1.4.3 Task Force

This involves federal, state and/or local agencies using portable and/or covert radios, requiring extensive close-range communications, and roaming in and out of infrastructure coverage. Normally, prior planning opportunity exists.

1.5 Interoperability Solutions

The ISC defined multiple levels of technological solutions to interoperability, both short term (defined to be within five years) and long term. These solutions can be categorized into infrastructure independent versus infrastructure dependent, both of which have ranges from simple to complex solutions. These solutions are not mutually exclusive and the optimum solution may use various combinations, especially as the interoperability requirement escalates from day-to-day to mutual aid or task force levels.

1.5.1 Infrastructure Independent

Infrastructure independent methodologies are communication links directly between radios over a direct RF path. These solutions are typically used for close proximity communications by multiple disciplines and jurisdictions converging on the scene to support the public needs. They are also used when radios are out of range of their infrastructure coverage, such as in rural areas or some in-building communications. Common analog FM technology and mutual aid frequencies allow users to communicate regardless of radio manufacturer.

Widespread implementation of infrastructure independent interoperability is hindered by a number of significant issues. First is the diversity of radio frequency spectrum in which public safety agencies operate. Individual agencies may be prevented from communicating with another agency because their respective radio systems operate in different frequency bands.

Second, there is a critical shortage of spectrum available and designated for interoperability.

Third, introduction of new technology creates the risk that equipment without common communication modes, such as a common air interface, will lack interoperability.

Other issues include non-technological factors, such as the lack of commonly used designators to identify channels among different agencies, the user ability to remember the interoperability channel assignments, and command and control issues allowing interagency communications.

More complex solutions include development of broad band, dual band and multi-band radios. Commercial viability of these approaches is yet to be proven.

1.5.2 Infrastructure Dependent

Infrastructure dependent methodologies and technologies require the use of some items(s) of equipment, other than a subscriber unit (radio), to establish a communications link and for complete radio operation. These solutions are typically used for wide area communications, where individual users are not within direct range of each other, and for on the scene communications where they may not have a common operating channel. This interconnection can be a temporary or permanent connection and can be accessed through a number of locations using various access methods. Once a permanent solution is in place, it can be idle in standby mode and be activated immediately when required, if all participating systems are operational.

Gateways between two or more system infrastructures can provide viable infrastructure dependent solutions at various degrees of complexity and may be one of the few available solutions in the short term. They can interconnect systems operating in different frequency bands, modes of operation, and manufacturer protocols. Most trunked radio systems require predetermined user or "talk" groups to be identified and programmed into the system. As systems become larger and additional user groups are identified, the problem of interconnecting users from other systems or non-trunked users becomes more complex. May be one of few viable short term solutions that can be implemented without modifying existing radios to bridge the different public safety frequency bands.

Infrastructure dependent methodologies and technologies have several disadvantages. First is that each participating network must have similar geographic coverage because interoperability is limited to the common overlap areas of the participating systems. Interoperability fails if any infrastructure is damaged or otherwise inoperable. Networks must generally be in place prior to an incident requiring their use because most often there is neither time nor opportunity to set up these solutions during emergency incidents. Deployable infrastructures can mitigate this problem. However, the degree of delay getting this equipment deployed often depends on the destruction severity of a disaster.

Infrastructure dependent solutions are typically spectrum inefficient because a separate talk path (channel) is required on each system for every simultaneous conversation.

1.5.3 Common Access to Infrastructure

Consolidated systems covering the same geographic area, either conventional or trunked, readily provide interoperability to those agencies sharing the system. Consolidated systems allow multiple agencies to operate in the same frequency band using compatible equipment on the same infrastructure.

Consolidated systems improve spectrum efficiency because they allow multiple agencies to interoperate without the need for additional spectrum. Agencies simply switch to the desired channel or system/talk group of the appropriate agency. Scanning between channels or systems provides for routine monitoring of the other agency's radio traffic on an

ongoing basis. Such shared systems must also be planned to accommodate the combined loading and traffic of multiple agencies.

However, unless non-resident radios are fully compatible with the system infrastructure, interoperability with other agencies not sharing this system will require a different methodology for achieving interoperability. Such interoperability is also subject to the same issues and disadvantages as the above solutions.

1.5.4 Establish New Interoperability Band

The move of the entire public safety operating environment to a single band is not practical, and cross banding existing bands is far less than fully effective. The former being unworkable financially and the latter being extremely inefficient in terms of spectrum use.

However, creating a single common Public Safety Interoperability Service (which is abbreviated as "PI") in one central band is very possible and very practical. This band would be dedicated exclusively for interoperation applications. This will not eliminate the need for dual band radios or two radio installations, but having a universal declared service gives an absolute common technical solution to the common operating requirements of a mutual aid incident. A field tactical vehicle (or hand-held) with the "PI" capability could interact with any other unit similarly equipped.

As an example, one unit's basic internal system dispatch operation could be in an 800 trunked environment while another unit could be operating in low band. If these field units' second band or second radio in each case were the common "PI" radio, they would technically be capable of true interoperability. Bringing a third unit into the picture more than clarifies the practicality of a common PI service band.

Could be a short term solution, depending on the frequency band that is selected by the Spectrum Requirements Subcommittee. This solution would likely require most public safety agencies to purchase an additional radio for the new "PI" band.

1.6 Commercial Services

Public safety agencies use commercial services, including cellular telephone, paging, satellite communications, and specialized mobile radio (SMR) and enhanced specialized mobile radio (ESMR) systems as an adjunct or supplemental solution for their non-mission critical communications.

Public safety agencies anticipate continued increase in their use of commercial services in the future, particularly for administrative and non-mission critical applications.

Commercial service providers typically do not provide the required features, priority access and command and control required by public safety for mission critical communications. As new and improved technologies and capabilities are introduced some of the problems experienced in the past may be resolved. Commercial systems are not likely to

meet all requirements within the public safety community. As new technologies emerge, objective experiments with and use of these systems will be necessary to determine the portion of public safety needs that can be satisfied.

The primary public safety requirements not provided by commercial services include failure to provide coverage needed by the public safety agencies, particularly in rural areas and inside buildings and tunnels for cellular services, as well as mountains and canyons for satellite services. Priority access is essential for public safety in mission critical situations. The ability to broadcast a message to specific groups and numbers of personnel within the agency is impractical (requiring detailed telephone number listings and numerous repetitive calls) or impossible with commercial service communications.

