FOREWORD

The PSWN Program Management Office commissioned Booz·Allen & Hamilton, Inc., a worldwide management and technology consulting firm, to conduct an independent study of public safety communications in the spectrum located around the 800 MHz band. This report assesses the relative merits of 800 MHz as an operating frequency band for public safety wireless communications, and the extent to which 800 MHz operations have affected interoperability among systems at all levels of government. The report is intended to serve as a catalyst for future discussions regarding the use of 800 MHz spectrum by the public safety community.

The findings contained in the 800MHz Study final report are aggregates of three primary sources of information. The first source is detailed analyses of filings to the Federal Communications Commission (FCC), including each of the 55 National Public Safety Planning Advisory Committee regional plans and subsequent docket histories. The second includes an initial technical analysis of radio frequency propagation characteristics. The third is a set of interviews conducted with several members of the public safety community. Specifically, the publicly available regional plans and docket histories were analyzed using a matrix that compared each of the plans across equivalent categories. Questions based on trends and hypotheses were developed during the analysis of FCC documentation. The trends and hypotheses were then further explored using the interview process. Together, the data contained in the matrix and gathered through the interview process serve as the basis for the final report.

To make comments regarding the information contained in this document, please contact Mr. Dave Williams, Booz·Allen & Hamilton, at 8283 Greensboro Drive, McLean, Virginia, 22102-3838, or by faxing comments to (703) 279-2035.

EXECUTIVE SUMMARY

The Public Safety Wireless Network (PSWN) program commissioned the consulting firm, Booz·Allen & Hamilton Inc. (BAH), to perform an independent study of the relative benefits and shortcomings of public safety land mobile radio (LMR) systems operating in the 800-Megahertz (MHz) frequency band. Public safety has been assigned frequencies in the 806-821/851-866 MHz and 821-824/866-869 MHz portions of the 800 MHz band. For the purposes of this study, these portions will be generically referred to as the 800 MHz band. Since the early 1980s, the Federal Communications Commission (FCC) has assigned approximately 300 channels located in the 800 MHz spectrum band for use by state and local public safety entities. The FCC has allocated 24 MHz of additional spectrum, in or near the 800 MHz band for public safety use and is currently engaged in establishing service rules for this spectrum. Given the availability of 800 MHz channels and the lack of additional spectrum resources at lower frequencies, many states, counties, and municipalities have installed or at least considered implementing 800 MHz systems. Unfortunately, the basis for public safety operation in this frequency range and the associated effect on interoperability has not been formally established. In addition, the costs and operational changes associated with 800 MHz systems have not been systematically assessed.

To increase general understanding and to begin to assess the relative merits of 800 MHz as an operating frequency band for public safety wireless communications, research and analysis was completed in three study areas. First, and primarily, the effectiveness of the two processes used to manage and administer 800 MHz spectrum to the public safety community was compared, contrasted, and assessed. Second, 800 MHz signal propagation was compared with propagation characteristics of other public safety bands. Last, BAH compiled technical and operational perspectives of several public safety officials who plan, administer, or use public safety radio systems.

Over the past thirty years, the FCC has provided two separate frequency allocations around 800 MHz for public safety use. The first of these allocations occurred in the early 1970s and involved the so-called "general service channels." The second of these allocations occurred in the 1980s in response to existing problems with interoperable communications among local, state, and federal public safety agencies. Each of these allocations was administered and managed by processes based on different regulatory philosophies.

The planning and management process used to assign and administer the general service channels located within the 806-821/851-866 MHz band allowed system administrators and engineers a great deal of flexibility to implement new 800 MHz systems for public safety use. The built-in flexibility encouraged LMR vendors to develop systems that used, and advanced the development of, emerging wireless communications technologies. Unfortunately, the flexibility within the general service channel process also led to a lack of system standardization and the proliferation of a variety of incompatible systems. Despite the involvement of the public safety community at the onset of the process, no vehicle was developed for coordination among separate public safety entities during the assignment and system development phases of the

process. The FCC and the public safety community recognized that future spectrum allocation processes should more actively involve the public safety community and contain provisions that encourage the use of spectrally efficient technologies.

In 1987, the FCC, working cooperatively with the public safety community[1], adopted the National Public Safety Plan—a more explicit and controlled process for assigning and administering an additional 6 MHz of spectrum in the 800 MHz band for use by the public safety community. The National Plan, as it is commonly called, provided the planning and management process for the assignment of frequencies within the 821-824/866-869 MHz bands. The FCC created the National Plan to specifically accomplish two goals: encourage efficient use of the spectrum, and increase interoperability among communications systems, thereby enabling local, state, and federal public safety agencies to better coordinate their activities.

To achieve these goals, the National Plan divided the Nation into 55 regions and called for the formation of regional planning committees (RPC), each consisting of members of the public safety community. The RPCs were chartered to describe how the 821-824/866-869 MHz bands would be efficiently used within their respective regions and also how intra- and inter-regional interoperability would be achieved or improved. The RPCs elected chairpersons and were encouraged to establish balanced membership with representation from multiple public safety entities within their respective regions. In reality, many of these committees have large contingents of law enforcement agencies from large metropolitan areas. Small public safety agencies consisting of less than 25 members usually lacked representation. The limited participation by the smaller public safety agencies may be due in large part to the lack of available funding to underwrite participation in the committees. Participation on the committees is voluntary and, in general, the costs are borne by the participant or the participant's agency.

Each of the 55 regional committees completed their respective plans within the five years allotted for the process. Some regions with dire spectrum needs or immediate plans to implement new 800 MHz systems expedited the completion of their plans; the earliest plan was approved nine months after the spectrum became available. Other regions were more deliberate, taking the full five years to submit a plan for approval. A significant number of the regional planning committees used a common template to create their regional plans. The templates simplified the plan development process and standardized its contents. Notwithstanding these positive effects, it is likely that the standard template may have stifled some creativity that could have further improved intra- and inter-regional interoperability.

The National Plan also created mutual aid channels to be used to facilitate interoperability among local, state, and federal public safety agencies. For a number of reasons, these channels have been largely ineffective at improving interoperability on any large scale. Many public safety entities operate in lower frequency bands, especially federal agencies, and communications on the NPSPAC mutual aid channels for these entities is difficult. Federal public safety agencies, for example, cannot license channels in the 800 MHz range. In order to use 800 MHz channels, federal agencies must be granted permission by the state or local entity licensed on those channels. No such agreements are necessary among local, state, and federal

[1] The FCC sponsored direct involvement of the public safety community through a newly established body called the National Public Safety Planning Advisory Committee (NPSPAC)

agencies for use of the NPSPAC mutual aid channels. However, several public safety officials who were questioned indicated that the mutual aid channels on their systems were largely unused. Despite this, few believe the concept of mutual-aid interoperability channels should be abandoned; to be effective, such channels should be identified in the multiple bands used by public safety. Also each public safety entity, whether local, state, and federal, should have equal licensing and usage rights on the interoperability spectrum.

The National Plan required that each regional plan be reviewed and signed by each of the adjacent regions in an effort to promote inter-regional coordination and ultimately improve inter-regional interoperability. While conceptually a good idea, this inter-regional vetting of plans was actually little more than a "rubber-stamp" process en route to regional plan approval. Inter-regional coordination and interoperability planning could have benefited from an effective oversight body that could assist in regional plan development and intervene in inter-regional disputes.

As part of the study, BAH was asked to assess, "Is 800 MHz truly right for public safety?" In comparing 800 MHz signal propagation with other frequency bands typically used by the public safety community, it is concluded that 800 MHz is not universally better or worse than other portions of the spectrum. Many states, counties, and municipalities are replacing aging public safety radio systems with new systems operating in the 800 MHz band. These groups have accurately identified benefits to migrating to the 800 MHz band. The lack of available spectrum in the lower frequency bands and the availability of 800 MHz channels have served as drivers for system planners to migrate to 800 MHz systems. Metropolitan users have, in some cases, achieved better coverage with an 800 MHz system as compared to the older VHF systems. This improvement in coverage may be due in part to the addition of new tower sites throughout the metropolitan area. The implementation of new infrastructure has allowed system planners to better plan and design new radio systems. These enhanced planning and design processes provide system users the possible perception of greater reliability.

Although spectrum is presently available in the 800 MHz band, some systems planners are choosing to build new systems using the lower frequency bands. Two of the deciding factors are coverage and system costs. Larger systems, in terms of coverage area, generally operate at lower frequencies, because an inverse relationship exists between frequency and range— as frequency increases, range decreases. Perhaps the most significant factor is cost. Since the range of lower frequency systems is greater, greater coverage area can generally be achieved with less equipment infrastructure.

An issue that system planners have had to consider is the proliferation of incompatible 800 MHz trunked systems. The lack of a trunking standard, which would allow for open architectures in radio systems, has led to the development of incompatible 800 MHz systems built by different vendors. The proliferation of these incompatible systems has impeded the improvement of inter-jurisdictional interoperability. Each major LMR vendor has its own signal processing scheme for implementing trunked networks. The differences among these schemes are a serious impediment to seamless communications among disparate vendor systems.

In summary, 800 MHz is in fact "… right for public safety," as is VHF and low-band UHF. LMR system planners, engineers, and users are thoroughly measuring the pros and cons of systems operating in each of these bands against their unique communications needs. They are assessing critical factors such as, spectrum availability, coverage within their environment, interoperability with neighboring systems, and cost. The percentage or number of new 800 MHz systems determined to be superior for public safety use within an area when compared to other systems in public safety bands is not yet known. It is certain, however, that an 800 MHz system "makes sense" in some situations, while a VHF or UHF system would be more efficient and cost-effective in other areas. The challenge for the public safety community is to obtain or maintain sufficient spectrum in each of the bands and create workable interoperability plans that fully integrate spectrum, systems, and system users into an interoperable, nationwide communications network.

ACKNOWLEDGEMENTS

The PSWN PMO wishes to thank the individuals who contributed to this 800 MHz Study. The individuals listed below provided valuable information by participating in the interviews, submitting written thoughts, and providing general input to guide the direction of the study and subsequent report.

The opinions expressed by the interview participants do not necessarily represent the views of the departments and agencies from which they are employed.

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Lieutenant Barry Barnard	Program Manager, Prince William County, Virginia Police Department
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Mike Borrego	Acting Director, Communications Services Group-Division of Colorado Information Technology Services-Department of General Administration
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SUMMARY REPORT

1. INTRODUCTION

This study assesses the relative merits of spectrum around 800 Megahertz (MHz) as an operating frequency band for public safety land mobile communications, and the extent to which 800 MHz systems have affected interoperability among public safety entities at all levels of government. The intent is to determine the impact of the 800 MHz band on intra- and inter-jurisdictional interoperability at the local, state, and federal levels.

There are some 300 channels within the 800 MHz band available for use by state and local public safety entities. Of these channels, 230 channels became available in the mid-1980's and are managed under a process set out by the National Public Safety Planning Advisory Committee (NPSPAC). In the fielding of new systems, many state and local public safety entities are using these so-called NPSPAC channels, together with other 800 MHz channels. The Federal Communications Commission (FCC) has allocated spectrum in the 800 MHz band to public safety because frequencies in this band were made available, not necessarily because it is the optimal frequency band for public safety communications.

Neither the FCC, nor any other body has conducted studies to establish the appropriateness or efficacy of the 800 MHz band for public safety radio operations. In addition, the costs and operational changes associated with 800 MHz systems have not been systematically assessed. Given the latest allocation of additional 800 MHz spectrum for public safety use, a deliberate assessment of 800 MHz is in order. Such an assessment has been performed and is documented in this study. This study provides an opportunity to understand the relative benefits and shortcomings of spectrum around 800 MHz as an operational frequency band for public safety purposes.

1.1 Scope

This report is considered a "first-brush" examination of spectrum around 800 MHz as an operating frequency band for public safety use. The report provides the findings of Booz·Allen and Hamilton's analysis of the 800 MHz band. It includes an examination of the allocation, assignment, and administrative procedures for 800 MHz spectrum. Additionally, the report contains high-level technical characteristics of the 800 MHz band including technical comparisons of 800 MHz, Very High Frequency (VHF), and low-band Ultra High Frequency (UHF) signal propagation effects, as well as a summary of questions and answers asked of several public safety officials.

1.2 Approach

Booz·Allen & Hamilton followed a three-phased approach in performing this study: data collection, analysis, and study reporting. This approach is illustrated in Figure 1-1 and described in the following paragraphs.

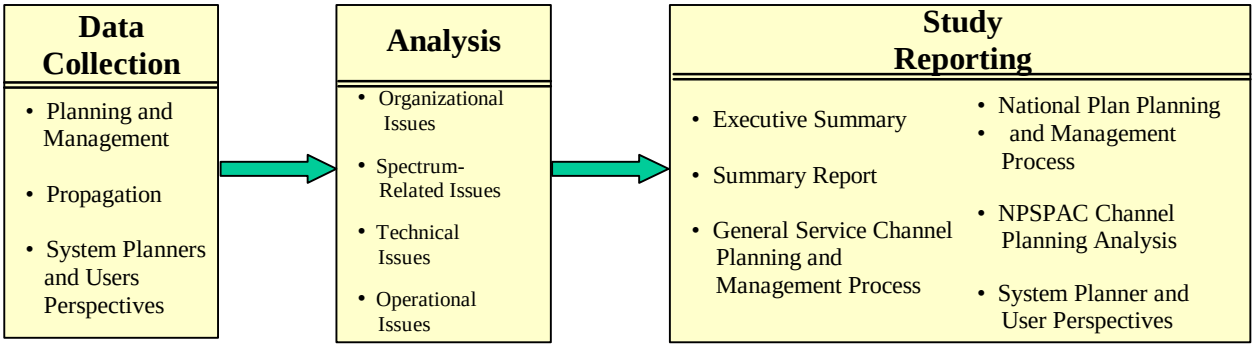

Figure 1-1
800 MHz Study Methodology

Data Collection…

In the data collection phase of the project, research efforts were organized into the following three subject areas based upon preliminary findings:

- **Planning and Management of 800 MHz Public Safety Frequencies.** The focus of this effort centered on FCC documentation (e.g., Notices of Inquiry, Public Notices, Notices of Proposed Rule Making, Reports and Orders [R&O], etc.) pertaining to the allocation and assignment of public safety spectrum at 800 MHz. Two planning and management processes for 800 MHz spectrum were studied: the process governing public safety's use of the general service channels (806-821/851-866 MHz band) and the process governing the NPSPAC channels (821-824/866-869 MHz band). Another critical component of the collected data was the 55 regional plans, and comments to these plans, outlining assignment and use of the NPSPAC frequencies. These plans were carefully analyzed and compared to one another for consistency, effectiveness, and overall utility.

- **Propagation Effects of 800 MHz.** Many concerns have been raised with respect to the propagation characteristics of radio signals at 800 MHz. Reports of dead spots and other common coverage problems are sometimes made by those operating, using, and considering new 800 MHz systems. In an effort to clarify these issues, an assessment of propagation effects at 800 MHz and at other public safety bands was included as part of this study. This assessment was performed by surveying the appropriate technical literature and applying the key principles from electromagnetic wave propagation theory to verify or refute common misconceptions of 800 MHz and other public safety bands.

- **System Planner and User Perspectives of 800 MHz Systems.** This effort was designed to provide system planners and users an opportunity to share their planning, implementation, and operational perspectives on all aspects of 800 MHz systems. A comprehensive interview guide was developed to collect information on these issues. The guide was used to conduct a series of face-to-face and telephone interviews with radio

managers, system administrators and regional planning committee chairmen. Insight was obtained into pressing issues such as:

- The drivers in the decision to move to 800 MHz or to remain in another frequency band
- The effects on operations and system costs
- The effects on interoperability among systems at all levels of government
- The extent that 800 MHz systems are installed as trunked systems
- The satisfaction with, and suggested changes to, policies, procedures, and technical standards that govern public safety spectrum.

Analysis…

To begin the data analysis phase, the overall findings of each of the aforementioned research efforts were assessed. In reviewing these findings, it was determined that the collected information could be organized into four areas of general interest:

- **Organizational Issues.** Several of the findings relate to how organizations responsible for the management and administration of the designated 800 MHz frequencies, such as the FCC and regional planning committees, performed their responsibilities. Of particular interest is the extent to which these organizations, and the procedures and processes they established and managed, enhanced or hindered the use of these 800 MHz frequencies by public safety entities.

- **Spectrum-Related Issues.** Some of the information uncovered by this study pertains to key characteristics of spectrum as a limited natural resource, whether around 800 MHz or any other public safety band. Issues addressed include the availability of spectrum, and a comparison of propagation effects at different bands.

- **Technical Issues.** Many findings of the study relate to technical characteristics of 800 MHz systems. These new 800 MHz systems are technically state of the art and offer their users a range of service and performance attributes that older, antiquated systems were simply unable to provide. Additionally this issue includes a discussion on schemes that make more efficient use of spectrum, and how these schemes are employed at 800 MHz.

- **Operational Issues.** Several of the findings relate to how 800 MHz systems have affected public safety operations. Among the points addressed are such issues as the need to better educate users about how the new system works, and how 800 MHz systems have altered day-to-day operations and how 800 MHz systems have improved or hindered inter-agency interoperability.

The findings of each area of study (i.e., planning and management, propagation, and system planner and user perspectives) are organized into the four issues of general interest identified above. Figure 1-2 illustrates the extent to which each area of study yielded findings in each of the issues of general interest. For example, the findings from the system planner and

user perspectives study area span each issue of general interest, but provides the greatest insight into operational issues associated with 800 MHz systems.

Figure 1-2
800 MHz Study Framework

Study Reporting…

The final phase of the 800 MHz Study was study reporting, which includes the organization of all collected data into key findings. The study is organized into six parts. The first is an up-front report summarizing the key findings of the study. The key findings are organized by the previously defined general issues (organizational, spectrum-related, technical, operational). Following the summary report are a series of appendices (A-E) that present detailed findings related to specific areas of the study. The data contained within each appendix is used to develop the findings contained within the summary report. A brief description of each appendix follows:

- *Appendix A* provides detailed analysis of the regulations and requirements of the general service channel (806-821/851-866 MHz) planning processes.

- *Appendix B* provides detailed analysis of the regulations and requirements of the National Planning process for the NPSPAC (821-824/866-869 MHz) frequencies.

- *Appendix C* provides analysis of the regional planning processes that were employed during the NPSPAC channel planning process.

- *Appendix D* is a collection of system planner and user reflections on many aspects of the 800 MHz band as a public safety operating band. This appendix also contains the results of the propagation area of study. This information is captured in the form of text boxes and is used to confirm or refute system planner and user realities and myths.

- *Appendix E* contains a list of commonly used abbreviations and acronyms.

The relationship between appendices and the summary report is shown in Figure 1-3.

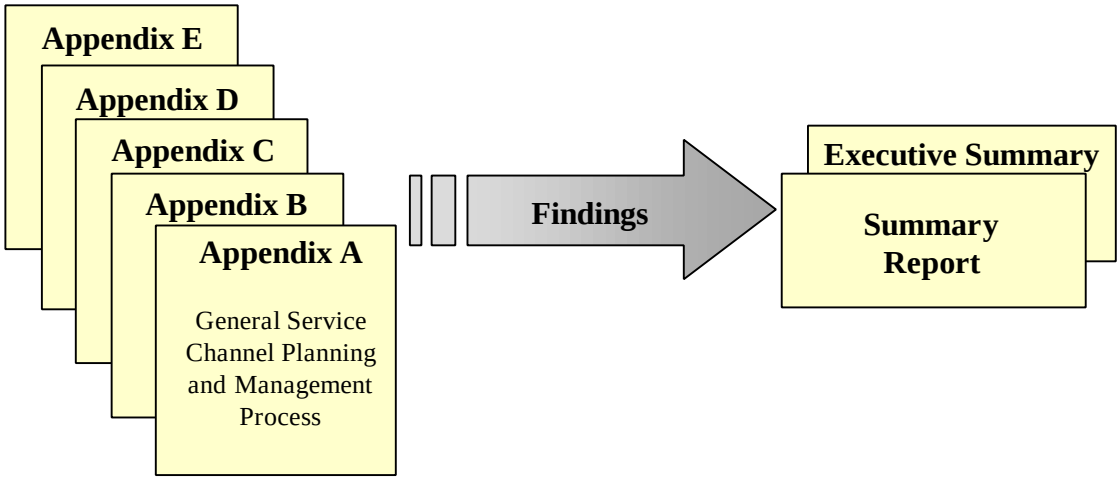

Figure 1-3
Document Organization

2. KEY FINDINGS

The analysis of 800 MHz systems for public safety based on the examination scheme described above yielded several key findings. These findings are organized and provided under each of the four issue areas (organizational, spectrum-related, technical, operational) as defined in the analysis phase of the approach.

Organizational Issues

General Service Channel Process . . .

- In the 1970s, the FCC allocated the general service channels in the 806-821/851-866 MHz band for public safety use. To assign and regulate these channels, the FCC adopted a flexible regulatory philosophy that allowed system planners a great deal of freedom to implement new 800 MHz systems.

- The flexible nature of the general service channel planning and management process led to the proliferation of a variety of incompatible systems. In the absence of any common standards or regulating guidelines, vendors, independent of one another, developed systems that lacked a common interface to allow interoperable communications.

- Despite the involvement of the public safety community at the onset of this process, no official procedure was developed for coordination among separate public safety entities during the frequency assignment and systems development phases of the process.

NPSPAC Channel Process . . .

- In the 1980s, the FCC allocated channels in the 821-824/866-869 MHz band for public safety use. These channels would become known as the "NPSPAC channels" because the regulations and policies governing the use of these channels were based on the recommendations of the NPSPAC.

- The inability of public safety radio communications to support, enable, and improve coordination efforts among multiple agencies was highlighted during response efforts to the Washington, D.C. Air Florida crash and the D.C. Metrorail derailment in 1982. Communications problems encountered during these response efforts included the lack of interoperability among agencies, overcrowded radio channels, and the lack of available spectrum for use by the public safety community. In response to these problems, the FCC, through the efforts of the NPSPAC, developed the National Plan.

- The National Plan led to the regional planning process that empowered state and local public safety entities to plan frequency assignments for systems within their regions.

  – This process lasted over five years, during which time most regional planning committees were inactive.

  – Success in achieving the primary goals (promoting spectral efficiency and improving interoperability) set forth in the National Plan was limited.

- The National Plan mandates that membership on the regional planning committees be open to representatives from all eligible user groups, including both governmental and non-governmental users. Under the Plan, the responsibility to determine eligibility was left to each regional committee. Although broad participation was desired, oversight activities to ensure robust committee membership were not performed.

  – Large portions of committee memberships consist of law enforcement agencies from large metropolitan areas.

  – Fire departments, emergency medical service (EMS) organizations, and emergency medical technicians (EMT) are underrepresented.

  – Small public safety entities consisting of less than 25 members lack representation in the regional planning committees.

  – Because of the voluntary nature of the regional planning process, many small public safety entities are unable to effectively participate in the regional planning committees.

- Federal public safety agencies operating in the regions were not involved in the planning sessions, therefore, opportunities for exploring shared system development between local, state, and federal agencies were missed.

- Lack of participation was driven, in part, by the high costs of travelling to meetings across the region and the administrative costs voluntarily absorbed by members of the regional committee.

- The majority of regional planning committees used a standardized regional plan developed by the Association of Public-Safety Communications Officials International, Inc. (APCO) as a template for creating their regional plans.

  - The use of a standardized regional plan may have stifled the creativity of the planning committees in developing their individual regional plans.

  - The use of a standardized plan to expedite the regional planning process is indicative of the lack of significance that some regional committees placed on the planning process associated with the NPSPAC channels.

- Several regional planning committees submitted regional plans to secure the NPSPAC channels regardless of their actual intent to use these channels.

- Some regional planning committees had token coordination with adjacent regions while developing their regional plans.

  - Ineffective coordination between regional planning committees led to the development of several unresolved inter-regional disputes

  - Ineffective coordination between regional planning committees contributed to the increasing problems of inter-jurisdictional interoperability.

- The National Plan created mutual aid channels to be used to facilitate interoperability among local, state, and federal public safety agencies.

  - The NPSPAC mutual aid channels are conventional mode channels. These conventional channels offer means of communication between incompatible trunked mode systems and provide spectrum for interoperability among public safety entities.

Spectrum-Related Issues

- Public safety radio systems serving areas of high population density (e.g., metropolitan areas) remain overcrowded and overloaded. There are two available means of relieving these deficiencies: 1) obtaining additional frequencies, and 2) using available spectrum more efficiently.

- Some system users associate increased capacity with the implementation of an 800 MHz system. In actuality, these systems are experiencing increased capacity due to the implementation of trunking technology or the availability of additional channels.

- Shortages of 800 MHz frequencies were identified in some metropolitan areas and at international borders. The allocation of additional spectrum for public safety in the 700 MHz band (764-776/794-806 MHz) should help relieve congestion in some of these areas.

- The majority of 800 MHz users have "given back" some previous operating frequencies to the FCC but retain the rest for continued radio communications use.

The propagation characteristics of public safety operating frequency bands were included in the study analysis. This analysis included a high-level comparison of physical propagation characteristics of public safety frequency bands and an assessment of these frequency bands with regard to specific propagation characteristics. Figure 1-4 illustrates the findings of this comparative analysis.

- The losses associated with certain signal propagation characteristics do not become significant until well into the GHz range.[1]

  - Losses due to terrain or forestation are less at lower frequency bands than at the higher frequency bands. The losses associated with terrain and forestation are insignificant for frequencies below 1 GHz.

  - However, at 800 MHz, higher losses have been noted for coniferous forests. This reported effect may be due to pine needles being of a similar size to quarterwave whip antennas, thus scattering radio signals and causing signal fading.

  - Even though signal fading is more pronounced at 800 MHz than at VHF, this propagation characteristic does not noticeably affect the performance of systems operating below 3 GHz.

- Some systems planners are choosing to build new systems in the lower frequency bands, despite the availability of 800 MHz spectrum. Some of the deciding factors are as follows:

  - An inverse relationship exists between frequency and range — as frequency increases, range decreases

[1] An empirical relationship for foliage loss is $L=1.33f^{0.284}d^{0.588}$, where L is foliage loss in decibels along a path blocked by dense, dry, in-leaf temperate-climate trees, *f* is the frequency in gigahertz, and *d* is the path length in meters. (See Hess, Garry C. Land-Mobile Radio System Engineering. Boston: Artech House, 1993: pp. 24.)

DEGREE OF EFFECT (Greater ↓ Less)	Common Propagation Concerns				
	Range (Note 1)	**Building Penetration** (Note 2)	**Terrain Loss** (Note 3)	**Foliage Loss** (Note 4)	**Signal Fading** (Note 5)
Greater	Low-Band VHF	Low-Band VHF	800 MHz	800 MHz	800 MHz
	High-Band VHF	High-Band VHF	Low-Band UHF	Low-Band UHF	Low-Band UHF
	Low-Band UHF	Low-Band UHF	High-Band VHF	High-Band VHF	High-Band VHF
Less	800 MHz	800 MHz	Low-Band VHF	Low-Band VHF	Low-Band VHF

Notes: (1) In some cases, propagation losses at 800 MHz are twice as great as the losses experienced at VHF frequencies.[2]

(2) The higher the frequency, the greater the reflective properties of the signal. Low frequency (VHF and below) signals will experience little reflection and will tend to penetrate large structures such as buildings.[3]

(3) Terrain loss, while increasing at higher frequencies is not significant until around 1 GHz.[4]

(4) Foliage loss, while increasing at higher frequencies is not significant until around 1 GHz.[5]

(5) Signal fading, while increasing at higher frequencies is only significant in the microwave range (>3GHz).[6]

Figure 1-4
Comparison of Signal Characteristics Across Public Safety Frequency Bands

[2] Bell Laboratories, Transmission Systems for Communications. Holmdel, NJ: Bell Telephone Laboratories, Incorporated, 1982: pp. 89-91.
[3] Hess, Garry C. Land-Mobile Radio System Engineering. Boston: Artech House, 1993: pp. 293.
[4] Bell Laboratories, Transmission Systems for Communications. Holmdel, NJ: Bell Telephone Laboratories, Incorporated, 1982: pp. 460-461.
[5] Hess, Garry C. Land-Mobile Radio System Engineering. Boston: Artech House, 1993: pp. 24.
[6] Bell Laboratories, Transmission Systems for Communications. Holmdel, NJ: Bell Telephone Laboratories, Incorporated, 1982: pp. 462-463.

