proceedings

(a) NTIA Proceedings

(b) FCC Proceedings

12.2 Congressional Action

(a) Legislative Proposals

12.3 Summary and Conclusions

13.0 Funding Options: Overview of Funding Issues.

Transition Funding Options.

This section provides a general plan for funding public safety agencies to move to newly issued spectrum in the event that current public safety spectrum is relinquished to commercial or other private sector entities. In addition the funding of public safety agencies to move to new spectrum without current spectrum relinquishment is addressed.

There are several considerations that this subcommittee examined in its recommendation findings. Local funding, State funding and Federal funding are outlined below. While all of these areas specifically address equipment acquisition, funding for training (both technical and operations) on new systems was also placed in equation.

13.1.0 Local Funding.

Funding on the local level sources (*i.e.*, cities, townships, counties, and other municipalities) will be achieved by local authority revenue raising programs. These include

new bond issues, tax levies, citation surcharges, and other programs that are in place throughout the country. These sources of revenue have historically been proven effective funding for public safety systems and will have to be put into place as each agency transitions or migrates into a new spectrum allocation.

These funding options are viable methods in which local governments can move to new bands. However, with governmental downsizing and budget restraints that are facing all levels and branches of government, this is a limited source of revenue. If there is a requirement to relinquish any current public safety spectrum, local funding sources will not be able to absorb all related costs of such relocation.

### 13.2.0 State Funding.

Funding sources for state radio systems and those state owned systems that operate in conjunction with local governmental bodies will face similar constraints in funding at the local level. State governments do have certain funding advantages that can allow transition with greater ease than those entities on the local government level. This report can only recommend that state governmental agencies and legislative bodies propose funding sources to help those on the local level reach transition goals. Again, many of these funding mechanisms are currently in place and operate effectively to provide new communications systems for public safety agencies on both the state and local level. These sources will be needed to move those agencies to new spectrum as equipment becomes obsolete or the agencies have needs to change to new systems.

### 13.3 Federal Funding.

13.3.1 Scenario One. No currently held public safety spectrum is relinquished and additional spectrum is allocated for public safety use.

The use of federal money to facilitate transition to new spectrum has been the subject of intense debate among the participants in the Subcommittee. There are numerous suggestions about the use of federal programs to purchase or assist public safety agencies in buying new radio systems as additional spectrum is allocated. If new "virgin" spectrum is granted in addition to the existing blocks of spectrum currently being used by public safety, the agencies who desire to move existing systems, immediately, to that new spectrum (i.e., for interoperability purposes in contiguous spectrum etc.) will need to rely on traditional funding sources that are currently in place.

In the case that no current public safety spectrum is marked for relinquishment, the agencies would have the option of keeping an existing system on current spectrum or building a new system, possibly when the current system was rendered obsolete, to take advantage of characteristics associated with any new spectrum (if any). In any event, traditional funding sources would be employed which may or may not include federal assistance.

It is suggested that the Commission take action to assist federal, state, and local government public safety agencies acquire systems that will provide mechanisms for

interoperability among both multi-jurisdictional boundaries and multi-echelons of government. Taking into consideration that the Commission has raised considerable revenue from spectrum auctioning, an initiative should be launched to use some of that money to assist transition into new spectrum. This may require Congressional action to allow the use of auction revenues for distribution to public safety agencies in the form of grants. Financial assistance from the federal government will provide incentive for state and local agencies to build systems that will have much needed interoperability capacity.

13.3.2 Scenario Two. Public safety must relinquish a portion of or all currently held spectrum and move to new blocks.

If public safety must give up currently used spectrum, gaining users of the forfeited spectrum must pay for all relocation costs to the public safety agencies to new spectrum. This should include new equipment (must meet new spectrum efficiency requirements), all associated consulting and legal fees, training, and other services connected with relocating an entire system to a new spectrum block. The recent 2 GHz proceedings can serve as a model for this relocation with several modifications.

If public safety agencies are not displaced by commercial entities, they will continue to operate on those frequencies until that life is exhausted. At that time, no new license in the current band will be issued to that entity. They will then be required to build their new system using new spectrum or public safety spectrum that was not required to be relinquished.

**APPENDIX A**

**NEW CATEGORY  
PART 90 RULES**

**EXISTING RADIO SERVICES**

Public Safety

Public Safety Radio Services

Police  
Fire  
Emergency Medical  
Highway Maintenance  
Forestry/Conservation  
Special Emergency/Government  
General Government

Police  
Fire  
Emergency Medical  
Highway Maintenance  
Forestry/Conservation  
Local Government

Special Emergency Radio Services

Public Service

Special Emergency/Non Government  
Power  
Petroleum  
Railroad  
Telephone Maintenance

Industrial Radio Services

Power  
Petroleum  
Forest Products  
Telephone Maintenance  
Film/Video Production  
Relay Press  
Special Industrial  
Business  
Manufacturers

Business/Commercial

Forest Products  
Film/Video Productions  
Relay Press  
Special Industrial  
Business  
Manufacturers  
Telephone Maintenance  
Taxicab  
Automobile Emergency  
Motor Carrier

Land Transportation Radio Services

Motor Carrier  
Railroad  
Automobile Emergency

NOTE: Intelligent Transportation Systems (ITS) applications may be included as public safety if eligible.