1.7 Costs and Benefits

(This section will be completed based on further activity of Working Group #7)

The cost and benefits of different interoperability solutions are defined in terms of relative comparisons and known relationships, rather than dollar estimates.

a) Costs are dependent on two main criteria:

   i) The degree of public safety spectrum dispersion.
   ii) The complexity of the interoperability solution.

b) Benefits attained through interoperability are categorized as follows:

   i) Intangible savings in suffering, lives and property are directly proportional to public safety response time.

   ii) Spectrum resource efficiencies are realized through infrastructure independent interoperability. Infrastructure dependent solutions normally require at least two channels for each communication.

   iii) Manpower resources required to attain various interoperability solutions, as well as possibility of human error.

   iv) Tangible dollar savings are realized through avoidance of property damages or losses as a result of greater interoperability.

1.7 Conclusions and Recommendations

Interoperability cannot be resolved without additional spectrum allocated to public safety. Consolidating the number of bands used by federal, state, and local public safety agencies into fewer bands will enhance the opportunity for interagency interoperability. Such

consolidation must be offset by increases in the total amount of spectrum allocated to public safety use. To promote interoperability, such additional spectrum should be provided immediately adjacent to existing, and possibly consolidated, number of public safety bands.

One of the ultimate and primary goals of the ISC is to reduce the number of bands that the Public Safety community currently operates their land mobile radio (LMR) systems. However, it is the general opinion of the members of the ISC that any significant reduction in the operational frequency bands cannot be realized in the PSWAC timeframe of 2010, without specific mandates and/or regulations. The ISC recommends that PSWAC Steering Committee, as well as the FCC and NTIA keep this recommendation in mind during future deliberations concerning rule-making and regulatory proceedings.

The ISC recommends the establishment of a new interoperability band. This solution may be a short term (less than five years) solution, depending on the availability of spectrum. This would require that a relatively free band of frequencies be identified, preferably central to existing public safety bands. Although the responsibility to identify spectrum rests with the Spectrum Requirements Subcommittee, the ISC suggests the UHF band below 512 MHz. Specific frequencies and pairs of frequencies using developed ICS guidelines should be defined.

The ISC further recommends that the FCC and NTIA freely license these frequencies to all eligible public safety/service providers under operational as well as technical regulations and they restrict use to mutual aid interoperation.

Aggregate numbers for interoperability links in existing bands and the new interoperability band indicate a total need for 21 repeatered voice links and 20 simplex voice links within current bands. It is believed that existing designated interoperability frequencies can be used for 13.5 of the repeatered and 13 of the simplex voice links. In addition, 31 repeatered voice, 70 simplex voice, 2 independent high speed data and 2 independent full motion video links must be provided in the new Public Safety Spectrum. Appendix A of this report further defines this requirement.

A national planning process should be established as soon as possible to address a nationwide mutual aid plan, define operational policies and procedures, provide guidance and procedures for regional planning processes, and define incident command system requirements. All levels of government should be involved in this planning effort and all public safety entities should have access to these interoperable channels. When guidelines are defined for a core nationwide use, individual regional concerns and issues should then be addressed and regional plans developed within two years of the national plan's completion.

The most critical interoperability requirement is for direct unit to unit communications, which requires a common mode of transmission. The ISC recommends that the minimum baseline technology for interoperability, for unit to unit voice communication, be 16K0F3E (analog FM), unless FCC and/or NTIA regulations stipulate a different emission in a specific operational band. This recommendation is applicable to public safety spectrum between 30 MHz and 869 MHz, and should be adopted as soon as possible by the FCC and NTIA.

Effective January 1, 2005, the minimum baseline technology for interoperability, for unit to unit voice communication, should be mandated as 11K25F3E (analog FM) in the public safety spectrum between 30 MHz and 512 MHz, unless FCC and/or NTIA regulations stipulate a different operation in a specific operational band. The maximum allowable interoperability bandwidth in any new spectrum allocation should not be allowed to exceed the bandwidth established for operational communications within that new spectrum.

Although it must be emphasized that the decision is not unanimous (see discussion in Section 10.[illegible] of this report), the majority consensus of the ISC is to recommend that as part of the Final PSWAC Report, a strong recommendation be made to establish a group comprised of experts representing government, industry and users to address baseline technology for interoperability. This effort should be managed by a neutral third party who has no vested interest in the outcome of the effort.

The ISC further recommends that any digital baseline standards for interoperability be open standards, developed/adopted in an open and fair process. With the emergence of digital technology it is imperative that this baseline be addressed and established within the next two years, to allow the public safety community to develop implementation and migration plans accordingly.

The separation of responsibility for allocation of federal and non-federal spectrum by NTIA and FCC has resulted in some roadblocks to shared use of spectrum in joint operations. To allow multi-level government interoperability, FCC and NTIA regulations must provide for equal access by both federal and non-federal public safety agencies.

The use of shared/consolidated systems by agencies covering the same geographic area has been hindered by the current licensing process, whereby a license to operate on certain frequencies is granted to the person/agency named on the license. This provides the named licensee with a certain amount of control over the unnamed users, such as requiring radio equipment or notice to vacate the system. This lack of control by participating agencies sharing the system needs to be addressed by the FCC and NTIA.

2.0 Interoperability Subcommittee Overview

The Interoperability Subcommittee (ISC) is one of five subcommittees formed under the Public Safety Wireless Advisory Committee (PSWAC). The ISC was developed to identify the interoperability requirements of the public safety community and make recommendations to resolve the historical inability of different agencies to communicate with each other, via radio, during routine, emergency and disaster response operations.

Although the "PSWAC mailing list" was quite extensive, the ISC consisted of approximately 150 members, representing the user community, as well as representatives from industry and commercial service providers.

2.1 Charter

The following goals, for the Interoperability Subcommittee, were developed by the PSWAC Steering Committee and approved December 4, 1995.

The Interoperability Subcommittee will examine the interoperability requirements between and among the various public safety entities and reduce them to writing (who needs to talk to whom and when). All phases of interoperability shall be explored, including command and control functions. The examination shall generally be technology neutral, although certain generic technologies may be suggested (e.g. multi-band radios should be employed that have as a minimum ten simplex and ten repeater pair channels, on all common spectrum nationwide). The subcommittee can also suggest ways to assure that recommendations are implemented in a timely fashion (e.g. no new radio for use on public safety channels will be type accepted after January 1, 1998, unless it contains provisions to operate on the nationwide interoperability channels). The final report of this subcommittee, which will form the basis for system planning by public safety agencies with regard to interoperability, will likely be used as input to the Federal Law Enforcement Wireless Users Group (FLEWUG) and will provide input to the Technology Subcommittee. This subcommittee will also define Public Safety.

