



*Public Safety Radio Frequency
Spectrum: Highlighting Current and
Future Needs*

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Final

INTRODUCTION

To protect life and property, public safety agencies must be able to communicate, both with staff in their own organizations and with other agencies or jurisdictions. Virtually all public safety agencies use the radio frequency spectrum for communications, but they currently have inadequate spectrum to communicate effectively. This paper examines potential solutions to alleviate public safety spectrum shortages.

More than 98 percent of public safety agencies use wireless radios as their primary means of communications.¹ To use these radios, agencies must have access to spectrum. Spectrum is a limited resource, however, eagerly sought by competing interests. Without the resources to compete with commercial interests, the public safety community suffers from spectrum shortages. Scarce spectrum results in congestion and interference, limiting the ability of public safety personnel to communicate. Lacking effective communications, public safety officials cannot accomplish their mission of saving lives and protecting property.

The Public Safety Wireless Advisory Committee (PSWAC) identified these spectrum shortages in its final report to the Federal Communications Commission (FCC) on September 11, 1996. PSWAC argued that to meet the demands placed on public safety communications, an additional 97 megahertz (MHz) of spectrum was required by 2010.² In 1998, the FCC allocated 24 MHz of spectrum to public safety in WT Docket 96-86, partially satisfying these recommendations. Nevertheless, spectrum is still insufficient to meet the public safety community's general communications needs. Public safety mission requirements have increased significantly. New technologies and applications, particularly in the data arena, aid public safety operations, but also require increased bandwidth and hence additional spectrum. Meanwhile, the need for interoperable communications among users has also grown. All these factors have made the need for public safety spectrum more acute than ever.

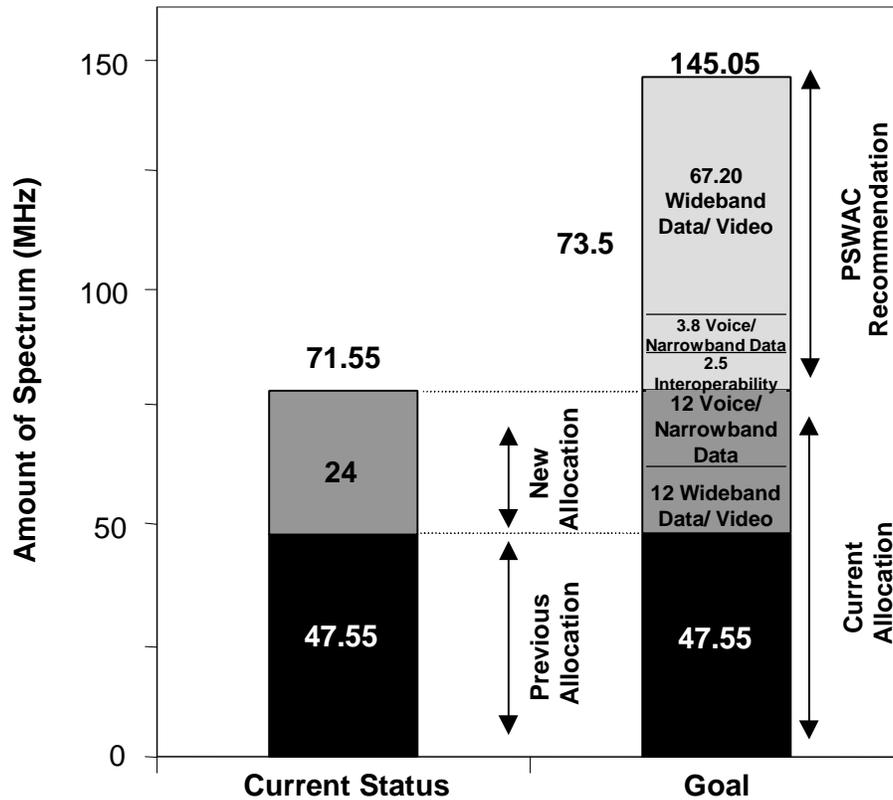
According to PSWAC recommendations, the public safety community still requires 2.5 MHz of spectrum under 512 MHz for interoperability purposes, 3.8 MHz for voice and narrowband data requirements, and 67.2 MHz for wideband data and video applications. Figure 1 compares the public safety community's current spectrum allocations with its spectrum needs. The left column represents the amount of spectrum currently allocated to public safety, including the 24 MHz of spectrum recently assigned. The right column represents the remaining 73.5 MHz of spectrum that is still required to satisfy the PSWAC recommendations. Of the recently allocated 24 MHz, 12 MHz is allocated to fulfill voice and other narrowband requirements, and the remaining 12 MHz is intended to meet requirements that rely upon wider-bandwidth channels.³

¹ Unless otherwise noted, all percentages are based on the combined results of studies published by the National Institute of Justice (NIJ) *State and Local Law Enforcement Wireless Communications and Interoperability: A Quantitative Study* and the Public Safety Wireless Network (PSWN) Program *Analysis of Fire and EMS Communications Interoperability*. Each study was based on nationwide surveys of public safety wireless communications and the interoperability issues facing public safety communities.