## APPENDIX B

The Spectrum Requirements Subcommittee has not completed its Final Report as of this writing of the Transition Subcommittee Final Report. Definitive spectrum recommendations for public safety use of new frequency bands have not been forwarded to the Transition Subcommittee. This appendix contains the draft report outline for Transition Subcommittee Work Group #7 - Transition to New Frequency Bands. In this draft report, questions are posed for which answers are dependent upon those spectrum recommendations. (June 11, 1996)

### B.1.0 TRANSITION TO NEW FREQUENCY BANDS.

#### Explanation:

One of the major endeavors of PSWAC is to determine whether the public safety community needs additional spectrum and, if so, how much and where that spectrum should come from. Once the Spectrum Requirements Subcommittee makes these determinations, the Transition Subcommittee must examine how the public safety community will migrate to the frequency band(s) identified. The purpose of this section is to examine technical, licensing and other considerations that the public safety community may encounter as they migrate to the new frequency bands.

[Overview of new frequency band(s) recommended by Spectrum Requirements Subcommittee (SRS). This area will be dependent upon SRS recommendations which involve frequency bands not presently available under Federal Communications Commission (FCC) Rules and Regulations to Public Safety Radio Services (PSRS) licensees.]

[As of this writing, there are no known Subcommittee plans to recommend that existing PSRS licensees involuntarily relocate from their present operating band to a different PSRS band. However, it is likely that PSRS licensees may wish to voluntarily relocate to a new or different PSRS band for the purpose of developing a new, high spectral efficiency radio system. ]

#### B.1.1 Availability/Time Line

Numerous factors come into play when radio communication systems are moved to another operational band. Not insignificant is the impact which the propagation characteristics of the new band have upon the operational coverage requirements of the impacted public safety licensees. Since it is highly likely that operating systems already exist in the proposed band, those incumbent systems will have to be relocated, which in itself has a significant impact on the overall time line for public safety to begin operations.

## (a) Band Clearing Issues

In order to clearly understand the scope of any band clearing issues, it will be necessary to study the impact on incumbents that must be relocated, since their relocation issues must be accommodated before public safety can relocate to achieve its goals.

- (1) Identify the systems presently operating in the proposed spectrum, and what geographic areas are served by them?

Identify each entity by name address and contact person, its general area of operation, number of stations and subscriber equipment by type and power, and any other pertinent data.

[ This report will attempt to scale a representative impact statement so that an appropriate overall impact can be derived. ]

- (2) Identify spectrum that will be available for incumbents to relocate to.
- (3) Identify the different propagation characteristics of the new band compared to the present band.
- (4) Identify any probable change in the number of fixed sites required to meet the public safety requirements of the new band.
- (5) Identify if existing infrastructure will support a band change. Quantify any modification of infrastructure that may be required.
- (6) Quantify the approximate cost of replacement system, providing same type and quantity of units, and same coverage area. Replacement equipment must comply with present day spectrum efficiency requirements (12.5 KHz).
- (7) If band clearing is required, identify the cost and time benefits of any inducements that may be required to expedite band clearing?
- (8) How will the cost to incumbents who must relocate from one band to a different band be funded? How will the cost of any inducements be funded? (See Transition Subcommittee Final Report Section 13.)

- (9) How will the relocation of the incumbent systems be accomplished and what time line issues pertain thereto?
  - (10) If an incumbent, who must relocate, chooses instead to use commercial services in lieu of relocating its previous system to another band, what financial consideration for band clearing is appropriate and how would it be funded?
  - (11) If temporary use of commercial services is a viable method of expediting band clearing prior to an incumbent's cut-over to a new system, how should that be funded?
- (b) International Frequency Coordination Issues.
- (1) A significant impact on transition to new frequency bands occurs along international borders, where use of frequencies is covered under international treaties and agreements. In the existing FCC Rules and Regulations, there are several different border area definitions which impact the licensing of new transmitter frequencies and locations.
    - (i) Line A. Begins at Aberdeen, Washington running by great circle arc to the intersection of 48° N., 120° W., thence along parallel 48° N., to the intersection of 95° W., thence by great circle arc through the southernmost point of Duluth, Minn., thence by great circle arc to 45° N., 85° W., thence southward along meridian 85° W., to its intersection with parallel 41° N., thence along parallel 41° N., to its intersection with meridian 82° W., thence by great circle arc through the southernmost point of Bangor, Maine, thence by great circle arc through the southernmost point of Searsport, Maine, at which point it terminates. (FCC)

Line A is a border definition line which generally applies to the use of frequencies below 512 MHz along the northern border of the 48 contiguous states with Canada. Within Line A, frequency coordination with Canada is required.
    - (ii) Line B. Begins at Tofino, B.C., running by great circle arc to the intersection of 50° N., 125° W., thence along parallel 50° N., to the intersection of 90° W., thence by great circle arc to the intersection of 45° N., 79° 30' W., thence by great circle arc

through the northernmost point of Drummondville, Quebec (Lat. 45° 52' N., Long. 72° 30' W.) Thence by great circle arc to 48° 30' N., 70° W., thence by great circle arc through the northernmost point of Campbellton, N.B., thence by great circle arc through the northernmost point of Liverpool, N.S., at which point it terminates. (FCC)

Line B is a border definition line which generally applies to the use of frequencies below 512 MHz along the southern border of Canada with the 48 contiguous states. Within Line B, frequency coordination with the United States is required.