2.2 Report Scope

This subcommittee report outlines and discusses the current communications interoperability requirements and capabilities, as well as the future needs of the Public Safety Community at all levels of government. The subcommittee has considered the interoperability needs that are currently unsatisfied. Those that have been unsatisfactorily provided are addressed as future needs. The interoperability issues, identified by the Operational Requirements Subcommittee, have also been considered and are addressed in this report.

The first tasks undertaken by the ISC were to define *Public Safety* and *Interoperability*. The definitions were developed by individual working groups, and a great deal of effort by a diverse group arrived at consensus recommendations which were adopted by the ISC and the Steering Committee. These definitions and supporting discussion are presented in this report. Subsequently, as discussions ensued and various levels of priority and control were addressed, the subcommittee felt there was a need to define the term "mission critical" as it is used to describe system requirements through the course of the deliberations.

After developing the definitions which would be used throughout the report, the subcommittee focused on identifying the current and future interoperability requirements. Three different operational types of interoperability are identified and discussed; Day-to-Day, Mutual Aid, and Task Force.

The report first discusses typical methods and technical solutions that are currently utilized to provide communications interoperability, as well as the problems and shortfalls experienced in today's environment. A number of incidents were identified to typify the

interoperability requirements and problems that the public safety community must routinely address.

These same incidents, involving multiple agencies and jurisdictions, were used to exemplify the scope of the interoperability needs that currently cannot be met and the possible impact in the future. Command and control procedures and policies are also addressed and possible changes are discussed where applicable. Possible methods and procedures to provide future solutions are addressed and the advantages and disadvantages are discussed.

The ISC formed a separate working group to address current policies and procedures that affect interoperability and existing regulatory issues that limit or prevent a cost effective solution to the interoperability problem. The working group then addressed possible changes and/or modifications to the policies/procedures and regulations that could enhance the interoperability capabilities. The working group also addressed the advantages and disadvantages of possible mandates or incentives to ensure interoperability in the future.

Another working group was formed to provide cost and benefit analysis of possible methodologies and alternatives that are identified to provide various levels of interoperability. This working group was also tasked to perform a cost benefit analysis of the recommended baseline technology for interoperability, as well as an analysis of costs versus benefits of utilizing commercial services to support the public safety community. Unfortunately, due to the time constraints for completion of the report and delays in formulating suggested methodologies, this working group was unable to perform a thorough analysis. If time and resources permit, the working group report will be provided as supplemental information to the ISC report.

Commercially provided services were also addressed by a working group. The report discusses how the public safety community currently utilizes commercial services, such as cellular and paging, and how commercial services can further enhance and support the interoperability requirements in the future, as digital and RF data technology matures.

3.0 Definitions

The Steering Committee tasked the Interoperability Subcommittee to provide a recommended definition of *Public Safety* to be utilized by all the subcommittees in their respective assessments of the current and future requirements for public safety communications. Likewise, the subcommittee decided it was necessary to define what is meant by "interoperability", before the communications capability could be identified and recommendations developed. The need to develop a definition for *mission critical* was identified during subsequent meetings as various levels of communications interoperability were addressed.

3.1 Public Safety/Public Services

At the first meetings of the five subcommittees conducted in Washington, D.C., in September, 1995, considerable discussion took place concerning the definition of *Public Safety*

for the purposes of the Public Safety Wireless Advisory Committee (PSWAC). Shortly after the September meetings, the PSWAC Steering Committee tasked the Interoperability Subcommittee to develop a definition for Public Safety. After considerable discussion of suggested definitions during the October ISC meeting, in Camp Dodge, Iowa, Working Group #4 (WG4) was formed and tasked to develop a definition for *Public Safety* and *Public Services*.

This dedicated subcommittee workgroup consisted of representatives from the public safety community from varying types of jurisdictions and disciplines at the federal, state and local government level, as well as representatives from the commercial and manufacturing community. One obstacle encountered in the process was the fact that the concept of public safety varied throughout the country based on the individual needs of a particular region. The workgroup discussed the idea of creating a "laundry list" of entities, but felt that this might become restrictive and exclude vitally important entities in different regions of the country.

There were basically two distinct opinions offered toward the development of a definition of *Public Safety*. One was a strict law enforcement, fire and emergency medical service definition, commonly referred to as "First Responders" during the discussions. The other was a definition which included the critical thought that public safety is above all a government responsibility, which more closely follows the existing service definitions within the Federal Communications Commission's rules. The latter opinion allowed for inclusion of government functions which cross the lines of disciplines and allows inclusion of government functions which are economically feasible and vital services provided to the public. The issue of listing or not listing selected entities in the definitions was an important point that many felt would seriously affect the way the definitions would impact various aspects of the public safety community.

The representative from the Union Pacific Railroad Company, representing the railroad industry, suggested that the definition be further expanded to include a paragraph to define *Public Safety Risk Avoidance*, which would more effectively include the railroads in the definition. It was the consensus of the working group, and ultimately of the subcommittee, that the definition did indeed include the railroad industry in performance of their public safety/-public service role.

The following definition was adopted by the ISC, with one dissenting vote by the representative for the Union Pacific Railroad, on December 14, 1995. The ISC Chair recognized a letter from the Union Pacific Railroad Company, dated December 12, 1996, as a minority report, which was forwarded to the Steering Committee. The minority report (document number PSWAC/ISC 95-12-059) is included as Attachment One of this report. The Steering Committee unanimously approved the recommended definition on December 15, 1995 at the public meeting in Washington, DC.

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

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

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

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

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

The term *Public Safety*, as defined, extends to all applicable functions of government at the federal, state and local levels, including public safety operations on Department of Defense facilities. There are two levels of public safety providers. The *Public Safety Services Provider* definition is focused toward entities performing such duties as emergency first response and similar activities. The Interoperability Subcommittee Workgroup recognized that this particular definition did not adequately cover the diverse public safety community and it was necessary to include another level of provider, the *Public Safety Support Provider*. This was in accordance with the question encountered by the Operational Requirements Subcommittee during the process to identify entity-specific needs. The Operational Requirements Subcommittee acknowledged that although a particular organization's primary mission might not fall within the classic public safety definition, some aspects of its operations could involve or impact public safety. The *Public Safety Support Provider* definition is meant to include entities whose primary mission is other than public safety services, but which may provide vital support to the general public and/or the Public Safety Service Provider.