- VHF and UHF systems experience better building penetration than do 800 MHz systems. The increased building penetration at lower frequencies allows public safety entities the ability to achieve in-building coverage with fewer repeater towers and less output power.

- Some metropolitan users achieved better coverage with new 800 MHz systems than with the older VHF systems. This improvement in coverage may be due in part to the addition of new tower sites throughout the metropolitan area.

- Because of added infrastructure and equipment costs at 800 MHz, the costs of VHF and UHF systems are generally less.

Technical Issues

- It is logical for system planners to consider the economic benefits of re-using existing infrastructure when considering migrating to 800 MHz. However, designing a new 800 MHz system based on old infrastructure generally leads to user dissatisfaction in terms of coverage (e.g., dead spots, dropouts). The additional infrastructure needed to implement the new system is costly, but necessary to ensure adequate coverage.

- Spectrum regulatory policy over the past 20 years has encouraged the use of more spectrally efficient technology. This trend is compelling vendors to take several actions:

  - Direct money for land mobile radio research and development into spectrally efficient technologies such as trunking technology and digital modulation schemes.

  - Direct money toward 800 MHz system development, to the exclusion of VHF and low-band UHF radio systems.

- The NPSPAC channels allow a 25 kHz channel bandwidth, which is adequate for data transmission. This issue is more fully discussed in Appendix B of the report (specifically, see page B-6, the paragraph labeled *Channeling Plan*). The FCC has adopted regulations that impose narrowband channel requirements on public safety radio equipment for bands below 512 MHz. These regulations, which apply only to new equipment, not legacy equipment, make data transmission more difficult at lower bands.

- The use of trunking technology has elicited mixed reviews regarding public safety communications. It is debatable whether the benefits provided through the use of trunking technology outweigh the costs associated with trunked systems and if trunked systems are needed by all public safety entities.

- Trunked systems allow improvement of system capacity. Trunking technology allows for the use of talkgroups as well as the efficient distribution of conversations over similar amounts of bandwidth.

- A common misconception associates increased capacity with the implementation of an 800 MHz system. In actuality, increased capacity is due to implementation of trunking technology or of additional channels.

- Capabilities associated with trunking (e.g., talkgroups, spectral efficiency) have helped to significantly improve intra-jurisdictional interoperability.

- Some systems engineers and administrators at both the state and county level are examining the possibility of migrating to trunked systems at lower bands as an alternative to implementing costly 800 MHz systems. Trunking in the public safety bands below 800 MHz is now allowed (FCC's Refarming Report and Order, 92-235, implemented in October 1997). Prior to this R&O, the lack of FCC provisions to develop trunking technology for bands below 512 MHz impeded the public safety's ability to improve communications systems with existing spectrum allocations.

- Concerns regarding the "push-to-talk" delay associated with establishing communications on a trunked system are often cited as a pitfall to the technology. This delay is minimal, on the order of hundreds of milliseconds, and can be compensated for with proper user training and education.

- Many small public safety entities (e.g., those that support rural, small counties) do not necessarily have the number of channels, the complex missions, or the system capacity problems to necessitate use of a trunked system.

- The lack of a trunking standard, which would allow for open architectures in radio systems, has led to the development of incompatible systems built by different vendors. The proliferation of these incompatible systems has impeded the improvement of inter-jurisdictional interoperability.

Operational Issues

- Many states, counties, and municipalities are replacing aging public safety radio systems with new systems operating in the 800 MHz band.

  - Channel congestion in the lower bands coupled with the availability of 800 MHz channels dedicated to public safety is prompting some level of migration by local and state entities to the 800 MHz band.

- Public safety agencies are currently operating on islands of spectrum that range from 30 MHz to 869 MHz. Due to the wide range of frequencies, it is difficult (but not impossible) to achieve, multi-discipline, multi-jurisdictional interoperable communications. The move to 800 MHz has both improved and hampered interoperability for some public safety agencies.

- Improvements in intra-jurisdictional interoperability at 800 MHz can be attributed to the use of trunked radio systems and more specifically to the use of talkgroups. The use of talkgroups provides public safety agencies with the capacity to establish interoperable communications on an as needed basis.

- Inter-jurisdictional interoperability has been hampered in some instances because many entities chose not to migrate to the 800 MHz. Without the use of a cross patching scheme or radio swapping, agencies operating in different frequency bands lose effective means of interoperable communications.

- The NPSPAC mutual aid channels have not improved interoperability among local, state, and federal public safety agencies on any broad scale.

  - A majority of public safety entities, especially federal agencies, operate in the lower frequency bands and are unable to easily or routinely communicate on the NPSPAC mutual aid channels.

  - Federal agencies were excluded from the NPSPAC planning and management processes and are not allowed to obtain licenses on 800 MHz frequencies to interoperate with other public safety entities.

  - These mutual aid channels that can provide the bridge between local, state, and federal governments go largely unused due to a lack of a common understanding of how to use these channels.

  - These mutual aid channels are sometimes not implemented because the costs of installing additional infrastructure to implement the channels is over and above the cost of installing a system that meets their requirements.

- Coverage areas are easier to identify with newer technology (800 MHz systems), because the portable and mobile radios indicate "in service" or "out of range," similar to commercial cellular and Personal Communications System (PCS) phones. Since no such indication was provided with previous radios, system users were unaware of exactly how large of a coverage area they were experiencing with these lower frequency systems.

- Planners who incorporated robust criteria within their Requests for Proposal (RFP) generally experienced greater critical in-building coverage and fewer overall coverage difficulties with their 800 MHz system.

- The 800 MHz radio systems are state of the art technology. As with any new technology there is an inherent transitional "learning curve."

  - User education and training for the new radio systems are critical components to a successful transition to, and implementation of, an 800 MHz system.

- Operationally, the new 800 MHz systems are more reliable than their predecessor systems. The reliability of the 800 MHz systems may be attributed to the technical capabilities and better planning and design associated with these systems.

  – Trunking technology permits a dramatic increase in capacity than previously experienced with older systems. This increase in capacity allows users to communicate on open channels and prevents overcrowding and overloading of systems.

  – The new 800 MHz systems represent a dramatic upgrade for many agencies whose previous radio systems were years past their original planned replacement age.

  – This perception of greater reliability may be skewed; users are comparing new 800 MHz technology to outdated and exhausted VHF or low-band UHF technology.

APPENDIX A
GENERAL SERVICE CHANNEL
PLANNING AND MANAGEMENT PROCESS

A.1 Historical Background of the General Service Channels

In May 1970, the Federal Communications Commission (FCC) released the *First Report and Order in the Matter of an Inquiry Relative to the Future Use of the Frequency Band 806-960 MHz; and Amendment of Parts 2, 18, 21, 73, 74, 89, 91, and 93 or the Rules Relative to Operations in the Land Mobile Service Between 806 and 960 MHz (First General Service R&O)* that allocated 115 MHz of spectrum in the 806–947 MHz band for use by the land mobile radio services. A portion of the spectrum, 40 MHz, was allocated for the development of private and shared systems to be used by eligibles in the industrial, land transportation, and public safety radio services. The remaining 75 MHz of spectrum was allocated for the development of high-capacity common carrier mobile communications systems, which were to be operated by wireline common carriers.

The release of the *First General Service R&O* coincided with the release of the *Notice of Inquiry in the Matter of an Inquiry Relative to the Future Use of the Frequency Band 806-960 MHz; and Amendment of Parts 2, 18, 21, 73, 74, 89, 91, and 93 or the Rules Relative to Operations in the Land Mobile Service Between 806 and 960 MHz (General Service NOI).* Within the *General Service NOI*, the FCC requested that any interested parties develop detailed technical and marketing studies with a focus on future use of the newly allocated spectrum. The studies were intended to demonstrate how this 115 MHz of spectrum, through the use of spectrally efficient technologies, could be used to meet the future needs of land mobile radio services. Most of these studies were submitted by July 1972, and many of them raised a number of issues concerning new technologies and revised policy procedures. Because of the success of these studies, the FCC held a 2-day seminar in May 1973, in which it provided a forum for oral presentations concerning the use of the reallocated spectrum.

Using the information and suggestions proposed through the *General Service NOI* process, the FCC released the *Second Report and Order in the Matter of an Inquiry Relative to the Future Use of the Frequency Band 806-960 MHz; and Amendment of Parts 2, 18, 21, 73, 74, 89, 91, and 93 or the Rules Relative to Operations in the Land Mobile Service Between 806 and 960 MHz (Second General Service R&O)*. The *Second General Service R&O* was released in May 1974. It proposed technical standards and policies to govern the use of the reallocated spectrum. Within the *Second General Service R&O,* the FCC proposed a new philosophy on allocating spectrum to the public. The FCC expressed its desire to develop an assignment plan that would allow enough flexibility "to cope with the new and unforeseen technological and economic forces."

A.2 *Report and Order* Approach for Spectrum Allocation

Before releasing the *Second General Service R&O* in 1974, the FCC used a "service perspective philosophy" to allocate blocks of spectrum to about 20 radio service categories

nationwide. The FCC stated within the *Second General Service R&O* that this method of allocation "has led to parochialism among the users and inequitable situations where spectrum shortage and abundance exist side by side in the same cities." Therefore, the FCC proposed a new "system perspective philosophy" for spectrum allocation. The proposal was to allocate spectrum by system type, not by service type, and to allow the market to ultimately determine how much spectrum is used by the various types of users. With this new allocation philosophy, the challenge then became defining the systems to be accommodated, determining the spectrum requirements of these systems, and arranging separate allocations in an orderly plan. To fulfill these goals, it was necessary to define not only the technical characteristics of the systems, but also the compatibility among the different systems. Within the *Second General Service R&O,* the FCC specified that the following five systems were under consideration for spectrum allocation:

- *Conventional and Trunked Communications Systems:* Of the 115 MHz of spectrum under consideration, 30 MHz of spectrum was allocated for use by conventional and trunked systems. This allocation was a reduction from the original allocation of 40 MHz that was proposed in the *First General Service R&O* in 1970. The FCC stated that it envisioned that the "allocation for conventional and trunked systems [would] be available for both private and commercial (third party) operation and used for either mobile telephone or fleet dispatch service." A portion of this 30 MHz of spectrum, which was located in the 806-821/851-866 MHz bands, became known as the "general service channels" used by the public safety services.

- *Cellular Land Mobile Communications Systems:* The *First General Service R&O* originally allocated 75 MHz of spectrum for wireline common carriers to develop cellular land mobile and air/ground systems. This allocation was determined in 1970 when the FCC admitted that little was known about cellular technology and the potential market for such systems. Most comments received in response to this allocation agreed that 75 MHz was an excessive amount of spectrum to allocate to cellular systems. Therefore, the FCC reduced the size of the allocation for cellular systems to 40 MHz in the *Second General Service R&O*. The FCC stated that "the full 40 MHz of spectrum would not be assigned to a single operator all at once. Rather, in each area the system operator will be given the minimum amount of spectrum required for that area initially. Additional spectrum will be made available upon a showing of need." An additional 20 MHz of spectrum was placed in reserve bands for possible future use by the cellular systems community.

- *Air/Ground Communications Systems:* The FCC decided not to allocate any spectrum for use by air/ground communications systems. The spectrum that was earmarked for these systems was placed in reserve bands for future use by other systems. These reserve bands could, however, be used by the air/ground communications systems if needed.[1]

[1] Currently, Commercial Aviation Air-Ground systems may operate on 10 channel blocks in the 849-851 MHz and 894-896 MHz bands.

- *Industrial, Scientific, and Medical (ISM) Devices:* Comments from manufacturers of microwave ovens disagreed with the FCC's proposal to reduce the ISM spectrum provision from 50 MHz to 26 MHz. These entities argued that at least 38 MHz is required to make an oven that is not only competitively priced but also capable of properly cooking all types of foods. The FCC accommodated the commercial industry and agreed to establish a 12 MHz guard band immediately above the spectrum provisioned for ISM. This 12 MHz of spectrum, coupled with the allocated 26 MHz of spectrum, provided the industry with the necessary spectrum to produce microwave ovens. However, the FCC stated the guard band would be available for only five years, after which time this spectrum would be reallocated for other uses. The FCC believed five years was ample time for the microwave manufacturing community to reduce ISM emission limits.

- *Land Mobile Reserve Allocations:* Numerous comments suggested establishing frequency reserve bands to accommodate new land mobile services or unexpected growth in existing systems. An additional 45 MHz of spectrum, consisting of eight reserve bands, was allocated for this purpose. The *Second General Service R&O* stated that the reserve bands were positioned to allow the "greatest flexibility in expanding the proposed services and for accommodating new services."

Within the *Second General Service R&O*, a special reference was made to areas located along international borders. To protect both Canadian and Mexican television channels in the 806–890 MHz region, land mobile operations close to the borders of these countries would have to be regulated by technical standards different from systems located away from the borders. These special regulations were provided to system manufacturers applying for licenses within the newly allocated spectrum.

A.3 Assignment Plan for General Service Channels

As previously mentioned the spectrum reserved for public safety use, the "general service channels," is situated within the spectrum allocation for conventional and trunked communications systems. Of the spectrum reserved for conventional and trunked communications systems, 70 channels were allocated for public safety communications. These 70 channels are located in the 806–821/851–866 MHz band.

The 1974 *Second General Service R&O* proposed regulatory control schemes for the general service channels (806–821/851–866 MHz spectrum) that were radically different from the FCC's past dealings with land mobile radio services. Before 1974, these services were separated into two groups: common carrier services and private services. The latter included such entities as the Safety and Special Radio Services. With the *Second General Service R&O* of 1974, the FCC adopted new policies to govern the private service entities, separate from those governing the common carrier entities. In reference to the common carrier-type regulatory policy, the *Second General Service R&O* states "that such manner of administrative control is neither appropriate nor desirable for the variegated systems of communication we plan to authorize in the 806–821 MHz and the 851–866 MHz bands."

The FCC explained that private land mobile communications systems have always been regulated in a specialized manner. However, the 1974 regulatory plan was intended to "cover a wider range of alternatives for establishing or obtaining communication services." The plan also stated "in accomplishing this objective, we have abandoned, to a large degree, the service categories employed in the past, and we have also combined private, shared, and common user systems under a single assignment and regulatory plan which we believe to be more efficient than that used in the past." The purpose of the new regulatory plan was to allow flexibility in system design by establishing a large variety of options for communications systems. These varied options allowed entities to choose a system configuration that best met the requirements of a particular user.

According to this 1974 regulatory plan, a police agency could establish its own radio facility and manage the facility in a way that best suited the needs of that department. A police department, for example, could share its facility with other classes of users on a cooperative basis or could form a nonprofit corporation to serve as licensee and manage the system for the police department. This scheme would allow the police department to reduce operating expenses and spread costs over several different agencies. The plan also makes provisions for licensing an individual to provide commercial service to a single customer, such as a large metropolitan police department. The FCC could also license a common user system to provide service to a number of small police agencies, which may be operating in adjacent jurisdictions, under an arrangement that would provide the necessary means of communication at a low cost to the users. Under the 1974 regulatory plan, any of the above options could be applied.

In addition, the plan also allowed considerable freedom in specifying the system configuration. For instance, eligible users could specify a trunked or conventional system. Once a system was chosen, the system users then had an option to switch from one type of system to another, and then back again, if any system was unsatisfactory. In summary, the new regulatory plan provided almost limitless freedom in specifying a new communications system using the newly allocated 30 MHz of spectrum.

Within the 1974 *Second General Service R&O,* the FCC explained that the large amount of spectrum that became available in the early 1970s made it possible to allow considerable freedom in specifying system configurations. The FCC stated "with the spectrum we are making available for immediate use and with what we are holding in reserve, we are assured . . . that we will be able to accommodate the needs and requirements of land mobile operations, in a most effective and efficient manner… for many years to come."

In proposing such a nonrestrictive regulatory scheme, the FCC relied on the competitive forces in the commercial industry to produce spectrally efficient and reliable equipment that would operate over the 30 MHz of spectrum. Because this 30 MHz of spectrum is located in a band much higher than existing public safety bands, the commercial industry needed to develop new system designs, equipment, and marketing practices. The success of the 1974 regulatory plan depended on the ability and the desire of the commercial industry to apply for available spectrum, develop new equipment using the spectrum, and then market this equipment to the user community. Within this process, it is assumed that the commercial industry worked in conjunction with eligible users to define user requirements. Without this dialogue between the

commercial industry and the user community, the commercial industry could develop systems using the new spectrum that did not fully meet the requirements of the eligible users. Furthermore, if the commercial industry did not foresee a profitable market before it developed new systems operating at the assigned frequencies, these systems might not have been created.

Despite its possible shortcomings, the 1974 regulatory plan was intended to provide system design flexibility, which would enable the user community to tailor a communications system to its specific needs. In the *Second General Service R&O*, the FCC stated that its objectives were "to provide a maximum number of ways under which a maximum number of qualified persons may . . . with the least administrative delay and under minimum procedural restraints, provide themselves with the means of radio communication they may require to enable them to conduct their affairs in an efficient and effective manner."

A.4 Regulations Governing Licensing and Use of Allocated Spectrum

Despite the level of freedom provided within the *Second General Service R&O*, a few regulations and technical standards were recommended. The main body of the *Second General Service R&O* proposed the regulations regarding the 900 MHz portion of the newly allocated spectrum. The regulations regarding the 30 MHz of spectrum located in the 800 MHz band were referenced within a subpart of the document's appendix. These regulations addressed issues such as eligibility, technical system specifications, application and processing procedures, and assignment of frequencies.

Eligibility. The *Second General Service R&O* defined the following persons or entities as eligible users of the 800 MHz spectrum:

- Any person or entity deemed eligible for licensing by the FCC
- Any person or entity proposing to provide dispatch service to any person or entity deemed eligible for licensing on a not-for-profit, cost-shared basis
- Any person or entity, except wireline telephone common carriers, proposing to provide dispatch service to any person or entity deemed eligible
- Any person or entity, except wireline telephone common carriers, proposing to provide radiotelephone service to the public over trunked systems of communication.

Within the *Second General Service R&O*, an individual or entity was deemed as an eligible user under Parts 89, 91, or 93 of Chapter I of Title 47 of the Code of Federal Regulations (CFR).

Limitations on Power and Antenna Height. The FCC specified power and antenna height

For suburban-conventional systems, the *Second General Service R&O* stated that the maximum effective radiated power and antenna height for base stations operating in the 851–866 MHz (transmit bands) shall be no greater than 500 watts (27 dBW) and 500 feet above average terrain (AAT), respectively. For trunked and urban-conventional systems, the *Second General Service R&O* stated that the maximum effective radiated power and antenna height for base stations operating in the 851–866 MHz band shall be no greater than 1 kW (30 dBW) and 1,000 feet AAT, respectively. If a different antenna height or power level was used in the system design, the *Second General Service R&O* specified an equivalent set of requirements, which are provided in Table A-1.

Table A-1
Antenna Heights and Associated Maximum Power Requirements

Antenna Height (AAT) (feet)	Power (watts)
4,501–5,000	65
4,001–4, 500	70
3,501–4,000	75
3,001–3,500	100
2,501–3,000	140
2,001–2,500	200
1,501–2,000	350
1,001–1,500	600
Up to 1,000	1,000

Restrictions on Operational Fixed Stations. With the exception of control stations, the *Second General Service R&O* did not authorize the use of operational fixed facilities in the 806–821 MHz and 851–866 MHz bands. The *Second General Service R&O* also required control stations to use directional antennae with a signal strength of no more than 6 dB. Before any control station operating in the 800 MHz band could be approved, the FCC required a statement certifying that the control station was in compliance with the above regulations.

Restriction on Licensing Manufacturers and Equipment Suppliers. The *Second General Service R&O* stated that "no person engaged in the manufacture or sale of radio equipment to be used in systems authorized by this subpart, or who has any direct or indirect interest in any such manufacturing or sales enterprise, may be licensed to operate more than one common user trunked system of communications used to provide commercial service to eligibles or to the public in any one market, and no more than five such systems in the United States."

Application and Processing Procedures. The FCC required that all applications for conventional or trunked radio facilities be submitted on FCC Form 400. If an applicant was proposing to provide a dispatch service to an eligible entity on a not-for-profit, cost-shared basis, the applicant was required to furnish the following information in addition to FCC Form 400:

- A copy of the plan or agreement under which the service would be offered, including verification that the service was being provided at cost

- A statement of the purposes for which the system was to be used and the planned mode of operation

- The names and addresses of each person who participated in the sharing arrangement

- A statement showing that each participant was eligible to use the system for the purposes for which it was to be employed.

Those applicants proposing to provide dispatch service to eligible entities on a commercial basis were required to supply the following information in addition to FCC Form 400:

- A statement of the purposes for which the system was to be used and the planned mode of operation

- A statement certifying that no person eligible to use the proposed facility for the purposes for which it was to be authorized would be offered or provided service over or through the licensee's system

- A copy of the basic agreement under which the dispatch service was offered.

Those applicants proposing to provide radiotelephone service to the public on a commercial basis were required to provide the following information in addition to FCC Form 400:

- A statement of the purposes for which the system was to be used and the planned mode of operation

- A copy of the basic agreement under which the radiotelephone service was offered.

The *Second General Service R&O* also required all applicants using conventional systems to provide the number of vehicle or portable units used at the time of the assignment approval and the number of these units in service 8 months after the date of the application approval. In addition, it required all applicants using trunked systems to specify the number of mobile units to be placed in operation within the terms of the license.

Once the FCC received all applications, it would first review them for completeness, in the sequence in which they were received. After the review process, an application would either be granted and the frequency assigned, or rejected and returned to the applicant with reasons for its rejection.

A.5 Selection and Assignment of Frequencies

For both conventional and trunked systems, the *Second General Service R&O* specified that channels within the 806–821 MHz and 851–866 MHz bands would be created using a

25 kHz channeling plan, with 45 MHz of spacing between mobile and base-station frequencies. Interference protection would be provided only by mileage separation. Both trunked systems and urban-conventional systems used a separation criterion of 70 miles between co-channel bases. The suburban-conventional system used a separation criterion of 45 miles.

Trunked systems were authorized on the basis of the loading criteria presented in Table A-2. The *Second General Service R&O* further stated that any licensee using a trunked system occupied at 90 percent would be permitted to apply for additional channels. The FCC also required that any licensee of trunked facilities must either begin construction on its new system within 6 months of the frequency assignment or risk losing the grant.

Table A-2
Loading Requirements for Trunked Systems

Service Group	Vehicular Radio Units		
	5-Channel Systems	10-Channel Systems	20-Channel Systems
Police and Fire Group	300	750	1,500
Business Radio Group	500	1,000	2,000
Motor Carrier Group	800	1,600	2,500
Other Services Group	400	800	1,600
Mixed Services Group	500	1,000	2,000
Radiotelephone Group	300	400	800

Conventional systems were authorized on the basis of the loading criteria presented in Table A-3. As was the case for trunked systems, conventional system users would be allowed to apply for additional channels if proof could be provided that the user's system was at least 90 percent occupied.

Table A-3
Loading Requirements for Conventional Systems

Service Group	Channel Loading—Units Per Channel Vehicular/Portable		
	Single Licensee	Two to Five Licensees	More Than Five Licensees
Police and Fire Group	50/100	40/80	30/60
Business Radio Group	90/180	70/140	50/100
Taxicab Radio Group	150	125	100
Motor Carrier Group	150/300	125/250	100/200
Other Services Group	70/140	50/100	40/60
Mixed Services Group	—	70/140	50/100

In conclusion, the *Second General Service R&O* stated that frequency assignments would be based not only on the spectrum availability but also on the applicant's ability to demonstrate a requirement for the additional spectrum.

A.6 Summary of *Report and Order* Regulations and Policies

A review of the basic regulatory philosophy of the *Second General Service R&O* indicates that the process can best be described in terms of "what it was not rather than what it was." The process, which was neither overly restrictive nor cumbersome, allowed applicants considerable freedom in specifying the system development and management criteria of proposed systems. Even the few technical standards set forth as requirements by the *Second General Service R&O* were not overly burdensome. Instead, the FCC decided to provide land mobile users with a section of spectrum in the 800 MHz band and allow the commercial industry to recognize this allocation of spectrum as an opportunity to develop a new market. In developing this market, it was hoped that the commercial industry would enlist the aid of appropriate users. The burden was placed on land mobile service users and the commercial industry community to decide the best use of this spectrum with regard to cost efficiency, spectral efficiency, and system interoperability. Figure A-1 illustrates the "general service channel" regulatory process.

In developing the policies set forth in the *Second General Service R&O*, the FCC attempted to develop a flexible process that would allow public safety agencies an ability to cater system specifications to meet specific needs without interfering with adjacent jurisdictions. In several sections of the document, the FCC suggested that adjacent jurisdictions work together with the commercial industry to develop usable systems for all potential users. Thus, as early as 1974, the need for interoperability was an issue. The issues with interoperability, overcrowding of channels and spectral inefficiency became important topics during the early 1980s.

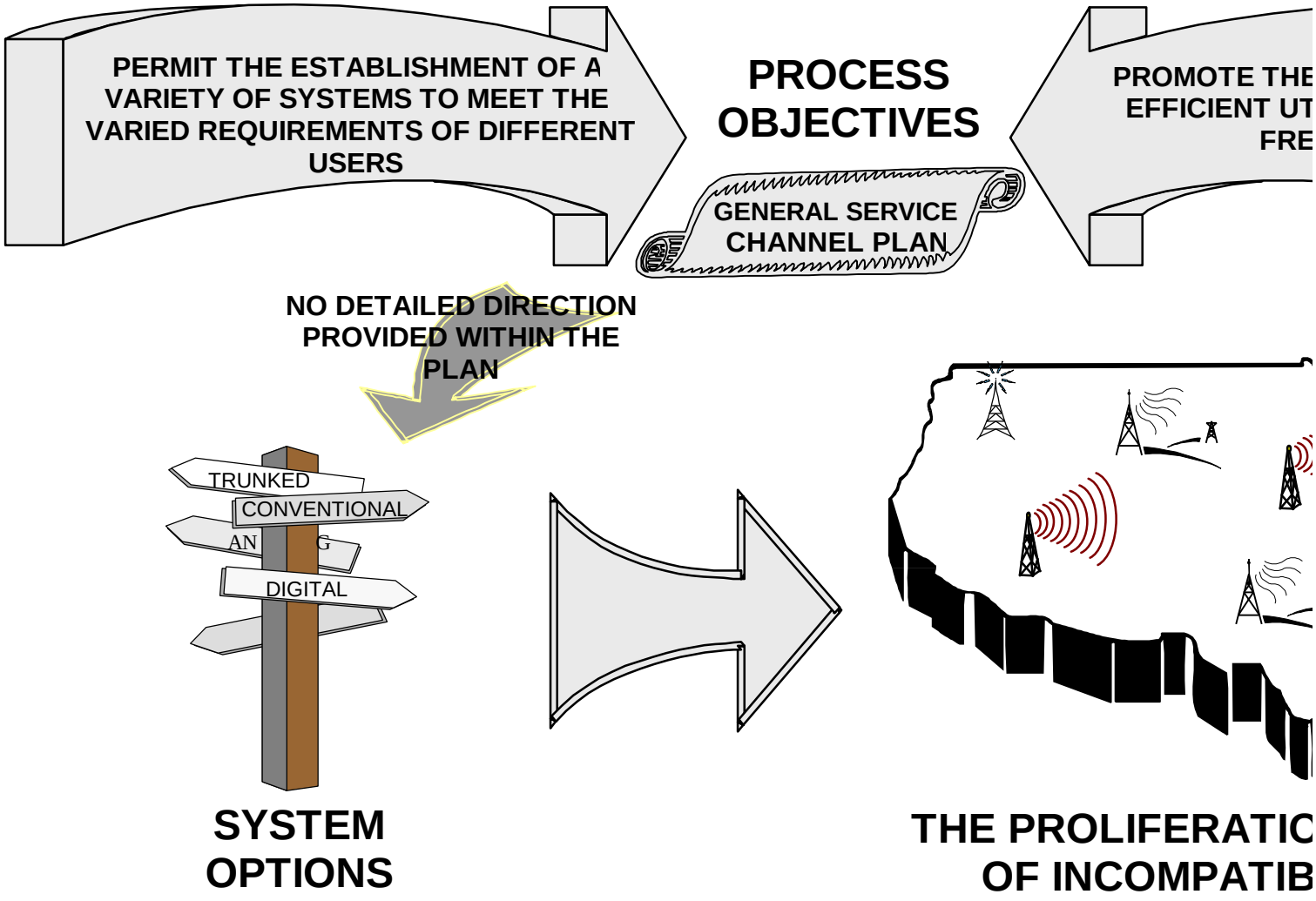

Figure A-1
General Service Channel Planning and Management Process

APPENDIX B
NATIONAL PLAN PLANNING AND MANAGEMENT PROCESS

B.1 Historical Background

In the early 1980s, coordination and communication among local, state, and federal public safety agencies became an important topic of discussion within the Federal Government. This discussion stemmed, in part, from two major disasters that occurred contemporaneously in January 1982: an Air Florida jet crash and a city metrorail train derailment. Each disaster occurred in Washington, D.C., within miles of one another. A winter storm passing through the region at the time of both tragedies added even more complications and hindered rescue efforts. Communication links quickly became overcrowded, and coordination among the many emergency personnel became impossible. These tragic events alerted the Federal Government that public safety communications had become inadequate and additional spectrum was needed for public safety services. These events also highlighted the problem of interoperability among local, state, and federal agencies. During these events, local, state, and federal public safety agencies from multiple jurisdictions were forced to borrow radios from one another to coordinate combined efforts. Recently, events such as the Oklahoma City bombing and the TWA Flight 800 crash have further emphasized a need for interoperability among various public safety agencies.