² Public Safety Wireless Advisory Committee (PSWAC) *Final Report* p. 3.

³ FCC, WT Docket 96-86, *First Report and Order and Third Notice of Proposed Rulemaking*, para. 43. September 29, 1998.

Figure 1
Current Public Safety Spectrum Allocations and Future Spectrum Needs



Additional spectrum is still required for voice and narrowband data communications, but given the PSWAC recommendations and the recent spectrum allocation to public safety, the most immediate need for spectrum is in the following areas:

- Wideband Data and Video Applications – Public safety seeks to take advantage of emerging technologies such as wideband data and video. These new technologies enhance the ability of agencies to interoperate, however, they require larger amounts of spectrum due to the higher data rates. The increased bandwidth requirements for advanced applications further strain already limited spectrum resources. Currently, the greatest public safety spectrum need exists for wideband data and video applications.
- Interoperability Spectrum Below 512 MHz – Public safety entities at all levels of government need to work together to meet mission requirements. This requires coordination of communications across and among agencies, also referred to as interoperability. Currently, there is only a small amount of spectrum allocated to the public safety community for interoperability. This is particularly true below the 512 MHz bands, where the majority of public safety organizations operate.

In addition to acquiring spectrum for these near term uses, the public safety community requires an immediate solution to meet current spectrum shortfalls. Spectrum sharing agreements between local, state, and federal public safety entities would allow agencies co-equal access to each other's existing spectrum. These agreements would provide immediate results and realize greater spectrum efficiencies. This concept is a possible mechanism for enhancing public safety's communications capabilities, but is not a solution to fulfill the unmet public safety spectrum requirements.

The following sections further describe public safety spectrum shortages and offer alternatives to alleviate these needs:

- The first section seeks to explore additional bands that could allow public safety to take advantage of wideband data and video technologies
- The second section identifies additional spectrum that can be acquired to fulfill interoperability requirements
- The third section further explores the concept of spectrum sharing.

GENERAL USE AND INTEROPERABILITY SPECTRUM TO SUPPORT PUBLIC SAFETY DATA AND VIDEO SERVICES

The emergence of new wireless technologies has the potential to shape and transform the way public safety agencies meet their mission requirements. In particular, wideband data and video technologies support a number of public safety applications, such as imaging and real-time video. These applications are quickly becoming necessary to meet the new challenges facing the public safety community. Agencies use these technologies to support such activities as geographic positioning, automatic vehicle location, report transmission, electronic messaging, and access to data repositories (i.e., the National Crime Information Center). Typical images transmitted by public safety users include building plans, mug shots, fingerprints, and snapshots of accidents, injured persons, and crime scenes. Agencies use video primarily to monitor critical public safety incidents such as crime surveillance, major fires, flooding, and prison riots. It is also used for day-to-day activities such as highway monitoring. Use of new technologies not only enhances the capability of individual units and agencies, it also has facilitated local, state, and federal agencies' capacity to interoperate in complex multijurisdictional situations such as high-speed pursuits or drug interdiction.

The public safety community currently makes limited use of wideband data and video mostly because they lack spectrum needed to implement these systems. Only one video channel is presently available for public safety use.⁴ Recent research indicates that although data channels represent a small percentage of all channels being used, the total number of channels

⁴ PSWAC *Technology Subcommittee Final Report*, p. 23.

being set aside nationally for that purpose is increasing by 70 percent.⁵ Additional spectrum is required to support these new capabilities and technologies. Unless it is addressed immediately, the lack of broadband spectrum will be a significant impediment to the implementation of wideband data and video technology that support public safety.

Wideband data and video systems need increased bandwidth because they require higher data rates than narrowband voice systems. A relatively larger piece of contiguous spectrum is required to transmit images. For example, recently allocated wideband channels intended for data applications have been assigned bandwidth 8 times larger than narrowband channels intended primarily for voice.⁶ Given the PSWAC recommendations and recent public safety allocations, at least an additional 67.2 MHz of spectrum is required to satisfy wideband data and video applications by the year 2010.

