infrastructure systems, encouraging the use of commercial systems where appropriate, providing gateways between and among independent public safety wireless infrastructures and between public safety infrastructures and commercial wireless providers, and encouraging increased planning efforts) are all useful in the longer term as well. However, it is evident that these shorter term alternatives do little to relieve the immediate problem of spectrum availability and that they do nothing to meet the requirement for providing infrastructure independent communications between end user radio units over a direct RF path.

These two issues are discussed in more detail below.

As stated at the outset of the section, it is clear that from the work of the ISC and the Spectrum Subcommittee, the loading on existing public safety channels is so heavy that shorter term interoperability requirements can be fully met only through the allocation of additional spectrum. While encouraging the use of shared infrastructure systems, and, where appropriate, commercial systems, may reduce the pressure on existing public safety spectrum resources somewhat, those steps will not solve the basic problem of lack of adequate spectrum to meet interoperability requirements. This conclusion serves to reemphasize the importance of the public safety and public service entities obtaining spectrum relief as soon as possible.

The importance of providing infrastructure independent methods for obtaining interoperability has been stressed throughout the PSWAC/ISC process. As pointed out in the analysis conducted by the ISC, the use of analog FM technology is widespread in the land mobile radio industry and provides the basis for existing infrastructure independent interoperability. The technology is well understood, and a common set of non-proprietary operating parameters has allowed end users to communicate directly over the air using radios produced by different manufacturers.

Alternatives for Enhancing Public Safety Interoperability

Alternative	Short Term Applicability (Five Years or Less)	Longer Term Applicability (More Than Five Years)	Notes
1. Providing, for interoperability purposes, additional spectrum immediately adjacent to or within existing public safety bands and requiring a common mode of communications (e.g., analog 25.0/12.5 kHz FM) on the resulting interoperability channels.	1. Represents a potential shorter term solution if suitable channels are made available immediately.	1. Would facilitate interoperability in the long term by providing adequate, common spectrum for interoperability purposes; *provides for infrastructure independent, unit-to-unit interoperability via a common mode of communication;* not a total solution because of the need for more than one band to meet total public safety spectrum operational requirements and the continued desirability of different bands in terms of their unique technical characteristic; end user radios capable of operating across multiple bands are not technically/ economically feasible.	1. More spectrum within existing bands would be achieved by designating for interoperability purposes certain of the additional channels created through the employment of more spectrally efficient technology (e.g., through refarming); this alternative could include regulations requiring public safety radios to be capable of operating on both the existing operational band *and* the designated interoperability channels associated with that band.
2. Reducing the number of individual bands used by public safety entities.	2. Not a shorter term solution because the large investment in existing bands, the continued desirability of existing bands in terms of their unique technical characteristics, and the lack of immediately available substitute spectrum mean that, as a practical matter, public safety users will occupy multiple bands for the foreseeable future.	2. Would facilitate interoperability in the long term by reducing the number of bands involved; not a total solution because of the need for multiple bands/radios.	2. Because of public safety's continued need for spectrum, it is recognized that reducing the number of individual bands may be difficult in practice; nevertheless, this alternative is recommended by PSWAC as part of the long term solution for enhancing public safety interoperability.

Alternative	Short Term Applicability (Five Years or Less)	Longer Term Applicability (More Than Five Years)	Notes
3. Requiring a planning effort to deal with the use of the reallocated interoperability channels.	3. Narrowly interpreted, does not represent a potential shorter term solution because the designated interoperability channels are not available; however, planning aimed at facilitating other shorter term solutions may be useful.	3. Would facilitate longer term interoperability by ensuring efficient and effective use of the designated interoperability channels; also necessary to overcome the non-technical (e.g., political) barriers to interoperability.	
4. Providing, for interoperability purposes, end users with multiple radios; includes two possibilities: a. Providing radios dedicated to interoperability and operating within an existing band using the recommended common mode of communications (analog FM). b. Providing radios dedicated to interoperability on an entirely separate group of new interoperability channels using the recommended common mode of communications (analog FM).	4.a. Associated with a frequent means of achieving interoperability today; hence, it represents a shorter term solution; the drawbacks (including costs) are described in the text of the PSWAC report. 4.b. Not a shorter term solution unless suitable channels are made available immediately; however, if such channels were made available immediately, manufacturers could provide the radios quickly because of the ease of developing analog FM equipment.	4.a and 4.b. While the longer term objective is clearly in favor of reducing the need for end users to employ multiple radios, as a practical matter they still may be needed in certain instances; *provides for infrastructure independent, unit-to-unit interoperability*	4.a. Adoption of other PSWAC interoperability recommendations could make the use of multiple radios under alternative 4.a. somewhat more efficient (e.g., by reducing the number of different bands used by public safety systems). 4.b. The capability to operate in the dedicated interoperability band could be built into all public safety end user radios in the longer term (multiband radios); alternative 4.b. and alternative 1. could be combined.

Alternative	Short Term Applicability (Five Years or Less)	Longer Term Applicability (More Than Five Years)	Notes
5. Encouraging the deployment and utilization of shared/consolidated systems (referred to by the ISC as common access to an infra-structure).	5. Represents a potential shorter term improvement since it does not depend on the reallocating and clearing of spectrum designated for interoperability purposes; *provides for infrastructure independent, unit-to-unit interoperability* for users sharing the infrastructure; it does not solve the shorter term spectrum scarcity problems in major urban areas.	5. Would facilitate longer term interoperability by reducing the number of independent infrastructures and the number of required gateways (see alternative 6., below).	5. An example of a positive incentive for the deployment and utilization of shared/consolidated systems would be to offer exclusivity to them; shared/consolidated systems may also improve spectrum efficiency due to gains in trunking efficiency; while listed as a short term alternative, making the necessary political, economic, and technical arrangements and then procuring shared/consolidated systems may take several years.