- (iii) Line C. Begins at the intersection of 70° N., 144° W., thence by great circle arc to the intersection of 60° N., 143° W., thence by great circle arc so as to include all of the Alaskan Panhandle. (FCC)

Line C is a border definition line which generally applies to the use of frequencies below 512 MHz along the eastern border of the State of Alaska with Canada. Within Line C frequency coordination with Canada is required.

- (iv) Line D. Begins at the intersection of 70° N., 138° W., thence by great circle arc to the intersection of 61° 20' N., 139° W. (Burwash Landing), thence by great circle arc to the intersection of 60° 45' N., 135° W., thence by great circle arc to the intersection of 56° N., 128° W., thence south along 128° meridian to Lat. 55° N., thence by great circle arc to the intersection of 54° N., 130° W., thence by great circle arc to Port Clements, thence to the Pacific Ocean where it ends. (FCC)

Line D is a border definition line which generally applies to the use of frequencies below 512 MHz along the western border of Canada with the State of Alaska. Within Line D frequency coordination with the United States is required.

- (v) In the 800 MHz band, sharing arrangements with Mexico and Canada, described in FCC 90.619, restrict which channels may be used by public safety licensees in the United States.

(2) To effectively make new spectrum bands available to public safety along the international borders, appropriate agreements must first be reached with the respective countries. Several states along the Canadian border have indicated a desire to develop shared statewide radio communication infrastructure. In order for such plans to proceed, international agreement on the use of new frequency bands for public safety use is critical.

(c) Other.

### B.1.3 Technical Considerations - public safety licensees moving to a new band.

(a) Propagation characteristics of the new band.

- (1) Changing to a new band will have an impact. Identify advantages and disadvantages such a change will have on the present system configuration.
- (2) Identify if additional or relocated tower sites will be required to achieve necessary coverage. Quantify the number of sites and cost. Include frequency coordination and licensing cost factors.
- (3) If new tower sites are required, identify the impacts of zoning type restrictions or state environmental quality review processes upon such construction. Quantify the time elements these processes, and frequency coordination and licensing, add to the implementation plans and their additive cost. Should federal legislation be enacted to preempt public safety radio sites from local zoning type restrictions?
- (4) If less tower sites are required, will the remaining number of tower sites have to be relocated to optimize system signal coverage and, if applicable, simulcast performance?
- (5) Where site relocations are required, identify the modification of infrastructure support links (i.e., microwave, fiber optic cable or leased line systems) and receiver voting, common equipment and control systems that may be required. Quantify the cost and time factors required for these modifications to be implemented.

(b) Other

B.1.4 Voluntary vs. Mandatory Transition

What are the expectations for a timely relocation of incumbent and public safety licensee's radio systems to new frequency bands if only a voluntary transition is required. Past history has shown that if deadlines for action are not imposed, the existing operations will likely go on indefinitely.

For that reason, mandatory transition is required. Since band clearing and public safety transition is a multiple step process, as noted above, the mandatory transition plan should have appropriate milestones established, by which, specific events must be completed. Intrinsic to this entire process is the mechanism for funding the work to be performed and the acquisition of new band equipment for the public safety entity, as well as, the incumbent, if any, being displaced.

(a) Non-Federal

In recognition of the federal initiative to establish a National Law Enforcement / Public Safety Network, IT04, federal and non-federal public safety communications infrastructures should be combined into a comprehensive system meeting the needs of all participants. Such a combined system development can start more easily with statewide systems, interconnected by appropriate gateways for wide area federal use, beginning with construction in the more rural areas and completing in the urban areas.

(1) Urban Areas

In extreme urban areas, such as New York City, NY; Chicago, IL; or Los Angeles, CA; the vast number of channels involved presents a monumental task. It may be possible to simplify the transition by use of cross-band patching of repeaters so that units in transition from one band to another can still communicate with each other. However, for tactical operations, unit to unit simplex operations must require similar equipment in use by all members within a working unit or "detail". Should large scale events occur during the transition period, the magnitude of this equipment-match requirement will present special difficulties. Cross-band repeating will result in a temporary surge in channel requirements since both bands will have to be fully operational during the transition period. Operating essentially two separate radio systems at radio system sites will require duplicate equipment space, infrastructure transmission links, and tower loading

capability. This issue can be directly compared to the current PCS, BAS and MSS displacement of public safety microwave incumbents in the 1.8 - 2.2 GHz bands.

(2) Rural Areas

In rural areas, where radio communication density is much lower compared to the major urban areas, and systems cover larger areas, the transition to higher frequency bands will likely require additional sites and possible relocation of existing sites. In this type situation, the transition is much easier, since new infrastructure links will be required and duplicate existing equipment space and tower loading are not required.

(b) Federal

In recognition of the federal initiative to establish a National Law Enforcement / Public Safety Network, IT04, federal and non-federal public safety communications infrastructures should be combined into a comprehensive system meeting the needs of all participants. Such a combined system development can start more easily with statewide systems, interconnected by appropriate gateways for wide area federal use, beginning with construction in the more rural areas and completing in the urban areas.