This study reviewed a number of spectrum bands as candidates for use by state and local public safety agencies to satisfy wideband data and video spectrum needs. The candidates were originally identified in reports authored by the National Telecommunications and Information Administration (NTIA) and by subcommittee members participating in PSWAC proceedings. Other bands were proposed in documents submitted as comments to FCC rulemaking proceedings. Certain bands were eliminated from consideration for several reasons. In some cases, loss of bands would adversely affect the mission of current users. Other bands would be technically unsuitable for wideband data and video or would be too expensive for the public safety community to acquire.

The bands shown in Table 1 are considered viable candidates for state and local public safety wideband data and video use. The following pages provide additional detail, including a summary of advantages and impediments to acquiring the bands for public safety use.

⁵ National Institute of Justice, *State and Local Law Enforcement Wireless Communications and Interoperability: A Quantitative Analysis*, p. 31.

⁶ FCC, WT Docket 96-86, *First Report and Order and Third Notice of Proposed Rulemaking*, para. 38-40. September 29, 1998.

Table 1
Frequency Bands Considered for Wideband Data and Video Applications

Frequency Band (MHz)	Total Bandwidth Available (MHz)	Current Use	Reallocation Considerations
698–746	48	<ul style="list-style-type: none"> Broadcast television channels 52-59 	<ul style="list-style-type: none"> Band is located adjacent to recently allocated public safety bands in 764 – 776 and 794 – 806 MHz The eventual transition of television stations to digital frequencies would create a spectrum reserve
944–960	16	<ul style="list-style-type: none"> FM Broadcasters Fixed microwave services 	<ul style="list-style-type: none"> Band has good propagation characteristics for users in rural areas The eventual transition of radio broadcasters to digital technologies may create a spectrum reserve for use by public safety The large number of current licensees may be difficult to relocate
1390–1400, 1427–1432, 1670–1675	20	<ul style="list-style-type: none"> Radiolocation, radio astronomy, radar, fixed and mobile services Military tactical radio relay communications and military test range aeronautical telemetry and telecommand Meteorological services 	<ul style="list-style-type: none"> Bands are ideal for wideband data and video services Temporary and permanent restrictions have been placed on bands because of concerns about interference with adjacent bands; sharing would be required Bands have currently been assigned for competitive bidding; the public safety community does not have the resources to compete for spectrum. It would have to be awarded to public safety free of charge
2500–2690	15	<ul style="list-style-type: none"> Wireless cable TV, instructional fixed TV, private operational fixed service, and narrowband audio response channels 	<ul style="list-style-type: none"> Band might satisfy long-term needs, but no compatible equipment currently exists to operate in the band Constraints will be imposed on users who are assigned this frequency because existing licenses have been grandfathered in by the FCC

698–746 MHz Band

Current Use

This band is currently occupied by television broadcasters operating channels 52–59. Broadcasters in this band are required to vacate these frequencies by 2006 and transition to digital television (DTV) frequencies.

Reallocation Considerations

The transition of broadcasters to digital frequencies will create a large spectrum reserve that could be used by public safety. This spectrum is desirable because it is adjacent to the recently allocated public safety spectrum located in the 700 MHz bands. Manufacturers could

easily develop and produce equipment to operate in both bands. In addition, this band offers a large aggregate portion of spectrum, which is ideal to support transmission of wideband data and video. However, it would be necessary for the FCC to enforce the DTV transition schedule to ensure that the public safety community could receive the frequencies in a timely manner.

944–960 MHz Band

Current Use

To satisfy the requirements of the Balanced Budget Act of 1997, the NTIA recommended that the FCC consider reallocating this band and assigning licenses through the process of competitive bidding. However, no action has been taken by the FCC to reallocate this band. This spectrum is currently divided into two discrete bands, 944–952 MHz and 952–960 MHz. The first is used by FM broadcasters. The second is designated for fixed microwave services. Fixed microwave services have two major types of use, multiple access systems (MAS) and private operational fixed (POF) systems. MAS systems occupy a total of 1.2 MHz of these bands and, as of 1997, held approximately 8,000 licenses. MAS services include supervisory control and data acquisition (SCADA) for utility customers, alarm systems, and credit card and checking account verifications. Private low-capacity voice and data applications occupy the remaining 6.8 MHz of the band and, as of 1997, had approximately 6,200 licenses.