In an apparent response to the Air Florida disaster, Congress passed the Federal Communications Commission Authorization Act in 1983. The Act directed the Federal Communications Commission (FCC) to "develop a plan to ensure that the present and future electromagnetic spectrum requirements of state and local public safety authorities are considered in the allocation of available spectrum." Specifically, Congress tasked the FCC to review the current and future requirements of public safety authorities and to consider the need for a nationwide spectrum allocation. In response to this directive, the FCC issued a *Notice of Inquiry in the Matter of Future Public Safety Telecommunications Requirements* (*Public Safety Requirements NOI)* on March 7, 1984, to solicit comments from the public safety community and all other interested parties. The *Public Safety Requirements NOI* addressed three main issues: present and future public safety communication requirements; emerging technological advances that could conceivably be used in support of public safety entities; and coordination of local, state, and federal communications concerns. Based on the comments received, the FCC decided to dedicate additional spectrum for use by the public safety community.

On July 24, 1986, the FCC adopted a *Report and Order (Allocation R&O)* that allocated 6 MHz of spectrum for public safety use. This directive allocated the 821–824/866–869 MHz bands nationwide. This band was chosen because of its availability and proximity to the existing frequency bands used by the public safety community (806–821/851–866 MHz). The FCC hoped selecting frequency bands close to the existing public safety spectrum would allow interoperability with existing public safety communications systems. As a stipulation of the *Allocation R&O* directive, the FCC prohibited any use of the new frequencies until a "National Plan" was developed to provide guidelines to ensure efficient use of the available spectrum. In developing the plan, the FCC decided to seek guidance from the public safety community and any interested members of the public.

B.2 The Formation of NPSPAC

To coordinate its efforts and to ensure the involvement of public safety entities in the development of the National Plan, the FCC formed the National Public Safety Planning Advisory Committee (NPSPAC) in December 1986. To facilitate participation, membership in NPSPAC was open, and all interested parties were encouraged to attend the meetings. The FCC set forth the following goals for the NPSPAC:

- Identify communications requirements of public safety services
- Develop a scheme for efficient use of the new spectrum
- Increase the utility of existing public safety spectrum
- Recommend a method to apply new technologies to public safety spectrum
- Recommend guidelines to ensure compliance with the National Plan.

As a result of the NPSPAC's important role, the channels that became available within the new 6 MHz of spectrum are commonly referred to as the "NPSPAC channels." After its third meeting, the NPSPAC submitted to the FCC its preliminary findings in the form of the *Initial Report* in March 1987.

B.3 Notice of Proposed Rule Making

The NPSPAC findings prompted the FCC, in May 1987, to issue a *Notice of Proposed Rule Making in the Matter of the Development and Implementation of a Public Safety National Plan and Amendment of Part 90 to Establish Service Rules and Technical Standards for Use of the 821-824/866-869 MHz Bands by the Public Safety Services* (*National Plan NPRM)*. The *National Plan NPRM* was based mainly on the NPSPAC *Initial Report* and it envisioned the National Plan "as a spectrum management scheme, including policy guidelines, technical standards, and procedures to satisfy public safety communications requirements for the foreseeable future." The *National Plan NPRM* also set forth two broad objectives for the National Plan: (1) facilitate interoperability among communications systems so local, state, and federal agencies may coordinate their activities as necessary, and (2) ensure the available public safety spectrum is used efficiently. To realize these goals, the *National Plan NPRM* proposed a set of initial policies and a plan of implementation to expedite the entire process.

The *National Plan NPRM*, based on the recommendations stated within the NPSPAC report, recommended the United States be divided into regions, each of which would be instructed to develop a regional plan. Regional plans would provide local implementation strategies for using the newly allocated 800 MHz spectrum. The *National Plan NPRM* also recommended that each region include several technical standards as part of its regional plan.

This implementation strategy and the technical guidelines to standardize the formation of regional plans formed the basis of the National Public Safety Plan.

B.4 Purpose of the National Public Safety Plan

The National Public Safety Plan, or National Plan, as it is commonly known, was intended to establish common elements, technical standards, and procedural guidelines for regional committees to observe in developing regional plans. These regulations, however, were not intended to be so restrictive that they would inhibit regional committees' freedom in developing regional plans. Regional committees were allowed to identify their system's specific users and their region's spectrum requirements within its regional plan. The rationale for allowing such freedom among the regional committees was fulfilling the FCC's "primary regulatory objectives of maximizing spectrum efficiency and ensuring the system has sufficient flexibility to accommodate the wide variety of specific communication requirements in different areas of the country."

B.5 Creation of the National Public Safety Plan

After the *National Plan NPRM* was issued, the FCC solicited comments from the public safety community, government agencies, and the commercial industry. In September 1987, NPSPAC issued its *Final Report on Public Safety*. Using the findings of the NPSPAC *Final Report* and the numerous comments received, the FCC issued a *Report and Order in the Matter of the Development and Implementation of a Public Safety National Plan and Amendment of Part 90 to Establish Service Rules and Technical Standards for Use of the 821-824/866-869 MHz Bands by the Public Safety Services (National Plan R&O)* in December 1987. The *National Plan R&O* adopted the official rules and regulations that comprised the National Public Safety Plan.

To realize the overall goals of improved interoperability among public safety entities and efficient use of available spectrum, the National Plan proposed several general regulations, or "technical standards." To understand the regulations presented in the National Plan, it is beneficial to understand not only the basic philosophy behind each regulation, but also its ramifications to the public safety community. To understand the possible effects of each element of the National Plan, it is prudent to examine the comments submitted nationwide. Therefore, to obtain at least a small sampling of opinion from the public safety community, it is advantageous to examine these comments quantitatively and qualitatively.

Because very few individuals commented on every element or regulation of the National Plan, a variable that must be considered in the analysis of these comments is the number of responses received for each plan element. For example, more individuals provided comments on the topic of mandated trunking than the topic of loading standards. Thus, it could be deduced that mandated trunking is a more important topic in the eyes of those public safety entities and individuals providing comments than the topic of loading standards. This fact itself provides useful information about the perceived importance or controversy of specific elements of the National Plan.

Figure B-1 illustrates those regions that contain entities from which comments to the *National Plan NPRM* and the *National Plan R&O* were obtained. Table B-1 lists the position titles of individuals from whom these comments were obtained. Only those comments from regional public safety entities have been included within the analysis. Commercial industry comments were excluded because they were considered to be comments from special interest groups and were not grouped with comments received from the public safety community.

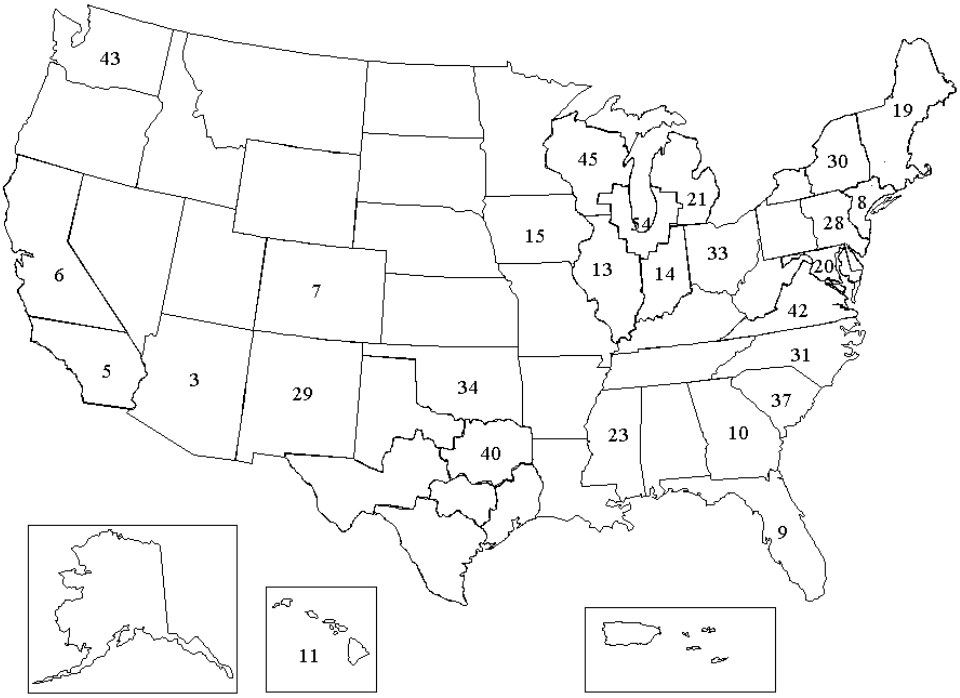

Figure B-1
Regions Providing Comments to the *National Plan NPRM* and the *National Plan R&O*

Figure B-2 presents an overview of the comments received in reference to the National Plan. The comments have been organized according to the National Plan technical standard to which each comment refers. The data presented in this figure, in conjunction with specific qualitative comments, are referred to within the next section as each technical standard/guideline is presented.

Table B-1
Breakdown of Individuals Providing Comments to the *National Plan NPRM* and the *National Plan R&O*

POSITION TITLE	QUANTITY
City or County Communications Director	21
Sheriff's Department Communications Officer	3
Fire Department Communications Director	1
Police Department Communications Director	4
Chief of Police	22
City or County Telecommunications Engineer	1
Chairman Regional Planning Committee	1
Fire Department Chief	1
State Police Communications Director	2
Regional Peace Officer's Association, President	2
Regional Department of Transportation Director	1

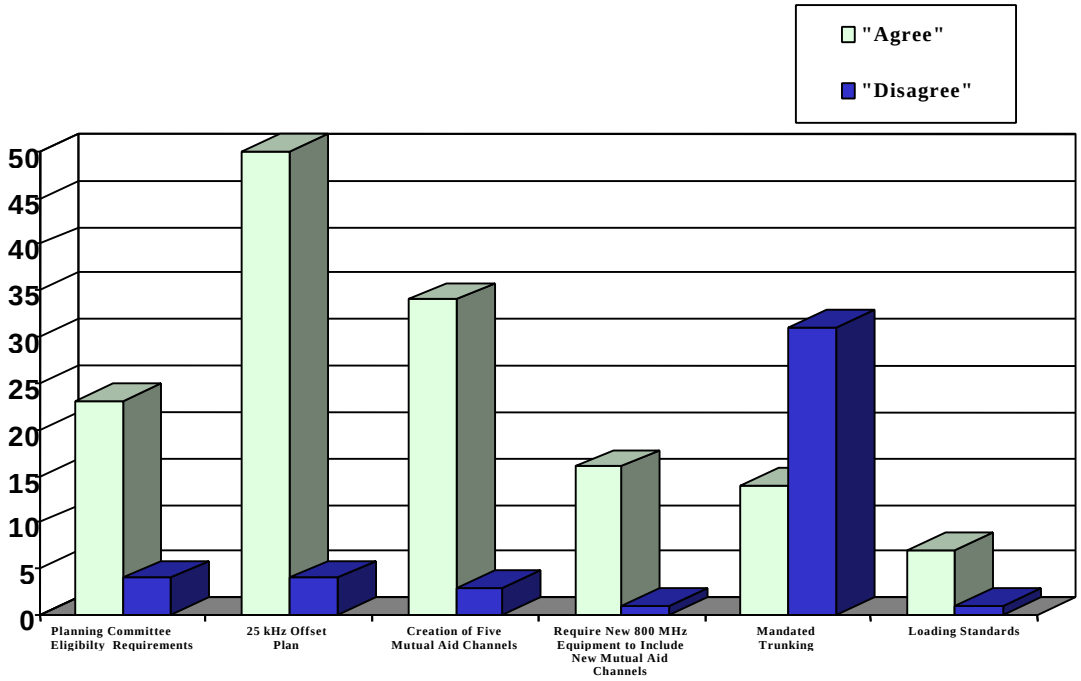

Figure B-2
Graphical Breakdown of Comments to the *National Plan NPRM* and the *National Plan R&O*

B.6 The Content of the National Public Safety Plan

The following sections describe the content of the National Public Safety Plan.

B.6.1 Technical Standards Presented in the National Public Safety Plan

The National Plan proposed technical standards addressing several major areas of concern. The following sections provide a brief description of these technical standards, along with the public safety community's reaction to each standard. These standards are as follows:

- Channeling Plan
- Mutual Aid Channels
- Trunking
- Loading Standards
- Eligibility in the National Public Safety Plan Process.

Channeling Plan. The National Plan recommends a channeling plan based on 25 kHz channels spaced every 12.5 kHz. This configuration has often been referred to as the 25 kHz offset plan. The *National Plan NPRM* proposed a channeling plan that consisted of 12.5 kHz channels that could be stacked, if needed, to provide 25 kHz of bandwidth. Some public safety entities require 25 kHz channels to support encryption technology and high-speed digital data transfer technology. The NPSPAC, in conjunction with these entities, argued strongly against the 12.5 kHz plan. Based on independent studies, NPSPAC demonstrated that the 25 kHz offset plan was nearly as spectrally efficient as the proposed 12.5 kHz channeling plan. The NPSPAC also argued that if the 12.5 kHz plan were adopted, much of the current equipment being used by public safety entities would be incompatible with the 12.5 kHz configuration and would have to be replaced to provide interoperability between the new and old systems. Public safety entities nationwide agreed with the findings of the NPSPAC. This overall concurrence prompted the FCC to modify its regulation proposed in the *National Plan NPRM*. Thus, the 25 kHz offset plan was adopted and recommended in the *National Plan R&O*.

As shown in Figure B-2, 50 out of 54 comments received supported the recommendation. This element of the National Plan incited the most comments, in fact 90 percent of the entities submitting comments referenced this aspect of the plan. The four entities that disagreed with the 25 kHz offset plan provided no rationale for their decision.

Mutual Aid Channels. The National Plan recommends the creation of five mutual aid channels nationwide within the 6 MHz of newly allocated spectrum. These channels would consist of four tactical channels and one National Public Safety Calling Channel. The National Plan also concluded that "the operation and management of these channels would be identified within the respective regional plans." These channels would ultimately be available for local, state, and federal disaster management and other emergency services. However, regions would have the option to include any local public safety disaster relief or emergency management services in the regional mutual aid network. The National Plan further recommended the following:

- All mobile and portable radios will be equipped to operate on the five channels.

- Manufacturers "are required to include interoperability channels in all equipment using the new 800 MHz channels."

- Channel assignments adjacent to the five mutual aid channels will be spaced no closer than 25 kHz.

- These channels should operate in the conventional mode (non-trunked) with tone coded squelch at a standard frequency of 156.7 Hz to minimize the effects of intermodulation interference.

As shown in Figure B-2, out of 37 responses received regarding the creation of nationwide mutual aid channels, 34 agreed with this action. The entities that did not support this recommendation raised the issue that these channels could better be used by local officials to satisfy a region's specific frequency requirements. In addition, several comments referenced the issue of requiring manufacturers to include the new "interoperability channels" in all new equipment using the new 800 MHz channels. Sixteen out of 17 responses regarding levying requirements for manufacturers of 800 MHz equipment agreed that new equipment should include the new "NPSPAC" channels. The entities that agreed with this requirement stated that they believed it would undermine the intention of the requirement if newly produced equipment operating in the new 800 MHz channels could not access the nationwide mutual aid channels. The one agency that disagreed with this proposal believed that the new requirements would create a drastic increase in the cost of new 800 MHz equipment.

Trunking. The National Plan recommends that all entities using more than four channels be required to implement trunked systems, and any entities using four channels or fewer be allowed to use conventional systems. With regard to exceptions, the National Plan states "exceptions, will not be granted routinely . . . strong evidence showing why trunking is unacceptable must be presented in support of any request for exception." To overcome the use of incompatible commercial trunked systems, the Plan further states that "trunked systems will be required . . . to operate in a conventional and compatible mode on the intercommunication channels . . . and will thus provide a common interface between different types of trunked systems."

Out of 45 responses received regarding federally mandated trunking, 14 agreed with the recommendation. This technical standard of the National Plan was proved the only one in which the majority of commenting entities disagreed with the Plan's recommendation. Most of the negative comments suggested allowing regional committees the power to mandate trunking on a case-by-case basis. Most entities felt regional interest would be lost if trunking technology was mandated at the federal level. Many of the entities that disagreed with the recommendation used trunking technology for their systems and supported the use of spectrally efficient technologies. However, these entities did not believe that the Federal Government should mandate the use of this technology. Various reasons were given for the opposition to mandated trunking, including the following:

- Trunked systems typically experience high delay factors during heavy usage periods.

- Trunked systems are expensive.

- National mandates on trunking technology ignore regional requirements.

Most public safety entities commented that exceptions to mandated trunking should be granted more regularly than is stated in the National Plan. Those entities that agreed trunking technology should be mandated at the national level added that their entities should be granted exceptions. These comments were categorized as dissenting votes. This aspect of the plan was the second most referenced regulation in regard to the total number of comments received. Despite the large number of public entities that opposed mandated trunking, the FCC decided to include the requirement in the National Plan so that spectrally efficient technologies would be used when possible. The FCC believed those entities that simply could not use trunking technology could apply for waivers.

Loading Standards. The National Plan recommended applying existing 800 MHz loading standards to the new public safety channels. The Plan further stated waivers would be issued when a compelling case was presented to the FCC. Despite NPSPAC's recommendation to develop new loading standards for the new channels, the FCC decided to continue using the existing loading standards. In refusing NPSPAC's recommendation, the FCC stated there was "no basis on which to apply a standard different from the standard for existing public safety services authorized in the 800 MHz band."

Out of only eight responses regarding loading standards, seven agreed with the recommendation. The vast majority of public safety entities that submitted comments to the National Plan did not refer to this requirement.

Eligibility in the National Public Safety Plan Process. As a part of providing a manageable framework, the National Plan proposed dividing the United States and its territories into regions. The original *National Plan R&O* document had divided the United States into 48 regions. In conjunction with the policies originally stated within the *National Plan NPRM*, the National Plan stated that each region would be instructed to develop a regional plan, the content of which would be governed by the National Plan. To expedite the formation of these regional plans, the National Plan proposed the formation of regional committees. The membership of these committees would consist of "public safety authorities," which the National Plan defined as "entities licensed in the Public Safety Radio Services and the Special Emergency Radio Services (SERS)." This definition had first been proposed in the *National Plan NPRM*. Numerous comments were received concerning this definition. Many public safety entities disagreed with classifying SERS as a public safety authority. These entities argued that SERS included such services as school bus services and trash collecting services within their regions. These public safety entities proposed that SERS not be included within the "public safety umbrella." The final version of the National Plan, in response to these comments, stated that the "regional planning committees are in the best position to determine which services are of the greatest importance to public safety in their regions." Therefore, the National Plan allowed regional committees to define eligibility requirements for participation in the regional planning process within their specific regions.

As shown in Figure B-2, out of 27 responses received concerning eligibility requirements, 23 comments supported this regulation. In total, 60 entities and individuals provided comments to at least one aspect of the National Plan.

B.6.2 Regional Planning Process Presented in the National Public Safety Plan

The National Plan, in addition to recommending technical standards, proposed a process by which the newly available spectrum could be assigned. This process involved dividing the United States into separate regions. As part of the requirements of the *National Plan NPRM*, the NPSPAC was tasked to provide recommendations for specific regional boundaries. Within the *National Plan R&O,* the FCC stated its agreement with the proposed NPSPAC regions and proposed only minor changes. Despite NPSPAC's suggestion that the United States be divided into 54 regions, the National Plan suggested only 48 regions and that Texas be considered a single region. This was in contrast to the NPSPAC proposal, which divided Texas into six separate regions, in which regional boundaries were determined by distinct geographical and operational characteristics. The NPSPAC had also recommended an interstate regional boundary along Lake Michigan consisting of portions of Illinois, Indiana, Michigan, and Wisconsin. The FCC decided that these boundaries suggested by the NPSPAC were ambiguous, and it divided these areas to their respective state jurisdictions. In proposing these modifications to the NPSPAC plan, the FCC explained its primary considerations in defining regions were to define regions so there were no ambiguities regarding the area included and to include all land areas of the United States, including Puerto Rico and the Virgin Islands.

In the *National Plan R&O,* the FCC also explained that it would "consider changes to the regional boundaries, provided the regional planning chairmen in the affected regions agree to the changes." Due to overwhelming support for the regional boundaries proposed within the NPSPAC *Final Report*, the FCC issued a *Memorandum Opinion and Order in the Matter of the Development and Implementation of a Public Safety National Plan and Amendment of Part 90 to Establish Service Rules and Technical Standards for Use of the 821-824/866-869 MHz Bands by the Public Safety Services (Regional Boundaries MO&O)* in March 1988. The *Regional Boundaries MO&O* adopted a regional boundary plan consisting of 55 regions. These regions are shown in Figure B-3. Table B-2 provides a detailed listing of the area included within each regional boundary.

The Recommended Process for Developing Regional Plans. Once the National Plan established regional boundaries, it set forth a process for developing regional plans. The FCC emphasized in the *National Plan R&O* that regions would have to work together to coordinate their respective regional plans. Emphasis was placed on inter-regional as well as intra-regional coordination. The FCC also reiterated that, for the process to be effective, participation within the regional planning committees should be widespread and open to non-government entities.

The *National Plan R&O* stated that the Associated Public-Safety Communications Officials International, Inc. (APCO), "acting under its frequency coordination responsibilities, will be responsible for convening a meeting to initiate the planning process in each region." APCO was instructed to choose a "convenor" for each region whose responsibilities would include

organizing and publicizing the first planning meeting. It was requested that APCO provide the Chief of the FCC's Private Radio Bureau with a listing of all convenors, nationwide, within 45 days of the release date of the *National Plan R&O.* Each convenor was then responsible for organizing the initial planning meeting in each region and was instructed to allow at least 60 days for public notification to ensure the maximum amount of participation possible. Any parties interested in attending this meeting were instructed to contact the convenor.

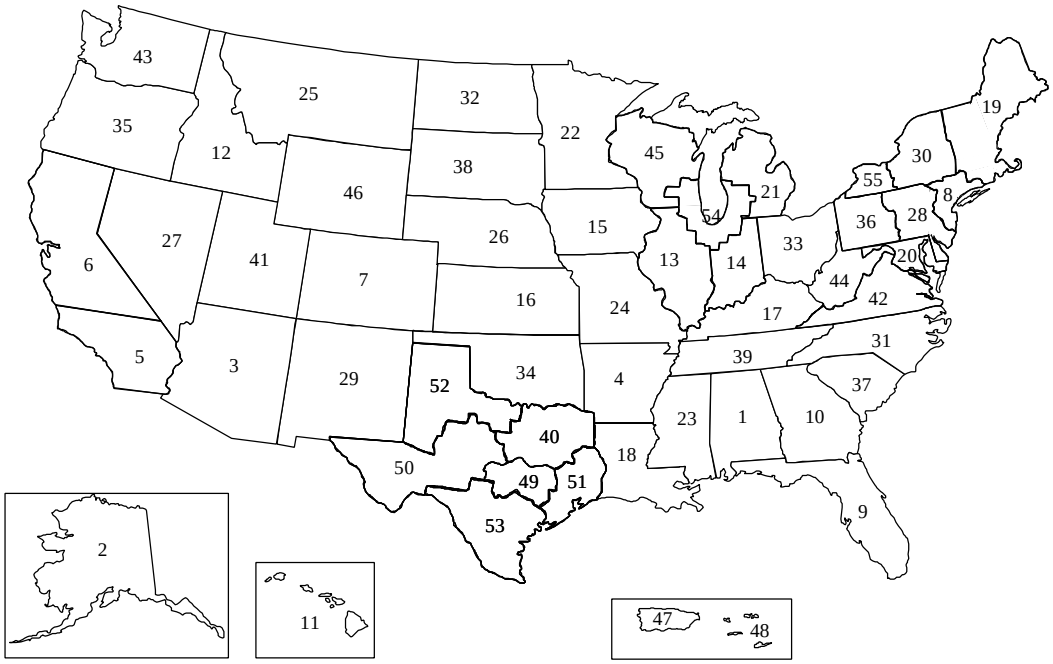

Figure B-3
The Final Regional Breakdown of the United States and Its Territories Proposed in the National Plan

Table B-2
Geographical Description of Each Region

Region Number	Description of Geographical Area Contained Within Each Region
1	Alabama
2	Alaska
3	Arizona

Region Number	Description of Geographical Area Contained Within Each Region
4	Arkansas
5	Southern California
6	Northern California
7	Colorado
8	New York City Metropolitan Area
9	Florida
10	Georgia
11	Hawaii
12	Idaho
13	Illinois
14	Indiana
15	Iowa
16	Kansas
17	Kentucky
18	Louisiana
19	New England
20	Washington, D.C. Metropolitan Area, including Maryland
21	Michigan
22	Minnesota
23	Mississippi
24	Missouri
25	Montana
26	Nebraska
27	Nevada
28	Philadelphia Metropolitan Area, including New Jersey and Delaware
29	New Mexico
30	Eastern New York (Albany)
31	North Carolina
32	North Dakota
33	Ohio
34	Oklahoma
35	Oregon
36	Western Pennsylvania
37	South Carolina
38	South Dakota
39	Tennessee
40	Northeastern Texas
41	Utah
42	Virginia
43	Washington

Region Number	Description of Geographical Area Contained Within Each Region
44	West Virginia
45	Wisconsin
46	Wyoming
47	Puerto Rico
48	Virgin Islands
49	Austin Metropolitan Area
50	El Paso Metropolitan Area
51	Houston Metropolitan Area
52	Lubbock Metropolitan Area (North Texas)
53	San Antonio Metropolitan Area
54	Chicago Metropolitan Area
55	Buffalo Metropolitan Area (Western New York)

The agenda of each initial meeting included elections for a regional chairman, chosen from among the membership. Once a chairman was elected, each regional committee was then responsible for adopting a set of operating procedures to govern its operations and ensure that all participants were treated fairly in the planning process.

Committees were instructed to use the National Plan criteria, local needs, and inter-regional considerations in developing their regional plans. Once the regional plans were completed multiple copies of the document were forwarded by the regional chairman to the Secretary, FCC, Washington, DC 20554.