[ (1) Urban Areas are expected to be similar to non-federal. ]

[ (2) Rural Areas are expected to be similar to non-federal. ]

B.1.5 Cost Considerations

As identified in section 6.1 above, costs are estimated for relocation of incumbents and the transition of public safety entities to new frequency bands. These costs will include the direct costs of new equipment, site relocation, and possibly new infrastructure / common equipment - resulting from a need to reconfigure the system in order to obtain required performance in the new frequency band. Additionally, the special or temporary costs associated with transition will include duplicate systems, possible temporary use of other facilities - including tower sites and commercial wireless services, etc. While any system conversion to a new band, in and of itself presents opportunity to "upgrade" communication capability, the costs described in this section do not include such upgrades, such as adding mobile digital equipment, where it does not presently exist within an agency.

## (a) To Public Safety

users

## (1) Cost Reductions due to proximity to other high volume

Significant economies of scale accrue, when manufacturers mass produce large numbers of equipment. For this reason, public safety equipment should not be located in a band which is far removed from high volume commercial services.

## (2) Summary of public safety identified costs from Section 6.1 above.

## (b) To Manufacturers

Significant economies of scale accrue, when manufacturers mass produce large numbers of equipment.

## (c) To Previous Users

Summary of costs attributable to the relocation of incumbents, identified in Section 6.1 above.

## (d) Other

## B.1.6 Environmental Considerations

There are many considerations referred to as environmental. These might include the actual impacts and public concerns for non-ionizing radiation emitted from radio communication systems. Typical land mobile communication systems, unlike broadcast and paging, do not require high power transmitters, and the power density calculations required to demonstrate compliance with ANSI C95.1 confirm this fact. Nevertheless, the public's perception of radio communication towers is that they present a radiation hazard to surrounding population. In addition, there is a great concern for visual impact. Local laws and ordinances have been proposed that would limit tower height to no greater than surrounding trees. Generally, visual impact has no quantified acceptable value.

The need for radio communication towers as a means of placing the transmitting radiation center away from people to ensure compliance with ANSI C95.1, and positioning receiving antennas optimally for reception of low power portable radio signals is technically without question. Towers used for microwave systems must provide sufficient height for those line-of-sight paths. Adequate space, clear of the large reflector microwave antennas, to mount land mobile system antennas so that desired radiation patterns are achieved, and to provide appropriate spacing between antennas for necessary signal isolation to be achieved, requires vertical tower height. Height versus quantity of tower sites becomes

an economic study of project cost effectively and overall system reliability. Tower size is frequently related to the strength required to support very narrow beamwidth microwave antennas so they do not result in unacceptable signal fading when the tower flexes during extremes of wind and ice conditions. After all, public safety systems have to work in the worst of conditions in order to provide the public necessary services in response to those conditions.

Infrastructure intensive public communication systems, such as cellular telephone and PCS which connect individual subscribers to the PSTN, can make optimum use of lower structures in order to achieve necessary local signal penetration and extensive channel reuse. Public safety systems, on the other hand, need the capability to talk to large groups of subscribers over large areas, where low towers tend to require a significantly more complicated and expensive fixed equipment infrastructure.

For these reasons, special legislative treatment to preempt public safety communication towers from local zoning type restrictions should be considered and given the same status as commercial providers as stipulated in the Telecommunications Act of 1995.

**6.6 APPENDIX F - PSWAC Members and Participants**

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
<b>NAME</b>	<b>ORGANIZATION</b>
Steve Adler	Motorola
Douglas M. Aiken	IMSA
E. John Alberts	MO Dept of Con.
Michael Alcalay	AirTouch Communications
John Alexenko	The Warner Group
Nick Allard	Latham & Watkins
Richard Allen	FBI
Lt. Craig Allen	Illinois State Police
Gary Allen	Berkeley Police/Fire Comm.
Chris Allman	Assn. of American Railroads
Michael Amarosa	Deputy Police Commissioner, NYC Police Dept.
Bob Amick	University of Colorado PD
Victoria Anderson	Booz, Allen & Hamilton
Dominick Arcuri	Ericsson
James Arnold	FHWA
Johnathan J. Bae	National Communications Systems
Barbara Baffer	Ericsson
John H. Bailey	ARINC
Mary Ball	COMNAVBASE San Diego Fire Department
Julie Banton	New York City Transit Authority
Raymond Barnett	U.S. Secret Service
Mike Bayly	Securicor Radiocom, Ltd.
Ashby Beal	Kelly & Povich
John Beckett	DOJ/DEA
Robert Becklund	The Associated Group, Inc.
Jean Bell	CA Hwy. Patrol
Lt. Michael E. Bennett	Maryland State Police
Charles Bennett, Jr.	Lynchburg Police Dept

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
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Donna Bethea	AirTouch Communications
Keith J. Biesecker	MITRE/FHWA (ITS)
Donna Bigby	PWC
Art Bishop	U.S. Secret Service
Gerald Bitner	City of Berkeley, CA Communications
Sgt. Bruce R. Blair	Montgomery Co. Police
Matt Blais	Naval Special Warfare Group-1
Tom Boeckmann	IA Dept. of Public Health, EMS
Sidney Bogan	Detroit Police Dept.
Rich Bohmer	SHL-Intl Public Safety Group
McKinley Boutte Jr.	Jacksonville Fire & Rescue
Dale Bowen	Public Technology
Thomas R. Brace	President, Natl Assoc. of State Fire Marshals
Edward R. Braden	City of Hoover
William Bratton	Police Commissioner, NYC Police Dept.
William T. Brennan	Rockwell
Bob Bridges	MCB Camp Pendelton
Joan Brody	NYPD, Staff to Police Commissioner
Joe Bruno	City of Phoenix
David Bryson	Department of Transportation NHTSA/EMS
David Buchanan	County of San Bernardino, CA
Steven L. Buckley	The Warner Group
Dave Bull	ABC Radio Networks
Thomas Buneo	NYC - Do iTT
Jim Burack	Police Exec. Research Forum