Alternative	Short Term Applicability (Five Years or Less)	Longer Term Applicability (More Than Five Years)	Notes
6. Providing interfaces/gateways between and among the (possibly reduced number of) independent infrastructures.	6. Represents a potential shorter term improvement since it does not depend on the reallocating and clearing of spectrum designated for interoperability purposes, nor does it depend on the use of a common mode of transmission; however, it does not meet the requirement for infrastructure independent unit-to-unit communications, nor does it solve the shorter term spectrum scarcity problems in major urban areas; improperly designed, it can add delays in the communications path.	6. Would continue to facilitate interoperability in the longer term; *it provides infrastructure dependent unit-to-unit communications across multiple bands* while avoiding the need for multiple radios.	6. Gateways and interfaces are general terms for techniques used to allow an end user on one system to communicate with end users on another system even though they are operating in different bands; these techniques can range from simple to complex; nevertheless, because it appears that it is unlikely that all future public safety spectrum requirements can be met in a single band, this method of providing for infrastructure dependent interoperability may remain a critical component in achieving enhanced interoperability in the longer term; issues regarding the potential impact of this alternative on spectrum efficiency have been raised (see the text of the PSWAC report for a discussion).

Alternative	Short Term Applicability (Five Years or Less)	Longer Term Applicability (More Than Five Years)	Notes
7. Promoting or requiring the build-out of some nationwide infrastructure to support interoperability; could include: a. a nationwide infrastructure operating on the designated interoperability channels b. deployment of gateways/interfaces between and among existing infrastructures	7.a. Represents a potential shorter term solution if suitable channels are made available immediately. 7.b. Represents a potential shorter term solution. (See 6. above.)	7.a. Could facilitate interoperability in the long term by providing a common infrastructure; not a total solution for the reasons listed in 1. above. 7.b. Would also facilitate longer term interoperability. (See 6. above.)	7.a. If the nationwide infrastructure is designed to serve agencies from all levels of government (federal, state, and local), then certain licensing issues must be resolved.
8. Encouraging the use of commercial systems where appropriate.	8. Represents a potential shorter term improvement since it does not depend on the reallocating and clearing of spectrum designated for interoperability purposes; however, does not meet the requirement for infrastructure independent unit-to-unit communications.	8. Could facilitate longer term interoperability for appropriate services; however, does not meet the requirement for infrastructure independent unit-to-unit communications.	8. Might involve gaining priority access within the commercial systems; other advantages and disadvantages associated with the use of commercial systems are discussed in the text of the PSWAC report.
9. Providing gateways/interfaces between public safety and commercial infrastructures to facilitate the use of the latter in public safety/public service applications.	9. Represents a potential shorter term improvement since it does not depend on the reallocating and clearing of spectrum designated for interoperability purposes; however, it does not meet the requirement for infrastructure independent unit-to-unit communications.	9. Could facilitate longer term interoperability between public safety and commercial systems, thus facilitating the use of commercial systems to back up public safety systems and facilitating the use of commercial systems in public safety applications (where appropriate).	

Extensive and effective implementation of infrastructure independent interoperability using this method has been hindered by a number of constraints including the fragmentation of public safety channels across multiple bands from low band to the 800 MHz band, human limitations on the number of channels that individual end users are able to handle, the general lack of sufficient channels for interoperability, and certain command and control issues. Almost by definition, encouraging the use of shared infrastructure systems, and, where appropriate, commercial infrastructure systems, does nothing to solve the infrastructure independent interoperability. Hence, during the transition period to the longer term solution put forth by the ISC, today's largely unsatisfactory solutions must suffice. These solutions include, for example, the use of multiple radios. Such solutions are regarded as unsatisfactory because of both technical and physical limitations.

The analysis contained in this section has focused primarily on voice communications but, as brought out in the Operational Subcommittee report and elsewhere, data, image and video requirements must also be met. Development of the necessary technology, products, and procedures for meeting these requirements in public safety applications is still in the formative stages. Hence, the Transition Subcommittee concludes that, as part of the immediate efforts to improve inter-agency communications, the industry and users should address interoperability issues through standards or other appropriate measures.

10.4 Additional Interoperability Channels

Appendix A contains recommendations for the number of simultaneous interoperability links required by user service category for two options. The first option is to implement interoperability within existing public safety bands. The second option is to implement interoperability at the minimum level within current public safety bands, while providing the majority interoperability spectrum within a new Public Safety Interoperability Band in spectrum below 512 MHz. After careful consideration, Working Group #3 recommended the second option. Section 12.3.7 discusses these options in detail.

Aggregate numbers for the first option (using existing bands) indicate a total need for 51 repeatered voice links and 83 simplex voice links within current bands, plus 2 independent high speed data and 2 independent full motion video links. It is believed that existing designated interoperability frequencies can be used for 17.5 of the repeatered and 28 of the simplex voice links. The high speed data and full motion video links must be provided within new spectrum.

Aggregate numbers for the second option (new interoperability band) indicate a total need for 21 repeatered voice links and 20 simplex voice links within current bands. It is believed that existing designated interoperability frequencies can be used for 13.5 of the repeatered and 13 of the simplex voice links. 31 repeatered voice, 70 simplex voice, 2 independent high speed data and 2 independent full motion video links must be provided in the new Public Safety Spectrum. The difference in the number of available frequencies in the current bands between the two options is due to eliminating the 220 MHz band in this option.

The basis of the recommendations for additional channels is detailed in Section 12.3 of this report. The Data Collection Instruments (DCIs), that were used to collect the data from the various sub-groups within the working group, are available for review upon request. The size of the data file made it impractical to include as part of this report. The discussion provided below provides the basic rationale for the number of interoperability channels recommended. It should be noted that in the Washington Area Council of Governments (COG) report (reference *Metropolitan Washington Area Interoperability* report at Appendix C) 100 channels were recommended, on a nationwide basis, for interoperability.