The Recommended Contents of the Regional Plans. The National Plan listed the following elements, which were the minimum requirements included for each regional plan:

- A cover page that associated the regional plan with its defined region
- The name of the regional planning chairman, including his or her mailing address and telephone numbers
- A summary of the major plan elements
- A general description of how the spectrum would be assigned among the various eligible users within the region
- An explanation of how the requirements of all eligible entities within the region were considered and met to the greatest degree possible
- An explanation of how eligible entities were prioritized in those areas where not all entities can receive licenses

- An explanation of how the plan was coordinated with adjacent regions
- A description of operational issues
  - An explanation of how interoperability channels would be managed within the region
  - A description of the provisions that were made to ensure that these channels would work and be managed effectively across regional boundaries
- A detailed description of how the plan would put the spectrum to the best possible use by requiring system design with minimum coverage areas, assigning frequencies to allow maximum frequency reuse and offset channel use, using trunking, and requiring small entities with minimal requirements to join together on a single system where possible.
- The signature of the regional planning chairman.

All of the above issues had to be addressed by each regional plan for it to be considered by the FCC. These 10 topics provided a template on which all regional plans would be based.

The Recommended Review Process for Regional Plans. Once a regional plan was completed and submitted to the FCC for approval, the FCC then placed the regional plan on public notice and solicited comments. Any parties wishing to comment to the regional plan had 30 days to do so and 15 days to reply to any comments that had been filed. In addition to considering the comments received with regard to each regional plan, the FCC examined each plan to ensure that it satisfied the following criteria:

- Public safety needs had been fully addressed and satisfied to the highest degree possible
- The region had promoted the efficient use of spectrum.
- The region had coordinated with adjacent regions
- All requirements of the National Plan had been satisfied.

Based on these criteria, each regional plan was either accepted or rejected by the Private Radio Bureau and the Office of Engineering and Technology. If a regional plan was rejected, it was returned to the regional planning chairman with reasons for its rejection.

The NPSPAC had recommended in its *Final Report* that a regional plan review committee (RPRC) be established "to provide guidance and assistance in developing regional plans, to mediate inter-regional resolution of problems that may arise, and to consider modifications to regional plans that may be necessary to satisfy future operational requirements." The NPSPAC

further recommended that the RPRC meet annually to monitor the progress of the regional planning process, consider any proposed changes, and send its recommendations to the FCC. Although the FCC supported the idea of creating such a committee and stated that the public safety community was "free to establish such a committee" if it wished to do so, the RPRC was never established.

Once a regional plan was approved, modifications could be submitted in writing to the FCC by the regional planning chairman or APCO. These proposed modifications would then be given prompt public notice, and comments would be solicited. The National Plan provided no timetable in regard to submitting modifications to approved regional plans.

The Recommended Policy for Vacated Frequencies. One of the primary goals of the National Plan was to develop a process to promote the efficient use of available public safety spectrum. In keeping with this directive, the National Plan recommended guidelines and timetables that would provide public safety entities with incentives to fully utilize all of their spectrum resources in a timely manner. The additional 6 MHz of spectrum for public safety was not acquired with the intention of creating an even larger pool of frequencies for use the public safety community's use. This new allocation was seen as useful spectrum that the public safety community could use, thus vacating the spectrum from which these entities would migrate.

To ensure that public safety entities did not unnecessarily hold old, unused frequency channels, the National Plan established a policy for retaining those frequencies. The FCC expected that any public safety entity shifting its operations to the new 800 MHz channels would make every effort possible to give up its older frequency channels. The NPSPAC *Final Report* suggested that when the following three criteria were met, public safety entities would be required to surrender their vacated frequencies:

- The new system fully replaced the functions of the old system
- The licensee had no other communications requirements that could be met through the use of the lower frequencies
- The new system operated satisfactorily for a long enough period of time to allow a smooth transition from former operations and to demonstrate the system's reliability.

The NPSPAC *Final Report* further proposed that "reassignment of vacated frequencies to public safety entities be accomplished on a regional level." The FCC did not officially adopt these criteria as part of the *National Plan R&O* regulations composing the National Plan. Thus, the National Plan provides no official criteria for retaining frequencies.

In comments in reference to the *National Plan NPRM*, most public safety entities did not agree with the National Plan's stated policy on vacated frequencies. Comments received regarding the *National Plan NPRM* and the *National Plan R&O* have been translated into a numerical analysis, which is illustrated in Figure B-4. As shown in this bar graph, out of 37 comments on this aspect of the National Plan, only 11 agreed with the Plan's stated policy

concerning vacated frequencies. Those individuals who disagreed with this policy remarked that some entities were using the new 800 MHz spectrum to augment their current capabilities and were not replacing those capabilities entirely. Others who disagreed with the recommendations pointed out that some smaller entities did not have the funding to switch entirely to the new 800 MHz spectrum in the allotted time frame. Several of those providing comments stated that, if the vacated channels were "given up," those channels should be provided to other public safety entities by the regional committees. Many entities that agreed with the National Plan's stated policy suggested this same approach.

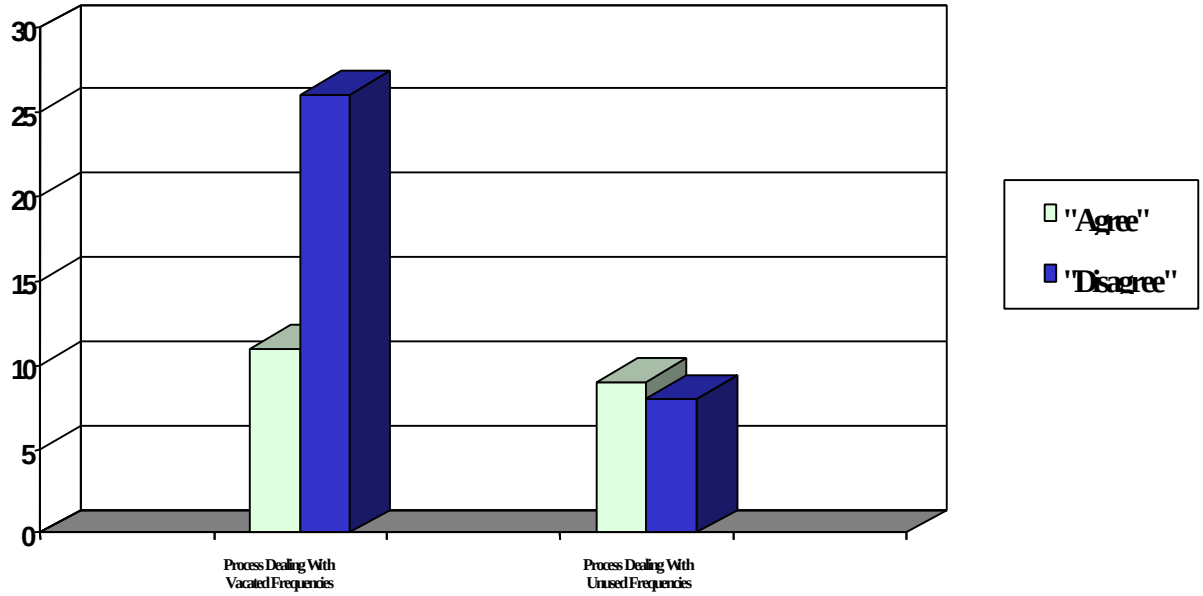

Figure B-4
Graphical Breakdown of Comments Concerning Vacated and Unused Frequencies

The Recommended Policy for Unused Frequencies. The National Plan also proposed a policy to address the frequency channels within the new 800 MHz allocation that were left unused. The policy stated that, after 5 years, the FCC would "…reassess the state of development of regional plans and the amount of unused spectrum. If no plan has been submitted for a particular region… [the unused spectrum] will be opened for inter-category sharing. Additionally, spectrum not identified for use in a region having a plan may be made available for inter-category sharing."

This reallocation plan was markedly different from the intricate plan proposed by the NPSPAC. The NPSPAC proposal suggested that 2 years after the adoption of the National Plan the public be notified of which regions had plans that had been approved or submitted. From this point, a 3-year deadline would be set for all regions that had not submitted plans. After this three year period, 50 percent of the spectrum would be reallocated for those regions that still had not submitted plans. After the second deadline—5 years after the first deadline—30 percent of the remaining spectrum allotment would be reallocated. Finally, the remaining 20 percent of allotted spectrum would be held in reserve for future public safety communications requirements. Within its *Final Report*, NPSPAC concluded that any region not using the newly allocated 800 MHz

spectrum within the specified time frame would be assumed capable of meeting its present and future public safety needs with its existing system.

The NPSPAC proposed this plan to provide public safety entities with enough time to acquire funding and determine each agency's spectrum requirements. The NPSPAC stated in its *Final Report* that the FCC's time constraints, stated in the *National Plan NPRM*, were too harsh and unrealistic. However, the FCC believed that the time frame projected within the National Plan was adequate.

Slightly more than half of those individuals providing comments regarding this aspect of the National Plan, agreed with the Plan's stated policy. Only 17 comments referred to this aspect of the Plan, and very few qualitative comments were provided in regard to this policy.

The public safety community concurred with most of the policies, regulations, and technical standards proposed within the National Plan. With the public safety community in general agreement, the regional planning process began in earnest with the official release of the National Plan. Figure B-5 illustrates the National Plan planning and management process.

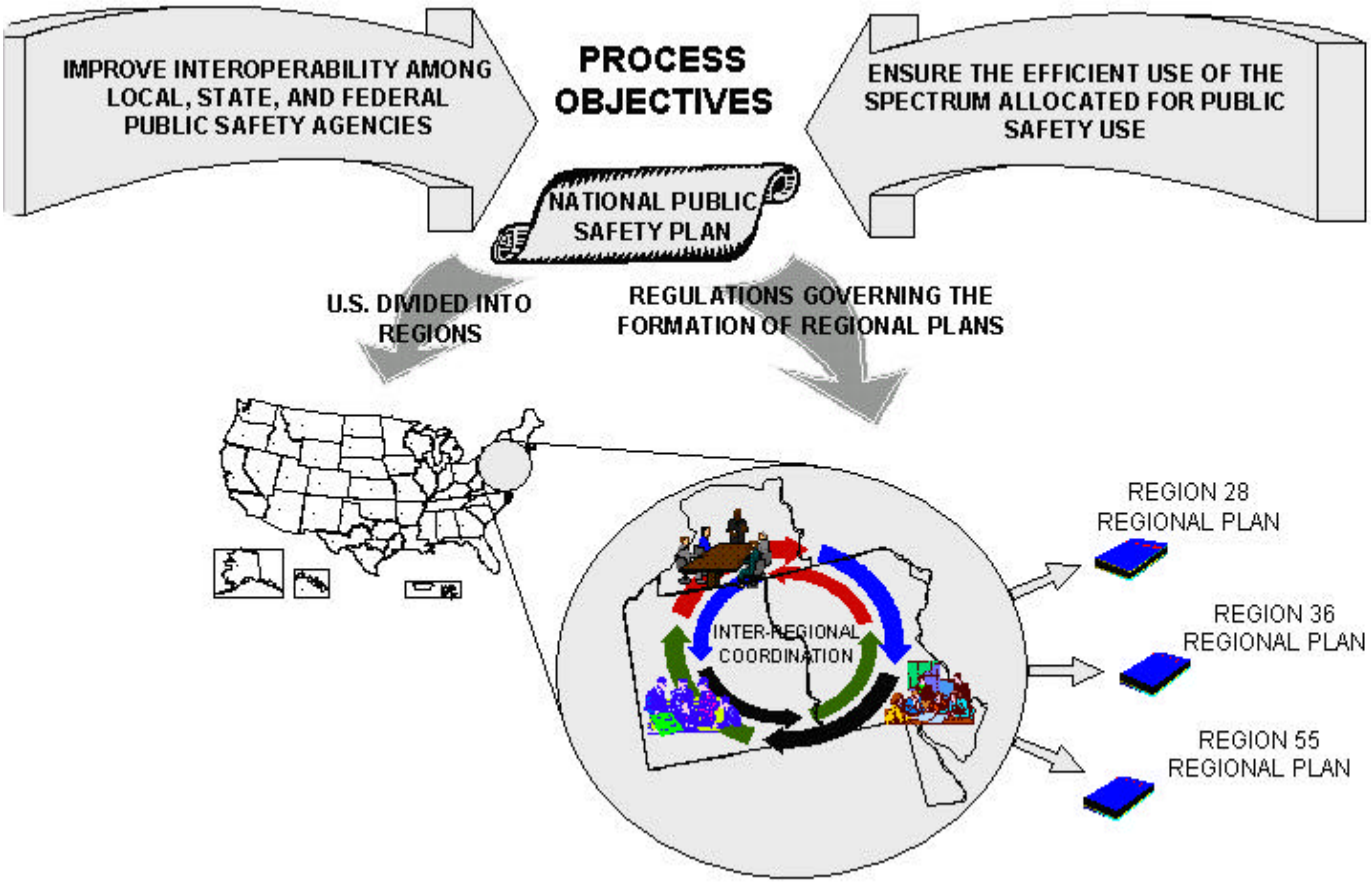

Figure B-5
National Plan Planning and Management Process

APPENDIX C
NPSPAC CHANNEL PLANNING ANALYSIS

C.1 Origins of the Regional Planning Process

The regional planning process began with the release of the National Plan. The regulations applicable to the process were provided in the Federal Communication Commission (FCC) *Report and Order in the Matter of Development and Implementation of a Public Safety National Plan and Amendment of Part 90 to Establish Service Rules and Technical Standards for Use of the 821-824/866-869 MHz Bands by the Public Safety Services (National Plan R&O)* released in December 1987. After the subsequent release of the *Memorandum Opinion and Order in the Matter of Development and Implementation of a Public Safety National Plan and Amendment of Part 90 to Establish Service Rules and Technical Standards for Use of the 821-824/866-869 MHz Bands by the Public Safety Services (National Plan MO&O)* in March 1988, the United States was split into 55 regions. At the direction of the *National Plan R&O*, each of the 55 regions formed regional committees to provide a forum that could examine local public safety communications requirements. The lengthy regional planning process began when the first regional plan was submitted by Region 8 in September 1988, and the initial planning process was completed when the last regional plan was submitted by Region 47 in December 1993.

Although the National Plan covered several key points required of every regional plan, the regulations allowed significant variation in the development of each regional plan. Thus, the regional planning process itself varies from region to region. However, close examination of the regional plans reveals many similarities among some plans as well as the processes used to develop those plans. The striking similarities among several of these plans warrant an analysis of each plan and an examination of any similarities and differences identified.

C.2 "Template" Analysis of the Regional Plans

Upon review of a number of the regional plans, it was determined that the plans could be grouped by similarities in their structures. Based on these similarities, the plans and therefore their associated regions could be divided into six groups.

After each plan was assigned to a group, it became evident that the plans within a single group were more than remotely similar. All plans within a group seemed to have been created using the same "template" as other plans within that same group. It is assumed that the first regional plan submitted within a group is the plan that was used as a template for other plans within that same group. Therefore, the study team named each group after the region that submitted the first plan. Although it appears that other regions within a group acquired the original plan and modified it to suit their own requirements, each plan retained a significant amount of the originally accepted plan's requirements. After all the plans were grouped, it was clear that several did not match any template or follow any previous order. Therefore, these region's plans were placed in the sixth group labeled "Random." The following lists the regional plan template groups:

- *Group I* – Region 52, North Texas
- *Group II* – Region 8, New York City Metropolitan
- *Group III* – Region 54, Chicago Metropolitan
- *Group IV* – Region 7, Colorado
- *Group V* – Region 40, Dallas Metropolitan
- *Group VI* – Random.

Groups I through VI are depicted geographically in Figures C-1 through C-6, respectively. The italicized date near to each region number indicates the submittal date of that region's regional plan. If no submittal date could be found for a regional plan, *X*'s appear in place of a date. The number in parenthesis under the submittal date represents the total number of participants in that region's regional committee.

Examining each figure reveals several key attributes within each group. For instance, groups II, III, and IV consist of regions that are closely located geographically. Oklahoma, located in group II, is the only exception. Therefore, geographic proximity is determined to have been an important factor in similarities among regional plans.

The regions in group VI, the "Random" group, do not appear to have any characteristics in common. However, an analysis of FCC comments shows that these regions have been relatively active in the regional planning process. Entities that provided comments to the *Notice of Proposed Rulemaking in the Matter of Development and Implementation of a Public Safety National Plan and Amendment of Part 90 to Establish Service Rules and Technical Standards for Use of the 821-824/866-869 MHz Bands by the Public Safety Services (National Plan NPRM)* and the *National Plan R&O* documents are located in many of these regions. Because these regions played such active roles in the planning process, it is understandable that these regions would take the time to develop their own individual regional plans.

Group I is similar to group VI in that the groups consist of regions that are somewhat scattered throughout the United States. The first plan submitted was from group I, Region 52 (North Texas), which may explain why the small group of regions bordering Region 52 used the same template. A reason why more distant regions used the same template can be found in their history of participation in the regional planning process—only a few of these regions contain public safety entities that provided comments to the *National Plan NPRM* and the *National Plan R&O* documents. As a whole, group I began developing regional plans a few years after the other groups began the process and did so in a very short time frame compared with regions in other groups. In addition, lack of participation is evidenced by the fact that, on a region-by-region basis, group I contains the fewest regional committees members. It also appears that each of these regions efficiently streamlined their own planning processes. In light of these facts, these regions belong in the same group.

C.3 Regional Committee Membership

The National Plan recommended the formation of regional committees with regional chairmen elected from among the committee membership. The National Plan allowed each region

a great deal of freedom in determining eligible participants for the regional committee. Analysis of the demographics of the regional planning committees provides another aspect on which to base an analysis of the regional planning process. Tables C-1 through C-6 list the membership of each regional committee, categorized by the departments. Each table represents a group, I through VI.

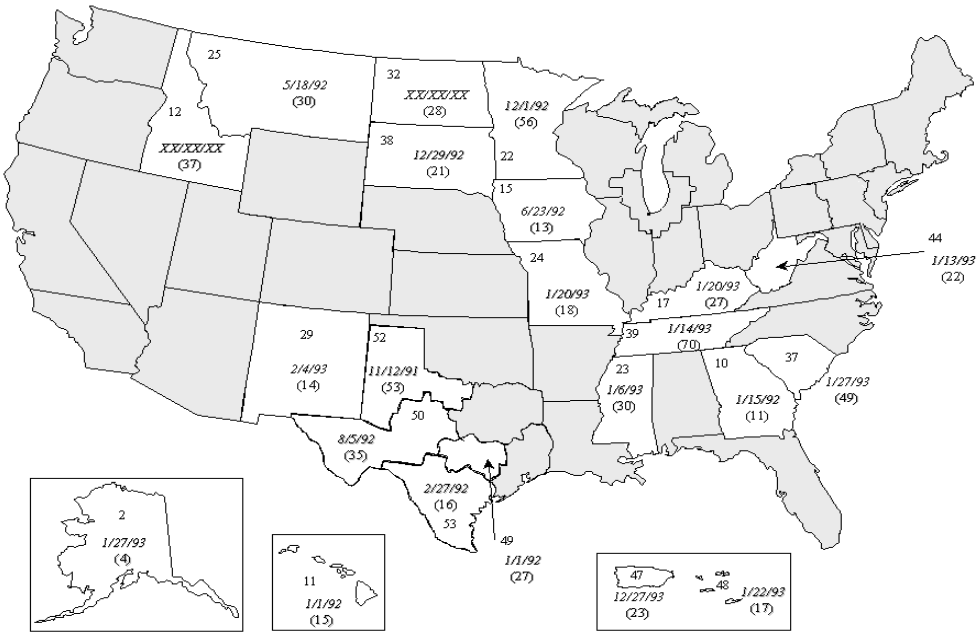

Figure C-1
Regional Breakdown of United States—Group I

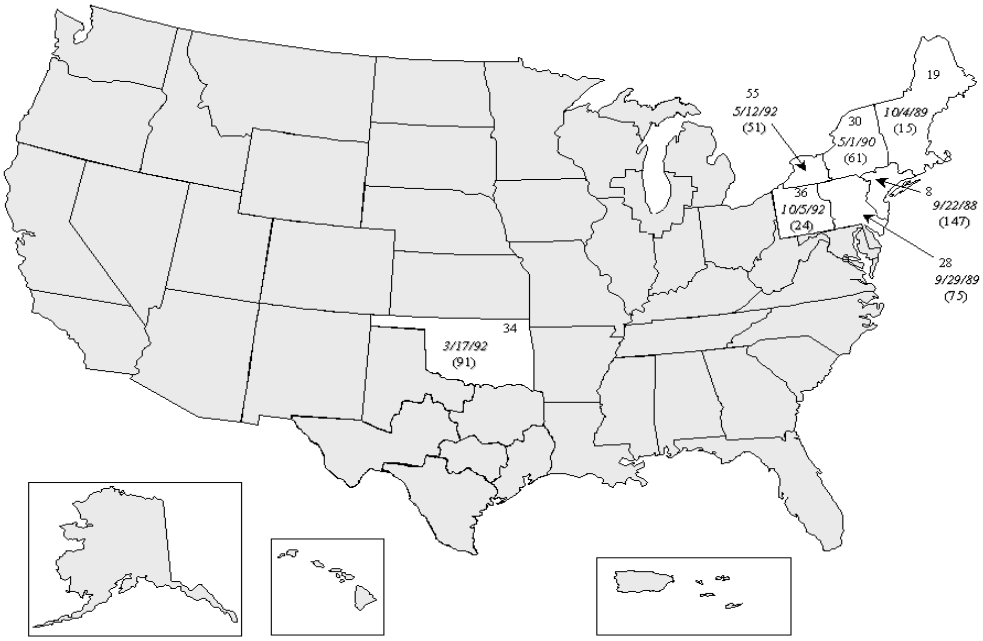

Figure C-2
Regional Breakdown of United States—Group II

Figure C-3
Regional Breakdown of United States—Group III

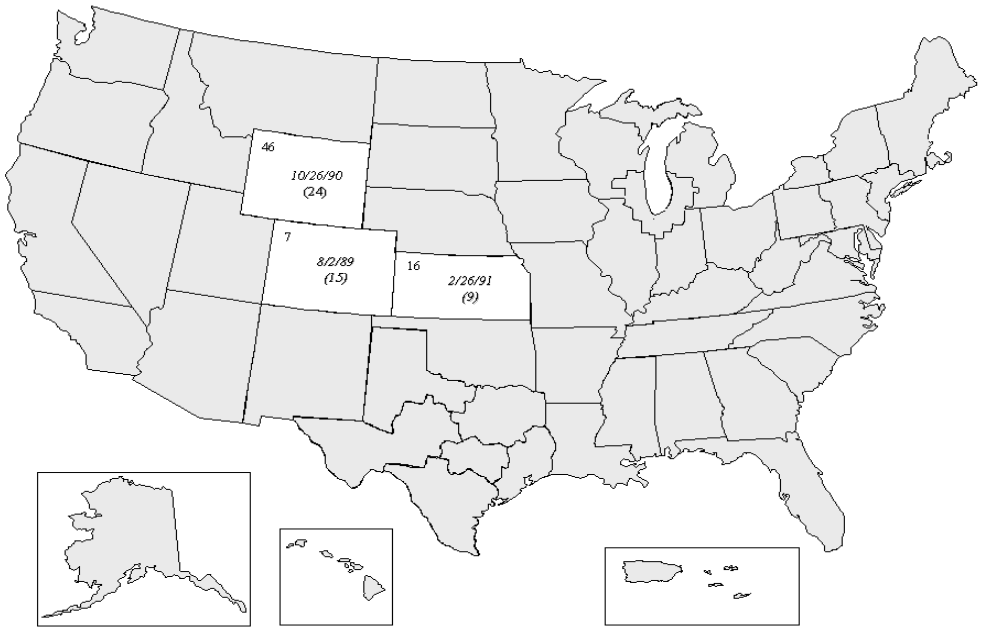

Figure C-4
Regional Breakdown of United States—Group IV

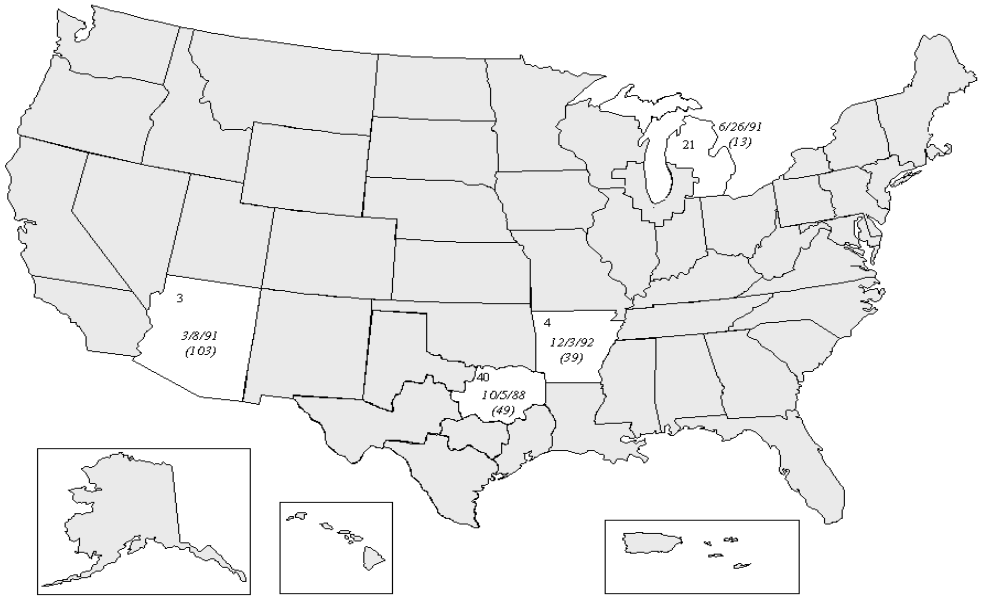

Figure C-5
Regional Breakdown of United States—Group V

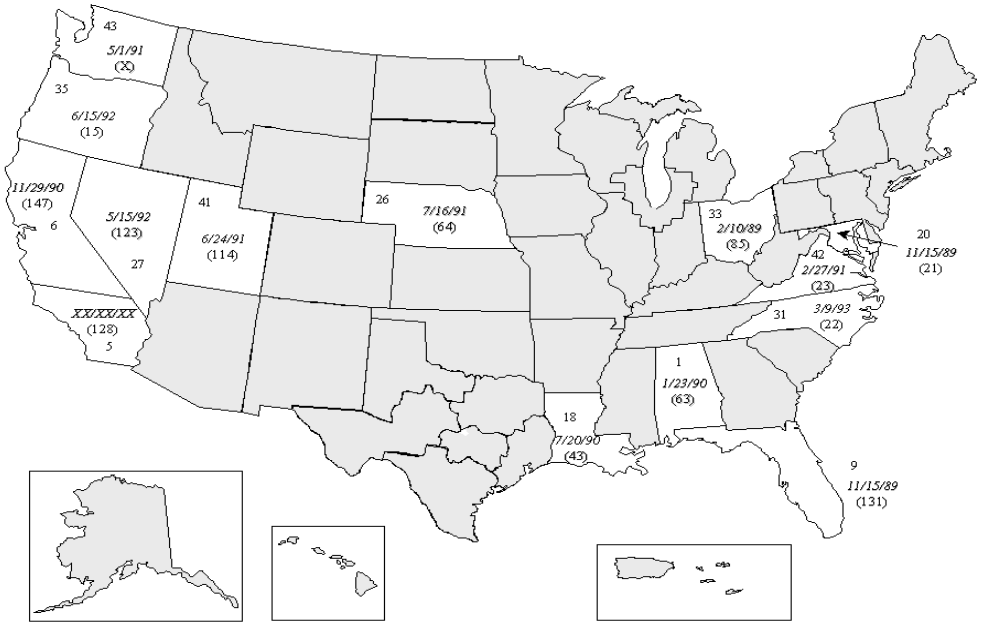

Figure C-6
Regional Breakdown of United States—Group VI

Throughout all regions, the majority of regional committee membership consists of police department representatives, fire department/emergency medical services (EMS) representatives, and representatives from county, state, and some federal government agencies. The category labeled "Other" consists of representatives from the local department of transportation, local forestry/conservation agencies, and other various local entities. The vast majority of regional committees did not include any APCO representatives.