Reallocation Considerations

This spectrum is desirable because it is close to the 800 MHz spectrum used by local and state public safety entities. The equipment currently used in the 800 MHz bands may be designed to operate in this band. Although it is not located in the higher frequency bands that are typically considered ideal for wideband data and video, it may be ideal for public safety agencies in rural areas, where the signal would propagate well and yield wider coverage.

Broadcasters in this band currently use analog technologies. Digital technologies will reduce the spectrum requirements for broadcast services, thus creating a spectrum reserve that may be utilized by the public safety community. However, the large number of users who operate in this band do not have alternate spectrum to transfer their applications, a limitation that may potentially inhibit public safety's ability to fully utilize the band.

1390–1400, 1427–1432, & 1670–1675 MHz Bands

In response to the Balanced Budget Act of 1997, the NTIA recommended that the FCC consider reallocating these bands and assigning the licenses through the process of competitive bidding. However, no action has yet been taken by the FCC to reallocate these bands.

The 1390–1400 MHz band is used for radiolocation, radio astronomy, long-range defense radars, and fixed, mobile, and meteorological services. The NTIA has mandated that radio astronomy observations must continue to use the band, which should be compatible with anticipated wideband public safety operations. In addition, the Federal Aviation Administration (FAA) and the Department of Defense (DOD) radars operate in the lower adjacent band and must be protected after the higher band has been reassigned

The 1427–1432 MHz band is currently used by military tactical radio relay communications and military test range aeronautical telemetry and telecommand. According to the NTIA, reallocation of this band has been delayed to phase out radio relay equipment, procure replacement equipment, and engineer new systems. Several military airborne operations will be continued until 2004.

The 1670–1675 MHz band is used for meteorological services. Reallocation of this band has been delayed to permit redesign and procurement of replacement equipment for meteorological systems. Use by two important meteorological satellites for earth stations at Wallops Island, Virginia and at Fairbanks, Alaska would remain protected.

Reallocation Considerations

These bands are ideal for wideband data and video services because they are located above 1 Gighertz (GHz). However, several factors must be considered. First, any reassignment would have to preserve several temporary and permanent restrictions that have been placed on the bands because of concerns about interference with adjacent bands. This constraint might limit use by public safety, which requires clear communications channels to accomplish critical missions. If the policies, procedures, and technical criteria for any interference rules prove to be overly restrictive, they would harm the performance of the public safety users and technologies in the band.

In some cases, permanent sharing with other users who occupy the bands would be required. Continued use of these bands by current users is vital, but might curtail public safety use of wideband data and video. The bands must also be sized large enough to meet wideband data and video requirements. In addition, the FCC should enforce the transition period for sites with temporary restrictions.

As previously noted, the NTIA recommended that the FCC consider reallocating these bands and assign licenses through the process of competitive bidding. Funding is a significant impediment for public safety organizations. They rarely have enough funding to obtain sufficient equipment, let alone the resources to compete for spectrum. Therefore, the spectrum would need to be awarded without charge to public safety in lieu of an auction.

2500–2690 MHz Band

Current Use

While the NTIA has recommended assigning these bands for competitive bidding, no action has yet been taken by the FCC to reallocate this spectrum. A number of services occupy the 2500–2690 MHz band, including wireless cable TV, instructional fixed TV service, private operational fixed service, and narrowband audio response channels. It is also used for radio astronomy purposes. The FCC auctioned 66 MHz of this spectrum in 1996 for multi-point distribution service (MDS). Only 15 MHz remains.

Reallocation Considerations

Although these bands are not necessarily technically suitable because they are located in higher-frequency bands, these frequencies may be used to satisfy future wideband video and data needs. Perhaps the biggest constraint on use of high-frequency bands is that manufacturers do

not yet produce compatible equipment. It is uncertain whether manufacturers will create equipment in these bands for public safety use, because development and production would be costly. However, given the spectrum congestion in the lower frequency bands, consideration should be given to use this band to satisfy future wideband video and data requirements.

In addition, costs associated with relocating current users to other frequencies might be high. NTIA also expects that restrictions would be placed on this band to avoid interference with radio astronomy users, and that band sharing would be required.