Public safety agencies presently have base-mobile frequency allocations in the 30-50 MHZ, 150-174 MHZ, 450-470 MHZ and 806-869 MHz bands. In addition, some major metropolitan areas are allowed shared use of portions of the 470-512 MHZ television band. The two primary bands containing the majority of non Federal users are 150-160 MHZ and 450-470 MHZ. Because many systems retained lower frequencies and added higher frequencies as technology made higher frequency equipment more available and reliable, it is common to see systems that use portions of all of these bands. Reliable and cost effective dual band radios have not been produced to date. However, individual radio users have either been contained on a single band or they have had to use multiple radios. The combinations of multiple bands, nonstandard repeater frequency spacings, nonstandard system access methods and no adequate allocation of clear nationwide emergency channels have contributed toward the inability for public safety users to interoperate with each other, for decades. Interoperability problems cannot be solved without some consolidation of more users on a larger band and without the dedication of specific channels for Interoperability.

Thrown into this mix is the fact that Federal and non-Federal users have been separated even further by philosophy, practice and infrastructure and frequency differences. Thousands of individual agreements have been promulgated over almost 50 years to give very specific system access to some users for interoperability. These cases are generally so specific however that they do not provide for itinerant or large-scale event use. In effect, they are simply band aids on a disabling wound.

The ISC recommends that contiguous bands of frequencies should be allocated for public safety's use to augment the existing public safety spectrum. The addition of spectrum technically close enough to these existing allocations could allow the manufacture of broadband radios capable of utilization of the existing and new allocations. Use of such radios would offer some spectrum relief; they would be economically viable for manufacturers and they would provide unoccupied spectrum for planning spectrally efficient use and, for the first time, nationwide interoperability. Spectrum allocated must be suitable for Land Mobile use. The Commission must concentrate on additional public safety spectrum below 1 GHz and this allocation must be nationwide.

Interoperability requires nationwide allocations of clear channels distributed in each of these new frequency bands. The allocations should be made under the umbrella of "public safety." They should not be made only to specific disciplines within public safety. They should also be usable by all levels of government depending upon the requirements of an event.

The channel recommendation is based upon providing usable communications within the Incident Command System (ICS). ICS is a standardized way for agencies to operate with one another in large-scale emergencies. ICS has a hierarchical structure for event management. It has a Christmas tree type of organizational structure which identifies lines of reporting (communications) throughout the organization. ICS is extensively used in fire and other large-scale emergency management. We offer the following discussion using the fire service as an example because large fires are more common than most other large-scale emergencies. The provision of a solution for fires however envelopes needs of other categories of events.

At the fire ground level, strike teams are composed of five units. These units can be five engines which act together in a specific assignment at a fire. Each engine can be operated with as few as two or as many as four people. The content of messages in incident management is generally less of an emergency nature the higher one goes in the management structure. These field located strike teams are where most emergencies occur. Because the need to communicate immediately and reliably is most severe at this level, each strike team should be able to use its radio channel within the mission group itself, and communications within the group should be interference free. Ten to 20 people at the head of a fire are all such a channel should handle. Present practice however finds multiple strike teams all on the same channel because of the lack of frequencies. The result can be chaos as individuals cannot tell which message is meant for them, and co-channel interference often critically reduces channel effectiveness. At this level of organization, the inability to communicate can be life threatening and such threats are immediate.

Even a medium scale wildfire can often have 10 or more strike teams working at a time. It is not abnormal to have 500-600 fire fighters on such an incident. Fire storms such as those which occurred in Berkeley-Oakland and the Los Angeles area used many more strike teams than that. ISC's recommendation is that there should be 10 channels set aside to support such tactical use. In very large-scale events, frequency reuse should allow multiple strike teams to operate on the same channel. Other interoperable channels could support national and local infrastructure channels for communications between the incident and the base for travel of personnel to the incident and for logistical and other such incident related functions. ISC believes two things must happen: First, there must be a planning effort (similar to NPSPAC) to deal with use of interoperability channels. Second, the FCC will need to mandate some limited buildout of some nationwide infrastructure to support Interoperability. Rules similar to those governing the NPSPAC nationwide Interoperability channels should be used as a starting model.

Going up in the hierarchy, there should be no more than five strike teams on a common upward coordination channel. At this level, there typically are communications responsibility for between 50 and 100 people who are involved in emergency response. The communications at this level are somewhat less peril-related, but they are more complex. These communications are often time-critical matters of logistics and support. They can involve critical communications dealing with situations such as water delivery, electrical power shutoff and gas shutoff. They also are frequently tactics related so strike team leaders know what is going on around them and what is needed from them. Channels close to each

other so that they are operable in one radio are necessary because of the need to separate critical communications while still allowing intergroup communications as they are needed. At the same time, these channels must be spaced far enough apart so that nearby off-channel interference does not disable critical communications paths.

There are many layers in these emergency management organizations. Damages frequently run into the millions of dollars, too often there are lives lost and there is a requirement for functions of mapping, logistics, finance, personnel assignment, emergency crew management and even multiple levels of aircraft coordination. Large fires almost always depend upon the use of aircraft to deliver water and retardant, to locate and map hot spots and to map the spread and direction of the fire. Again, these communications can be critical and they must be interference free. Of necessity in present practice, these communications are often overlaid onto the few channels that are available on the incident. The result is often confusion and danger to the participants.