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
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Joseth Camacho	NAVCOMTELSTA San Diego
Michael J. Cannon	NSWG-1
Rod Canter	Department of Justice
Kevin Carlton	U.S. Coast Guard
Vince Carter	DSM Police
Louis Cegala	US Customs Service
Jim Chadwick	MITRE/FHWA
Jim Chang	Bell Labs
Marin Chang	City of New York
Wil Chase	Director of Community Relations
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Thomas W. Christ	HDS
Bruce Christensen	Hill AFB
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Dave Climek	MITRE Corp., Rome Laboratory/USAF
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Stanley Cohn	Concepts to Operations, Inc.
Rich Comroe	Motorola
Jen Connell	AT&T
Royce Connerley	Union Pacific Railroad
Dennis Connors	Vice President, Engineering Marketing, Ericsson, Inc.
Mark A. Cooper	LA County Fire
Mike Corbett	Buford Goff & Assoc., Inc.

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
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Andre Cote	ITA
Darrel Cox	Iowa State Patrol Planning & Training
C. David Crandall	VSE Corporation
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Elaine D. Critides	Kurtis & Assoc., P.C.
Anthony Crook	Bureau of Alcohol, Tobacco and Firearms
Robert Crosson	Self
Steven Crowley	NTT America
Corey Cummings	CA. Dept. Corrections
Jesse O. Daniels	N3FC NAVCOMTELSTA
Phil Davey	ADCOM
Allen Davidson	Motorola
Thomas Davis	Department of Public Safety
Florence Dean	NYCTA
Richard DeMello	Forestry Conservation Communications Assoc.
Eric Desilva	Wiley, Rein & Fielding
Alan Dewitt	Provo City
Lynn Diebold	CA Highway Patrol
Peter J. Dieppe III	City of Charleston
John DiSalvo	State of Florida
Rachel Donald	State of South Carolina
William Doolittle	The Warner Group
Joseph Douglas M. Akers	Noble
James E. Downes	U.S. Dept. of Treasury
Jack Duncan	Buford
Tim Dunn	Arvada Police Department
William Dunning	City of Dearborn Comm. Dept

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
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John Dupuis	Aerospace Corp.
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Gil Edwards	State Highway Administration
David Eierman	Motorola
Paul Einreinhofer	Bergen County Police
Kent Eldridge	Tennessee Department of Safety
Bob Ensminger	State of Calif. Telecom Div.
Robert Epper	Natl Law Enforcement & Corrections Technical Center
Janet Ernest	Motorola
Kamilo Feher	Univ. of California, Davis
Robert Fenichel	National Communications System
Richard Feser	E.F. Johnson
Brent Finster	Aspen-Pitkin County Communications Center
Matt Foosaner	NEXTEL Communications
Michael Forest	Federal Bureau of Prisons
Steve Frackleton	Ericsson, Inc.
Honorable Louis J. Freeh	Director, Federal Bureau of Investigation
Honorable Michael Freeman	Fire Chief, LA County Fire Dept.
Joseph F. Friend	FCCA
Patricia A. Frosio	County of San Diego
Gordon Fullerton	Director of Information Systems and Engineering
Joe Gallelli	Midland
Scott Gardner	AFC4A/TWSDW
Ralph Gay	IRS Criminal Inv.
Wendell Giggey	DCFD
Ed Gilbert	AMSC
Jerry Goff	MO Dept of Con.

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
<b>NAME</b>	<b>ORGANIZATION</b>
Benjamin Golant	E.F. Johnson Company
Donald W. Goodwin	LMR International, Inc.
Bob Gorandier	Lakeside Police Department
Nick Gorham	Motorola
Hugh Ol Gouldman Jr.	Telecommunications Consultants, Inc
Michael R. Granados, Sr.	IAFC Communications Comm.
Gary David Gray	County of Orange, GSA Communications Div.
Dr. John S. Gregory	Stanilite Pacific Ltd.
Frederick G. Griffin	Frederick G. Griffin, P.C.
CDR Debra A. Gross	Office of the Assistant Secretary of Defense
Marvin Grossman	Allen Telecom Group
Michael Grunden	NAVEMSCEN
Robert Gurs	Wilkes, Artis, Hedrick & Lane
Carl Guse	State of Wisconsin Dept. of Trans.
Stephen W. Haller	Frederick Police Dept.
Philip B. Hallpern	Asst. U.S. Attorney, So. District of CA
John A. Hampton	Howard County, MD Bureau of Communications/911 Center
Joe Hanna	Richardson Police Dept.
Ron Haraseth	State of Montana
Walt Hardesty	W-Y Combined Communications
Kevin D. Harper	Kern County Fire Department
Cheryl Harrer	APCO
Gene L. Harrison	MITRE Corp.
Tony Harrison	Oklahoma City Police Department
Stan Harter	APCO and California OES
Curtis Hatamoto	UC Davis
Dale Hatfield	Hatfield Associates, Inc.
Bryan Hawkins	City of Long Beach Telecommunications Bureau
Terry Hayton	FBI

