Department of Agriculture

Department of Commerce

Department of Defense

Department of Energy

Department of Homeland Security

Department of the Interior

Department of Justice

Department of State

Department of Transportation

Department of the Treasury

Department of Veterans Affairs

National Aeronautics and Space Administration

National Science Foundation

Broadcasting Board of Governors

U.S. Postal Service

SPECTRUM MANAGEMENT FOR THE 21ST CENTURY
THE PRESIDENT'S SPECTRUM POLICY INITIATIVE

FEDERAL STRATEGIC SPECTRUM PLAN

U.S. DEPARTMENT OF COMMERCE

CARLOS M. GUTIERREZ, SECRETARY

MEREDITH A. BAKER, ACTING ASSISTANT SECRETARY FOR COMMUNICATIONS AND INFORMATION

March 2008

This page intentionally blank

LEADERSHIP AND CONTRIBUTORS

National Telecommunications & Information Administration

Meredith A. Baker
Acting Assistant Secretary for Communications
and Information

Office of Spectrum Management

Karl B. Nebbia
Associate Administrator

Strategic Planning Division

Byron K. Barker
Division Chief

Leslie A. Taylor
Team Lead

Geri Averytt
Regina Harrison
Fredrick Matos
Delmon Morrison
Eric Rosenberg

This page intentionally blank

ACKNOWLEDGEMENTS

The National Telecommunications and Information Administration (NTIA) would like to thank the Federal agencies who submitted agency-strategic spectrum plans which provided the foundation for this Federal Strategic Spectrum Plan as well as their outstanding cooperation in clarifying information and reviewing drafts. In addition, the Strategic Planning Division acknowledges the contributions from the Division Chiefs and staff of other Office of Spectrum Management Divisions, as well as from the NTIA Associate Administrator for Policy Analysis and Development (OPAD) and the staff of OPAD.

TABLE OF CONTENTS

I. OVERVIEW **1**

II. TODAY'S SPECTRUM ENVIRONMENT **3**

III. FUTURE FEDERAL SPECTRUM REQUIREMENTS **4**

IV. THE FEDERAL STRATEGY **7**

V. RECOMMENDATIONS **13**

APPENDIX A **A-1**

PRESIDENTIAL MEMORANDUM **A-1**

APPENDIX B **B-1**

CURRENT FEDERAL SPECTRUM USE AND FUTURE REQUIREMENTS **B-1**

SECTION B-1 .... **B-3**

RADIOCOMMUNICATION SERVICES **B-3**
- **AERONAUTICAL MOBILE SERVICE** B-29
- **MARITIME MOBILE SERVICE** B-36
- **MOBILE-SATELLITE SERVICE** B-42
- **AERONAUTICAL MOBILE–SATELLITE SERVICE** B-51
- **MARITIME-MOBILE SATELLITE SERVICE** B-52
- **FIXED-SATELLITE SERVICE** B-52
- **FIXED SERVICE** B-59
- **RADIODETERMINATION SERVICE AND** B-69
- **RADIODETERMINATION-SATELLITE SERVICES** B-69
  - **RADIONAVIGATION SERVICE** B-70
  - **AERONAUTICAL RADIONAVIGATION SERVICE** B-73
  - **MARITIME RADIONAVIGATION SERVICE** B-78
  - **RADIODETERMINATION-SATELLITE SERVICES** B-79
  - **RADIONAVIGATION-SATELLITE SERVICE** B-80
  - **RADIOLOCATION SERVICE** B-86
- **EARTH EXPLORATION-SATELLITE SERVICE, SPACE RESEARCH SERVICE AND METEOROLOGICAL-SATELLITE SERVICE** B-103
- **EARTH EXPLORATION-SATELLITE SERVICE** B-103

METEOROLOGICAL-SATELLITE SERVICE **B-109**
- **METEOROLOGICAL-SATELLITE SERVICE** B-109
- **SPACE RESEARCH SERVICE** B-112
- **METEOROLOGICAL AIDS SERVICE** B-114

RADIO ASTRONOMY SERVICE **B-119**

SPACE OPERATION, INTER-SATELLITE AND SPACE-TO-SPACE SERVICES **B-124**
SPACE OPERATION SERVICE B-124
INTER-SATELLITE SERVICE B-125

BROADCASTING AND BROADCASTING SATELLITE SERVICES **B-127**
BROADCASTING SERVICE B-127
BROADCASTING SATELLITE SERVICE B-129