10.5 Establish Standards Working Group

Working Group #3 recommended that a working group be established to address a digital baseline technology in the future. The specific recommendation in the Working Group #3 DRAFT Report is as follows:

> While the Minimum Baseline for Interoperability presented in Section 11.2.3 will suffice for some time, perhaps as long as 2010, the time will come when most, if not all, users in a given area will be using a digital voice communications platform and will not want to give up the capabilities provided by that platform when switching to analog FM for direct unit-to-unit communications. Therefore, it is recommended that, after the PSWAC process is completed, the FCC and NTIA together establish a working group compromised of experts representing government, industry, and federal, state and local government users similar to, but smaller than the PSWAC effort, to address base line technology for interoperability. It is further recommended that another PSWAC should be convened within ten (10) years to evaluate technology development and the effect that actions stemming from this PSWAC have had on meeting the needs of public safety's spectrum and interoperability problems.
>
> Considering the evolution to digital technology, we should not limit future interoperability to an analog baseline. Just as the AMPS cellular standard (which clearly goes far beyond simple analog FM) provides North America-wide cellular interoperability, there is clearly a future need for digital interoperability standards for public safety communications. It is imperative that this baseline be addressed and established within the next two years, to allow the public safety community to develop implementation and migration plans accordingly.
>
> Any group selected for the purpose of such an evaluation should be composed of experts representing industry and users. The selection methodology must be weighted towards the needs of the end user. Refer to Section 12.3.9.5 for further discussion within the working group.

During the ISC meeting on July 18, 1996 an alternative recommendation was offered by representatives from Ericsson, which included specific text referencing Section 273 in the 1996 Telecommunications Act. Many members expressed concern that ISC was establishing rules that should be the responsibility of the group after it was formed, while others expressed unfamiliarity with Section 273 of the 1996 Telecommunications Act, stating that they could support the verbiage.

No members present expressed any reluctance to support open standards that are developed in an open and fair process, but the concerns were whether the ISC was acting within the scope of the subcommittee and the unfamiliarity with Section 273.

Mr. Charles Jackson offered a compromise resolution and it was decided to reconvene the next morning (July 19th) prior to the Spectrum Requirements Subcommittee meeting.

The suggested text offered by Mr. Jackson follows:

The ISC recommends that the digital baseline standard be an open standard; unconstrained by Intellectual Property Rights (IPR) of any party, and that this standard be developed in an open and fair process, based upon consensus, using an accredited standards making entity.

There was significant opposition to this verbiage, due to some confusion about definitions and exactly what the procedure would be. There was also concerns again expressed that the action was outside the scope of the subcommittee. After significant discussion a compromised resolution was offered as follows:

The ISC recommends that any digital baseline standard for interoperability be open standards developed/adopted in an open and fair process, using an accredited standards making entity.

There seemed to be consensus among those present, although at least two members expressed some concerns that this may put undue restrictions on the group. The ISC Chair stated that in light of the time expended on this issue, any further comments should be submitted in writing after the next revision of the DRAFT Report (Revision 9) was distributed.

There was an overwhelming number of responses submitted objecting to the verbage in the DRAFT Report (Revision 9, dated 7/22/96). An overwhelming majority of the comments stated that they felt the verbiage put undue restrictions on the group and suggested that new verbiage be incorporated.

Although it is not full consensus, the recommendation provided in Section 11.2.4 reflects the vast majority of the members.

Mr. Jackson in an effort to ensure that everyone understood the standards process and the meaning of Section 273, specifically subsection (d) (4), provided the following text to be included in the report:

Formal development of industrial standards grew to a large scale activity in the late nineteenth century with the rise of standards organizations. Today, the primary body overseeing the development of standards in the U.S. is the 76 year old American National Standards Institute. ANSI does not write standards, but serves as an impartial organization which, through its procedures, validates the general acceptability of the work of the technical experts. It ensures that any standards writing group uses democratic procedures that give everyone who will be "directly and materially" affected by the use of the standard an opportunity to participate in the development work or to comment on the document's provisions. ANSI voluntary standards include more than 100,000 product standards developed by more than 400 standards development organizations, including government, industry, technical societies, trade associations and companies. ANSI, with its nearly century of experience has developed procedures for assuring fairness and openness in the standards process. Becoming ANSI accredited is normally not difficult and many organizations have done so.

At times, the development of standards has been contentious and difficult. The current process of the accredited standards organizations reflects decades of experience with these sometimes difficult tasks. In extreme cases, groups engaged in standards development have been found to have violated the antitrust laws.

Congress, in the recently enacted Telecommunications Act of 1996, recognized the important role of accredited standards organizations. In Section 273(d)(4) of that act, it imposed special obligations on other groups (not-ANSI accredited) engaging in standards development in telecommunications. Those requirements were the basic elements of fairness and openness including:

i. Public notice of the development of a standards,

ii. A public invitation to interested parties to participate in a a reasonable and nondiscriminatory basis, administered in such a manner as not to unreasonably exclude any interested industry party,

iii. Texts shall be published with opportunity for comment and response,

iv. Final texts shall include, if requested, additional comments by participants,

v. The group must attempt to establish a mutually satisfactory dispute resolution process.

Openness, permitting all to participate, transparency, open procedures allowing all to see how decisions are made, and fairness (due process requirements) are the heart of these congressional requirements.

However, there were a number of members that felt that Section 273 of the *1996 Telecommunications Act* was not applicable to the land mobile radio environment and maintained that it was inappropriate to put restrictions on a group before it is formed.

10.6 Availability of Commercial Services

Information gathered about the current use of commercial services shows continued growth. The experience with commercial services in the public safety community is based on currently installed and available commercial services and while these experiences are indeed valid some of the emerging technologies may solve some the problems experienced in the past.

Commercial systems are not likely to meet all requirements within the public safety community, at all times and at all locations. Objective experiments with and use of these systems will be necessary to determine the portion of public safety needs they can satisfy. Issues such as costs, transmission delays, size of units, building penetration, and coverage in rugged terrain will need too be assessed.