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
<b>NAME</b>	<b>ORGANIZATION</b>
Trae Heath	Alexandria Police Dept.
Michael Heavener	Manager of Mobile Corporation
David Held	Communications Supervisor
Ralph C. Henderson	Defense Protective Service
Joe Hersey	Commandant U.S. Coast Guard (G-TTM)
Maralyn Hershey	Metro Police Dept.
Robert D. Hewitt	L.A. County Fire Department
David Hewitt	State of Wisconsin Dept. of Trans.
Laura Hoffman	Vinson & Elkins
Dr. Ernest L. Hofmeister	Ericsson, Inc.
Michael Hogan	State of Nebraska
Ed Hollingsworth	Union Pacific Railroad
Donald Hollisysworth	Lafayette Group
Laura Holloway	Nextel
Lavern Holtorf	IA D.O.T. AHSHTO
Mark Hoppe	E.F. Johnson
William Hopstetter	FCCA
John Noland Hudson III	State of CA
Arthur D. Hurtado	CACI Inc.
Kris Hutchison	ARINC
Al Ittner	Motorola
Robert S. Jack II	HQ AFC4A/SYXM
Charles L. Jackson	Strategic Policy Research
Andrew L. Jackson, Jr.	D.C. Fire/EMS Dept.
Lalit K. Jain	Self
Mark Johnson	Chief, Emergency Medical Services Section, Dept. of Health and Social Services, St. of Alaska
Dan Johnson	Caltrans
John Jones	DSM Police

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
<b>NAME</b>	<b>ORGANIZATION</b>
Don Josephs	U.S. Dept of Justice
Bobby Joyner	National Volunteer Fire Council
Carl Kain	MITRETEK Systems
George Kamerer	Consultant
Alan T. Kealy	Maryland State Police
Kevin Kearns	King County, WA
Jerry Keene	Los Alamos Fire Department
Thomas J. Keller	Verner Liipfert Law Firm (for AAR)
Jim Kelley	FCCA
Roger B. Kelley	Kelly & Povich, PC
Raymond W. Kelly	Department of the Treasury
Edwin F. Kemp	Union Pacific Railroad/Assc. of American Railroads
John Kenty	FCCA
David Kernan	Ericsson Inc.
Roy C. Kime	International Assoc. of Chiefs of Police
Capt. Arthur D. King	Virginia State Police
Kathryn Kleiman	Fletcher, Heald & Hildreth
Sam Knott	Cala Knott Memorial Foundation
R. David Koilpillai	Ericsson, Inc.
Harvey Kramer	Omnico
Philip L. Kramer	United States Park Police
Rhonda Kurtis	Kurtis & Associates, P.C.
Michael S. Kutch	E.F. Johnson
Fred Kuznik	Senior Vice Pres. and General Manager, Motorola, Inc.
Burel Lane	E.F. Johnson Company
Michael D. Langan	Dept. of Treasury
Lars G. Larsson	The Ericsson Corp.
Otis J. Latin, Sr.	Fire Chief
Peter A. LaVenja	Nat. Assoc. of State Telecommunications Directors

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
<b>NAME</b>	<b>ORGANIZATION</b>
Terry Lawhan	Longmont Police Dept.
Frederic C. Leiner	MITRE Corp.
Ed Leisten	Motorola
Wayne Leland	Motorola, Inc.
Elwood Lewis	U.S. Postal Service
Shanna H. Liable	Info Sys Mgr.
George Lieberman	NIST
Ted W. Lienhard	Div. of Wildlife, St. of NV Cons. Nat Resources
Gill Lineberry	Fla. APCO
Dwight A. Locke	U.S. Secret Service
Ajejandro Longoria	McAllen Police Dept
Jaci Marie Louise	Summit County Communications
Sue Love	Staff Mgr, ICR
Barry H. Luke	Gainesville Police & Fire
Joseph G. Lundholm, Ph.D.	Montgomery Co. Dept. of Police Vol.
Michael Lynch	Northern Telecom
Michael Lynn	Motorola RNSG
Roger D. Madden	Roger Madden Company
Paul G. Madison	Reed, Smith, Shaw & McClay for the Office of Information, State of SC
Frank J. Mammano	Federal Highway Admin.
Ray Marler	National Training Center
Robert Marz	State of Utah
Steven Marzolf	Prince William Co. Public Safety Comm.
Dr. Joseph H. Massa	FEMA
Jack Masser	Frederick Police Dept.
Bob Matheson	NTIA/ITS
Dan Matkin	City of Fort Worth
Gail Matuszak	Estes Park Police Dept.
Garrett G. Mayer	L.A. County Communications

