service classifications and particular use. The FCC has done so in other areas.[12] 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

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

Police Radio Service (PRS)	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.
Fire Radio Service (FRS)	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.
Highway Maintenance Radio Service (HMRS)	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.

[12] 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).

Table 1-2

Forestry-Conservation Radio Service (FCRS)	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.
Local Government Radio Service (LGRS)	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.
Emergency Medical Radio Service (EMRS)	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.
Special Emergency Radio Service (SERS)	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.

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

EXISTING STATE AND LOCAL PUBLIC SAFETY SPECTRUM ALLOCATIONS			
Band (MHz)	**Channels**	**MHz (est.)**	**Comments**
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.
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
	941	**23.2**	**TOTAL**

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.[13]

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.

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

Table 1-4

EXISTING FEDERAL PUBLIC SAFETY SPECTRUM ALLOCATIONS

Band (MHZ)	Total Govt Allocation (MHz)	Public Safety Allocation (portion) (MHz)	Comments
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.

[13] 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.

Table 1-4

EXISTING FEDERAL PUBLIC SAFETY SPECTRUM ALLOCATIONS			
Band (MHZ)	**Total Govt Allocation (MHz)**	**Public Safety Allocation (portion) (MHz)**	**Comments**
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.
	38.89	**24.45**	**TOTAL**

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.[14] 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.

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[14] See Letter of Honorable Emmet Paige, Jr., Assistant Secretary of Defense, to Philip L. Verveer, dated July 29, 1996.

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.

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:[15]

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 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.[16]

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[15] 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.

[16] 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

(continued...)

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 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.

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16 (...continued)
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 dispatch. Unfortunately, in many places, communications systems cannot grow because there is no available spectrum.

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 capsulize 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.[17] 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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[17] 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.[18] 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

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[18] 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."

systems. Thousands of individuals may be involved. The 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

Expected Advances in System Building Blocks	
Technology Building Block	**Observations**
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

Expected Advances in System Building Blocks	
Technology Building Block	**Observations**
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	A variety of techniques are used today to access channels including: FDMA (frequency-division multiple access), TDMA (time-division multiple access), and CDMA (code-division multiple access). 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.
Error Correction Coding	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. The Technology Subcommittee projected the widespread use of error-correcting coding technology in land mobile communications.

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.