These tables also highlight the level of committee participation in each region. Regions in group VI had high levels of representation from many different departments. This high degree of attendance could be due to extensive advertisement of the regional committee meetings, the perceived importance of obtaining additional frequencies for public safety, or both. No regional committee membership data was provided for those regions marked with an *X*.

Table C-1

Regional Committee Membership Listed by Department (Group I)

REGION	POLICE	FIRE/EMS	GOVERNMENT	INDUSTRY	ACADEMIA	APCO	OTHER
2	0	1	3	0	0	0	4
10	4	1	3	1	0	0	3
11	5	4	3	0	0	0	3
12	22	1	7	6	0	0	1
15	6	1	4	1	0	0	1
17	9	4	8	3	0	0	9
22	1	2	45	7	0	0	1
23	4	7	11	3	0	0	5
24	4	9	2	0	0	0	3
25	4	8	7	3	1	0	7
29	4	3	4	0	0	0	3
32	4	7	2	5	1	0	9
37	9	5	25	2	1	0	7
38	6	1	5	4	0	0	5
39	7	17	15	16	3	0	12
44	3	3	6	6	0	1	3
47	3	2	12	4	0	0	2
48	3	2	6	3	0	0	3
49	2	4	7	3	0	0	11
50	7	4	14	3	0	0	7
52	23	15	13	0	0	0	2
53	5	2	9	0	0	0	0
AVG	6	4	9	3	0	0	4

Table C-2
Regional Committee Membership Listed by Department (Group II)

REGION	POLICE	FIRE/EMS	GOVERNMENT	INDUSTRY	ACADEMIA	APCO	OTHER
8	55	30	27	16	0	1	18
19	4	5	1	4	0	0	1
21	5	2	5	0	0	0	1
28	11	8	24	18	0	0	14
30	20	11	8	16	0	1	5
34	45	3	21	5	1	0	16
36	2	1	12	0	0	0	9
55	24	13	5	5	0	0	5
AVG	20	9	12	8	0	0	8

Table C-3
Regional Committee Membership Listed by Department (Group III)

REGION	POLICE	FIRE/EMS	GOVERNMENT	INDUSTRY	ACADEMIA	APCO	OTHER
13	19	7	11	6	1	1	6
14	56	11	6	5	3	0	5
45	X	X	X	X	X	X	X
54	37	13	10	12	0	2	16
AVG	37	10	9	8	1	1	9

Table C-4
Regional Committee Membership Listed by Department (Group IV)

REGION	POLICE	FIRE/EMS	GOVERNMENT	INDUSTRY	ACADEMIA	APCO	OTHER
7	3	2	7	2	0	0	1
16	2	1	3	0	0	1	2
46	6	5	6	3	0	0	4
AVG	3	2	5	2	0	0	2

Table C-5
Regional Committee Membership Listed by Department (Group V)

REGION	POLICE	FIRE/EMS	GOVERNMENT	INDUSTRY	ACADEMIA	APCO	OTHER
3	43	27	23	5	1	1	3
4	12	10	3	3	0	0	11
40	13	5	19	8	1	0	3
AVG	23	14	15	5	1	0	6

Table C-6
Regional Committee Membership Listed by Department (Group VI)

REGION	POLICE	FIRE/EMS	GOVERNMENT	INDUSTRY	ACADEMIA	APCO	OTHER
1	17	8	17	10	3	0	8
5	33	16	60	0	10	0	9
6	15	25	82	13	4	0	8
9	44	19	41	12	0	0	15
18	13	5	8	14	0	0	4
20	4	4	9	0	0	0	5
26	18	14	20	2	3	0	7
27	38	28	35	1	0	0	21
31	5	4	8	5	0	0	0
33	17	13	23	16	3	0	13
35	4	0	6	0	0	1	4
41	46	8	23	5	6	0	29
42	3	6	6	6	0	0	2
43	X	X	X	X	X	X	X
AVG	20	12	26	7	2	0	10

C.4 Key Regional Plan Similarities

In developing regional plans, each regional committee's task was to determine the communications requirements of local public safety entities while coordinating its efforts with adjoining regions. Despite the intention to create independent, specialized regional plans, several key similarities appear in all regional plans. These similarities are generally consistent from one region to the next and from one group to the next. The first step in understanding the regional planning process at the local level is to understand these common sections. The section headings were standardized across the 55 regional plans. The similarities in these plans were generally in the following standardized sections:

- Preface
- Plan Development
- Agency Application Process
- Mutual Aid Requirements
- System Design Requirements
- Frequency Assignment.

Each of these headings contains several subheadings, which specifically describe each aspect of the regional plan. Many of the sections in the regional plans are required by the National Plan and are designated by the plan section number from which they were taken.

C.4.1 Preface

Each regional plan begins with a preface section, which includes a few introductory comments. This section generally provides historical background information. All of the regional plans contain some form of introduction, which typically provides the background of the NPSPAC and the National Plan. In many cases, a short history of the NPSPAC channels is provided as well as a short description of the National Plan.

C.4.2 Plan Development

The introduction portion of each regional plan is typically followed by sections that provide details of the regional plan development process. These sections address such issues as forming the regional committee, determining eligible committee participants, and defining the committee's goals.

Regional Planning Committees. This subsection provides details about the formation of the regional planning committees. In this subsection of the regional plan, the committee provides the name of the first meeting convenor, who is selected by APCO and serves as the coordinator of the planning process. The *National Plan R&O* states APCO, "acting under its frequency coordination responsibilities, will be responsible for convening a meeting to initiate the planning process in each region." Therefore, APCO was instructed to select a convenor for each region whose responsibilities would include organizing and publicizing the first planning meeting. A typical regional committee comprises representatives from public safety radio services and special emergency radio services. Section IV.B of the National Plan proposes the formation of regional committees.

Eligible Agencies. This subsection states that any entity eligible to be licensed under the FCC Rules and Regulations, Part 90, Subparts B or C (Public Safety Radio Services and Special Emergency Radio Services) is eligible to apply for NPSPAC channels. The requirements of this subsection were taken from the National Plan, Section III.B.

National Interrelationships. Each regional plan expresses its observance of the guidelines set forth in the National Plan and explains that any conflicts between the National Plan and regional plans will be governed by the National Plan. Each regional plan states that conflicts between regions are expected, but the judgment of the FCC would prevail in any of these conflicts.

Federal Interoperability. Interoperability between local, state, and federal agencies will take place primarily on the five common channels using S160[1] or equivalent agreements. Government use of non-government systems using S160 agreements must comply with FCC Rules and Regulations, Section 2.103. Nonfederal licensees can increase channel requirements to account for a 2 to 10 percent increase in mobile radios from federal agencies.

[1] The S160 is a special record note applied to the Federal Government frequency assignment that applies the conditions under which the Federal Government may obtain authorization to use a non-Federal Government frequency.

C.4.3 Agency Application Process

This section provides information about which agencies are given priority in applying for available channels. This section also describes the application process to which these agencies must adhere.

Application Procedures. Regional plans require that applications be submitted to the local frequency advisory committee chairman (usually the APCO frequency coordinator). The chairman inspects each application for completeness and determines the eligibility of the applicant. Incomplete or unsuitable applications are returned with remarks to the applicant, and complete applications are forwarded to the review committee.

Required Application Information. Many regions require other information in addition to the frequency application form (APCO Form FDR2). The following list includes all additional information requested in regional applications:

- System overview (e.g., trunked or conventional, voice, data)
- Service duties of agency
- System engineering exhibit and design parameters
- Intersystem interoperability capability
- Channel loading factors
- Coverage area
- Existing and vacated frequencies statement
- Implementation plan and/or schedule
- Coordination and licensing forms
- Funding statement and/or budgetary commitment
- Interface with long-distance radio
- Statement of need
- Compliance with common channel implementation requirements
- Interference studies
- Control station exhibit
- Special consideration.

Agency Priority. Two methods are used to assign a priority to applicants. The first method which is relatively simple, assigns a priority based on the type of agency and the type of system used. The following criteria are used in this method:

- Public safety agencies
- Public service agencies
- Multi-agency systems
- Multi-agency/multi-jurisdiction systems
- Single agency/jurisdiction systems.

The second, more complex method, uses an evaluation matrix to assign a priority based on a number of criteria. Each region includes different criteria with different point values based on which aspects are most important. The following categories are used in this second method. These categories are listed in a random order and do not reflect a priority assigned to each element:

- Service
- Intersystem communications
- Loading
- Spectrum-efficient technology
- System implementation factors
- Geographic efficiency
- Give-backs
- Combined systems
- Budgetary commitment
- Planning completeness
- Channel reuse potential
- Jurisdictional concurrence
- Responsibility for calculations
- Frequency reuse statement
- Number of give-back channels
- Effective system design
- Consolidation or use of channels by others.

C.4.4 Mutual Aid Requirements

The National Plan requires that regional plans contain several sections concerning the implementation of the five nationwide mutual aid channels. These sections typically define the use of each of these channels and provide detailed standards and operating procedures to govern the use of these channels.

Common Channel Implementation. The National Plan sets forth the guidelines for using and implementing the five National Common Channels. Four of these channels are dedicated as National Tactical Channels and one channel is dedicated as the National Calling Channel. The National Calling Channel, channel 601, is to be implemented as a full mobile relay, with wide area coverage transmitters to maximize coverage. Large system users (five or more channels) are required to monitor this channel and could be required to provide satellite receiver feeds into the wide coverage area. The four National Tactical Channels are to be assigned throughout the region for use by all eligible entities. Large system users could be required to sponsor one or two localized mobile relays to cover specific geographic areas. The users of these channels must be eligible for licensing on other 800 MHz public safety channels (FCC Rules and Regulations Section 90.616 (a)), but no special licensing is required. The National Common Channels are to be available for use throughout the region. Table C-7 lists the National Common Channels and each channel's specific frequency.

Table C-7
National Common Channels

Channel Name	Channel Number	Frequency (Mobile/Base in MHz)
CALL	601	821.0125 / 866.0125
TAC 1	639	821.5125 / 866.5125
TAC 2	677	822.0125 / 867.0125
TAC 3	715	822.5125 / 867.5125
TAC 4	753	823.0125 / 868.0125

Operation on Common Channels. The five common channels are only to be used for activities requiring intersystem communications between entities not already sharing communications systems and are not to be used for any daily operations. In emergencies, the channels may be assigned by the primary public safety agency in that area. On all common channels, plain English and familiar words and phrases should be used. The calling channel is used to establish contact with other users and determine which tactical channel to use. It is not to be used as an ongoing working channel. Tactical channels are reserved for inter-agency communications and are used as directed by the primary public safety agency in the area. Tactical channels can be assigned by the various public safety services or they can be assigned by county or area.

Network Operating Method. A wide area network will be established on the National Calling Channel. The tactical channel communications systems will be implemented by volunteer entities, and each primary geographic section of the region is covered by at least one tactical channel.

Coded Squelch on Mutual Aid Channels. The National Common Tone Squelch of 156.7 Hz will be used on all equipment operating on the five common channels. This requirement is proposed in the National Plan, Section III.C.2.

C.4.5 System Design Requirements

Several sections in each regional plan define the specific system design requirements. The content of these sections depends on the region's particular communications requirements. Even among regions in the same group, these plan sections are typically the most diversified with respect to the content and requirements.

System Coverage. System coverage is limited to the coverage area plus no more than 3 miles (5 miles for some regions) beyond coverage area boundaries and is included in the regulations to maximize frequency reuse. The system coverage area is defined as the area in which the received signal strength of a system signal is greater than 40 dBu (41 dBu for some regions). In most cases, the coverage area should be similar to the jurisdiction of the agency in question. Systems that use antennas that are not in the center of the jurisdiction are encouraged to use directional antennas to contain the coverage area. The FCC provides guidance for the calculations in the FCC Rules and Regulations, Section 90.309 (a) (4). The following four variables are used to determine a system's coverage area:

- *Received Signal Strength*—Minimum signal level at system boundary in dBu (same as designed mean signal strength described in the previous paragraph)

- *Antenna Height*—Height above average terrain (HAAT) surrounding the antenna site

- *Effective Radiated Power (ERP)*—Product of the power supplied to the antenna and its gain relative to a half wave dipole

- *Environment Type*—The Okumura/Hata[2] method uses the following four different classifications to describe terrain:

  – Urban: Built-up city with large buildings or closely interspersed houses with thickly grown trees

  – Suburban: City or highway scattered with trees, houses, and other mid-sized buildings

  – Quasi-Open: Outside city limits with few buildings and houses

  – Open: No obstacles such as tall trees or buildings

Trunking/Usage Guidelines. Systems with five or more channels must be trunked, and systems with four or fewer channels may be conventional. The FCC allows exceptions on a case-by-case basis if it can be shown that an alternative technology is as efficient as trunking or that trunking would not meet operational requirements. Conventional systems of four or fewer channels that do not meet FCC loading standards must share their frequency with others operating on the same channels. Smaller 800 MHz conventional systems must not interfere with the region's trunked system. Also, communications systems supporting life and property protection receive the highest priority, therefore interference with these systems must be minimized. Antenna heights and ERP are to be limited to provide only necessary coverage and to facilitate maximum frequency reuse. Separation of co-channel transmitters will not be held to 70 miles; instead, separation will be determined by the applicant's coverage needs. The National Plan, Section III.C.3, requires the elements of this subsection.

Channel Loading Requirements. Another similarity between most plans is that of channel loading. The following list indicates the variety of statements regarding channel loading found in the regional plans:

- Entities using conventional systems and requesting a new 800 MHz channel to replace a channel they are giving back for reassignment, will not be required to meet loading requirements to obtain that channel. However, if the system is not loaded to 50 or

[2] The Okumura/Hata method provides a means for determining the terrain surrounding an antenna site.

more units (70 for some regions), that frequency will be available to other entities on a shared basis (Source: FCC Rules and Regulations, Section 90.633).

- Entities that use trunked 800 MHz systems or are requesting multiple 800 MHz channels must comply with the loading tables provided in the National Plan. These loading tables are given in terms of emergency and non-emergency channels (Source: FCC Rules and Regulations, Section 90.631).

- Entities requesting additional 800 MHz channels must show the existing channels are 100 percent loaded in terms of the number of units assigned per channel. If a demand for additional channels exists with no available frequency, any system using these frequencies for 4 or more years and not loaded to 70 percent will lose a sufficient number of channels. These released frequencies can then be reassigned to other public safety entities.

- Additional channel requests can also be justified through a traffic loading study. The study must show "air-time" usage during the peak busy hours greater than 70 percent per channel on 3 consecutive days to justify the need for additional channels.

- Entities that support interoperability by permitting federal use of their frequencies through S160 agreements may augment channel requirements by 2 to 10 percent due to increased radio usage.

Encryption Standards. Encryption is encouraged for entities that conduct covert operations and require communications security. It is recommended that encrypted transmissions be in a digital format using an analog-to-digital converter with a bit rate that will fit in a 25 kHz channel. Encryption is prohibited on the National Calling Channel. Encryption is allowed on the tactical channels but is not recommended due to system incompatibilities. If an agency requires encryption on the tactical channels, it must provide the needed equipment to compensate for system incompatibilities and maintain interoperable communication on these channels.

Use of Cellular Service. Automatic interface to the public switched telephone network (PSTN) using 800 MHz radio requires longer channel use than normal transmissions. Using cellular telephones to connect to the PSTN is recommended instead of an 800 MHz interface, especially when duties require connection to the PSTN. The use of automatic interconnection of 800 MHz radio to the PSTN is not recommended. The use of cellular telephones for this purpose is recommended in the National Plan, Section V.B.

Use of Long-Range Communications. In situations requiring long-range communications into a disaster area, alternate methods should be determined by the region's primary public safety agency. These alternate methods should be capable of interfacing with the National Common Channels.

Expansion of Existing Systems. Existing systems that will be expanded to include the NPSPAC channels will have their mobile radios "grandfathered," if the modifications conform with the

National Plan MO&O, FCC GEN. Docket 87-112. These requirements primarily involve reducing the modulation deviation to +/- 4 kHz. Existing base stations in the 806–821/851–866 MHz frequency band may *not* be used in the NPSPAC frequency bands. This requirement is cited in Section III.C.2 of the National Plan.

Slow Growth. All entities implementing systems in the NPSPAC bands and following the regional planning process will be allowed to follow slow growth provisions in accordance with Section 90.629 of the FCC's Rules and Regulations. These rules allow those requesting frequencies to take up to five years to construct a system.

Adjacent Region Coordination. As part of the planning process, each region coordinated with adjacent regions. Letters of coordination sent to adjacent regions may be included in an appendix to the regional plan. Section IV.B.8 of the National Plan requires inter-regional cooperation and coordination.

Channeling Plan. As required by Section III.C.1 of the National Plan, any system licensed in the NPSPAC bands must have a 25 kHz channeling plan.

C.4.6 Frequency Assignment Process

Typically, the last several sections of each regional plan provide information about the assignment and frequency review processes.

Application, Assignment, and Review Process. The application, assignment, and review processes typically include a filing window for submitting applications, an evaluation matrix for prioritizing applicants, and a method for assigning the frequencies, respectively. A flow chart may be included to outline this process in detail. The National Plan recommended these processes in Sections IV.B.6 and IV.B.7.

Regional plans typically include a frequency assignment table with the channel number, frequency, and assignee. Many regions also include other regional mutual aid and regional non-mutual aid channels in their tables.

Additional Channel Assignments. Many regional committees made frequency assignments based on county population (e.g., two channel pairs per county). Counties with higher populations were allotted one channel for each additional increment of population (e.g., counties above 20,000 receive one channel pair for each additional 20,000 citizens). This method provided a basis for the initial frequency assignment. The development of a channel assignment process is stated in Section III.C.2 of the National Plan.

Frequency Sorting Methodology. The development of some form of frequency sorting method was recommended in the National Plan, Sections IV.B.5 and IV.B.9. Most regional plans specify that frequencies be assigned by a frequency-sorting program designed by APCO/CET. This program has a high degree of spectrum efficiency and a low probability of co-channel and adjacent channel interference. The following factors are considered by the APCO/CET program:

- *Geographic area.* Geographic area is defined as one or more circles of equal radius. These circles should ideally include an applicant's entire jurisdiction area but should not exceed the jurisdiction boundary by 3 miles.

- *Environment.* Environment is defined by the Okumura/Hata method of classification.

- *Blocked Channels.* The five National Common Channels and any other regionwide mutual aid channels that are spaced at 0.5 MHz intervals and excluded from the frequency sort.

- *Transmitter Combining.* The program provides a minimum frequency separation between channels assigned at the same site to enable efficient combining of multiple transmitters to a single antenna.

- *Special Considerations.* Licensees planning to expand systems that are unable to operate on 12.5 kHz separated carrier frequencies may operate on only even-numbered channels.

- *Interference Protection Ratios.* Built into the computer program. The co-channel ratio gives the desired-to-undesired signal ratio (in dBu) for co-channel assignments, and the adjacent channel ratio gives the same for adjacent channel assignments. Normal ratios are 35 dBu for co-channel assignments and 15 dBu for adjacent channel assignments.

- *Adjacent Region Considerations.* The program requires a list of channels to be blocked because of use by adjacent regions.

Give–Back Frequencies. As required by the National Plan, Section V.A.1, any agency using the new 800 MHz spectrum should submit a plan of abandonment for current licensed frequencies in the lower bands. These frequencies will then be made available to agencies that are not moving to 800 MHz or returned to the radio service to which they were originally assigned. Frequencies are not to be handed down within a jurisdiction but should be reassigned in the proper and normal manner. Time frames for phasing into 800 MHz should be included.

Unused Spectrum. Any unused 800 MHz frequencies will be returned to a reserve pool, which will be used to resolve conflicts with adjacent regions and to fill any additional public safety communications needs (Source: National Plan, Section V.A.2).

Appeal Process. As proposed in the National Plan, Section V.A.2, an applicant can appeal an assignment or rejection with the regional review committee and the FCC. If the appeal reaches the FCC, its decision will be final.

C.5 Key Regional Plan Differences

The previous discussions outlined common sections among the regional plans. Although there are many similarities between the groups of plans, there are also significant differences. This section outlines differences discovered among the five definable groups of regional plans as well as the significant differences found among individual regional plans in the "random" group. Many of these differences are elements that were included in some regional plans but not others. This section presents the differences in much the same manner as the similarities were presented. The differences are organized into sections that follow the structure of the regional plans. Again, section headings were standardized across the 55 regional plans. Using this same organization should facilitate a comparison of the similarities and differences discovered among the regional plans. The differences in these plans were generally in the following standardized sections:

- Plan Development
- Region Description
- Agency Application Process
- Mutual Aid Requirements
- System Design Requirements
- Frequency Assignment Process.

C.5.1 Plan Development

This portion of the regional plan addresses such issues as forming the regional committee, determining eligible committee participants, and defining committee goals. The differences found among the regional plans are highlighted and explained in the following sections.

Regional Planning Committee Member Demographics. The backgrounds of each regional planning committees' members vary among regions. The diverse demographics of the regional committees did not appear to follow any recognizable pattern. A further analysis may be needed to examine the relationship between committee demographics and frequency assignment (e.g., a committee with a majority of state police members might assign more channels to the state police). Tables C-1 through C-6 in Section C.3 show the committee demographics of each region.

Previous Existing Interoperable Systems. Three regional plans mention interoperable systems currently in place. These regions are Region 5 (Southern California), Region 6 (Northern California), and Region 27 (Nevada). California has implemented a Statewide Mutual Aid Radio System (SMARS) to establish interoperable channels throughout the state and in various frequency bands (e.g., VHF and low-band UHF). This system includes 14 mutual aid channels: six statewide high-band VHF, one statewide UHF, and seven county area UHF mutual aid channels. Also, cross-band patches are used by many dispatch centers to patch the various channels together.[3] Nevada has existing interagency frequencies in the 150 MHz range. Table C-8 lists the frequencies and usage of each of these channels.

Table C-8

[3] *Region 5 Public Safety Plan*

Nevada Existing Inter-Agency Frequencies

Channel	Frequency (MHz)	Usage
State 1	154.280	Fire
State 2	154.265	Fire
State 3	154.295	Fire
State 4	155.145	Division of Emergency Management (Simplex)
State 5	155.715	Division of Emergency Management *
State 6	155.475	Federal Law Enforcement
State 7	155.655	State Law Enforcement
State 8	155.160	State Search and Rescue
State 9	156.075	State Incident Command
State 10	UHF	Future Assignment
State 11	UHF	Future Assignment

*State 5 is a repeater control frequency paired with State 4.

Questionnaire Development. As part of the planning process, some regional committees used a questionnaire to identify radio spectrum needs and elicit meaningful information on current and future spectrum needs. Regions 3, 9, 13, 14, 21, 26, 27, 35, 41, and 54 included some form of questionnaire in their plans. Most of the regions in group III (regions 13, 14, and 54) and regions 21, 26, and 41 all sent out similar questionnaires, which included the following sections:

- *General Information*—Agency identification information
- *Demographic Information*—Agency's service area information
- *Frequency Needs*—Information regarding the use of radio frequencies for voice and data
- *Equipment*—Radio equipment inventory information.

These regions also included a discussion of the results with information and statistics. The questionnaires contained about 50 questions, mostly of the *yes* or *no* variety. It should be noted that Region 45, which belongs to group III, did not send out a questionnaire but did send representatives to talk with public safety radio users. Region 3 sent out a simple, one-page questionnaire to determine who desired public safety radio channels. Region 9 included a similar questionnaire with four sections, including general information, agency frequency use, additional information, and license information. Region 27 included extensive information about existing state and local antennas on mountaintops, state and local equipment inventories, and state and local interoperability requirements. Region 35 performed a survey of current use, expectations of future 800 MHz needs, and return of frequencies for reuse. This survey revealed very little interest in 800 MHz, except in the Portland area, and it generated many questions about additional spectrum in lower bands.[4]

4 *Region 35 Public Safety Plan*

C.5.2 Region Description

Several regional plans contain a series of sections that provide details on the demographics of the region, as well as a geographical description of the area. These are not considered key sections because the majority of regional plans provide only sparse regional information and little emphasis is placed on this portion of the plan. However, a description of the differences among plans may be helpful.

Region Defined. In regions containing dense urban areas, it was believed to be necessary to subdivide the region into zones. Primary zones are jurisdictions that are severely affected by excess demand for scarce spectrum. Secondary zones are general areas that are affected to a lesser degree. Regions 8, 14, 19, 21, 33, and 54 identified primary and secondary zones within their regions.

C.5.3 Agency Application Process

As stated in the discussion of the regional plans' key sections, the following sections provide information about which entities are given priority in applying for available frequency bands and about the application process to which these entities must adhere.

Agency Priority. As stated previously, there are two major methods of prioritization, both based on point systems. The first method was used by group I and prioritizes applicants by service and type of system. The plan priority for group I states that "Prioritization shall be done according to a final score, based on applicant criteria. The highest score, in points, shall be given priority in a situation where spectrum is insufficient to fulfill the needs of all." Within group I, Region 11 followed a different point-scoring scheme, which is also presented in Table C-9.

The second method, used by most other regions, applies a list of criteria to assign priority. A priority evaluation matrix is used to assign points for the following categories, and the agency with more points is given higher priority:

- Service
- Intersystem communications
- Loading
- Spectrum–efficient technology
- System implementation factors
- Geographic efficiency
- Give-backs
- Combined systems (points per additional agency).

Table C-9
Agency Priority (Method 1)

Criteria	Points (Group 1)	Points (Region 11)

Public Safety Agencies	2	4
Public Service Agencies	1	2
Multi-Agency Systems	2	3
Multi-Agency/Multi-Jurisdiction Systems	3	1
Single Agency/ Jurisdiction Systems	1	1

C.5.4 Mutual Aid Requirements

The mutual aid channel sections of the regional plans are required by the National Plan. The regional plans fulfill this requirement in several different ways.

Tactical Channels (National or International). Many regional plans assign usage for each tactical channel in one of two ways. Group I (except for Region 44) and Regions 3 and 27 assign the channels by service, as shown in Table C-10. Whereas, Regions 1, 21, 28, 30, and 36 assign the four tactical channels by county or area of the region. Regions 28 and 36 include a table with primary and secondary tactical channel assignments by county.

Table C-10
Tactical Channel Assignments (Method 1)

Channel	Assignment (All But Region 25)	Assignment (Region 25)
ITAC 1	Law Enforcement	Highest Level of Operational Command
ITAC 2	Fire	Highest Level of Law Enforcement Command
ITAC 3	Emergency Services	Highest Level of Fire Command
ITAC 4	Command and Control	Highest Level of EMS command

Operational Requirements. Regions 1 and 9 require that each major user of five or more channels sponsor one or two localized conventional relays to cover specific areas to provide a fixed number of working channels in the given area.[5] Regions 42 and 44 require only that primary system users (five or more channels) monitor the calling channel and maintain a radio watch at all times.

Group IV and Regions 4, 18, 31, 35, 40, and 43 divide users into two categories: primary and secondary users. Primary users are agencies that operate on five or more channels. They are required to operate a receiver for continuous monitoring of the calling channel and a separate mobile relay base station equipped to operate on all five tactical channels. All primary users will maintain a radio watch on the calling channel for the purpose of monitoring the channel and rendering assistance. Secondary users are agencies that operate on four or fewer channels and are required, as a minimum, to operate a base station for continuous monitoring of the common channel.

[5] *Region 1 Public Safety Plan*

Mutual Aid Channels. Several regions included additional requirements concerning the mutual aid channels:

- *Voice Privacy, Paging, Alerting, and Signaling.* Regions 5, 26, 27, and 35 mandate that voice privacy, paging, alerting, and signaling are prohibited on the common channels. However, Regions 5 and 27 state that encryption or voice privacy may be allowed on tactical channels in unique circumstances.