The ISC also addressed *Public Safety Service Providers* that were non-governmental. Properly authorized non-governmental, private organizations performing public safety functions on behalf of the government are included in these definitions. The need for this portion of the definition is becoming more evident with the privatization of certain governmental services. For example, a number of local governments contract private organizations for emergency medical and/or ambulance service. Although private, these entities are authorized by the applicable government entity to provide life-saving functions on its behalf. Specific licensing concerns have been surfaced through this mode of operation and will be discussed in a later section of this report.

The *Public Services* definition outlines the basic functions of non-public safety groups and was created primarily to support the discussion of interoperability, among various organizational disciplines, throughout this report.

Dr. Michael C. Trahos, representing the medical interests in the NPSPAC Region 20, filed comments (document number PSWAC/ISC 96-02-020) to the ISC regarding the definitions. Dr. Trahos felt that the definitions, as approved by the PSWAC, were in conflict with proceedings within the FCC concerning definitions for the various radio services. Dr. Trahos' comments which are included as Attachment Two of this report, pointed out a possible problem with the perceived meaning of "appropriate government authority whose primary mission is providing public safety services." The problem was corrected with an editorial change to reflect the true intent of the definition.

3.2 Definition of Interoperability

The following definition of interoperability and supporting information was unanimously adopted by the ISC during the public meeting on December 14, 1995. The Steering Committee unanimously approved the ISC recommendation during the public meeting on December 15, 1995, in Washington, DC.

> *An essential communication link within public safety and public service wireless communications systems which permits units from two or more different agencies to interact with one another and to exchange information according to a prescribed method in order to achieve predictable results.*
>
> *The communications link, whether infrastructure dependent or independent, must satisfy one or both of the following requirements:*
>
> > *Multi-jurisdictional: Wireless communications involving two or more similar agencies having different areas of responsibility. Some examples include a fire agency from one city communicating with a fire agency from another city and the Federal Bureau of Investigation (FBI) communicating with a County Sheriff.*
> >
> > *Multi-disciplinary: Wireless communications involving two or more different agencies. Some examples include a police agency communicating with a fire agency and a parks agency communicating with an emergency medical services agency.*
> >
> > *The communications link may involve any combination of subscriber units and fixed equipment (e.g., repeaters, dispatch positions, data resources). The points of communication are dependent upon the specific needs of the situation and any operational procedures and policies which might exist between the involved agencies.*
> >
> > *The communications link may be classified as either of the following two types:*

Infrastructure independent: The communications link occurs between subscriber units over a direct RF path. An example is portable-to-portable tactical communications at the scene of an incident.

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

3.3 Definition of Mission Critical

As various levels of communications interoperability were discussed and considered, the term *mission critical* was typically used to describe the importance and priority of communications, particularly as it applied to interoperability and the utilization of various alternative methods.

The ISC introduced a definition for mission critical to be used as a reference and guideline as the interoperability requirements were identified and various methodologies were considered.

The definition of mission critical was introduced during the ISC meeting on May 29, 1996, at Scott Air Force Base, Illinois as follows:

> *A mission critical communication is that which must be immediate, ubiquitous, reliable and, in most cases, secure.*
>
> *EXPLANATION: An "immediate" communication must be capable of being transmitted and received instantaneously, without waiting for a system to be set up, a clear channel or a dial tone. A "ubiquitous" communication is that which can be transmitted and received throughout the area that the mission requires. A "reliable" communication system must be designed, constructed and maintained such that short-term disruptions are minimal. Finally, security, while not currently available in many situations, is increasingly a requirement for law enforcement and other sensitive communications. In this case, "security" is provided with "voice privacy" encryption.*

There was some discussion of whether public safety agencies have a requirement to interoperate unless some significant event is occurring. Therefore, all or virtually all interoperable communications should be defined as "mission critical". However, there was not a general consensus that this statement was an "absolute" and therefore should not be included as part of the definition.

4.0 Background and Overview

4.1 Background

Wireless communications interoperability has been a historic problem, almost since the time public safety agencies started using two-way radios. The first need for interoperability became apparent when law enforcement agencies from various jurisdictions attempted to respond to mutual aid requests. As other public safety services and agencies radio communications systems, it became obvious that communications interoperability could lend to the effectiveness of on-scene operations and response coordination.

Interoperability is a formidable problem. It is a problem that is often associated with risk of life during natural disasters and national emergencies.

The use of analog Frequency Modulated (FM) technology has been dominant in the land mobile radio industry and provides the basis for existing infrastructure independent interoperability. As this technology developed over the past forty years, it became well understood and a common set of operating parameters has allowed users in the same frequency band (within limitations) to communicate regardless of manufacturer of the individual radios. Yet, widespread implementation of interoperability capabilities are hindered by a number of issues.

One issue is a limitation of the number of channels that individual users are able to handle. Originally, this issue was a technological issue that related to the number of channels for which a radio could be "programmed". When crystals were the primary means for selecting the radio frequency, physical limitations and other considerations limited the number of channels (frequencies) available in the radio, which was typically a maximum of four, as well as limited by the frequency spread that the radio could be "tuned"[1]. Thus, users were forced to be very selective of the frequencies that were available in their radios. Oftentimes, the need for "routine" communications prevented inclusion of any frequencies that would provide interoperability with other agencies. Today, as synthesized radios are available with a capability to operate on multiple channels over a wider frequency spread, the problem is less technological, but one of human interface. As the technological problems are solved, the human factors become more important, as most users are unable to remember the specific channels assigned for interoperability and scrolling through the list becomes very time consuming and impractical in an emergency. There have been several recent incidents in which users operating field units have complained about the inability to communicate with other "on-scene" agencies, only to later discover that they unknowingly had a common channel available in their radios. This problem is sometimes further compounded with a lack of commonly used designators to identify the channels among different agencies.

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[1] Typically, while radios were limited in the number of channels available, due to the physical space required for "crystals" and later "channel elements", there were also limited by the frequency spread (difference between the highest and lowest frequency) within the radio. Typically, radios were limited to spreads between 2-3 MHz. The combination of these technological limitations limited the capability to operate on multiple channels even within the band.