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
<b>NAME</b>	<b>ORGANIZATION</b>
David McCartney	Ericsson
Barbara A. McCoy	DOJ/Immigration & Naturalization Service
Art McDole	No. California APCO
Harlin R. McEwen	Deputy Asst. Director, CJIS Div., FBI; IACP
Lew McIntyre	Focused Research, Inc.
Sgt. Brian J. McKeon	Largo Police Dept.
Joe McNeil	Harwich Fire Dept.
Clancy McQuigg	OWL-VFD
Jim Medlock	Self
Beth Meek	Grand Junction RCC
Lee Meinert	Iowa State Patrol - Special Services Officer
Alfred Mello	Public Safety Communications Council IMSA/IAFC
Rodney Mickelson	Rockwell
Larry A. Miller	AASHTO
David Miller	Iowa Emergency Mgmt. Division
Gregg D. Miller	Racom Corp., Ericsson - GE
J. Miller	Aravada
Kenneth Allan Mitchell	Californis Highway Patrol
James P. Mitchell	Rockwell
Lorin Mock	Jacksonville Fire & Rescue
Steve Montealegre	Ericsson
Jane Montoya	Arvada
Susan Moore	Mobile Telecommunications
Radford Moore	City of Aurora
Mary Moore	Loveland Communications
Bill Moorhead	Pulson Communications
Ramon Torres Morales	Economic Development
Michael Morgan	County of Los Angeles Fire Dept.
Ross Morris	WA St. Patrol
Carolyn Morris	Federal Bureau of Investigation
Kevin Morrissette	Prince Georges Co. Fire Dept.

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
<b>NAME</b>	<b>ORGANIZATION</b>
Cpt. Mike Mulligan	Union Vol. Fire Department
Curt Munro	County of San Diego
Julio Murphy	DOI
Patrick B. Murray	House Judiciary Comm.
Glen S. Nash	State of California
Richard Neat	ARINC
Emily Nelms	American Personal Comm.
Dallas Neville	Rancho SantaFe FD
Eric Nevins	DSM PW
Kenneth E. Newcomer	STARSYS
Paul A. Nichols	Fairfax Co. Fire Dept.
Steve Nichols	E.F. Johnson
Joe Nordgaard	AT&T Bell Labs
James W. O'Connor	Howard County Government
Jan O'Dell	San Diego Police
Tom O'Keefe	Sate of Maine, Dept. Of Conservation
Linda Oliver	H&H
Vic Olmiecinski	Village of Dolton
Paul Orbuch	Western State Governors' Association
Jack Oslund	Comsat Mobile
Charles Ostrofe	Frank Thatcher Associates
Richard Paddock	Orange County Sheriff's Dept.
Gary L. Page	IDR, Inc.
Frank Parker	U.S. Coast Guard
Thomas E. Patterson	Houston Fire Dept.
R. M. Patterson, Jr., Ph.D.	Police Dept.
Sgt. Jeffrey L. Pauley	Montgomery Co. Park Police
Dr. Clarence Peecher	Illinois State Police

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
<b>NAME</b>	<b>ORGANIZATION</b>
Jeff Pegram	VA Office of EMS
John L. Penido	Chief, Fire Operations, City of San Marino
Mel Pennington	State of Nevada
Tim Peters	Ill. Dept of Transportation
Don Pfohl	City of Mesa, Communications Division
Shawn Pindell	NCS
John Pongu	UL Berkley
Fredrick Potter	U.S. Customs
John Powell	APCO/Univ. of California
Alvin Prant	New Jersey Dept. of Transportation
Don A. Premo	Technical Committe of Montgomery County, MD Police Dept.
John A. Prendergast	AAA
Laurance Price	Price & Sons
Eldon Prochnow	U.S. Secret Service
Steven Proctor	Technical Services Manager, Utah State Telecommunications Division
Dwight Purtle	Johnson County Emerg. Communications
Ron Quaglan	West Haven Police Dept
Mark Racek	Ericsson
Richard Rahto	IA DOT AHSHTO
Cindy Raiford	DoD
L. Robert Raish, Esq.	Fletcher, Heald & Hildreth
April Ramey	Dept. of Treasury
John Ramsey	APCO
Ronnie Rand	Ex. Dir., APCO, Inc.
Stephen J. Rapiejko	Ericsson
M. Scott Rappeport	AT&T Bell Labs
Dennis R. Raymond	Self

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
<b>NAME</b>	<b>ORGANIZATION</b>
Martin Reilly	Hazeltine Corp
Jerry Remhof	Iowa State Patrol Comm.
Oscar Reverz	SCT - Mexico
Emery Reynolds	Colorado APCO & Arapahoe County, CO
Gregg Riddle	Elk Grove Fire Dept.
Bette Rinehart	Motorola
Jose Rivera	SBRPCA
Natalee Roan	Nextel Communications, Inc.
Leon Roberts	US Marshals
Nicole Robilotto	House Judiciary Comm.
Jerry Robinson	Chicago Police Dept
Chief Thomas J. Roche	IACP/Communications Comm. Vice Chairman
Richard Roley	State of GA DOAS
Paul Roman	ASTM Committee F30 on EMS
Don Root	State of California
Nicole B. Rossignol	The Warner Group
Bill Ruzzamenti	Lafayette Group
Col. Ryan	HQ AFC4A
Allan E. Rypka	Focused Research International
Howard Safir	Police Department, City of New York
Paul Salter	City of San Diego
Paul Sautter	IIT Research Institute
Tom Savage	NYC Transit
John Schaaf	American Paging
Gary Schlanger	AT&T Bell Labs
Robert Schlieman	New York State
Alex E. Schultz	Northern Telecom
Dick Schurman	Joplin Missouri Police Department
Bob Schwartz	E.F. Johnson
Lt. Lawrence Schwartz	Los Angeles Co. Sheriff's Dept.