- *Unit Identification.* Regions 3, 5, 16, 26, and 27 require that units operating on the mutual aid channels include their agency names in their unit identifications. All but Region 27 encourage Automatic Transmitter Identification System (ATIS) usage; however, voice identification is still required.

- *Cross-Band Repeating.* Regions 5, 16, 25, 26, and 27 permit agency or mutual aid channels outside the 800 MHz spectrum to link to the national common channels in accordance with FCC rules and regulations. This cross-band repeating is to be used to provide interoperability among users on different radio bands.

- *Mutual Aid Channels Priority Usage.* Many regions set up priority communications levels for the mutual aid channels. When a higher priority use is required, all lower priority use must cease in any area where interference could occur.

- *Subregions.* All regions in group II (except for Region 30) and Regions 1 and 7 are broken into subregions that conform to political boundaries in the region. Each of these, except Regions 7 and 34, must have a primary public safety dispatch center operating a base station on the CALL and TAC1-4 channels.

- *Primary Network Control Centers.* Group III and eight other regions established a Primary Network Control Center in each area to monitor the national calling channel. This center responds to calls for assistance within its area and coordinates the assignment of the tactical channels for ongoing emergency operations.

- *Cross System Patches.* Group III includes the following section regarding cross system patches:

  - Cross system patches to existing day-to-day systems, other mutual aid channels, or long range communications systems must be manually controlled. Automatic patches are not permitted. Cross system patches are normally handled by the Primary Dispatch Center in the section of the region involved.

- *Coded Squelch on Mutual Aid Channels.* Groups I, IV, and V and a few other regions require that all equipment with the capability to operate on the five common channels be equipped with the National Common Tone Squelch of 156.7 Hz, as recommended by the FCC. Group I states that mobile relays on the common channels

may use additional tone or digital squelch to select individual mobile relay stations, provided the National Common Tone Squelch Code is used on the output.

C.5.5 System Design Requirements

This portion of the regional plans proved to be the most diverse among the regions. The differences arise due to the unique geography and demographics of each region.

System Coverage Definition. Almost all regional plans include a section concerning the system coverage definition, which is required in the frequency assignment process. The system coverage is typically defined as a dBu value (dB above one microvolt per meter), which represents the maximum designed mean signal strength at a certain distance outside the boundary of the agency's jurisdiction. This signal strength for each region is either 40 dBu or 41 dBu, and the distance outside the boundary is either 3 or 5 miles. This limitation of signal coverage is designed to maximize frequency reuse. Groups I and V also discuss the determination of system coverage area according to the following four variables (three variables for group V):

- *Received Signal Strength*—Minimum signal level at system boundary in dBu (same as designed mean signal strength described above)

- *Antenna Height*—Height Above Average Terrain (HAAT) surrounding the antenna site

- *Effective Radiated Power (ERP)*— Product of the power supplied to the antenna and its gain relative to a half wave dipole

- *Environment Type*—The Okumura/Hata method uses four different classifications to describe terrain. These classifications are urban, suburban, quasi-open, and open (see Section C.4.5 for definition).

Carey Propagation Curves. Eight regions use Carey propagation curves as guides to determine system coverage areas, even though the APCO packing program uses the Okumura/Hata method. Data tables taken from Carey propagation curves are included in each plan, along with formulas and methods for determining service areas and co-channel interference.

Annexation and Other Expansions. Group I includes recommendations regarding expansion of jurisdictions. If a system needs to be expanded, the increased range will be determined at the time of modification. If it is found that interference with another system is likely, alternate methods of expansion, such as satellite systems, will be required.

System Loading. Groups I, IV, and V use the following requirements for NPSPAC channel loading:

- *Conventional Systems*—Entities requesting one channel to replace a channel they are giving back for reassignment will not be required to meet loading requirements to

obtain that channel. However, if the system is not loaded to 50 or more units (70 for group IV) within 3 years, that frequency will be available to other entities on a shared basis.

- *Trunked Systems or Requests for Multiple Channels*—Entities requesting channels must comply with the loading tables provided in the plan. These loading tables are given in terms of emergency and non-emergency channels.

Four other regions also include loading requirements, but instead of using the standards above, they simply state that conventional systems shall comply with FCC Rules and Regulations, Part 90.633, and that trunked systems shall comply with Part 90.631. Group III uses existing loading standards, which are as follows: 70 units per conventional channel, 100 units per trunked channel and conventional data channel, and 150 units per trunked data channel.

Traffic Loading Study. Group I and a few other regions require justification of additional channels through a traffic loading study. The study must show "air-time" usage during the peak busy hours greater than 70 percent per channel on 3 consecutive days to justify additional channels. Alternatively, Region 25 uses the Grade of Service (GOS) method to justify additional frequencies. The GOS is a measure of the probability that a communication channel is available. Additional frequencies may be allowed if the following conditions exist:

- The GOS is less than 0.85 at peak busy hour (PBH).
- The GOS is less than 0.92 at the bouncing busy hour (BBH).
- The GOS is less than 0.95 at the time consistent busy hour (TCBH).

Federal S160 Agreements. Group III and a few other regions allow entities that support interoperability by permitting federal use of their frequencies through S160 agreements to augment channel requirements by 2 percent because of increased radio usage.

Encryption Standards (Groups II and IV). Groups II and IV include standards dealing with encryption. Encryption is encouraged for entities in covert operations, and these groups recommend techniques that produce high levels of communications security and decoded voice recognition. No form of encryption is allowed on the National Calling Channel. Encryption is recommended on the Tactical Channels; however, compatible equipment must be provided by the agency requiring such encryption.

Use of Cellular (Groups II, III, IV, Region 31). Group II does not recommend the use of automatic interconnection to the PSTN using 800 MHz radios because this interconnection requires significantly longer channel use time. Instead, cellular telephone usage is recommended for connection to the PSTN, especially in situations requiring one-on-one communications between a mobile and telephone user. Region 31's plan is similar, except it makes no mention of cellular telephones as an alternative.

Group III discusses cellular radio technology as a future alternative for trunked radio for public safety use. The plan cautions users that any proposal of cellular radio as an alternative to a

trunked radio system must demonstrate that cellular radio can provide the same or a greater degree of spectrum efficiency as trunking and it can handle emergency situation communications. Group IV simply recommends the use of cellular telephones for non-emergency connection to the PSTN.

Expansion of Existing Systems. All groups, except group III, state existing systems that will be expanded to include the NPSPAC channels will have their mobile radios "grandfathered," if the modifications conform with the *National Plan MO&O,* FCC Docket 87-112. This primarily involves reducing the modulation deviation to +/- 4 kHz. Existing base stations in the 806–821/851–866 MHz band may *not* be used in the NPSPAC bands.

Many of the regions in group I exclude the statement about modulation deviation reduction to +/- 4 kHz. Region 5 allows radio equipment that is type accepted for operation in the 806–821/851–866 frequency band to operate indefinitely on the National Common Channels, with a maximum permissible modulation deviation of +/- 5 kHz. Region 6 also allows other 800 MHz equipment to be used on the five common channels, but only for mutual aid purposes.

Slow Growth (Groups I, III, IV, and V). All groups except group II include provisions for slow growth. Groups I, III, IV, and V require that all systems in the NPSPAC bands under the regional plan be slow growth, in accordance with Part 90.629 of the FCC's Rules and Regulations. These rules allow those requesting frequencies to take up to five years to construct a system. In addition, Region 7 requires compliance with Part 90.631 and Part 90.633. Region 40 requires compliance with Part 90.62e of the FCC's Rules and Regulations.

Transmitter Time-Out Timers. Region 30 includes the following section on transmitter time-out timers:

> "Any communications plan which requires the development of multiple base station with capability on one or more common channels, carries associated risks. Pursuant to this plan, within this region, transmitter 'time-out timers' will be required on all transmitters."[6]

Frequency Reuse. Several regions within group IV chose to maximize the use of the NPSPAC frequencies. Therefore, the regions state that any agency's proposed system should be modified to increase frequency reuse. These modifications include antenna design, transmitter power, transmitter location, and frequency assignments.

Regions 3, 4, 34, 18, and 40 handled the frequency reuse issue differently. These regions propose that adherence to the technical design requirements of the plan will result in maximum co-channel use within the region, and adjacent channel considerations should be similar to co-channel considerations because of the close proximity of adjacent channels. Furthermore, applicants must show that their proposed systems will not interfere with any existing co-channel system and will provide an existing-to-proposed signal margin of greater than 35 dBu at the

6 *Region 30 Public Safety Plan*

existing system's coverage area boundary. Each of these regions has a section called "Adjacent Channel Design" that follows the section on frequency reuse in their plan. This section states that systems must be designed to have no interference with adjacent channels. The method of determining adjacent channel interference is the same as for the co-channel case, outlined elsewhere in the plan (generally in the Frequency Reuse section), except that the existing-to-proposed signal margin will be reduced to 15 dBu. These numbers are included in the Interference Protection Ratios subsection of the Frequency Sorting Methodology section of this appendix.

Regions 35 and 43 are similar to those mentioned above, but their method of determining interference is different than the existing-to-proposed signal level. These regions state that the proposed co-channel signal level must not exceed 5 dBu, and the proposed adjacent channel signal level must not exceed 25 dBu at any point within the service area of an existing system. These signal levels are included in the Spectrum Allocations and Frequency Assignment Statistics section in this appendix.

Control Stations. Eleven regions limit the received signal strength of control stations to no more than 6 dBu above that of a mobile unit on the system at its outer boundaries. Criteria concerning control stations must be included in the frequency applications. Regions 23, 49, 50, and 52 also discuss using control stations as system backups, with minor modifications in some applications to avoid interference.

Region 3 requires control/base stations to conform to the radio service area 41 dBu boundary requirement.[7] Region 20 requires control stations to use directional antennas located within the service area with a received signal strength at the repeater of less than 20 dBu above receiver quieting (20 dBq). Criteria concerning control stations must be included in frequency applications. Region 42 has similar requirements but does not include the 20 dBu requirement.

Adjacent Channel Interference (Group V). Group V and several other regions state that, where co-channel and adjacent channel systems are separated by a certain distance, the interference studies required elsewhere in the plan are unnecessary. This distance is 50 miles for Regions 4 and 40, and 70 miles for Region 3. Region 18 has a similar statement but requires 100 miles for co-channel systems and 50 miles for adjacent channel systems. Region 1 requires at least 20 miles of separation between adjacent channel systems. Also, the co-channel separation of 70 miles may require modification to prevent interference but will be held to 70 miles where reasonable. This separation will be determined by a number of factors at the time of application. Region 26 states that co-channel separation will not be held to 70 miles but will be determined be a number of factors. Region 26 also states that system tests and studies should be performed to establish minimum separation distances.

Aircraft to Ground Communication. Group III restricts the use of 800 MHz radio in aircraft. Air-to-ground transmissions are limited to a maximum ERP of 1 watt (0 dBW). No transmissions on area channels are allowed above 2,000 feet above ground level (AGL), and no transmissions

[7] *Region 3 Public Safety Plan*

are allowed above 3,000 feet AGL on wide-area Mutual Aid Channels. Several regions do not mention AGL distances, and Region 3 limits ERP to 3 watts (4.8 dBW).

Satellite Receivers. Region 22 recommends the use of "satellite receivers" to boost the talk-back of low powered transmitters.

Satellite Services. Regions 45 and 54 suggest the use of Mobile Satellite Service (MSS) during major disasters that require long-range communications. However, the plans state that this service should be restricted to frequencies above 960 MHz.

C.5.6 Frequency Assignment Process

The last several sections of each regional plan typically provide information about the assignment process and the regional plan review process.

Application, Assignment, and Review Process. Group II includes a flow chart to illustrate the application, evaluation, and assignment process. This process includes a filing window for submitting applications, an evaluation matrix for prioritizing the applicants, and a process for assigning the frequencies.

Additional Channel Assignments. Many regions manage frequency assignments by allotting a defined minimum number of channel pairs per county for counties with populations below a certain level (e.g., two channel pairs per county). The counties with higher population are allotted one channel for each additional increment of population (e.g., counties above 20,000 receive one channel pair for each additional 20,000 citizens). This method provides a basis for the initial frequency assignment.

Frequency Sorting Methodology (Groups I, II, III, and V). Most groups and regions use a frequency sorting program from APCO to assign frequencies. This program has a high degree of spectrum efficiency and a low probability of co-channel and adjacent channel interference. Groups I and III also include the factors that contribute to the assignment created by the APCO/CET program. Group I included these factors, as listed below, in a section entitled "Initial Frequency Assignment."

- *Geographic area.* The geographic area is defined as one or more circles of equal radius. These circles should ideally include an applicant's entire jurisdiction area but should not exceed the jurisdiction boundary by 3 miles.

- *Environment.* The environment is defined by the Okumura/Hata method of classification.

- *Blocked channels.* The five National Common Channels and any other regionwide channels that are spaced at 0.5 MHz intervals and excluded from the frequency sort.

- *Transmitter combining.* The program provides a minimum frequency separation between channels assigned at the same site to enable efficient combining of multiple transmitters to a single antenna.

- *Special Considerations.* Licensees planning to expand systems that are unable to operate on 12.5 kHz separated carrier frequencies may operate on only even-numbered channels.

- *Interference protection ratios.* There are two interference protection ratios built into the computer program. The co-channel ratio gives the desired-to-undesired signal ratio (in dBu) for co-channel assignments, and the adjacent channel ratio gives the same for adjacent channel assignments. These numbers were different for each region because they depend on such factors as geography and population. The co-channel ratio ranged from 35 to 40 dBu and the adjacent channel ratio was 15 dBu in most cases.

- *Adjacent Region Considerations (Group I Only).* The program requires a listing of channels to be blocked because of use by adjacent regions.

Spectrum Allocations and Frequency Assignment Statistics. In addition to the normal spectrum allocation table and channel assignments, many regions assign other regional channels and some include other assignment statistics with the tables—

- *Regional Mutual Aid Channels*: Many regions implemented other mutual aid channels in addition to the five NPSPAC channels.

- *Regional Non-Mutual Aid Channels.*

- *Statewide Allocations*.

Group I and various other regions include the following frequency assignment statistics with their plans:

- Maximum field strength for co-channel operation in dBu (also included in groups III and IV). This field strength must not exceed 5 dBu.

- Maximum field strength for adjacent operation in dBu (also included in groups III and IV). This field strength must not exceed 25 dBu.

- Total number of channels assigned (also in group III).

- Total number of unassigned channels (also in group III).

- Total number of reserved channels.

- Total number co-channels assigned.

Expansion of Initial Assignment. Group I provides for the depletion of channels for any county. The regional review committee can then take action to assign more channels to that county, if frequencies are available. The county or agency must resubmit any appropriate licensing forms.

Unused Spectrum. Groups I and II require that any unused frequencies be returned to a reserve pool. These channels will be used to resolve conflicts with adjacent regions and fill any additional needs.

Frequency Recall. Groups II and IV include, in the frequency assignment process, a provision to monitor the progress of entities in implementing systems using the newly assigned frequencies. If no progress is made in implementing these entities' systems, the agencies are then warned of the consequences of not progressing. Subsequently, if progress is still not being made, the committee may notify the FCC and an entity's license may be revoked.

Appeal Process (All Groups). All plans include an appeal process, but they vary by region. For many of the regions, the appeal process has two levels: The regional review committee and then the FCC. If an appeal reaches the FCC, its decision will be final. In many regions, the first level of the process is APCO rather than the regional review committee. Two other regions have a three-level appeal process: review committee, National APCO, and then the FCC.

C.6 Submittal and Review of Regional Plans

The first regional plan was submitted by Region 8 in September 1988. The final regional plan was submitted for approval by Region 47 in December 1993. The detailed description provided in the previous sections describes the content of the regional plans submitted within this time frame. By examining the contents of the regional plans and the demographics of the regional committees, this appendix provides a limited view of the regional planning process, which took place over the five years between 1988 and 1993. However, to view the entire process, it is also necessary to examine any activity that occurred after the submission and approval of a regional plan.

In the National Plan, the FCC recommended rules and regulations to govern not only the regional plan approval process, but also the plan amendment process for regional plans that had already been approved. However, after the vast majority of regional plans were approved, the FCC reiterated its amendment policy in a *Regional Public Safety Plan Handbook* issued in August 1997. This handbook reiterated the following points concerning the amendment policy:

- "Applications for amendment to public safety plans should include an original and five copies, and should be forwarded by the regional planning Chairman to the Secretary, Federal Communications Commission, Washington, D.C. 20554."

- "Requests for amendments revising allocation of frequency spectrum must be coordinated with adjoining regions."

- "Regions should promptly notify the FCC when a new regional chairman is appointed . . . including the date the new Chairman was elected . . ."

- "Comments or reply comments to regional plan amendments should include an original and five copies and be forwarded to the Secretary, Federal Communications Commission, Washington, D.C. 20554."

The FCC reiterated these requirements to ensure timely processing of all amendment applications and stated that any application that does not follow these guidelines will be returned as deficient. The FCC also advised all applicants to adhere to the regulations and guidelines recommended in the National Plan.

C.7 Regional Plan Docket History

When regional plans were received, the FCC assigned a docket number to each plan for internal tracking purposes. The FCC uses the docket numbering system to track the evolution of each regional plan. Tables C-11 through C-16, organized by regional group numbers, provide a docket history for each of the regional plans. The tables include the date of submittal of the regional plan, the date the public notice was issued by the FCC, the date the *National Plan R&O* adopting the regional plan was issued, and a brief description of any actions that have taken place since the plan's approval. Although most of the dockets were reviewed in producing these tables, several dockets could not be obtained. Therefore, those regions with incomplete docket histories are designated as such.

Table C-11
Docket History of Group I Regional Plans

REGION NUMBER	DOCKET NUMBER	DATE SUBMITTED	DATE OF PUBLIC NOTICE	DATE OF ORDER	ACTION TAKEN AFTER APPROVAL OF REGIONAL PLAN
2	PR 93-81	01/27/93	03/23/93	06/02/93	
10	PR 92-189	01/15/92	08/11/92	10/09/92	
11	PR 93-80	01/01/92	03/22/93	02/07/94	
12	PR 93-149	XX/XX/XX	05/28/93	08/03/93	11/18/93 - Amendment
15	PR 92-288	06/23/92	11/27/92	02/10/93	02/03/94 - Amendment
17	PR 93-132	01/20/93	05/05/93	07/28/93	
22	PR 93-130	12/01/92	05/05/93	07/12/93	
23	GN 89-478	01/06/93	10/26/89	01/10/90	
24	PR 93-131	01/20/93	05/05/93	07/12/93	
25	PR 92-267	05/18/92	11/09/92	01/12/93	
29	PR 93-86	02/04/93	03/26/93	06/02/93	incomplete docket history
32	PR 93-77	11/12/91	03/19/93	06/02/93	
37	PR 93-78	01/27/93	03/19/93	06/02/93	
38	PR 93-57	12/29/92	03/12/93	05/14/93	
39	PR 93-58	01/14/93	03/12/93	05/14/93	
44	PR 93-79	01/13/93	03/22/93	06/02/93	

REGION NUMBER	DOCKET NUMBER	DATE SUBMITTED	DATE OF PUBLIC NOTICE	DATE OF ORDER	ACTION TAKEN AFTER APPROVAL OF REGIONAL PLAN
47	PR-93-82	12/27/93	03/23/93	06/02/93	
48	PR 93-105	01/22/93	04/08/93	06/15/93	07/13/95 - Comments received from Anchorage Amateur Radio
49	PR 92-190	01/01/92	08/18/92	11/06/92	incomplete docket history
50	PR 92-286	08/05/92	11/27/92	02/10/93	incomplete docket history
52	PR 92-1	11/12/91	01/03/92	03/18/92	incomplete docket history
53	PR 92-169	02/27/92	07/28/92	10/02/92	

Table C-12
Docket History of Group II Regional Plans

REGION NUMBER	DOCKET NUMBER	DATE SUBMITTED	DATE OF PUBLIC NOTICE	DATE OF ORDER	ACTION TAKEN AFTER APPROVAL OF REGIONAL PLAN
8	GN 88-476	09/22/88	09/29/88	05/12/89	07/03/89 - Present: Numerous comments and amendments were received during this period
19	GN 90-53	10/04/89	02/12/90	04/26/90	03/21/97 - Amendment 06/26/97 - Application filing window opened
28	GN 89-573	09/29/89	12/07/89	12/16/93	06/28/96 - Present: Numerous comments received from Region 20 05/01/97 - Application filing window opened
30	GN 90-394	05/01/90	08/29/90	05/24/91	incomplete docket history
34	PR 92-171	03/17/92	08/03/92	10/06/92	
36	PR 92-274	10/05/92	11/18/92	02/01/93	6/18/97 - Public Notice for Reorganization
55	PR 92-287	05/12/92	11/27/92	02/10/93	5/15/97 - Public Notice for filing window

Table C-13
Docket History of Group III Regional Plans

REGION NUMBER	DOCKET NUMBER	DATE SUBMITTED	DATE OF PUBLIC NOTICE	DATE OF ORDER	ACTION TAKEN AFTER APPROVAL OF REGIONAL PLAN
13	PR 91-228	03/07/91	07/31/91	09/30/91	08/25/94 - Amendment
14	GN 90-17	11/21/89	03/21/90	05/30/90	incomplete docket history
45	PR 92-273	08/14/92	11/18/92	06/02/93	12/28/92 - Comments received from Region 22
54	GN 89-363	07/14/89	08/17/89	12/05/89	03/28/91 - Comments received concerning reallocation of frequencies 06/24/97 - Application filing window opened

Table C-14
Docket History of Group IV Regional Plans

REGION NUMBER	DOCKET NUMBER	DATE SUBMITTED	DATE OF PUBLIC NOTICE	DATE OF ORDER	ACTION TAKEN AFTER APPROVAL OF REGIONAL PLAN
7	GN 89-452	08/02/89	XX/XX/XX	XX/XX/XX	incomplete docket history
16	PR 91-162	02/26/91	06/12/91	08/08/91	
46	PR 91-59	10/26/90	03/12/91	05/20/91	incomplete docket history

Table C-15
Docket History of Group V Regional Plans

REGION NUMBER	DOCKET NUMBER	DATE SUBMITTED	DATE OF PUBLIC NOTICE	DATE OF ORDER	ACTION TAKEN AFTER APPROVAL OF REGIONAL PLAN
3	PR 91-143	03/08/91	05/16/91	09/04/91	incomplete docket history
4	PR 93-3	10/05/88	01/13/93	03/18/93	incomplete docket history
21	GN 90-221	06/26/91	04/17/90	06/22/90	incomplete docket history
40	GN 88-549	10/05/88	12/07/88	06/22/89	09/05/89 - Submission of revision 07/09/90 - Submission of revision 01/07/93 - Submission of revision

Table C-16
Docket History of Group VI Regional Plans

REGION NUMBER	DOCKET NUMBER	DATE SUBMITTED	DATE OF PUBLIC NOTICE	DATE OF ORDER	ACTION TAKEN AFTER APPROVAL OF REGIONAL PLAN
1	GN 90-280	01/23/90	05/23/90	08/01/90	incomplete docket history
5	GN 89-97	XX/XX/XX	04/27/89	11/08/89	12/22/89 - 02/28/95: Numerous comments and amendments submitted
6	GN 90-287	11/29/90	05/29/90	11/20/90	06/12/92 - 10/31/94: Numerous comments and amendments submitted
9	GN 90-119	11/15/89	03/05/90	03/23/94	10/28/94 - Present: Amendments submitted and approved
18	GN 90-498	07/20/90	10/17/90	12/19/90	07/13/93 -Present: Amendments submitted, still pending
20	GN 90-7	11/15/89	01/17/90	02/10/94	09/01/94 - Present: Numerous comments regarding Region 28 Plan
26	GN 89-608	07/16/91	12/18/89	10/23/91	incomplete docket history
27	PR 92-268	05/15/92	11/09/92	01/12/93	05/23/93 - Amendment
31	PR 93-150	03/09/93	05/28/93	08/03/93	
33	PR 91-258	02/10/89	08/30/91	02/06/92	incomplete docket history
35	PR 92-269	06/15/92	11/09/92	01/12/93	incomplete docket history
41	PR 91-282	06/24/91	09/27/91	11/27/91	
42	PR 91-300	02/27/91	10/09/91	12/11/91	incomplete docket history
43	PR 91-270	05/01/91	09/12/91	11/15/91	08/23/94 - Amendment

C.8 Status of Regional Committees Today

The last column of each table, labeled "Action Taken After Approval of Regional Plan," highlights those regional committees that have remained active since the process began. An examination of these tables reveals that although many of the regional committees have not remained active since their plan's approval, some regions have remained extremely active. Groups II and VI, for instance, have, in large part, remained very active. Regions 5, 6, 8, 9, 18, 20, and 28 have had very active docket histories from the beginning of the process to the present day. Many of these active regions contain large municipalities where additional spectrum is a valuable commodity. This high value may account for the high activity witnessed within these regions. Much of these regions' docket histories involve receiving comments aimed at acquiring additional spectrum for public entities not originally considered within the regional plan. Many of the docket histories also involve submitting amendments to the approved regional plans.

In reviewing the data as a whole, it appears, however, that most regional committees became largely inactive after their associated regional plans were approved. Several regions submitted minor amendments to the regional plans, but these amendments were very limited in scope and once these amendments were approved, no further activity occurred. The perception in these regions appears to be that regional committees were formed only to produce regional plans. Because, in these cases, very few comments were received regarding the regional plans after their approval, the regions could not justify continuing the regional committees process.

C.9 Summary of the Regional Planning Process

The policies and technical standards proposed in the National Plan represent a new scheme by which the FCC could manage the newly allocated 800 MHz spectrum for use by the public safety community. By empowering regions throughout the country, the FCC involved state and local public safety entities in the spectrum management process. Many of the comments and suggestions proposed by the public safety community were used in developing the regulations that comprised the National Plan.

The National Plan became the template for each regional committee to use in developing their own regional spectrum management plan. These regional committees were required to adhere to the high-level requirements proposed in the National Plan but were given the freedom to determine system-specific requirements to meet local needs within a region. Regional committees acted as local extensions of the FCC in that each committee developed its own spectrum management plan and was tasked to ensure that this plan was carried out. The FCC acted as the oversight body of the entire process.

However, after the development and approval of a region's plan, the regional committees typically disbanded or became inactive. This level of inactivity tended to undermine the general feeling of the National Plan's success. Those committees that became inactive were not overseeing the local management process they had developed and proposed in the regional plan. Therefore, it appears regional committees were formed merely to develop a regional plan so the region would be granted licenses to operate in the newly allocated spectrum band. Thus, the actual goals of most regional committees may have undermined the entire National Plan process. This process, however, focused national attention on the inherent problems with the public safety

community's communications system and the spectrum management process used to govern the assignment of these frequencies.

APPENDIX D
SYSTEM PLANNER AND USER PERSPECTIVES

The 800 MHz Study assesses the relative merits of 800 MHz as an operating frequency band for public safety wireless communications and the extent to which 800 MHz operations has affected interoperability among systems at all levels of government. A requisite component of the assessment is cataloging the views and opinions of public safety officials who have contributed, at some level, to installing or operating an 800 MHz system. Additional valuable data were also obtained from public safety officials who have chosen to upgrade their public safety networks using systems at frequencies other than 800 MHz. The goal of Appendix D, System Planner and User Perspectives, is to understand, at a functional level, how 800 MHz systems have either improved or hindered interoperability, and how satisfied or dissatisfied users are with operations, system costs, and assignment and management of additional spectrum allocations.

Maintaining objectivity was as important as the information itself. Efforts were made attempting to obtain and include as many views as possible within the relatively short 3-month study period. Our objectives for this part of the study were to contact public safety officials, interview them about their current and planned land mobile radio (LMR) systems, and provide their comments and responses in an objective manner. Those efforts were achieved by the following –

- Creating a set of interview questions
- Compiling a list of possible interview participants
- Conducting six face-to-face interviews with several local public safety officials
- Conducting 22 telephone interviews with state and local public safety officials nationwide.