Widespread implementation of infrastructure independent interoperability is limited by the diversity of radio frequency spectrum in which public safety agencies operate, ranging from the 30-50 MHz portion of the VHF band to 869 MHz in the UHF band. No single radio is capable of operating in the numerous radio frequency bands that the federal, state and local organizations currently utilize. Thus, individual agencies may be prevented from communicating with another agency simply because their individual radio systems operate in different frequency bands. Only until recently, technological problems associated with building wide-band radios resulted in the frequency spread of an individual radio being limited to two or three megahertz. As newer synthesized radios were introduced that were capable of operating in wider bandwidths, new technology also introduced additional barriers to interoperability.

As manufacturers introduced new features and functions within the radio system, many of which were proprietary and not available to other manufacturers, the interoperability problem was amplified. Two specific examples of this problem is the introduction of voice encryption and trunking systems. Voice encryption, which is widely used by the federal law enforcement community was introduced by two major land mobile radio manufacturers. However, the encryption algorithms offered were not compatible with each other and therefore created a situation that did not allow follow-on purchases on a competitive basis. The introduction of trunking systems created a similar problem, in that the trunking systems that were offered utilized proprietary technology and equipment was not compatible among different manufacturers.

Currently, numerous public safety agencies operate multiple radios, not only in different frequency bands, but with different proprietary technologies, to satisfy their interoperability needs with multiple agencies. This practice is not only costly, but also very cumbersome for the users as law enforcement agencies attempt to maintain "low-profile" vehicles and more users operate low power hand-held portable units.

A lack of established policies and procedures among public safety agencies and public service organizations has contributed to the interoperability problem. The Ericsson White Paper (document #PSWAC/ISC 95-10-030/2 included as Attachment 2) states "The real tragedy of the Polly Krause case in terms of radio equipment, was the technology allowed the system to interoperate between adjacent counties, however, interoperation was not part of routine procedures".

The importance of developing command and control procedures and establishing operational policies is as important as identifying and resolving the technological issues. Mr. Gilbert provides an example of the effects of lack of procedures in his white paper submitted to the ISC (document #PSWAC/ISC 96-02-018 included as Attachment 4). Mr. Gilbert states "During the Titanic disaster, other ships that could have helped were not alerted because standardization on radio frequencies to be guarded had not occurred. Even SOS had not been designated as a universal call for help, and nearby ships sailed on unaware of the unfolding tragedy. The Titanic's loss caused the first Safety of Life at Sea Convention (SOLAS) that ultimately led to the formation of the International Maritime Organization (IMO) to provide international coordination of maritime telecommunications, training, operational procedures, standards, and the acceptance of new technology".

Mr. Gilbert points out that there is no similar national organization for the public safety community and suggests that one is needed to provide a continuous focus on all the issues important to success in the community.

There have been some improvements that have enhanced the interoperability capabilities in some cases. The NPSPAC identified a national "calling channel" and four tactical channels for mutual aid the new NPSPAC bands in 800 MHz. The NTIA identified specific channels, in both the VHF and UHF portion of the federal government spectrum, for interoperability as part of the narrowband channeling plan. Although this is a clear improvement, these channels are inadequate as it limits interoperability to those users in those specific bands.

Infrastructure independent interoperability will remain to be a significant problem as long as the public safety community operates in multiple bands, until a common channel (or channels) is identified for interoperability or a multi-band radio is available at an affordable cost.

4.2 Overview

Almost universally, responses by public safety forces to large scale emergencies and disasters have been hampered by the lack of communications interoperability. The primary reason for this has been the lack of clear and immediately available radio frequency resources devoted exclusively to interoperability. Secondarily, there is no nationwide process for standardized link identification nor for other command and control functions for interoperability. On FCC administered frequencies there has never been the luxury for letting an adequate number of interoperability links remain clear waiting until they were needed. Frequency congestion on FCC public safety frequencies has been so severe that virtually all channels must support operational uses. Under NTIA administered frequencies there are some nationwide frequencies assigned to the National Interagency Fire Center for such uses. NIFC uses these frequencies to support their large scale cache operations. Although these frequencies are clear nationwide, NIFC rarely gives anyone else permission to load these frequencies into non-NIFC radios. This is because of the concern that when NIFC needs the frequencies, they cannot afford the time to get the frequency "cleared" because they find someone else is using the channel. NIFC is, however, very responsive in deploying their cache(s) of radios.

Emergency management and response at all levels of government has experienced increased demands for emergency service in recent years with hurricanes and floods in the east, earthquakes and wildfires in the west, and floods and tornados in the heartland, plus recent bombings in New York and Oklahoma. One common problem in each case has been lack of sufficient frequencies to protect life and property. Dedicated channels are needed to permit immediate communications interoperability between all agencies in these critical incidents.

Emergency operations and disaster response typically involves a large number of resources from many agencies. Organized communications between these agencies is absolutely necessary to place resources where they are needed at the time they are needed.

Communications is also needed to get rapid assistance to the public to save lives and protect property. At the same time, effective communications are needed to protect the very forces responding to the event itself. In the face of the need for immediate interoperability links, emergencies simultaneously severely load the available operational links. At the time that these operational links become most needed for interagency or mutual aid communications, they are loaded with internal traffic created by the event. Currently, there is not currently an adequate number of available communication links to support the intra-agency level of communications for most major incidents, let alone the required communications links required for interoperability.

The large incident is not the only example of public safety's need for interoperability resources. Every day there is an enormous number of examples where communications interoperability is required. Some are between jurisdictions such as when a local police department communicates with a county sheriff to coordinate aid or to alert the other agency of an observed problem in their jurisdiction. Not all of these occurrences involve hot pursuit; in fact, many involve the recent trend in the public safety services to have the nearest available unit respond to an incident, regardless of jurisdiction. This "breaking down" of political barriers has proven to be beneficial in reducing response times to emergencies, but interoperability is critical to the success of these mutual aid responses. Helicopters and marine units, as well as other specialized equipment are typically shared among various agencies, each requiring a common mode for communications interoperability. Daily, hundreds if not thousands of similar communications take place across the nation. Some involve police and fire, some are between fire agencies, and some are between fire and EMS providers. Many of these types of needs can be met by shared or "cross" use of each others' operational system or by crosspatches between the respective systems. However, in many cases the number of such cross channel uses can become extremely large. The more frequencies that field units must have, the chance that they will be used decreases. Field emergency forces need communications as a tool to accomplish their job. They cannot be expected to play a radio as one might play a piano. Common, universally identified communications links for interoperability must be made available.