INTEROPERABILITY SPECTRUM BELOW 512 MHZ

In addition to the need for more general-use spectrum, a strong demand exists for spectrum identified specifically for interoperability purposes. Interoperability refers to the ability of public safety personnel to communicate by radio with staff from other agencies on demand and in real time. Historically, public safety incidents have been localized, requiring response over a limited geographic range. Today, police, fire, and emergency medical operations are becoming increasingly complex. Fire officials are concerned with hazardous materials, police officials are responding to domestic terrorism, and paramedics are now training for mass casualties associated with catastrophic accidents or chemical and biological attacks. Increased threats and changing mission requirements have placed new responsibilities on public safety agencies, changing the very nature of their operations.

To respond to these new demands, public safety agencies increasingly find themselves needing to communicate across agency and jurisdictional boundaries. Currently, more than 90 percent of agencies operating at the local level report the need for daily or weekly interactions with other agencies. While this communications capability continues to become a requirement of everyday public safety operations, current spectrum limitations hinder ability of agencies' to successfully communicate. In fact, more than a third of the public safety agencies report that lack of interoperability has affected their ability to interact with other agencies in surrounding jurisdictions. Lack of critical communications capability curtails the ability of public safety agencies to fully meet their missions, often putting life and property at unnecessary risk.

Public safety has been allocated 71.55MHz of spectrum with only 4.7 percent (3.363 MHz) being set aside for interoperability purposes. Moreover, interoperability spectrum is not evenly distributed. Although public safety assignments are spread over 11 frequency bands, interoperability spectrum exists only in 4 of these bands (i.e., 150-174, 406.1-420, 764-776/794-806, and 821-824/866-869 MHz - See Table 2). Public safety agencies using the remaining seven bands face major interoperability obstacles, because communications systems currently cannot operate in multiple bands. Interoperability spectrum is needed in the bands that public safety agencies currently use below 512 MHz.

Table 2
Public Safety Interoperability Spectrum Allocations

Public Safety Frequency Band (MHz)	Total Bandwidth (MHz)	Spectrum Allocated for Public Safety Interoperability (MHz)
25–50	25	0
72–76	4	0
138–150.8	12.8	0
150–174	24	.338
220–222	2	0
406.1–420	13.9	.3
450–470	20	0
470–512	42	0
764–776 794–806	24	2.6
806–821 851–866	30	0
821–824 866–869	6	.125

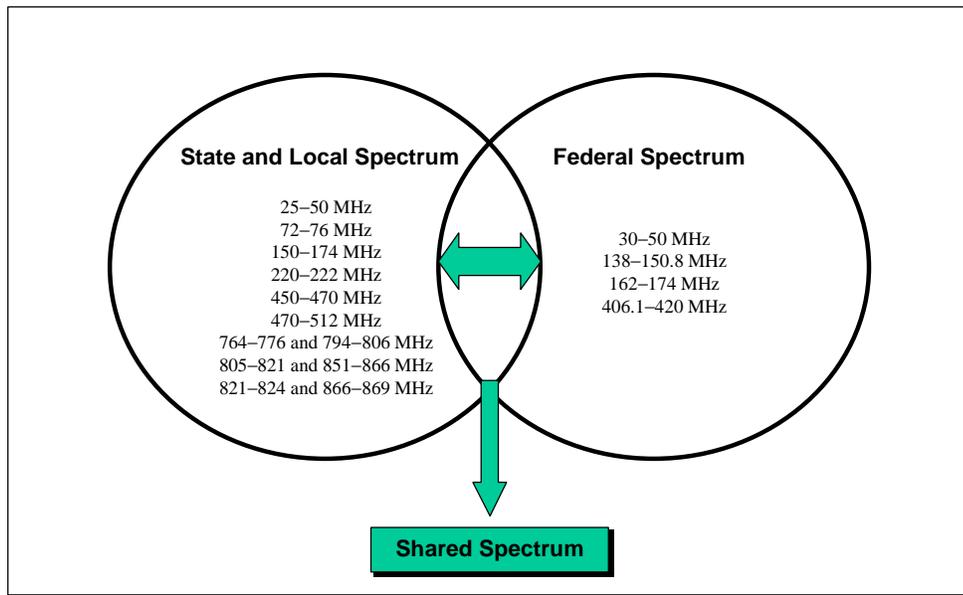
Efforts to gain spectrum for interoperability should be focused on lower bands for several reasons. Interoperability spectrum has been designated in the 800 MHz range (e.g., National Public Safety Planning Advisory Committee [NPSPAC]); public safety has recently received allocations in the 700 MHz band, including 2.6 MHz strictly for interoperability purposes; and most agencies operate at least one channel in the very high frequency (VHF) band. In addition, PSWAC determined that an additional 2.5 MHz of interoperability spectrum was required below 512 MHz for public safety use.

