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 may 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 statue 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 in 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 an 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:

	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 AREA 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:

	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 AREA 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:

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

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[1]
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