As is discussed throughout this report, one of the most critical needs for the public safety users is direct unit-to-unit interoperability. There are numerous occasions when interoperability is needed in close proximity or in the absence of infrastructure, where gateways and/or interconnects cannot be utilized. As has been mentioned previously and will be discussed throughout this report, the public safety community operates in ten different frequency bands covering 839 MHz (30 MHz to 869 MHz) of the spectrum.

For decades every critique or after incident report of a major emergency contains statements concerning the absence of an adequate ability to communicate between incident responders. Some such events were irritation, some resulted in extreme danger to personnel. Added to this history is the day-to-day need for hundreds of communications between all levels of government. This history is addressed to some degree in this process to identify the interoperability needs of the public safety community.

The need for protected communications on the common communications channels are becoming increasingly evident. This is true not only in the law enforcement environment, but expands into other public safety entities, such as the release of victims names by fire or EMS units, or in the case of the Oklahoma City disaster, when information concerning additional threats that could endanger the safety of the on-scene personnel needs to be transmitted.

The issues of land mobile radio system cost, maintenance, expansion and spectrum support have moved beyond the means of many public safety organizations to afford or acquire. Business as usual in developing land mobile radio systems can no longer be tolerated by many public safety organizations and their governments. Many of the elected officials who serve as the final authorities for sources of funding and other support misunderstand the purpose and the critical services these systems provide. In real terms to the law enforcement and public safety agents and officers, the loss of support to develop or maintain systems or the replacement of systems with commercial services threatens the security, availability, and reliability of vital radio communications.

The regulatory bodies allocating spectrum and the industry which sets the course for equipment and systems abilities, tend to approach their tasks with "efficiency" defined either in terms of users per channel or dollars per some division of air time. Their definition of efficiency is typically not the same as the public safety community where the importance of the systems and spectrum is in terms of safety of the public and the ability to immediately respond to threats to life or property. The importance and amount of radio spectrum in public safety operations is measured by how quickly a clear channel can be accessed and the flexibility for the needed resources to respond to events without overloading the system in times of emergency.

These misunderstandings and attitudes tend to suppress the ability of public safety organizations to establish and maintain sufficient radio communications networks.

These are not the only impediments to attaining sufficient radio systems or more efficient use of land mobile radio resources and radio spectrum. Until the last three to five years, the readily available resources needed for systems development has led to independent and parochial attitudes within the public safety community.

Today the law enforcement and public safety community finds itself in increasing numbers of situations of both disaster response and investigation where interagency support cooperation between multiple and diverse agencies are imperative. The real time coordination in most situations is accomplished through the practical communications medium of land mobile radio systems.

The diversity of systems, spectrum assignments and organization missions compound the effort to interoperate.

A recommendation from Vice President Gore's National Performance Review, IT04: *Establish a National Law Enforcement/Public Safety Wireless Network*, recognizes these issues

and provides a basic picture of circumstances associated with law enforcement and public safety land mobile radio systems.

"Whether the situation is responding to a natural or technological disaster, or performing search and rescue or interdiction activities, federal, state, and local law enforcement and public safety workers must be able to communicate with each other effectively, efficiently, and securely. Most of this communication occurs over tactical land mobile radio systems."

"However, interoperability across these different radio systems is difficult to achieve. Federal, state, and local law enforcement agencies operate in different parts of the radio spectrum."

Moreover, every federal, state, and local law enforcement agency operates separate tactical networks in every metropolitan area in the country. Often, there are several independent network control centers operating within the same federal building with no interoperation. This expensive duplication of effort prevents the use of spectrally efficient equipment and results in less-than-optimum coverage for many agencies. In addition, technical and administrative support is duplicated throughout the federal government."

The importance of interoperability has been identified in a number of documents published in the last few years.

The recent airline crashes and Amtrak Train Collision are examples of the inefficiencies experienced with incompatible and noninteroperable radio communications systems. The life saving efforts, speed of rescue and recovery efforts are devastated with the inability to communicate and coordinate actions and resources from different government jurisdictions.

Even as we establish the criteria for today's needs and uses of the spectrum, given time, technology will change the options and services available and present more practical and attractive approaches to providing communications for the public safety community.

5.0 Inventory

5.1 Requirements

5.1.1 Day-to-Day

- Most often encountered type of interoperability.

- Commonly used in areas of concurrent (shared jurisdiction across common geographic area) jurisdiction.

- Interagency interoperability is a form of day-to-day interoperability that requires users from different agencies which do not share a common communications system to be able to communicate.

- Commonly used where agencies need to monitor each other's routine traffic.

- Commonly used where units from two or more different agencies need to interact with one another and to exchange information.

- Often involves different public safety disciplines responding to the same incident.

- Minimizes the need for dispatcher-to-dispatcher interaction in the exchange of information among field units.

> In addition to the time delay involved in establishing a communications path between dispatch centers and the time required to physically restate information, it is a known fact that the more times a message is repeated from one party to another, the chances increase to having error introduced into its content. It is critical for tactical field situations that concise and accurate information is relayed.
>
> There may be events where dispatcher intervention or monitoring of information is appropriate for resource management, administrative command/control, etc. This is especially true when command-level information is being passed between agencies.

- If agencies are in different bands, this may involve the use of multiple radios.

- Difficult to implement for field personnel using portable radios unless all equipment operates on the same band and with the same type of technology.

5.1.2 Mutual Aid

- Can involve multiple agencies with little opportunity for prior planning (riots or wildland fires).

- Often requires assignment of several to many small groups, each on their talkgroup or frequency (tactical communications).

- Once on scene, typically involves use of portable radios.

- Many incidents are in rural areas outside the range of fixed infrastructure.

- Many incidents are in difficult to cover terrain

- Could be solved by deployable units

5.1.3 Task Force

- Usually involves several layers of government (federal, state, and/or local).

- Typically, an opportunity for prior planning exists.

- Usually involves use of portable and/or covert equipment.

- Often requires extensive close-range communications.

- Nature of radio traffic is such that wide area transmission is usually undesirable.

- Users may rove in and out of infrastructure coverage (metro to rural, in and out of buildings).