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
<b>NAME</b>	<b>ORGANIZATION</b>
Dan Scrivner	City of Dallas
R. Michael Serkowski	Wiley, Rein & Fielding
Alireza Shahnami	APCO
Barry Shay	CACI
Jeffrey Sheldon	UTC
Steve Shelton	Kenwood Communications Corp.
Mike Shepherd	Harris/Farion
Richard J. Shiben	Ericsson
Kevin Shoemaker	City of Tulsa
Richard Shulak	Wisconsin State Patrol
Ann L. Sigei	Wiley Rein and Fielding
Barry Simmon	Federal Aviation Administration
Stanley Sines	Metro Police Dept.
Lt. Raymond Skopin	Metro North Police
Addison E. Slayton, Jr.	Virginia Department of Emergency Services
McRae Smith	Self
Merae Smith	FBI
Assistant Chief Ron Smith	Laramie County Fire District #2
Linda Smith	San Miguel County
Karen L. Smith	U.S. West Communications
J. Dale Smith	Arlington County Fire Dept.
John Smyth	Motorola RNSG
Samuel Somers	County of Prince William, VA
Steve Souder	Arlington County, VA - Emergency Comm. Center
John Spellman	KCMO Police
Mike Steeves	La Junta Police Dept.
Jeff Steffel	Michigan State Police
Russ Stein	City of Berkeley, CA Communications
Meyer Stender	NYCTA
Gary Lee Stevens	Iowa State Patrol - Communications
Larry Stewart	Office of the Deputy Assist. Sec. for Enforcement

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
<b>NAME</b>	<b>ORGANIZATION</b>
Vincent R. Stile	Suffolk County Police Dept.
Edward G. Stillwell	Naval District Washington
Frank W. Stoda	Fairfax Co. Gov.
Sean Stokes	UTC
Dr. Gregory M. Stone	INS/CECOM
James Stoneback	County of Fairfax, Dept. of Information Technology
Marvin T. Storey	USDA Forest Service/IST
Dave Stratton	Navy PWC San Diego
Dean Strid	State of Alaska
Thomas Struzzieri	Department of State Police
Kenton E. Sturdevant	Forest Industries Telecom.
David Swan	Swan & Associates
Robert E. Tall	Center for Public Safety Studies
Jim Tedrick	OMNICO
Sean Thakkor	United States Marshal Service
Robert Thiel	Electrical Superintendent of the Golden Gate Bridge District
Dr. Robert I. Thompson	Thompson Group
David Thompson	SEA, Inc
Paul Tinney	Motorola
David Toll	Phillips Business Information
Tom Tolman	Adams County Communications Center
Dr. Michael C. Trahos	Region 20 Public Safety
Larry Trevor	Nextel Communications, Inc.
Tony Tricoci	
Tom Trimmer	U.S. Army Pentagon
Keith D. Turney	Joliet Police Dept.
Tom Tuttle	WI Dept of Nat Res.
Peter Ungar	City of Fort Worth

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
<b>NAME</b>	<b>ORGANIZATION</b>
George Valenzuela	Aerospace Corp.
John M. Vallarelli	Metro North Police Operations Div
Don Vaughan	SHL Corp.
Gerrit Veenhof	State Highway Administration
Philip L. Verveer	Willkie Farr and Gallagher
Emil Vogel	Motorola
Ronald Wade	City of Roanoke Communications
Greg Wagner	IIT Research Institute
Robert Waldron	Aerospace Corp.
Ronald Wallace	NASA
Steve Wallace	CDF
John Walsh	VGS
Charles Walters	Orange County Sheriff's Dept.
Marilyn Ward	APCO - Orlando Police Communications
Dennis Warren	SBRPCA
Joyal Watkins	FCCA
Scott Webber	Naval Station Security Dept.
Melvin G. Weimeister	Phoenix Police Department
Jeff Weinberg	OMB
Chuck Wexler	Police Executive Research Forum
George Wheller	Koteen & Nattalui
John D. White, Jr.	Tennessee Emergency Management Agency
Carroll White	APCO
Vern Whybrew	Long Beach Police
Paul Wieck	Dept. of Public Safety
R. Mark Wildey	Aurora Fire Dept.
Ted Wilienhard	State of Nevada Dept. of Conservation
Steve Wilkins	CHP
Mickey Williams	Fisher, Whalen, Cooper, Leader & Zaragoza

<b>PUBLIC SAFETY WIRELESS ADVISORY COMMITTEE MASTER MEMBERSHIP LIST — August 1, 1996</b>	
<b>NAME</b>	<b>ORGANIZATION</b>
Kevin Williams	Tennessee Bureau of Investigation
Ernest E. Williams	GSA, FPSD
David Wong	Wireless & I/T /SAIC
Henry Wood	Prince William Co. Police Communications
Don Woods	NCTS N210
Barry Worden	City of Arlington Texas
Debbie Worthen	Canon City Police Dept.
Clare Wren	FCCA
Jeffrey W. Wright	CACI
Beverly Wright	Federal Bureau of Prisons
Ken Yoder	Texas Dept. of Public Safety
Chris A. Young	FBI
Joseph Yurman	MTA, N.Y.C. Transit
Larry Zabkowski	APCO - Michigan