As commercial vendors have added increased capabilities,

Applications focused on:

- *productivity gains*
- *faster access to data*
- *facilitation of increased mobile communication with public assistance groups*
- *emergency back-up use where there is a lack of private infrastructure*

First response, and life threatening applications still depend on private radio. Public safety describes these as time critical and mission critical applications.

A short-term migration to commercial services for first response, and/or life threatening applications is not realistic. Commercial infrastructure presently does not generally serve the best interest of the public, the public safety agencies that, provide these services, nor the commercial vendors that would need to support these applications.

The initial effort would require a thorough understanding by commercial interests of the coverage, security, reliability, and immediate access needs of public safety. After these system design parameters are fully known, then trust, familiarity, tradition, training, perceived network control and investment in private radio are all issues which would have to be addressed before commercial services could be fairly evaluated.

Working through each of those issues will require information exchange, planning, educating, building relationships, testing in controlled environments, and perhaps incentives for both public safety agencies and providers to work together.

Today the manner in which commercial services are often offered to, and evaluated for use by public safety agencies is inconsistent.

Vendors, anxious to do business, often provide products without fully understanding the application environment. Some offer products without providing an effective evaluation plan. Few provide training, troubleshooting and/or escalation procedures.

Agencies, often agree to test or purchase products without adequately explaining the application environment to vendors. In some cases, an agency will accept a product for evaluation and refuse training, because the product is considered to be a commodity item in the marketplace, and is assumed to be "user friendly". Although it may be true that users are familiar with the devices they are issued, the services activated in conjunction with those devices can vary greatly in coverage, reliability and levels of service offered.

Commercial providers often sell services through resellers. Some resellers work from a storefront to offer a variety of services. In small towns, local agencies may find themselves testing commercial services where the actual providers have no idea that the agency is actually using their service. Unless commercial providers have special programs for there resellers specific to public safety, agencies will often receive service commensurate with the general public.

Vendors and agencies that have entered into casual business arrangements, without taking the time to set objectives, to establish measurements for performance based on the application environment, and to understand troubleshooting procedures, etc., have walked away with disappointing results.

Test plans must be carefully conceived and executed before conclusions can be reached. Valid tests cannot be performed without realistic measurement criteria.

Standards for emergency communication services have only been addressed in private radio today.

Commercial performance criteria for reliability, security, access time, coverage, etc. like private system performance, are application specific. They have not been globally established by public safety agencies for different types of applications.

Once performance criteria are established, providers can evaluate their own capabilities and assess any shortfalls they may have against a standard of measurement. Based on the results, they can take steps to market to the public safety community for applications where their offering already fits, or they can modify their networks to meet more exacting defined criteria.

However, even if providers find that they meet public safety criteria for performance, there are no guarantees that they will commit to supporting public safety as a market segment either directly or in conjunction with value-added resellers. They may have already made a decision to support other vertical markets, or believe that they do not have the resources to effectively support public safety.

From another perspective, providers may be anxious to commit to supporting public safety as a vertical market, and not fully comprehend what that commitment requires. Without a full understanding of the Public Safety market, their actions could result in a poor showing for commercial vendors in general.

So far, inconsistent and uncontrolled evaluations of commercial services have not shed a lot of light on the effectiveness of their use. In general, misconceptions providers have about what is required to support public safety communications, and agency misconceptions about actual provider capabilities are major issues. They are issues unlikely to go away without a plan for vendors and agencies to educate one another.

A formal planning and evaluating process would help zero in on what agencies today see as unsettling issues about the effective use of commercial services in their environment.

The process should allow for open information exchange between agencies and vendors, with easy access for both, to information regarding the other's environment. Consistent and controlled evaluations must be conducted for specific technologies in specific environments with defined applications. The costs of services could then be compared as part of the evaluations.

Tests should be rolled out cautiously, taking into account environmental factors specific to each agency. Ongoing evaluations and modifications should be performed to ensure that services continue to meet performance standards.

In conclusion:

a) Performance criteria for public safety requirements to be met with commercial resources, are application specific and have yet to be defined by the public safety community.
b) A consistent plan needs to be developed for evaluating and integrating commercial services.
c) Public safety agencies and providers need incentives to work together to develop long term relationships.

Much work needs to be done to prepare commercial providers to support public safety as a vertical market.

An equal amount of work needs to be done to help public safety agencies evaluate where commercial services are effective and appropriate.

Both will take time. when the need for interoperability is now.

Vendors and commercial service providers need to spend the next five years making plans and conducting evaluations to determine where commercial services are appropriate for public safety applications and where vendor services need to change in order to support other public safety applications.. Migration to some commercial services will continue to evolve as certain technologies are seen as suitable by public safety communication officials within that time frame.

It is likely that widely accepted use of commercial services may take longer than five years. The need for spectrum to provide interoperability is immediate, and the alternatives for short-term solutions are limited.

Public safety cannot afford to wait five or more years for spectrum relief assistance from the commercial sector as a solution to pressing interoperability problems today. By the time commercial services become more widely used for Public Safety applications, the amount of spectrum needed to accommodate yet-to-be-discovered applications will likely increase with those new requirements.

11.0 Recommendations

One of the ultimate goals of the ISC is to reduce the number of bands that the Public Safety community currently operates their land mobile radio (LMR) systems. However, it is the general opinion of the members of the ISC that any significant reduction in the operational frequency bands can be realized in the PSWAC timeframe of 2010, without specific mandates and/or regulations. The ISC recommends that the PSWAC Steering Committee, as well as the FCC and NTIA keep this recommendation in mind during the deliberations concerning future rule-making and regulatory proceedings.

11.1 Short Term Solutions

Reflecting the analysis and conclusions contained in Section 10.1.3, the Interoperability Subcommittee makes the following recommendations for improving interoperability in the shorter term. Namely, the FCC and the NTIA:

1. Should take steps to immediately allocate additional spectrum adjacent to current operational bands in order to minimize the time period needed to reach the longer term solutions.