- Often implemented by exchanging equipment to ensure that all users have identical or compatible equipment.

5.1.4 Additional Federal Government

- typically the federal government interoperability needs are similar to that of their particular state and local government counterparts.

- interoperability becomes more complex for the federal government agencies with a nationwide responsibility.

    - wide area coverage requirement

    - diversity of the communications systems utilized by the various public safety and public service agencies throughout the country.

    - law enforcement agencies have requirement for voice encryption in most cases.

5.2 Coordination Issues

Some coordination issues are identified and discussed in Sections 6 and 7, that users felt limited or hindered their ability to achieve interoperability. Some of these issues are discussed in Section 7.5 (*Regulatory Issues*).

Although all agreed that there are a number of issues that are important, the subcommittee decided that there was insufficient time to properly evaluate the issues.

6.0 Interoperability Today

Federal, state, and local law enforcement and public safety agencies rely on radio spectrum for command, control, and execution of operations. The existing spectrum allocation is insufficient to meet existing and future needs and does not support interoperability. Due to the increase in joint operations, interoperability among law enforcement/public safety agencies is a major concern. Ten different frequency bands are used for tactical mobile communications by federal, state, and local agencies; no single radio that operates on all bands is currently available at an affordable price.

6.1 Typical Methodologies and Technologies Employed

6.1.1 Infrastructure Independent

Infrastructure independent methodologies and technologies are typically utilized for on the scene communication by individual users or groups within close proximity of each other. Some scenarios are: a highway accident where police secure the scene to conduct an investigation, fire fighting personnel extinguishing or preventing a fire or the numerous instances where police, firemen, emergency medical technicians work in coordinated effort to evacuate and provide critical life saving medical attention to victims. Examples of large scale incidents that require immediate response, with no specific prior warning or planning, are the wildfires and natural disasters, such as earthquakes and hurricanes although in some cases there is some time for prior planning. The Air Florida crash in Washington, D.C., the bombing of the Federal Building in Oklahoma City and the World Trade Center in New York City and the Los Angeles riots are also examples of man-made disasters that have become major incidents. These events required coordinated efforts by the public safety community as well as by civilian services. Such incidents highlight the use of infrastructure independent methodologies and technologies where multiple disciplines and jurisdictions converged to support the public needs.

Today, the use of analog Frequency Modulated (FM) technology is dominant in the land mobile radio industry and provides the basis for existing infrastructure independent interoperability. As this technology developed over the past forty years, it became well understood and provided a common set of operating parameters that have allowed users in the same frequency band to communicate regardless of manufacturer of the individual radios. Yet, widespread implementation of interoperability capabilities are hindered by a number of issues.

Widespread implementation of infrastructure independent interoperability is limited by the diversity of radio frequency spectrum in which public safety agencies operate. No single radio is capable of operating in numerous radio bands that the federal, state and local organizations currently utilize. Some public safety entities operate in the 30-50 MHz portion of the VHF spectrum, while other entities operate in the VHF highband portion of the spectrum between 150-174 MHz. The federal government users operate land mobile radio systems in the 406.1-420 MHz portion of the UHF band, while the non-federal public safety community utilizes the 450-470 MHz portion of the band, as well as some portions of the UHF-TV Broadcast spectrum in a limited capacity. The non-federal public safety users also

operate systems in the 800 MHz portion of the spectrum. Thus, individual agencies may be prevented from communicating with another agency simply because their individual radio systems operate in different frequency bands. Only until recently, technological problems associated with building wideband radios resulted in the frequency spread (the difference between the highest and the lowest frequency) of an individual radio being limited to one or two megahertz. While newer synthesized radios are capable of operating in wider bandwidths than radios produced a decade ago, commercial grade radios are not yet produced which are capable of operating in across all the public safety frequency bands.

There are other issues that limit interoperability that are common to both infrastructure independent and dependent methodologies. These limitations are discussed in Section 6.2.3.

Many agencies utilize multiple radios to resolve some of these problems. However, besides the obvious cost impact of purchasing and maintaining multiple radios, agencies have experienced both technical and physical limitations when dealing with downsized vehicles and multiple antenna systems within the vehicle. Multiple radios create more critical problems for personnel that typically utilize portable (hand-held) equipment.

Public safety agencies have utilized scanning receivers to provide personnel with the capability to simultaneously monitor multiple channels . In some cases, the scanning function is built into the same receiver that is used for primary communications, resulting in some problems associated with priority features to ensure normal communications are not disrupted. Some agencies have used separate multi-band scanning receivers, but have experienced difficulties due to the less demanding equipment specifications, compared to the typical public safety radios. These lower specifications make these units more susceptible to interference. Problems have also been experienced with scanners operating in the trunked radio environment, due to the number of channels involved and the control protocols required.

6.1.2 Infrastructure Dependent

Infrastructure dependent methodologies and technologies typically are utilized for wide area and high density system communications and for on-scene communications wherein the individual users may not have a common operating channel. Typical scenarios include large scale disasters such as an earthquake, flood or hurricane. They also include campaign-type fires such as the Oakland Hills fire or any of the forest or wildland fires that commonly occur each year. These incidents could include any man-made or natural disaster that encompasses a wide geographical area or a number of different incidents that cover a large area, which may cross a number of jurisdictional boundaries. Both preinstalled and deployable units can be within the infrastructure dependent classification.

Infrastructure dependent methodologies and technologies have an obvious application in scenarios in which the individual users are not within radio range of each other, or who do not have a common channel in which to directly communicate. In its simplest form, communicating through a repeater station, which receives an incoming signal on one frequency and retransmits (repeats) the same signal on another frequency, is an infrastructure dependent methodology. Many of the problems experienced, relative to an infrastructure

independent methodology, are also applicable to repeater operation. The individual user radios must be capable of operating on the repeater access channel and the individual users must recognize the availability of this common mode of operation. Finally, the individual users must all be within the range[2] of the repeater station.