MISCELLANEOUS SERVICES **B-130**
STANDARD FREQUENCY AND TIME SIGNAL SERVICE _AND THE STANDARD FREQUENCY AND TIME SIGNAL-SATELLITE SERVICE B-130
SOUNDER NETWORK AND SOUNDER PREDICTION B-132
SPACE TELECOMMAND SPACE STATION _AND SPACE TELECOMMAND EARTH STATION B-132
SPACE TRACKING SPACE STATION _AND SPACE TRACKING EARTH STATION B-132
SPACE TELEMETERING SPACE STATION _AND SPACE TELEMETERING EARTH STATION B-133

SECTION B-2 .... **B-134**

PUBLIC SAFETY SPECTRUM NEEDS **B-134**

STATE AND LOCAL PUBLIC SAFETY SPECTRUM NEEDS **B-134**
FEDERAL PUBLIC SAFETY SPECTRUM NEEDS B-141
OTHER ISSUES RELATING TO PUBLIC SAFETY SPECTRUM USE B-144

CONTINUITY OF GOVERNMENT/CONTINUITY OF OPERATIONS NEEDS **B-146**
SUMMARY OF COOP AND COG REQUIREMENTS B-148
CONCLUSION B-149

SECTION B-3 .... **B-150**

NEW TECHNOLOGIES, EXPANDED SERVICES, AND NEW SPECTRUM MANAGEMENT APPROACHES **B-150**

SECTION B-4 .... **B-157**

SUMMARIES OF AGENCY-SPECIFIC STRATEGIC SPECTRUM PLANS **B-157**

BROADCASTING BOARD OF GOVERNORS **B-157**

DEPARTMENT OF AGRICULTURE **B-160**

DEPARTMENT OF COMMERCE **B-166**

DEPARTMENT OF DEFENSE **B-173**

DEPARTMENT OF ENERGY **B-177**

DEPARTMENT OF HOMELAND SECURITY **B-181**

DEPARTMENT OF INTERIOR **B-183**

DEPARTMENT OF JUSTICE **B-187**

DEPARTMENT OF STATE **B-191**

DEPARTMENT OF TRANSPORTATION **B-192**

DEPARTMENT OF TREASURY **B-199**

DEPARTMENT OF VETERANS AFFAIRS **B-203**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION **B-205**

NATIONAL SCIENCE FOUNDATION **B-208**

TENNESSEE VALLEY AUTHORITY **B-211**

UNITED STATES COAST GUARD **B-213**

UNITED STATES POSTAL SERVICE **B-217**

LIST OF TABLES **B-220**

ACRONYMS AND ABBREVIATIONS **B-221**

I. OVERVIEW

A. The Presidential Mandate

Today, wireless technologies are essential in supporting Federal agency missions crucial to the nation and enabling commercial and non-Federal public safety operations that support economic growth and safeguard lives and property. As changing government missions increase demands for mobility and agility, and private sector uses continue to expand, spectrum's role as a critical asset intensifies. To ensure that United States' spectrum policy for the 21st Century continues to harness fully the power of the airwaves to meet Federal mission requirements and to enhance prosperity, President George W. Bush established the Spectrum Policy Initiative (Presidential Initiative) in 2003.[1] The goal is a U.S. spectrum policy for the 21st Century that will foster economic growth; ensure our national and homeland security; maintain U.S. global leadership in communications technology and services; and satisfy other vital U.S. needs in areas such as public safety, scientific research, Federal transportation infrastructure, and law enforcement.

B. The Federal Response

The Federal Strategic Spectrum Plan (Federal Plan) is an important component of the *Presidential Initiative*. In a 2004 Executive Memorandum (Appendix A), the President directed Federal agencies to formulate within one year agency-specific strategic spectrum plans ("agency plans") that include: (1) "spectrum requirements … for future technologies or services," (2) "the planned uses of new technologies or expanded services requiring spectrum," and (3) "suggested spectrum efficient approaches to meeting identified spectrum requirements." The 2004 Executive Memorandum also required that the Department of Homeland Security (DHS), through consultation with other Federal, state and local agencies, develop a Spectrum Needs Plan "to address issues related to communications spectrum used by the public safety community, as well as the continuity of Government operations."[2] The Federal Plan thus incorporates these two additional key elements.