2. Should take pro-active steps to encourage the deployment and utilization of shared/consolidated systems (referred to by the ISC as common access to infrastructure).

3. Should encourage the provision of interfaces/gateways between and among remaining independent public safety and public service infrastructures.

4. Should take pro-active steps to encourage the use of commercial systems where appropriate.

5. Should encourage the development, provision, and utilization of interfaces/gateways between public safety and commercial infrastructures.

6. Should encourage coordinated planning at the federal, state, and local levels of government in order to facilitate implementation of the previous five recommendations.

7. Should recognize and take into full consideration in their deliberations that the ultimate solution to the interoperability problem is critically dependent on additional spectrum.

11.2 Long Term Solutions

Based on the discussion provided in previous sections of this report and the supporting detailed information in Section 12, the Interoperability Subcommittee (ISC) has adopted the recommendations provided in the following sub-sections to satisfy the interoperability requirements that have been identified and addressed.

11.2.1 Additional Interoperability Channels

Appendix A contains recommendations for the number of simultaneous interoperability links required by user service category for two options. The first option is to implement interoperability within existing public safety bands. The second option is to implement interoperability at the minimum level within current public safety bands, while providing the majority interoperability spectrum within a new Public Safety Interoperability Band in spectrum below 512 MHz. After careful consideration, the ISC recommends the second option (see Section 10.3 and Attachment 7). Section 12.3.7 discusses these options in detail.

Aggregate numbers for the first option (using existing bands) indicate a total need for 51 repeatered voice links and 83 simplex voice links within current bands, plus 2 independent high speed data and 2 independent full motion video links. It is believed that existing designated interoperability frequencies can be used for 17.5 of the repeatered and 28 of the simplex voice links. The high speed data and full motion video links must be provided within new spectrum.

Aggregate numbers for the second option (new interoperability band previously discussed in Section 10.1.3 and later in Section 11.2.2) indicate a total need for 21 repeatered voice links and 20 simplex voice links within the existing bands. It is believed that existing designated interoperability frequencies can be used for 13.5 of the repeatered and 13 of the simplex voice links. It is further recommended that 31 repeatered voice, 70 simplex voice, 2 independent high speed data and 2 independent full motion video links be provided in the new Public Safety Spectrum. The difference in the number of available frequencies in the current bands between the two options is due to eliminating the 220 MHz band in this option.

11.2.2 Establish New Interoperability Band

Although this solution is listed as a long term (longer than five years) solution, depending on the availability of spectrum, this new band could be available within the short term.

The PI Solution

The descriptions outlined in Section 10.3 and in Attachment 7 include the following basic requirements:

* Find a relatively free band of frequencies, preferably central to existing public safety bands. The ISC recommends the UHF band below 512 MHz.

* Define specific frequencies and pairs of frequencies using developed ICS guidelines.

* Freely license these frequencies to all eligible public safety/service providers under operational as well as technical regulations.

* Restrict use to mutual aid interoperation.

The preceding requirements may seem somewhat simplistic, however there is a flexibility to the operational aspects of the PI solution that could allow for much higher levels of robust capabilities. **This would be a fresh and new service which could be implemented without regard to any backward compatibility requirements.** It need not be tied to existing technology and modulation schemes. This leads to a plethora of possibilities:

* Narrow channel bandwidth (or equivalent) should be specified for maximum spectrum efficiency.

* Digital modulation could be required for the same reason.

* Digital modulation leads to the fact that data transfer would be a natural possibility.

* Bandwidth on demand applications (or the equivalent) could also be implemented for the very same reason.

* Encryption could also be very easily adapted considering the possible digital nature of the service. Over the air rekeying (OTAR) should be a requirement.

* Although conventional mode infrastructure independent operation is basic and mandatory to support first response capabilities, trunking should be encouraged for escalated incidents. Trunking would have several advantages for implementation of escalated incidents or for systems embedded in local or regional systems. Caches could be developed that include base/controller equipment that would allow dynamic over the air reconfiguration of all units involved in the incident. This could be enhanced by

requiring every radio manufactured to have an internal unique ID similar to the NAM in cellular radios. The ID should be easily read by units entering the incident either by physical connection, optical, or wireless. While such advanced types of operations would require knowledgeable and available communications unit leaders, this activity already takes place on large ICS incidents with existing programmable equipment.

Migration to this interoperability solution could take place as soon as rules and regulations were put into place. There are of course stumbling blocks such as adopting standards for a new operation, but these could also be looked upon as building stones. This solution would not require scrapping any existing system or worry about compatibility with existing systems and the associated costs.

11.2.3 Establish Planning Process

The ISC recommends that a nationwide planning process should be established as soon as possible which provides guidance and outlines procedures for a regional planning process to be completed within two years from completion of the national plan.

The nationwide planning effort should identify and address operational policies and procedures. This process could be accomplished with a FCC comment and reply procedure, however it is the general consensus that a definitive interoperability process would be more effective and provide a better solution. All levels of government should be involved in this planning effort and all public safety entities (as defined in Section 3.1) should have access to these interoperable channels. Most of the concerns of the federal users, including the use of the United States Search and Rescue Teams (USART) established by the Federal Emergency Management Agency (FEMA), should be addressed during the national process. While regional differences are certain to occur, nationwide concerns should be addressed only once during the national process as much as possible. When guidelines are defined for a core nationwide use, individual regional concerns and issues should then be addressed and regional plans developed.

11.2.4 Baseline Technology (for Interoperability)

The ISC recommends that a common mode of transmission be adopted, by the FCC and NTIA, as a mandatory requirement for interoperability on these channels.