Infrastructure dependent methodologies and technologies can also be used to resolve incompatibilities between user radios and systems. For example, a FEMA vehicle with deployable radios and a mobile base station could be sent to the incident. In another instance, a VHF highband radio system could be interconnected to a UHF radio to establish a communications link between field units operating in the two different bands. This interconnection can be a temporary or permanent connection and can be accessed through a number of locations using various access methods. One example of a temporary interconnection would be a connection provided at one or more dispatch console(s), upon request, such as the system currently utilized with Police Mutual Aid Radio System (PMARS) in the Washington (DC) Metropolitan Area. This method is very inefficient, because typically two dispatchers are involved and two channels are used to establish one talk path. Consequently, this system is seldom used by the law enforcement agencies in the region. An example of a permanent interconnection is the cross-connecting of two repeaters or the use of a cross-band repeater, such that all incoming traffic (on one band) is retransmitted on the other. Either interconnection is not spectrally efficient, as at least two channels are occupied to support one communications path. While many agencies utilize the temporary interconnections due to system and budget constraints, most agree that temporary interconnections are less than desirable due to the time required to set-up the connection and the possible geographic limitations of the individual "home" systems. Nonetheless, to date, no other technology solutions can bridge two bands. Therefore, gateways still provide a viable solution.

Trunked radio systems present a further challenge when attempting to interconnect systems. Most systems require predetermined user, or "talk" groups be identified and programmed into the system. As systems become larger and additional user groups are identified, the problem of interconnecting users from other systems or non-trunked users becomes more complex, although it is not an insurmountable requirement. In addition, when interconnecting trunked radio systems which use different proprietary protocols, access times can suffer, and the geographic coverage patterns must be congruent to support field unit use.

6.1.3 Commercial Services

Cellular Telephone

Public safety agencies make use of commercial services every day. Cellular telephone, for instance, provides access to the public switched telephone network (PSTN) from which many other resources can be contacted. The cellular telephone has proven to be particularly useful when the public or other non-public safety agencies must be contacted. Police and fire units have been able to talk directly with a 9-1-1 caller while enroute to an incident. As a

[2] Typically, the limiting factor of the range of the repeater is the transmitter power of the individual user's radio which is normally a mobile or hand-held portable unit.

result they were better prepared to handle the situation when they arrived. Cellular telephones have been used to talk with the suspect in hostage and barricade situations, oftentimes resulting in resolution of the situation without injury. Cellular telephones have been used to establish communications between command personnel from different agencies responding to ıe same incident. They have been used to establish communications with utility companies :lectric power. gas, water) needed to assist during an incident. These and many other useful unctions have been provided through cellular telephone services.

Cellular telephone services, however, also have limitations when used in the public safety environment. First, they are not ubiquitous and oftentimes do not provide the coverage needed by public safety agencies, particularly in the more rural areas where the customer density does not warrant infrastructure costs. In the more populated areas, coverage problems exist in areas such as tunnels and inside buildings, particularly lower levels and parking garages.

Another limiting factor that has been experienced with cellular telephone service during major disasters and/or emergencies, is system access. Each cell site is capable of supporting a specific number of simultaneous conversations. At any given point in time, all of the available communication links may be fully occupied by other, non-public safety users. While there have been discussions concerning priority access for public safety users, many of the proposals include "top-of-queue" methods, rather than "pre-emptive" or "ruthless preemption" methods. Many users feel that "Top-of-Queue" priority access procedures results in a finite wait for access which will likely be unacceptable for the public safety user in mission critical situations. This has been particularly apparent in emergency situations where the news media access one or more cellular channels and remain "off-hook" for the duration of the event to provide "instantaneous communication links" to their main office or studio. This access problem is exacerbated if the incident is moving or expanding, thereby requiring the communications link to be passed from one cell site to another. In some areas of high use, there have been problems with calls being "dropped" during the "hand-off" process due to all channels already being in use at the new cell site. When this occurs and there is no communication link available in the next cell, the call already in progress is dropped. The user must then re-initiate the call, and then go into "queue" for an available channel at the already fully loaded cell site.

The use of cellular telephone services is also limited by the "one-to-one" nature of the service. Currently deployed technology limits conversations to two people, unless some conferencing capabilities exist, which also takes time. Thus any requirement for broadcasting a message to a number of people[3] is impractical and in most cases impossible. Currently, the need to remember telephone numbers or maintain a telephone list can become very cumbersome during a major event. Because of access and dialing delays, the only way to have instant use of the channel is to hold it open. This only makes the cell site less effective as channels are taken out of the possibility of reassignment.

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[3] A significant requirement for mission critical public safety communications is the ability for conversations to be heard by a number of personnel within the organization. This has been commonly referred to as "broadcast" or "one-to-many" communications.

Paging Services

Public safety agencies make extensive use of paging services for alerting personnel. While some public safety agencies may need to maintain their own separate paging systems (such as a paging system within a hospital to alert "code-blue" teams), commercial paging systems are cost effective and provide acceptable levels of service in a great many cases.

Satellite Services

Commercial satellite communications have also proven to be useful resources. These services provide communications links over virtually any distance with little regard to terrestrial infrastructure. Thus, a satellite link can provide communications from within a disaster area to mutual aid responders outside the disaster area. They also provide a means of rapidly establishing new service at the scene of an incident. The cost of currently available services has been a factor in the limited use of satellite services, due to the air time charges and connection fees, for most routine applications. Historically, available services also have not offered practical solutions to most public safety land mobile communications requirements. The size and weight of the devices needed to operate through the geo-synchronous satellites, as well as the requirement to orient the antenna can make land mobile applications difficult, particularly portable operations. Although improved technologies and equipment have recently been introduced that may resolve some of these issues, public safety users have not yet utilized many of these improved systems.

The use of satellite based systems may be limited by local terrain features, such as mountains and canyons, as well as by man-made structures, which may block the signal path of the satellite. Most public safety users need radio systems which operate in these areas as well as in the more open areas, which might be accessible via a satellite based system.

Transmission delay may adversely impact some of the currently available satellite based systems . Operation of some of the existing systems has required that all messages pass through one of the satellite service provider's message switches. As a result, a message between two mobile units may pass from one unit, through the satellite, through a terrestrial message center, back through the satellite, then to the other mobile unit. The "double hop" through the satellite (which was geo-synchronous) resulted in objectionable transmission time delays.

Specialized Mobile Radio

Specialized Mobile Radio (SMR) services were established by the Federal Communications Commission (FCC) in the mid-1970's when the FCC allocated a portion of the 800 MHz spectrum for use in private land mobile communications. Primarily "dispatch communications", these analog services are commonly employed by companies with fleets of vehicles operating throughout a local area. They typically permit two-way mobile communications between a dispatcher and one or more mobile/portable units, which enables groups of users to communicate simultaneously.