This "perspectives" portion of the 800 MHz Study is a *qualitative* assessment of public safety usage of 800 MHz spectrum. The data sample size is very small when compared with the entire public safety community. The interviewees responses, while germane, are indicative only of their individual thoughts and opinions concerning the specific questions asked during 1– to 2– hour interview sessions. The views of interviewees were their own and do not necessarily reflect the opinions of the public safety community as a whole or the city, county, or state government by which they are employed. The charts and percentages shown in the following sections are designed to show relative responses of the 28 participants. The study includes an adequate representation from a balanced group of participants in hopes that the concerns of most eligible public safety entities are addressed in the report.

Because of the short time frame available for interviews, certain biases were introduced into the study process. The first is the preponderance of participants in the Washington, DC, metropolitan area cities and counties. Over 20 percent of the participants were from this area of the country. Secondly, representation of non-800 MHz systems is limited to statewide systems.

Finally, only a small number of statewide systems were surveyed, and of those, few were considering 800 MHz systems. These biases prevent detailed analysis and may influence any conclusions about the entire nation. However, they do not prevent constructing a reasonable composite view of the effectiveness of 800 MHz systems from the data that have been collected.

D.1 Approach

The approach for this part of the study was to interview 800 MHz and non-800 MHz system planners and users about several issues relating to spectrum around 800 MHz as an operating frequency band for public safety.

D.1.1 Formulating Questions

A discussion guide was developed to ask general and specific questions important to understanding public safety's use of 800 MHz systems (i.e., operational impacts, system cost implications, optimal applications, and improvements to interoperability). A set of issues and questions was identified at the outset of the study and the following questions provided a basis from which the discussion guides were developed:

- What were the drivers for the decision to move to 800 MHz? Why 800 MHz?
- What is the effect on operations, coverage, and system costs?
- Assuming available spectrum, would agencies have remained in the very high frequency (VHF) or ultra high frequency (UHF) bands? Why?
- What effect did the switch to 800 MHz systems have on intra- or inter-jurisdiction interoperability?
- Has the migration to 800 MHz removed one of the barriers (i.e., spectrum) to achieving intra- or inter-jurisdiction interoperability?
- Are there other barriers to achieving intra- or inter-jurisdictional interoperability in the 800 MHz band? If so, what are they?
- How many radio channels were released with the migration to 800 MHz? From what portion of the spectrum? Was there a spectrum allocation plan? How was it structured? Why was the spectrum plan structured in this manner?
- Were radio channels from other parts of the spectrum retained? If so, from what part? Why were they retained?
- Are state and local governments assigning additional channels and talkgroups for intra- or interoperability? If so, how many? Why?

- Under what conditions is 800 MHz 'optimal' for public safety? Under what conditions is a different available band (e.g., UHF, VHF) 'optimal'?

- To what extent are the 800 MHz systems trunked systems? Conventional systems?

- Are trunked systems the preferred technology for public safety applications?

- Did or will 800 MHz systems cost more or less than the current systems in use? If so, what is the reason for the cost difference?

- Is 800 MHz right for public safety?

D.1.2 Obtaining Participation

Identifying possible participants was the first step in the interview process. The search for participants began through extensive use of available resources such as various industry-related documents, the World Wide Web, and database search engines (e.g., Lexis-Nexis and Proquest). The search enabled the acquisition of information on the implementation and purchase of 800 MHz communications systems by public safety entities. Using these data, a comprehensive list of possible interview participants was created.

Parallel to this process the Public Safety Wireless Network (PSWN) Program distributed a Participation Questionnaire to the public safety community. This questionnaire attempted to identify members of the public safety community willing to volunteer their time to participate in PSWN studies. When an analysis of the previously identified areas of interest and the responses received from the PSWN Participation Questionnaire was conducted, it became apparent that certain areas overlapped. Given the limited time frame for the study, the PSWN Participation Questionnaire respondents comprised the majority for 800 MHz study participants. A complete listing of agencies involved in the interviewing process of this study is included in the acknowledgements section of this report.

D.1.3 Measuring Balance

A critical element of the interview process was to survey a diversity of planners and users. This approach provided the most accurate view of all the variations and nuances that system planners and users face when considering upgrades to their radio systems. The interviewees were selected from a variety of categories primarily focusing on geographic dispersion, demographic dispersion, terrain, and system size and type. Figures D-1, D-2, and D-3 show a comprehensive view of the type of participant balance obtained statewide and locally. The remainder of the section analyzes these major categories to achieve the type of balance that was desired.

	Population (in Millions)			Square Mileage (in Thous.)			Terrain					Forestry			System						Vendor				
	10+	5-10	0-5	100+	50-100	0-50	Coast	Plains/ Flat	Rolling Hills	Mid - Mts.	Rocky Mts.	Barren	Deciduous Forest	Coniferous Forest	800 MHz	Other MHz	Analog	Digital	Trunked	Conv.	Motorola	Ericsson	EF Johnson	Lease	RFP
ska			●	●			●	●			●	●		●	●										
fornia	●			●			●	●			●	●		●		●	●			●					
orado			●	●				●			●	●		●	●			●	●		●				
ois	●				●			●	●			●	●												
a			●		●			●	●			●	●			●	●			●					
sas			●		●			●	●			●	●		●		●		●	●	●				
ntana			●	●				●			●	●		●		●		●	●						
State Patrol	●				●		●		●	●			●	●		●	●			●	●				
o	●				●			●	●				●												●
nsylvania	●					●			●	●			●	●	●				●						
th Carolina			●			●	●		●	●			●		●		●	●	●		●				
a			●		●			●			●	●		●											
State Patrol		●				●	●		●	●			●			●			●						
shington		●			●		●		●		●	●	●	●	●								●		
consin		●			●			●	●				●			●		●	●			●			

Figure D-1
Statewide System: Balance Matrix

	State	Population (in thousands)			Square Mileage			Terrain					Forestry			System						Vendor			
		500+	100-500	0-100	150+	75-150	0-75	Coast	Plains/ Flat	Rolling Hills	Mid - Mts.	Rocky Mts.	Barren	Deciduous Forest	Coniferous Forest	800 MHz	Other MHz	Analog	Digital	Trunked	Conv.	Motorola	Ericsson	EF Johnson	Lease
' York City	NY	●			●			●		●				●		●			●	●			●		
olk Co.	NY	●			●			●		●				●		●			●	●		●			
ıtgomery Co.	MD	●			●					●				●		●			●	●					
ce George's Co.	MD	●			●					●				●		●	●	●		●	●		●		
candria	VA		●				●	●		●				●		●			●	●		●			
ngton	VA		●				●			●				●		●			●	●		●			
ce William Co.	VA				●					●				●		●			●	●					
ngsville	OH															●		●			●		●		
ver, City of	CO								●	●			●			●		●		●			●		
ada	CO		●						●	●			●			●							●		
nge County	CA	●			●			●				●	●			●									
g County	WA	●			●			●		●	●			●	●	●	●	●		●		●		●	
kamas County	OR				●					●		●		●	●		●	●			●	●			
as	TX	●							●				●	●											
Worth, City of	TX				●				●				●	●		●		●		●		●			

Figure D-2
Local System: Balance Matrix

	State	Population (in thousands)			Square Mileage			Terrain					Forestry			System						Vendor			
		500+	100-500	0-100	150+	75-150	0-75	Coast	Plains/ Flat	Rolling Hills	Mid - Mts.	Rocky Mts.	Barren	Deciduous Forest	Coniferous Forest	800 MHz	Other MHz	Analog	Digital	Trunked	Conv.	Motorola	Ericsson	EF Johnson	Lease
ta	GA		●		●					●				●		●									
n County	NJ																								
ge Station, City	TX															●		●		●		●			
n County	NC																●	●			●				
on	TX	●			●				●				●	●											
Moines	IA		●			●			●	●				●		●			●				●		
	MO															●		●		●		●			
on	KS																●				●				
s City	MO															●		●	●	●			●		
Orleans	LA		●		●			●	●					●											
orage	AK		●		●								●		●	●				●					
-Phoenix	AZ	●			●				●				●			●	●	●			●				
ose	CA	●			●			●		●				●											

Figure D-3
Local System: Balance Matrix

Geographic Dispersion. The first critical factor in achieving balance was obtaining adequate samples of respondents nationwide. In such a large and diverse country, this factor is important because different geographic areas experience varying environmental conditions such as weather, terrain, and foliage, which can affect the propagation of radio waves, influencing their view of 800 MHz systems. Additionally, various political dynamics in different areas contribute to public safety entities opinions of 800 MHz systems.

Demographic Dispersion. A second important factor in achieving balance was interviewing in areas with varying population and square mileage to cover. Population is directly related to system size and the complexity of the public safety mission. For statewide systems, the interviews surveyed areas in three population categories:

- Greater than 10 million people
- Between 5 and 10 million people
- Below 5 million people.

For local and county systems, the population areas were also divided into three groups:

- Greater than 500,000
- Between 100,000 and 500,000
- Less than 100,000.

The coverage area of the system is also an important factor in measuring balance. The interviewees were selected from several different size coverage areas because this factor dramatically affects not only the system architecture but also system costs. Again, the three distinct categories for size of states were as follows:

- Greater than 100,000 square miles
- Between 50,000 and 100,000 square miles
- Less than 50,000 square miles.

For local and county entities, coverage requirements were categorized as follows:

- Greater than 150 square miles
- Between 75 and 150 square miles
- Fewer than 75 square miles.

Terrain. Terrain can affect signal propagation and drive, in part, the selected frequency band of systems installed. It was important to interview participants located in a variety of terrain to understand their views on which systems perform better in specific environments. The terrain for state and local systems was divided into five distinct categories:

- Coastal
- Plains/flatlands

- Rolling hills
- Mid-mountain regions (such as Appalachian sized mountains)
- Rocky Mountain regions.

Additionally, forestation is an important factor in terrain. Deciduous and coniferous trees have different effects on various radio signals. These effects make it extremely important to capture responses from areas with varying forestation. For both state and local systems, forestation was divided into three categories: barren, deciduous forest, and coniferous forest.

System Dynamics. A final critical factor used to measure the balance of the interviews was system dynamics. It is important to obtain a good cross section of statewide systems and local systems. Because of the high concentration of public safety services and systems at the local level, it was deemed reasonable to interview more people at the local level than at the state level.

To understand 800 MHz system issues, it is critical to have representative input from both "general service" 800 MHz systems and National Public Safety Planning Advisory Committee (NPSPAC) 800 MHz systems. It is also important to understand the issues of public safety systems operating in various bands and the reasons certain system designers did not choose to move to 800 MHz. The interviewees represent members from each of these categories as well as those who are operating on lower band systems but are in the process of migrating to 800 MHz systems.

Vendors. One added factor at the system level is the use of different equipment vendors. It was critical to identify and question users of a variety of vendor equipment. The category was divided into the three major radio system vendors: Motorola, Ericsson, and E.F. Johnson. The team attempted to include systems for each of these vendors. In some instances, systems could not be categorized by vendor in this way. In these cases, most systems were in one of two situations: either the system is the subject of an active solicitation and the vendor is not yet known, or the system or its service is leased from a commercial service provider.

D.1.4 Conducting Interviews

An interview guide was developed to assure that each interview was conducted in a similar fashion. As discussed earlier, this guide contained a series of questions developed to focus interviews on the issues that the 800 MHz Study was trying to examine. Although the interview guide was used to direct the flow of conversation, interviewees generally provided additional information on a variety of topics.

Face-to-Face Interviews. Six interviews were conducted in the Washington, DC, area. Because of the proximity of Washington, DC metropolitan area public safety entities, six interviews were conducted in person. Each interview consisted of two to three Booz·Allen staff who interviewed representatives from local city and county public safety entities.

Phone Interviews. The remaining 22 interviews were conducted via telephone. These phone interviews occurred at scheduled times and averaged 1 hour in length. Each phone interview

consisted of two to three Booz·Allen staff who interviewed representatives from various public safety entities nationwide.

D.1.5 Analyzing Responses

Once the interviews were completed, it was imperative to develop efficient mechanisms for analyzing the collected data. Two strategies were implemented to capture the unique responses from each interview, interview notes and an interview comparison matrix. The following paragraphs briefly describe these tools and the methods of assuring accuracy of analysis.

Interview Notes. After the interviews were completed, the responses were collated into interview packets. The interview team double-checked the results for accuracy and then used those results for analysis. The interview notes were used as the major repository of unique comments captured from the interviews as well as a means to effectively relay the discussion to team members who could not attend an interview.

Interview Comparison Matrix. The interview criteria matrix tool was used to compare and contrast all interview responses. Common answers were compared using a matrix format that allowed for all responses to be placed side by side to assess similarities and differences. The tool compared the responses of planned systems to implemented systems, 800 MHz systems to non-800 MHz systems, as well as responses from regional, state, county, and local interviewees. These divisions helped display specific trends across the various categories.

D.2 Overview of Perspectives

The previous sections outlined the process that was followed to capture and analyze perspectives of system planners and users. In the following sections, this analysis is more formally structured into three sections. The first deals with the perspectives regarding the regional planning process. This section provides discussion points concerning the effectiveness of the regional planning process employed for the allocation of the 821–824/866–869 MHz band. The second section chronicles many of the suggestions system planners and users cited as possible improvements to the regional planning process. The third section deals with technical issues of concern to those migrating to 800 MHz systems. This section covers issues such as spectrum usage, interoperability, coverage, vendor technology, as well as several other topics of interest.

D.3 Planning Process Perspectives

Several interview guide questions concerned the national planning and regional planning processes. The following sections discuss the interview participants' responses to these questions.

D.3.1 Regional Planning Effectiveness

To evaluate the effectiveness of the planning process established by the National Plan, participants were asked to rate their regional plan as a tool for achieving systems interoperability. Four ratings were given: very effective, effective, minimally effective, or unused. Figure D-4 illustrates the responses of the participants.

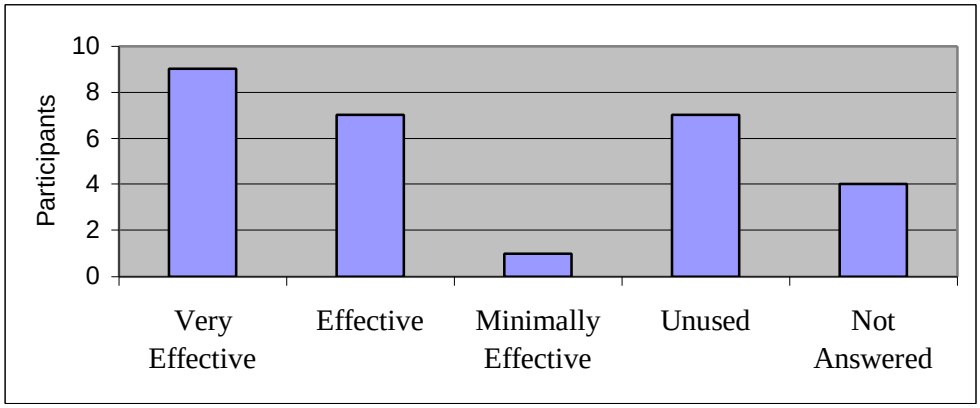

Figure D-4
Rated Effectiveness of Regional Plans

Very Effective. Participants who selected this rating thought that regional plans were very effective in meeting the spectrum needs of all affected public safety entities. The interview participants noted several common attributes associated with an effective regional plan despite their dissimilar system requirements. The following interview excerpts identify common attributes of an effective regional plan:

- The regional plan worked well because it envisioned solving the problems of the public safety community. As a tool for promoting interoperability at the national and regional levels, the regional plans acknowledged the urgency of addressing and solving the problems of public safety communications.

- A NPSPAC frequency user stated that because of the lack of available general pool channels, many frequency-starved areas found spectrum relief by obtaining frequencies through the regional planning process.

- The regional planning committee worked well as the "gatekeeper" of frequencies. Meeting continuously throughout the months, the regional planning committees overcame parochial needs to fairly assign frequencies in their regions.

- A user indicated that the influence of the Council of Governments (COG) in their region greatly increased the effectiveness of the corresponding regional plan. Because COG actively addressed public safety issues in this area, a strong working relationship with all local jurisdictions had already been established. This relationship facilitated

efforts among the region's public safety entities to address the issues plaguing public safety communications systems.

- One participant stated that developing the regional plan was virtually painless. The template[1] sufficiently addressed all topics and streamlined the entire process allowing the region to quickly and thoroughly complete the regional plan and submit it for approval.

Effective. Although some participants were pleased with the effectiveness of the regional plans, others were reluctant to claim the regional plans were very effective. Many participants stated the idea of the plans are "sound" but were critical of plan implementation. The following interview excerpts identify some of the flaws in the implementation of the planning process:

- A regional planning committee member in a highly congested area stated most regional planning committee participants came mainly from large jurisdictions with many users. The interviewee indicated certain public safety entities are under- represented on the regional committees[2] and 75 percent of the public safety agencies located in the region are composed of fewer than 25 officers and therefore were not involved. The unbalanced participation between large and small public safety entities demonstrates that although some areas benefit from the planning process, others do not.

- Another participant stated that although the regional plan was an effective planning tool, it has not improved interoperability, nor will it in the next 3 to 5 years. This participant claimed that the plans address only immediate communications needs and fail to address long-term issues.

Minimally Effective and Unused. This grouping consisted of three displeased 800 MHz users and all of the non-800 MHz users. These participants believed that in each case, the plans ineffectively addressed the needs of affected agencies. The following comments depict reasons the plan was viewed as minimally effective or unused:

- A participant stated the regional planning committee was ineffective because of its inability to reassign unused spectrum to more frequency "starved" areas within the region.

- A state agency participant thought the plans responded only to the voice of local entities and limited the involvement of state entities. The participant indicated that local groups working on these problems focused on immediate spectrum relief only and not on long-term improvements such as interoperability.

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1 The Association of Public-Safety Communications Officials International, Inc. (APCO) created a standardized regional plan to expedite the regional planning process. The standard plan was used by a significant number of the 55 regions.

2 To meet public safety communications needs, the National Plan mandates regional planning committee memberships be open to representatives from all eligible public safety user groups, including governmental and non-governmental. Although participation is required, the FCC made no efforts to assure that robust participation was achieved.

- A common complaint is the involvement, both past and current, of regional planning committees. Although the committees still exist, many have had no substantial actions or have been rendered inactive.

D.3.2 User Recommendations To Improve the Planning Process

Participants were asked to make suggestions on how to improve the effectiveness of the national and regional planning process. Regardless of their level of support for the planning process, participants were quick to make suggestions. The ideas presented below are not necessarily opinions of all participants but reflect both common and unique themes stated throughout the span of all the interviews:

- Most participants stated involvement of the public safety community is essential to the planning process. The participation of all affected entities (local, state, and federal) is imperative to achieve common goals within the public safety community. Based on survey results, if one were to create an ideal committee, it would include a complete representation of federal, state, county, and city participants.

- Another common suggestion was to identify a significant source of funding for support of the regional planning committees. Advocates of funding believe that financial support will promote the involvement of many local entities that previously could not afford travel expenses. These funds would also pay for reproduction costs, postage, and other miscellaneous items.

- Approximately one-half of the participants criticized the FCC's ineffectiveness in dealing with regional needs. Examples of the problems included the slow response to pending decisions and regional disputes. The participants suggested that the FCC define more specific rules and guidelines at the national and regional levels as well as expeditiously address and resolve any regional issues that arise.

- Many participants advocated the idea of a neutral oversight committee. This committee was described as a limited policy-making authority, composed of technical and political representatives from various levels of government, strictly facilitating discussions and overseeing action toward reaching a common national goal. Another possible role for such a committee was portrayed as a coordinator between federal and non-federal resources. For example, the coordinator could identify unused federal resources for potential public safety use.

- Several participants stated inter-regional coordination needed further attention. Whether through the FCC, a neutral oversight committee, or another entity, increased coordination among regions must improve to achieve efficient inter-regional communications.

- Two participants claimed the biggest improvement to the process would be to make the APCO/CET frequency-sorting program[3] more realistic and catered to specific geographies and needs.

D.4 Technical Issues Perspectives

Several questions contained in the interview guide concerned the technical aspects of 800 MHz systems as understood by the system planners and users. The following sections discuss the interview participants' responses to these questions.

D.4.1 Spectrum Usage

Throughout the Nation, public safety radio communications reside in multiple frequency bands within VHF, low-band UHF, and 800 MHz. Members of the public safety community have varying opinions about which frequency band best suits their communications needs. Table D-1 shows that although some agencies are migrating or planing to migrate to 800 MHz as an operating frequency band, others have chosen to remain at VHF and other UHF frequency bands. Therefore, to assess the relative merits of 800 MHz as an operating frequency band, it is necessary to consider the reasons for operating at frequencies within the VHF, UHF, or 800 MHz frequency bands. This section highlights responses demonstrating the merits of these different frequency bands.

Table D-1
Interviewee Operating Frequency Bands

Band of Operation	Number of Agencies*
VHF	4
UHF	2
800 MHz	24
*Includes implemented and planned systems	

VHF. The reasons that the VHF band is still considered viable spectrum for public safety are threefold: the significant amount of embedded infrastructure at VHF, the advantages of low-frequency propagation characteristics, and the newly realized ability to trunk at VHF. Most, if not all, participants who stated that VHF was the ideal band were currently operating in that band and had decided not to move, or were hesitant about their upcoming move to 800 MHz. These same participants also tended to advocate a specific means for determining the usage on government and military frequencies in that range, and if frequencies were found unused, establishing a quick mechanism to reallocate them to public safety. The following excerpts present opinions on why some feel VHF best suits public safety communications.

[3] The APCO/CET frequency packing program assigns frequencies to specific public safety eligibles and to pools for future assignments. This program is designed to result in a high degree of spectrum efficiency and low probabilities of interference. Analysis of the regional plans indicates that 84% of the regional planning committees used this program to assign frequency.

- An administrator from a large western state indicated the state would stay in the VHF range because trunking and digital capabilities are available in this band[4], allowing nearly all the same features of an 800 MHz system.

- Many agencies have a significant embedded infrastructure that meets the needs of the agencies' specified mission. To move bands, they would have to engineer the new systems to be backward compatible with existing systems. Because the existing systems are deeply embedded, there is no compelling reason to move.

- A representative of a large state police agency suggested that the optimal frequency would be wherever the military operates because "chances are they use all of the good frequencies." The participant continued by stating that the worst public safety spectrum would be in the frequencies where no one is licensed, such as around 800 MHz.

Low-Band UHF. To some, low-band UHF is seen as the best compromise among all public safety spectrum. Although several interviewees identified this band as the optimal spectrum for public safety, few interviewees gave any details or compelling support for use of this spectrum. The following responses capture the benefits of the UHF band.

- A system manager of a large county stated the county currently operates on UHF T-band channels (470-512 MHz). These T-band channels suit public safety communications because only 13 of the largest metropolitan areas across the nation were granted licenses on these channels.[5] Because there are few licensees, channel interference on the T-band channels is less than the interference present at other frequency bands. In general, channel interference is correlated to spectrum traffic capacity. As traffic on the public safety spectrum increases, channel interference also increases.

- In many markets, only 3 to 10 broadcast television channels are being used, leaving several allocated channels unused. These unused channels are located in the UHF band near current public safety frequencies. If available, these channels would be prime spectrum for public safety use, offering many systems planners a powerful reason not to migrate to 800 MHz.

800 MHz. The lack of spectrum in VHF and low-band UHF, coupled with the availability of spectrum designated for public safety use in the 800 MHz band was commonly cited as a reason driving public safety communications to the 800 MHz band. Many participants claimed that over the past several years, radio communications traffic has grown faster than expected. Because

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[4] On February 20, 1997, the FCC adopted *Second Report and Order* (FCC 97-61), allowing centralized trunking in the 150-174 MHz, 421-430 MHz, 450-470 MHz, and 470-512 MHz frequency ranges. The *R&O* was implemented on October 17, 1997.

[5] T-Band channels can only be used in 11 of these 13 areas. Cleveland, OH and Detroit, MI have active licenses but are not allowed to use the channels until further notice from the FCC.

current radio systems were not originally designed to support the unexpected surge in public safety radio communications, many systems have become overcrowded and overloaded.

Regardless of the system size or geographic location, a majority of interviewees indicated spectrum-related issues such as interference and availability factors affected their decisions to migrate to 800 MHz. The following excerpts from interview participants give unique insight into the impact of spectrum availability on the migration to 800 MHz.

- A state radio planner was trying to expand his system in the VHF range, however, because of heavy congestion in the state's most densely populated corridor, the planner was unable to obtain additional VHF frequencies. After a failed attempt to develop a new frequency plan, the state decided to pursue an 800 MHz system.

- A county communications director, whose jurisdiction is adjacent to a major metropolitan area, was extremely critical of the 800 MHz band, specifically because of the propagation effects through areas of dense foliage. Although the frequency band is not optimal for use in this area, the agency is still planning to migrate to 800 MHz because it is available.

- A county radio manager whose operational jurisdiction borders Canada expressed concern about the lack of spectrum in any band. Treaties force the county to split frequency assignments with jurisdictions across the border. To alleviate the frequency crunch, the county is choosing to move to an 800 MHz system. Although frequencies will still have to be shared, interference problems will be lessened as a result of the reduced radio traffic in the 800 MHz bands.

Vacated Channels. The availability of frequencies to support the needs of public safety communications is a constant concern of public safety officials. As previously mentioned, the availability of spectrum to expand current radio systems in VHF and low-band UHF is scarce. To alleviate the spectrum congestion in the lower bands, the FCC included a provision within the *Report and Order in the Matter of Development and Implementation of a Public Safety National Plan and Amendment of Part 90 to Establish Service Rules and Technical Standards for Use of the 821-824/866-869 MHz Bands by the Public Safety Services (National Plan R&O)* of the National Plan to address the issue. Public safety radio system managers who migrate to the 800 MHz bands via the national planning process and operate on the NPSPAC channels are required by the National Plan, with some exceptions, to release their vacated frequencies for reassignment. This begs the question: are public safety entities complying with this provision and returning frequencies? If not, how are the vacated frequencies being used? To begin to answer these questions, the interview participants were asked two questions:

- What happened to the frequencies at which you were previously operating?
- Are you still using this spectrum?

Respondents fell into three categories: agencies that gave back all previously used frequencies, agencies that gave back some previously used frequencies, and agencies that did not give back any previously used frequencies. These categories are provided in Table D-2.

Table D-2
Frequency "Give Back" Activity

Amount of Frequencies Given Back	Percentage of Agencies (%)
All	18
Some	54
None	7
Unanswered	21

Agencies that claim to have given or plan to give back all previous operating frequencies thought that the new 800 MHz systems would sufficiently support their communications needs. For these respondents, available frequencies are plentiful, eliminating any need to retain frequencies for additional use. The following examples of comments depict the willingness of these entities to return their frequencies to the Commission:

- A system administrator operating on the general service channels indicated that his agency is attempting to give back its old frequencies, but nobody in the area really needs or wants them.

- A director of communications whose radio system is migrating to the NPSPAC channels stated that after the migration is complete, all agencies will be operating on one system and no additional channels will be needed. Therefore, the frequencies will be given back as mandated by the National Plan.

A majority of 800 MHz users have given back some of their previously used frequencies to the Commission but continue to use the remainder. Because these systems are located in highly congested and frequency-starved areas, the retention of some frequencies is necessary to support the growing need for public safety communications. For NPSPAC frequency users, the lack of available new spectrum has meant retaining previously used frequencies instead of abiding by the provision within the National Plan mandating the return of previously used frequencies. Because of the need for additional channels, both general pool and NPSPAC system users generally continue to use their retained frequencies. The following excerpts convey participants' reasoning concerning retaining previously used frequencies and the uses that these retained frequencies serve:

- A system manager of a large city's congested communications system operating on general pool frequencies stated that all but five previously used VHF channels had been returned to the FCC. The other channels were retained to support the increasing needs of public safety communications and were split among fire, law enforcement, and local mutual aid.

- A manager of a large, frequency-starved county migrating to the 800 MHz band indicated that because not enough channels are available in the NPSPAC band, current operating channels will be retained for data communications.

- Other NPSPAC system users stated that to remain interoperable with adjacent public safety entities using non-800 MHz frequencies, a few frequencies were kept for mutual aid communications.