The ISC unanimously adopted a revised recommendation from Working Group #10 on April 12, 1996, in San Diego. For detailed information concerning the adoption of this recommendation, refer to the Working Group #10 Report at Section 12.10. The following recommendation was adopted and forwarded to the Technology and Spectrum Requirements Subcommittee Chairs:

> *It is the recommendation of the Interoperability Subcommittee that the minimum "Baseline Technology for Interoperability", for unit-to-unit voice communication, be 16K0F3E (analog FM), unless Federal Communications Commission (FCC) and/or National Telecommunications and Information Administration (NTIA) regulations*

stipulate a different emission in a specific operational band. This mandatory requirement should be adopted as soon as possible by the FCC and NTIA. This recommendation is applicable to the public safety spectrum between 30 MHZ and 869 MHZ.

Effective January 1, 2005, the minimum "Baseline Technology for Interoperability", for unit-to-unit voice communication, should be mandated as 11K0F3E/11K25F3E (analog FM) in the public safety spectrum between 30 MHZ and 512 MHZ, unless FCC and/or NTIA regulations stipulate a different emission in a specific operational band.

The maximum allowable interoperability bandwidth in any new spectrum allocation should not be allowed to exceed the bandwidth established for operational communications within that new spectrum.

11.2.5 Establish Standards Working Group

Although it must be emphasized that the decision is not unanimous (see discussion in Section 10), the general consensus of the ISC is to recommend:

The ISC recommends that as part of the Final PSWAC Report, a strong recommendation be made to establish a group comprised of experts representing government, industry and users to address baseline technology for interoperability. This effort should be managed by a neutral third party who has no vested interest in the outcome of the effort.

The ISC recommends that any digital baseline standards for interoperability be open standards, developed/adopted in an open and fair process.

With the emergence of digital technology, it is imperative that this baseline be addressed and established within the next two years, to allow the public safety community to develop implementation and migration plans accordingly.

11.2.6 Recommendation for PSWAC Committee

It is further recommended that another PSWAC should be convened within ten (10) years to evaluate technology development and the effect that actions stemming from this PSWAC have had on meeting the needs of public safety's spectrum and interoperability problems.

12.0 Working Group Reports

The product of some of the working groups was directly reflected in specific text within the main body of the report.

12.1 Working Group #1 Report (Define Interoperability)

Working Group #1 was the first working group formed in the ISC. The output of this working group is reflected in Section 3.2 of this report.

12.2 Working Group #2 Report (Develop DRAFT Report Outline)

Working Group #2 developed the outline and list Addressable Issues from which this report was developed. The members of Working Group #2 were then assigned to Working Group #6, which was assigned the task to develop the DRAFT Report.

12.3 Working Group #3 Report (Define Future Interoperability Requirements)

12.3.1 Introduction and Overview

This working group report describes possible methodologies, operational policies and procedures, spectrum use and considerations and regulatory issues as they pertain to future interoperability needs.

The report proceeds in six steps. First, the three major types of interoperability (day-to-day, mutual aid and task force) are addressed. Second, we discuss a number of major mutual aid and task force incidents requiring significant use of interoperability which have occurred in the past few years; these are broken down by type of service (emergency medical, fire, general government, law enforcement, etc.) and summarize unmet needs. Third, we summarize the possible methodologies which might be employed to meet these and future requirements. Fourth, we discuss operational policies and procedures based on experiences from the major incidents and current trends in incident management. Next, we present and discuss spectrum issues related to interoperability. Finally, regulatory issues related to interoperability are presented and discussed.

12.3.2 Key Conclusions

12.3.2.1 The single greatest impediment to interoperability is the large number of radio frequency bands assigned to the Public Safety Radio Services by the FCC and administered by the NTIA for federal government users.

Current bands spread 839 MHz from 30 MHz to 869 MHz for normal land mobile radio (LMR) systems in 10 major bands:

* 30-50 MHz (federal, state and local)

* 138-144 MHz (federal. primarily Department of Defense)

* 150-162 MHz (state and local)

* 162-174 MHz (federal)

* 220-222 MHz (state and local)

* 406-420 MHz (federal)

* 420-430 MHz (state and local in two N/E Canadian border areas only)

* 450-512 MHz (state and local)

* 806-815 and 851-860 MHz (state and local)

* 821-824 and 866-869 MHz (state and local; National Public Safety Planning Advisory Committee - NPSPAC or national plan band)

Radio equipment manufactured today is limited to an operational bandwidth that is approximately 24% of its center operating frequency. Therefore, the operational bandwidth is inadequate to cover the 839 MHz frequency spread listed in the previous paragraph.

The assignment of new bands for use by public safety agencies will only increase the interoperability problem for the near future.

Future technology developments, including wide-band and/or multi-band radios will offer some relief, but radio equipment manufacturers have publicly stated that it is doubtful that one piece of equipment, particularly the important personal portable radio, will be able to function adequately to meet public safety requirements across the entire 839 MHz range (or even the narrower 150 MHz to 869 MHz range where most LMR communications occurs) in the foreseeable future.

12.3.2.2 The introduction of equipment using newer technology during the past 10-15 years without appropriate standards leaves this equipment unable to communicate with that of other manufacturers equipment with dissimilar protocol and modulation techniques. For example:

* Analog trunked LMR equipment introduced into the 800 MHz public safety market by the three major US-based equipment manufacturers is not compatible in analog trunked mode.

* Digital encryption provided by the two major US-based equipment manufacturers is not compatible in protected

(encrypted) mode. Indeed, some of these manufacturers own lines are not compatible with each other.

* New equipment introduced in the past three years for the 220-222 MHz band, primarily based on advanced single-sideband technology, is not compatible between manufacturers, nor with other technologies

* The baseline technology for voice interoperability within existing compatible bands is the use of analog frequency modulation (FM), potentially leaving the user without some critical features such as encryption (see Section 12.3.3.2).