Currently, public safety agencies operate in eight different bands below 512 MHz. However, 71 percent of public safety agencies operate at least one channel in the high-band VHF range and 29 percent in ultrahigh frequency (UHF) range. Therefore, the 2.5 MHz required should be proportionally drawn from allocations in these two frequency ranges. Thus, to meet the needs of public safety agencies, 1.775 MHz should be designated for interoperability purposes in the high-band VHF frequency ranges and .725 MHz should come from spectrum adjacent to current public safety UHF bands.

SPECTRUM FOR SHARED USE

Another possible solution to alleviate the spectrum shortage experienced by public safety is spectrum sharing, in which a number of agencies establish agreements to share assigned frequencies. Shared systems allow the pooling of spectrum resources and can promote efficient use of spectrum. Sharing Federal Government spectrum with local and state public safety users would indirectly increase the amount of spectrum available to users. This concept is illustrated in Figure 2.

Figure 2
Shared Spectrum Concept



Spectrum sharing is not a new concept. It already exists in the private sector in the form of low-power, unlicensed operations. Such operations include wireless intercom systems and limited-area broadcast networks at airports or tourist attractions. Most agreements governing such usage are informal, and the functions served usually are not critical and involve low equipment and operating costs. The FCC has generally taken a hands-off approach to monitoring these agreements. An agreement involving the public safety community must outline terms and conditions of spectrum sharing due to the critical nature of their missions.

The FCC recently established rules that allow federal organizations to share, under certain circumstances, state and local licensee spectrum in the newly allocated public safety 700 MHz bands. The rules governing the 700 MHz band allow federal entities with public safety responsibilities access to state and local agencies' licensed frequencies, for the purpose of developing joint-use and shared systems, provided both parties agree and the frequency license holder submits a request to the FCC. The new rules establish a foundation for sharing spectrum in the 700 MHz bands, allowing co-equal access, with no one user or group of users having the entitlement to pre-empt other users.

Federal frequency bands could be made available to local and state users under the same or similar terms and conditions, whereby state and local users would have equal rights to federal spectrum, unless it was otherwise specified in a mutual aid agreement. While sharing currently occurs on a limited basis, the lack of structure or formality in existing sharing arrangements creates a degree of uncertainty that is unsuitable for public safety use. To justify the cost of new equipment, public safety agencies must be guaranteed that shared spectrum will remain accessible to them in the future. Without this assurance, neither party has much incentive to pursue a shared system arrangement. The Federal Law Enforcement Wireless Users Group (FLEWUG) clarified this type of understanding in a paper filed with the FCC on September 16, 1999. FLEWUG emphasized that co-equal access was critical to ensure the success of these agreements.

The implementation of shared systems supports the broad-based adoption of technologically advanced radio communications equipment and services, which, in turn, greatly enhances public safety operations. Although technological advancement can be achieved through single-agency systems, shared systems accelerate the introduction and integration of new technologies and applications throughout the public safety community. The addition of shared spectrum will directly increase the spectrum available for public safety, serve as a model for co-equal access, and impress upon the public safety community, the public, and the regulators the feasibility of such arrangements.

CONCLUSIONS AND RECOMMENDATIONS

Wireless communications are critical to the operation of public safety organizations. The lack of public safety spectrum greatly hinders the ability of these organizations to perform mission-critical communications. The following recommendations should be considered to satisfy public safety agencies' spectrum needs:

- **Spectrum for Wideband Data and Video**– The public safety community should fully consider each of the bands identified in this report to determine the most appropriate bands for their wideband data and video needs. Given the current and anticipated demands on the radio frequency spectrum, the bands in the higher frequency range should also be considered to satisfy these spectrum requirements. The public safety community should petition the FCC for reallocation of said spectrum to public safety for these purposes.
- **Interoperability Spectrum Below 512 MHz**– The FCC should grant the public safety community additional spectrum below 512 MHz to meet interoperability communications needs, as recommended by PSWAC. This spectrum should be allocated proportionally to the number of users operating in the VHF and UHF bands under 512 MHz. Specifically, 1.775 MHz should be designated for interoperability purposes in the high-band VHF frequency ranges and .725 MHz should come from spectrum adjacent to current public safety UHF bands.
- **Shared Spectrum**– The federal community and the NTIA should formulate policies that encourage shared spectrum arrangements. The rules governing federal frequency bands should be modified to allow similar sharing arrangements as those being developed in the recently allocated 700 MHz public safety bands.