Few participants retained all previous channels. In each case, the respondents stated that these channels were being reserved to support future needs of public safety communications. The following comment eloquently states the reasoning behind retaining all previously used frequencies:

- Two managers of congested county communications systems stated that because they are operating on the general pool channels, the counties have no obligation to give previously used frequencies back. As a result, both areas are holding their previously used frequencies for future purposes.

D.4.2 Interoperability

Interoperability of radio communications systems is a critical issue within the public safety community and the primary concern of the PSWN Program. Because of the importance of this issue, a series of questions were developed to ask system users and planners to address the extent to which 800 MHz systems have affected the interoperability issue. The questions are divided into two distinct sections: "Achieving Interoperability," which addresses how interoperability is accomplished as entities migrate to 800 MHz systems, and "Influencing Interoperability," which addresses the factors affecting interoperability (both positively and negatively).

Achieving Interoperability. During the interviews, respondents discussed how interoperability was achieved before implementation of the new 800 MHz systems. Most reported that there was either limited or no interoperability among entities within their jurisdictions. The majority stated that police and fire departments operated on separate systems and achieved interoperability through the exchange of spare radios. Interoperability with adjacent jurisdictions and federal or state agencies was also realized through radio swapping. In some instances, though, jurisdictions did use a radio console patching capability that allowed a limited talk capability between agencies.

Table D-3 depicts the different methods by which public safety agencies achieved interoperability following the implementation of 800 MHz systems. Many of the respondents using 800 MHz trunked systems indicated that they achieved intra-jurisdictional interoperability by using dedicated or as-needed mutual aid talk groups. If adjacent jurisdictions are also using 800 MHz trunked systems, inter-jurisdictional interoperability is also achieved using talk groups. Those entities that use 800 MHz conventional systems or non-800 MHz systems generally achieve interoperability through cross patching, radio swapping, and the localized use of mutual aid channels. Interoperability with federal entities continues to be achieved mainly by radio swapping. Several respondents stated that the Federal Government has provided no guidance on

interoperability requirements; therefore, respondents continue to purchase systems that work well for their jurisdictions and have not focused on interoperability with federal entities.

Table D-3
Common Methods for Local Agencies To Achieve Interoperability

Method	With Agencies in Own Jurisdiction	With Agencies in Adjacent Jurisdictions	With Federal Agencies
Common Talk groups	√	√	
NPSPAC Mutual Aid		√	
Cross-Patching	√	√	
Phone			
Voice Through Dispatch		√	
Radio Swapping	√	√	√
Monitor Other Frequencies	√	√	√
State and Local Mutual Aid Channels	√	√	√

The following comments offer insight into the different ways jurisdictions achieve interoperable communications:

- A radio manager from a small city indicated that the city has a dedicated talk group for interoperable communications. A cross-connection links this dedicated talk group to the county sheriff's VHF channel.

- An administrator of a small metropolitan county stated that, as a part of the county's system procurement, spare radios were purchased to issue to federal agencies such as the Federal Bureau of Investigation (FBI) and Drug Enforcement Administration (DEA) on an as–needed basis.

- A system planner of a large county indicated that the county interoperates with adjacent jurisdictions through a multi-channel local mutual aid system.

- A city representative commented that the local low-band UHF mutual aid channel was very effective, and the city had no plan to vacate its use.

Influencing Interoperability. Using 800 MHz does not inherently improve interoperability. There are, however, capabilities routinely and predominantly found and implemented at 800 MHz that have had an influence on interoperability. The use of trunking technology, and the availability and use of the NPSPAC mutual aid channels at 800 MHz, have had significant effects on interoperability. These effects, both positive and negative, are discussed below.

Interoperability Improvements Created by the Use of Trunking Technology. The primary benefit of trunking technology is that it allows reuse of spectrum resulting in a spectrally efficient system.

In addition to providing improved spectral efficiency, trunking technology allows the development of talk groups. Such talk groups provide virtual independent networks for specific user groups and a means for intra- and inter-jurisdictional communications that was previously unavailable. Overall, interoperability has improved with the implementation of 800 MHz trunked systems. The following reflections provide evidence of the positive effects of trunking on interoperability:

- One county representative stated that improvements in interoperability were related not so much to the move to 800 MHz but to the technological and operational improvements offered by trunking, which is a readily available system architecture option at 800 MHz.

- A city communications director consolidated 27 individual radio systems into a single 800 MHz trunked system, which led to improvements in intra-jurisdictional interoperability, reliability, coverage, and operations.

- A radio manager of a suburban area indicated the decisions to implement an 800 MHz system and to select a specific vendor were influenced significantly by the systems and vendor decisions that had been made in the neighboring jurisdictions of the metropolitan area. The radio manager indicated the suburban area wanted to maximize the degree of interoperability with its nearest neighbors and made system design and vendor decisions accordingly.

- A communications manager for a smaller city, whose jurisdiction is adjacent to larger counties, selected 800 MHz primarily because the larger counties had successfully tested and implemented an 800 MHz system, and the smaller city wanted to "piggyback" off the larger system to achieve interoperability.

Interoperability Impairments Created by the Use of Trunking Technology. From the interviews, the greatest impairment to interoperability appears to be incompatibility with neighboring jurisdictions. Participants stated that different vendor trunking technologies lead to incompatibility among 800 MHz trunked systems, which diminishes interoperability. In most cases, respondents said that the absence of a technical standard for trunking technology has had an adverse effect on interoperability.[6] The following comment provides insight into this problematic issue:

- A metropolitan area had significant interoperability problems because half of the cities and counties had chosen the equipment of one of the major vendors, while the remaining cities and counties had primarily selected the products of other vendors. In some cases, cities had chosen different vendors than the counties in which those cities were located, resulting in incompatible systems and further impediments to interoperability.

[6] Each major LMR vendor has its own signal processing scheme for implementing trunked networks.

Interoperability Improvements Created by the Use of the NPSPAC Mutual Aid Channels. In addition to trunking, the five NPSPAC mutual aid channels have added another means for achieving interoperable communications. The NPSPAC regional plans contain guidelines for the operational use of the five NPSPAC mutual aid channels, which have been allocated specifically to promote public safety interoperability. The extent to which these mutual aid channels have enabled interoperability is a function of how effective the respective regional plans were in laying out a governing framework and how diligent system implementers have been in building out the mutual aid capability.

As a measure of the impact that the regional plans have had on facilitating interoperability, participants were asked to comment on their familiarity with the NPSPAC mutual aid channels and their role, if applicable. None of the survey respondents were able to seamlessly interoperate with federal agencies on the NPSPAC mutual aid channels. They said that federal radios do not operate in the 800 MHz range and were therefore incompatible with their systems. Interoperability with federal users was achieved by swapping radios. The following are reflections regarding the use of the NPSPAC mutual aid channels on implemented 800 MHz systems:

- One county planner said that the five NPSPAC mutual aid channels are used as specified by the National Plan. The county follows the established procedures set by the regional plan, and interagency communication has been effectively accomplished during disaster situations.

- A respondent indicated that because of different vendor trunking technologies deployed in adjacent jurisdictions, the conventional NPSPAC mutual aid channels are the only means of interoperability. Because all efforts to patch together differing systems have failed, there is extensive use of the NPSPAC mutual aid channels to coordinate efforts among neighboring systems.

- A Washington, DC, respondent indicated that the metropolitan COG has assigned six channels solely for mutual aid by its members in addition to the NPSPAC mutual aid channels. These additional channels are intended to enhance mutual aid efforts throughout the metropolitan area.

Interoperability Impairments Created by the Use of the NPSPAC Mutual Aid Channels. Not all public safety entities capable of using the NPSPAC mutual aid channels have experienced an improvement in interoperability. The following comments address some of the inefficiencies attributed to the NPSPAC mutual aid channels:

- One system planner stated that even though the channels are technically working, operationally they seem nonexistent. He claimed that the NPSPAC mutual aid channels are monitored regularly, but no communications have ever been heard.

- Two respondents stated that although the NPSPAC mutual aid channels are monitored constantly, a call has never occurred on the channels, and the channels have never been used for mutual aid purposes.

- One radio manager of a large city attributed the limited use of these channels to funding issues. This person indicated that implementing the channels within local systems requires additional expensive equipment (e.g., repeaters) for which funding is uncertain or unidentified.

To overcome these impairments, participants planning new 800 MHz systems were projecting the use of the NPSPAC mutual aid channels in the new system. In each case, the participants indicated that plans are under way to use the NPSPAC mutual aid channels to support the increased communications needs between various public safety entities. From this observation, it seems that as the need for interoperability increases, many system planners are now implementing the NPSPAC mutual aid channels within their new systems.

Interoperability Impairments Created by Other Factors. The interviewees identified several other factors that have hampered interoperability. These factors include the following: system incompatibility, lack of spectrum, operational and political issues, and deviation from the regional plan.

In addition to system incompatibility, which was discussed earlier, other problems attributable to operational and political issues were identified. Several respondents stated that "egos" and "turf battles" between departments and jurisdictions were a stumbling block to developing an interoperable system. Differences in operational procedures between fire and police departments have caused splits in systems, deepening the technology barrier with respect to interoperability. Additionally, the move to 800 MHz further segregated an already splintered public safety spectrum. The following comments address these factors identified as impairing interoperability:

- A planner for a large county indicated that "ego" and long-standing personal opinions of managers have led to systems designed along strict jurisdictional boundaries, hampering interoperability.

- An administrator for a large county indicated that he was concerned about a move to 800 MHz in part because the entities moving would lose interoperability with the entities remaining in the VHF band.

D.4.3 Technical Capabilities

Most interviewees expressed concerns regarding the technological capabilities of 800 MHz systems when they were planning the acquisition and implementation of these systems. During the planning and design stages, system managers had serious concern, regarding the performance of the new systems. In retrospect, however, they have realized that many, if not all, of these concerns were unfounded or at least overstated. They now view the technical features of 800 MHz systems as clear benefits and, if they were now back in the planning stages, would view the technical capabilities as a positive driver for selecting an 800 MHz system.

Data Transmission. The ability to realize higher data transmission rates at 800 MHz is one of the attractive technical capabilities mentioned by most participants. Data transmission is needed to support increasing mobile data requirements, or at a minimum, provide entities with an ability to support their own data networks rather than lease from vendors. Many mobile data applications are supported at 800 MHz because of the amount of spectrum available here and because the channel widths have been defined and implemented. The following thoughts provided by interview participants concern the use of data transmission at 800 MHz:

- A police chief in a mid-size city in the process of planning a system indicated that if the city were to implement an 800 MHz trunked system, it could eliminate the monthly $80 to $90 per unit charge for mobile data service.

- A state communications manager indicated the wide bandwidth of channels[7] at 800 MHz allows the state to implement many data applications.

Trunked Technology. Trunking technology allows simultaneous use of several channels within a given system. The computer-controlled system automatically assigns available channels to different talk groups, thereby maximizing the use of the available channels. With more channels available, users are far less likely to experience a channel "not-available" condition. Several respondents stated that their systems almost never experience conditions where all channels are busy. They stated the time saved by not having to wait for a clear channel has increased productivity and greatly improved law enforcement operations.

Trunking technology has greatly increased the channel availability to the users. This, coupled with the development of talk groups for specific user groups, has greatly improved interoperability within jurisdictions. Formerly, the technology was only available in the 800 MHz frequency band. However, in 1997 the FCC adopted FCC 97-61, which allows the use of trunking in lower frequency bands. Therefore, many system planners are assessing the ability to trunk their current VHF or low-band UHF systems rather than migrate to 800 MHz. This indicates strong support for trunking technology and its capabilities.

Perspectives of Trunking Technology. From interview results, the use of trunked 800 MHz systems seems widespread throughout the Nation. Of all the respondents who have moved to or planning to move to 800 MHz, all but two claimed to be using a trunked system. Among the reasons for trunking are that it allows for better and more efficient use of channels, enables operational efficiencies, decreases access times to open channels, and encourages greater integration among systems. Radio communications systems developers are realizing the utility of shared resource schemes such as channel trunking. The benefits they are realizing are analogous to those gained by public switched network managers after they began building access lines into trunked cables and started offering "bandwidth on demand" virtual circuits between points on a network.

[7] The NPSPAC channels allow a 25 kHz channel bandwidth. The FCC has adopted regulations that impose narrowband channel requirements on public safety radio equipment for bands below 512 MHz. These regulations apply only to new equipment, not legacy equipment.

Among participants with implemented 800 MHz systems, there was a nearly unanimous view that trunking was the preferred technology. Only a small percentage disagreed, taking the more cautious approach that trunking preferences primarily depend on agency or area specific requirements. The following comments reflect some common thoughts on trunking preferences:

- A system administrator indicated that trunking is a smart design choice irrespective of system size.

- Another administrator said trunking is also preferable for jurisdictions seeking to reduce costs by merging different operations and still meet the mission of each agency.

- One agency representative felt that if enough frequencies were available, the agency would stay conventional; however, a trunked system would be implemented to stretch spectrum resources through channel reuse.

- One radio system planner indicated that trunking is preferable but significant planning and coverage testing is required before implementation to ensure proper configuration of the trunked system.

Included in the discussion of trunking technology was the idea of regulating trunked systems for public safety communications systems. Most people, including radio system planners, were leery of any government regulation. Radio systems have a wide variety of qualities: geography, weather, forestation, system size, coverage area, and radio service mission. Because all of these qualities contribute to defining the essential characteristics of a radio system, it would be very difficult to develop one all-encompassing standard for trunking regulations. Many differing opinions were stated, but two main issues were discussed in regard to government regulation of trunking: regulated trunking requirements on public safety radio systems, and trunking technology standards that would allow for an open architecture.

Perspectives on Mandated Trunking. Analysis of the comments from those participants who felt there should not be a government regulation on trunking shows their primary concern is that there is no "standard" radio system; each peculiarity should be examined on an individual basis. Most pointed to the fact that although trunking is beneficial, and perhaps should be regulated in large, frequency-starved metropolitan areas, trunking is not necessary, and should not be forced on smaller systems that have no need for trunking and no frequency crunch.

Most felt that if a trunking regulation is developed, the Government must allow sufficient time for system planning. Additionally, there would have to be a funding source to assist those who are forced to migrate and those who would never migrate without legislation. Some participants thought that trunking should be regulated, regardless of the frequency band of operation. The respondent added, however, that funding such an initiative would be critical. The following selected comments show the variety of views on governmental trunking mandates:

- One user suggested that the FCC should allocate adequate spectrum for public safety so that system planners would have an adequate number of channels to implement trunking technology regardless of the frequency band of operation.

- A radio manager for a metropolitan suburb indicated the need for public safety to have a mandated trunking standard because it would allow governments to serve their jurisdictions more effectively.

- Trunking should be mandated or, at a minimum, the FCC should regulate spectrally efficient technology regardless of the frequency band.

- Another user emphasized the necessity to leave a way out of the regulation by offering loopholes to those who will use alternate spectrally efficient technologies.

Trunking Standards. If trunking is to be mandated on a governmentwide basis, the participants indicated that a trunking standard must be developed. Many of the concerns regarding interoperability focused on the need for a standardized architecture, the lack of which stems specifically from differing vendor trunking technologies. Several respondents pointed to television and computer manufacturers that developed standards making their equipment interoperable with that of other manufacturers' equipment. Because LMR users do not have the advantage of standardized systems, they feel that once they select a vendor, there is no more product competition.

Not all the participants shared this view. Some were less receptive to the idea of a trunking standard because they felt it would slow down the technological progress and inhibit new development in LMR. Some groups pointed to Project 25 as a basis for a nationwide trunking standard. The following comments were made concerning the development of standards for trunking and open architecture:

- A trunking standard should be developed that does not favor a specific vendor. Such a standard would allow for multivendor radio systems, improvement in interoperability, and reduction in the cost of radio equipment.

- A large state supports the work of Project 25 and feels that it has the greatest potential of becoming an adopted standard.

- A nationally supported standard would be preferable, but it could effectively force entities to use a specific technology that may in turn limit or preclude future technical progress.

D.4.4 Influence of Vendor Technology

Demand focuses on technologies that promote interoperability and spectral efficiency. To satisfy the demand for new communications systems, vendor technology has followed suit. Several participants commenting on this issue noted that because vendor

technology, research, and development is primarily focused on 800 MHz, most innovations have come and will continue to be made in technology for resources in this frequency band. Additionally, with the vendors spending a preponderance of their resources on 800 MHz technology to the exclusion of VHF and low-band UHF technologies, many system users and administrators are concerned about the sustainability and continued viability of current VHF or low-band UHF radio technologies. Many participants hinted that to remain current with technology, the transition to an 800 MHz radio system is imperative. The following examples offer evidence that users are aware of, and driven by, the direction of vendor technology:

- A manager of a populated county system stated that because vendor research and development is primarily directed toward 800 MHz technology, any move away from this apparent mainstream would lead to higher costs for that county's radio system and greater isolation in the marketplace.

- A communications director from a small county expressed the need to implement a system that was at the forefront or at least on par with LMR technology advances.

For some entities, the influence of vendor technology on the decision to move to 800 MHz was not seen as a point of pressure but as a fortuitous development. These respondents realized that their systems were aging. System maintenance required a significant and often increasing expenditure. Many users believed that it would be nearly as cost effective to implement new systems as to try to maintain their old systems. The advances by vendors in the 800 MHz marketplace support such decisions. The following comment is an example of how system age is affecting public safety radio systems:

- A state radio manager commented the state is operating 15 to 25-year-old radio equipment. Additionally, they have more than 500 unique tower sites, many of which are deteriorating and in need of serious repair or replacement. Because the system costs are already high and the system needs to be replaced, the state is more willing to face the costs of a new state-of-the-art radio system in the 800 MHz band. In addition, the manager noted that a lack of available frequencies in lower bands was a factor driving him to look at 800 MHz.

D.4.5 Coverage

Coverage is a contentious issue for 800 MHz implementations. Nearly all the respondents indicated that problems with 800 MHz coverage were drawbacks of their new radio system implementations. Additionally, the cost associated with resolving these coverage problems was often brought forward as a negative point. Although coverage problems are not limited to the 800 MHz band, of late they are more visible because of the preponderance of 800 MHz system implementations. The following sections discuss system user and planner perspectives regarding the effects of terrain and the environment, and in-building coverage effects. Additionally, perspectives regarding the affects on "system cost related to coverage" are also discussed.

Terrain and Environment Characteristics. Coverage problems dominated the responses to the questions regarding operational effects at 800 MHz. Several system users indicated that their 800 MHz system, when constructed, had more dead spots than the previous system. Users also indicated that signal range is worse and is affected more by foliage and changes in terrain than had been the case with their previous systems. States and counties responded less favorably regarding coverage than did cities. The following comments reveal some of the coverage barriers associated with 800 MHz migration:

- A state system administrator was adamant that 800 MHz system tests indicated coverage problems in the mountainous and densely forested portions of the state. Because the agency's mission is to cover the entire state, and in some instances serve as a primary responder, this lack of coverage prevented them from moving to 800 MHz.

- A planner for a large county attempted to install an 800 MHz system using four existing tower locations. The system coverage was so poor that the county had to add four more sites to obtain adequate coverage.

- One representative attempted to dispel concerns regarding 800 MHz coverage by indicating that all of the previous systems had coverage problems as well. It is only because of the more capable 800 MHz radios that users can see that they are out of range. This creates the perception that there is a greater coverage problem than actually exists.

In-Building Characteristics. Perhaps the most significant coverage problems are experienced inside buildings. In many cases, it is necessary to maintain routine radio communications within a facility such as a jail or courthouse, or event-driven communications during times of emergency (e.g., evacuation or fire). Firefighters require extensive portable-to-portable coverage because most of their communications occur on scene at the emergency site. Firefighters frequently complained about in-building coverage afforded by their 800 MHz systems. The interviews also found system planners that specified precise coverage levels in specific buildings tended to have the most success with in-building coverage. The following perspectives provide further insight into in-building coverage at 800 MHz:

- One fire department official indicated that that in-building coverage was a severe limitation of his county's new 800 MHz system. The official attributes this problem to trunking and the repeating of 800 MHz channels. He notes that coverage problems are not experienced on the department's VHF channels which are not repeated.

- A system planner of a large fire department had expressed concerns with in-building coverage before moving to the 800 MHz band. However, the current system has not been as problematic as the previous system, and has yet to endanger any of the firefighters.

- Some systems planners indicated that they received surprisingly good coverage from their 800 MHz systems, including improved portable-to-portable coverage and in-building coverage.

Cost Characteristics. The interviews uncovered two major causes of cost concerns. First, the limited number of vendor choices dramatically increases system costs. Secondly, because the coverage area of 800 MHz is significantly less than at lower bands, radio infrastructure improvements must be made to increase coverage. Such infrastructure improvements are often expensive. Most respondents discussed the rather high costs of implementing an 800 MHz system, although many had anticipated those costs and planned accordingly. For those states, counties, and cities that had successful funding initiatives and long-range planning established, the costs tended to be in line with their expectations. Agencies and departments that chose not to move to 800 MHz systems stated that cost was the most significant factor. No mention was made that recurring costs or post-installation costs were a problem; however, most systems are still under warranty, and it may be too early to predict the consequences of recurring costs. The following points provide users perspectives regarding cost and 800 MHz systems:

- An interviewee whose state was considering a new LMR system stated that a cost analysis considered maintaining the current VHF system, upgrading the VHF system, and/or installing an 800 MHz system. The 800 MHz system would have cost more than six times as much as maintaining the current system, and about twice as much as upgrading the VHF systems.

- Another large state that is considering migrating to 800 MHz has shown that, because twice as much coverage can be obtained from a VHF system, migration costs could be halved by constructing a VHF system.

- The only planner who thought that the 800 MHz system cost less than expected believed that the vendor had consciously underbid the work to obtain business from neighboring jurisdictions. The vendor, the planner claimed, had taken several shortcuts that prevented the city from accepting the system.

- A participant from a large state now implementing a system referred to the installation costs of an 800 MHz system on a statewide scale as “outrageous.”

D.4.6 Operations

Performance is the key of any radio system’s effectiveness. With public safety systems, superior performance is critical. Strong operational performance can often mean the difference between life and death, causing radio operations to be among the most important issues deliberated about when decisions regarding new radio systems are made. For system planners to make informed decisions, it is critical to understand the operational impacts that users have experienced after implementing their 800 MHz systems. The following sections present overviews of commonly cited issues affecting the operations of 800 MHz systems.

Reliability. Reliability is perhaps the most critical operational component of a radio system for public safety use. A system whose performance is unreliable can lead, at the least, to dangerous operational scenarios, or worse, to scenarios that are deadly for public safety officials. To determine the relative reliability of the 800 MHz radio systems, interviewees were asked to compare the reliability of their previous radio system to that of their 800 MHz systems. Table D-4 shows the results.

Table D-4
Effects of 800 MHz System Use on Reliability

System Reliability	Number of Responses
Improved	17
Similar	5
Worsened	1
Unanswered	5

Most respondents indicated that their 800 MHz systems are or will be more reliable than their current or previous systems. The interviewees provided four reasons that 800 MHz networks are more reliable: the new systems are newer and more durable; 800 MHz users reported minimal down time; the systems are redundant and it now takes multiple failures to knock users off the systems; and specific design requirements were established and achieved.

Several respondents indicated that 800 MHz systems did not improve the reliability of their current or previous system, rather reliability was equivalent. These opinions were based on two issues. First, some respondents stated that the terrain and environment of system usage have had some limiting effects on coverage area. Secondly, a few participants claimed that user skepticism about computers running their communications system has affected the general perception of the 800 MHz system. The following comments are examples of the prevailing effects 800 MHz has had on system reliability:

- A planner for a large southwestern city indicated that the city's successful design implementation allowed for a network that has no single points of failure and usually requires three to four failures before a user is knocked off the system.

- A system administrator for a large city stated the city's 800 MHz system had successfully handled about 3 million calls per month with no problems. This many calls could never have been handled by the previous 30-year-old system.

- In a mid-size mid-western town, a planner indicated that the 800 MHz system was more reliable and credited this to the durability of the new equipment.

- An administrator for a small, densely populated metropolitan county stated that the county's 800 MHz system had failed only twice during the 5 years since implementation. The total down time has been only 39 seconds.

- A planner for a small southwestern town felt that the town's 800 MHz system was viewed as being only as reliable as their previous system because of problems arising from user anxiety over the complexity of the new system and stemming from the system's reliance on computers.

System Capacity. Many system users claimed to have experienced significant improvements in their radio system capacity, with greater ability to manage frequencies as a result of trunking at 800 MHz. One-user-per-channel capacity problems no longer bind public safety systems. With trunked 800 MHz systems, entities can create many talk groups with a set number of channels. Talk groups allow multiple groups operating independently of one another to communicate without interfering with separate groups' operations. The following are comments from individuals who have positive experiences with their system capacity:

- A planner for a mid-size western city stated that with the city's 800 MHz system, users receive far fewer busy signals and have had no problems with queuing on the 10-channel system.

- A system planner for a large southwestern city indicated that 7,500 units could be loaded on the city's 20-channel system running at approximately 40 percent usage with almost no blocks.

Education and Training. Many system users and administrators who had moved to 800 MHz systems identified education and training as a significant operational problem. Often, this was attributed to computerized technology so radically different from any previous radio technology that the learning curve is exceptionally steep. Others attributed it to an attitudinal problem, with users unwilling to give the new technology a chance. The following are examples of the effects 800 MHz systems have had on user training:

- A planner for a large pacific coast county stated that a definite learning curve is associated with 800 MHz usage. The delay in the press-to-talk feature, combined with other technologies that alter the quality of sound, further reinforce an already innate human instinct to resist change.

- An administrator for a large eastern state commented on the problem of education and training impeding the use of 800 MHz systems to their full potential, and how training brings officers off the streets when already too few are on the streets.

- A radio manager for a large metropolitan county stated that 800 MHz systems face a standard transitional problem in retraining their radio users. The county believes that these impacts are only temporary.

- A manager for a large mid-western state indicated that a critical element of the successful implementation of an 800 MHz system is to understand that 800 MHz radios are far more sophisticated than previous radios. For this reason, system planners must provide adequate education and training in the use of the radios.

APPENDIX E
ABBREVIATIONS AND ACRONYMS

AAT	Above Average Terrain
AGL	Above Ground Level
ANSI	American National Standards Institute
APCO	Association of Public-Safety Communications Officials International, Inc.
ATIS	Automatic Transmitter Identification System
BBH	Bouncing Busy Hour
CDMA	Code Division Multiple Access
COG	Council of Governments
COGMARS	Council of Governments Mutual Aid Radio System
CFR	Code of Federal Regulations
dBu	Decibel above 1 mV
DEA	Drug Enforcement Administration
EMS	Emergency Medical Services
EMT	Emergency Medical Technician
ERP	Effective Radiated Power
FBI	Federal Bureau of Investigation
FCC	Federal Communications Commission
GHz	Gigahertz
GOS	Grade of Service
HAAT	Height Above Average Terrain
HF	High Frequency
ICS	Incident Command Structure
ISM	Industrial, Scientific, and Medical
kHz	Kilohertz
LMR	Land Mobile Radio
MHz	Megahertz
MO&O	Memorandum Opinion and Order
MSS	Mobile Satellite Service
NOI	Notice of Inquiry
NPRM	Notice of Proposed Rule Making
NPSPAC	National Public Safety Planning Advisory Committee
PBH	Peak Busy Hour
PMARS	Police Mutual Aid Radio System
PMO	Program Management Office
PSTN	Public Switched Telephone Network
PSWAC	Public Safety Wireless Advisory Committee
PSWN	Public Safety Wireless Network
R&O	Report and Order
RF	Radio Frequency
RFP	Request for Proposal
RPC	Regional Planning Committee

RPRC	Regional Planning Review Committee
SERS	Special Emergency Radio Services
SMR	Specialized Mobile Radio
TCBH	Time Consistent Busy Hour
UHF	Ultra High Frequency
USSS	United States Secret Service
VHF	Very High Frequency
WTB	Wireless Telecommunications Bureau