12.3.2.3 *There is a critical shortage of frequencies specifically designated for interoperability uses in all 10 of the public safety bands, although some regions of the country have opted to designate additional frequencies beyond the 5 pairs mandated in the 821-824/866-869 MHz NPSPAC band thereby minimally meeting the interoperability needs of that region.*

12.3.2.4 *The grade of service (GOS) for interoperability paths can be no less than that for operational paths as detailed in Appendix A of the Operational Requirements Report. Interoperability is often used under circumstances that are less tolerant of error than during normal operations, therefore a similar GOS is required.*

12.3.3 Key Recommendations

12.3.3.1 Additional Channels for Interoperability

Appendix A contains recommendations for the number of simultaneous interoperability links required by user service category for two options. The first option is to implement interoperability within existing public safety bands. The second option is to implement interoperability at the minimum level within current public safety bands, while providing the majority interoperability spectrum within a new Public Safety Interoperability Band in spectrum below 512 MHz. After careful consideration, this Working Group recommends the second option. Section 12.3.7 discusses these options in detail.

Aggregate numbers for the first option (using existing bands) indicate a total need for 51 repeatered voice links and 83 simplex voice links within current bands, plus 2 independent high speed data and 2 independent full motion video links. It is believed that existing designated interoperability frequencies can be used for 17.5 of the repeatered and 28 of the simplex voice links. The high speed data and full motion video links must be provided within new spectrum.

Aggregate numbers for the second option (new interoperability band) indicate a total need for 21 repeatered voice links and 20 simplex voice links within current bands. It is believed that existing designated interoperability frequencies can be used

for 13.5 of the re-peatered and 13 of the simplex voice links. 31 repeatered voice, 70 simplex voice, 2 independent high speed data and 2 independent full motion video links must be provided in the new Public Safety Spectrum. The difference in the number of available frequencies in the current bands between the two options is due to eliminating the 220 MHz band in this option.

12.3.3.2 Baseline Technology for Interoperability

The most critical Interoperability requirement is for direct unit-to-unit communications. Normally, a common over-the-air interface must be used for direct unit-to-unit communications; to that end, the Interoperability Subcommittee adopted a recommendation for a *Baseline Technology for Interoperability* on April 12, 1996. The text of that resolution is included in the main body of this Interoperability Subcommittee Report.

12.3.3.3 Establish Standards Committee

While the Minimum Baseline for Interoperability presented in Section 11.2.4 will suffice for some time, perhaps as long as 2010, the time will come when most, if not all, users in a given area will be using a digital voice communications platform and will not want to give up the capabilities provided by that platform when switching to analog FM for direct unit-to-unit communications. Therefore, it is recommended that, after the PSWAC process is completed, the FCC and NTIA together establish a working group compromised of experts representing government, industry, and federal, state and local government users similar to, but smaller than the PSWAC effort, to address base line technology for interoperability. It is further recommended that another PSWAC should be convened within ten (10) years to evaluate technology development and the effect that actions stemming from this PSWAC have had on meeting the needs of public safety's spectrum and interoperability problems.

Considering the evolution to digital technology, we should not limit future interoperability to an analog baseline. Just as the AMPS cellular standard (which clearly goes far beyond simple analog FM) provides North America-wide cellular interoperability, there is clearly a future need for digital interoperability standards for public safety communications. It is imperative that this baseline be addressed and established within the next two years, to allow the public safety community to develop implementation and migration plans accordingly.

Any group selected for the purpose of such an evaluation should be composed of experts representing industry and users. The selection methodology must be weighted towards the needs of the end user. Refer to Section 12.3.9.5 for further discussion within the working group.

12.3.3.4 Establish National Frequency Plan

A national frequency plan and regional frequency plans (as applicable) must be developed and mandated. These plans must include voice (simplex, mobile relay and trunked), data and video.

Standard nomenclatures and identifiers for channels/talk groups must be mandated by the FCC and NTIA for use on all equipment, to include approved identifiers to be displayed for interoperability channels/talk groups on equipment with varying numbers of characters in the channel/talk group display window.

A National Calling Channel and one or more Tactical Channels must be established in **EACH** of the public safety frequency bands. Use of these channels should be similar to that currently designated in the NPSPAC plan (47 CFR 90.16 and §90.34).

As with other mutual aid frequencies, it is important to consider placement within each band. There have been significant problems when mutual aid channels have been placed side-by-side or next to other statewide or nationwide assignments due to adjacent channel interference which can render such channels unusable when operating within close proximity to each other.

Some of the Interagency Frequencies identified in Appendix B may be candidates for this use. However, many of these have already been designated for specific purposes in state and regional plans. Caution is urged; a great deal of research must be done prior to making any reassignment of the Interagency Frequencies.

12.3.3.5 Establish Incident Command System

Appropriate regulatory agencies (including the Congress and state legislatures) must enact legislation requiring use of the Incident Command System for multi-agency incidents.

If addressed by the federal government and other states in a manner similar to that implemented in California, this becomes not an unfunded federal or state mandate but a requirement for disaster relief reimbursement from FEMA or the affected state(s) following any declared disaster.

12.3.4 Review of Working Group 3 Process

12.3.4.1 Background

The Interoperability Subcommittee (ISC) was formed in conjunction with the establishment of the PSWAC. One of its first tasks was to develop a report outline and divide into appropriate Working Groups to prepare its report. Working Group 3 (WG-3) was established to address Future Interoperability Needs.

During the Interoperability Subcommittee Meeting on January 9, 1996, at the University of California, Berkeley, ten subgroups were established within WG-3 to collect data for specific public safety services; membership of these groups is listed in Appendix A. The groups are:

WG-3-1: Fire/Emergency Medical Service (EMS)
WG-3-2: Emergency Management