C. The Federal Needs

Fifteen Federal agencies submitted agency strategic spectrum plans to the National Telecommunications and Information Administration (NTIA) in November 2005 for inclusion in the Federal Plan.[3] As directed by the President, NTIA integrated the agency plans and the DHS

---

[1] Memorandum for the Heads of Executive Departments and Agencies, *Spectrum Policy for the 21st Century*, 69 Fed. Reg. 1569 (Jan. 9, 2004), 39 WEEKLY COMP. PRES. DOC. 726, 727 (May 29, 2003), *available at* http://www.whitehouse.gov/news/releases/2003/06/20030605-4.html.

[2] Presidential Determination: Memorandum for the Heads of Executive Departments and Agencies, *Improving Spectrum Management for the 21st Century*, 40 WEEKLY COMP. PRES. DOC. 2875 (Nov. 30, 2004), *available at* http://www.whitehouse.gov/news/releases/2004/11/20041130-8.html (hereinafter "2004 Executive Memorandum"), attached as Appendix A.

[3] In response to the 2004 Executive Memorandum, the following agencies submitted agency-specific plans in November 2005: the Departments of Agriculture, Commerce, Defense, Energy, Homeland Security, Interior, Justice, State, Transportation, Treasury, and Veterans Affairs; and the United States Postal Service; the Broadcasting Board of Governors; the National Aeronautics and Space Administration; and the National Science Foundation.

Spectrum Needs Plan into a Federal Strategic Spectrum Plan that provides the foundation for a national strategic vision to meet critical future spectrum needs. This foundation supports NTIA's goal of changing the current spectrum management system into a new model. This new and evolving spectrum management system will 1) enable more efficient and effective use of this vital resource; and, 2) where feasible and appropriate, increasingly allow dynamic access to spectrum.

Appendix B to this document is organized as follows: (1) B-1 provides a comprehensive description of current Federal spectrum use and future spectrum requirements of the 15 Federal agencies, by radio service, frequency band, and spectrum-supported systems; (2) B-2 addresses public safety spectrum requirements; (3) B-3 discusses new technologies; and (4) B-4 contains summaries of the agency-specific strategic spectrum plans.

D. <u>The National Response</u>

The President directed that NTIA consult with the Federal Communications Commission (FCC) on the creation of a National Strategic Spectrum Plan (National Plan) that will provide a basis for meeting future Federal and private sector radio-frequency needs.[4] This National Plan will address spectrum requirements for essential Federal missions, including national and homeland security, critical infrastructure, transportation, law enforcement; state, local and tribal public safety spectrum needs; and requirements of non-Federal entities for spectrum to support new services and systems.[5]

NTIA initiates in this Federal Plan a strategy to address the diverse mission-driven needs of the Federal agencies as well as the President's broadband goals and protection of lives and property. This strategy is needed to support Federal missions and the spectrum-dependent systems upon which they rely, while at the same time fostering the commercial systems that underpin the nation's economic growth and technological innovation. This unified strategy must ensure that Federal spectrum-based systems possess the necessary capabilities, including speed and mobility, that 21st Century defense, homeland security, law enforcement, and other priority undertakings demand.

This initial Federal Plan recognizes that Federal agency missions will continue to rely on the use of radio frequencies for the long-term. The agencies' plans indicate a future need for greater, dynamically available data throughput and mobility, often requiring additional spectrum or significant advances in technology. Recognizing that Federal and non-Federal spectrum requirements, much of which are below 5 GHz, will continue to grow, new methods must be

---

DHS submitted a DHS agency-specific strategic spectrum plan, as well as a separate Coast Guard plan. In addition, DHS completed a Spectrum Needs Plan with a Continuity of Government operations plan (COG Annex) attached.

4 Jurisdiction over spectrum management in the United States is divided between NTIA and the FCC. NTIA manages Federal spectrum uses for agency missions such as defense, homeland security, and science. The FCC manages all non-Federal spectrum uses, including commercial wireless communications and state and local public safety. There are also many bands which have shared Federal and non-Federal jurisdiction. *See generally*, National Telecommunications and Information Administration, U.S. Dep't of Commerce, *Spectrum Policy for the 21st Century – The President's Spectrum Policy Initiative: Report 1* (2004) (Report 1), *available at* http://www.ntia.doc.gov/reports/specpolini/presspecpolini_report1_06242004.htm.

5 *See supra* note 2, at 1.

established to enable more use in the same amount of spectrum space. These requirements necessitate a new, evolutionary model for spectrum management, one that will encourage and facilitate spectrum efficient and effective operations and will meet the need to rapidly exploit the various aspects of spectrum operations, for example, dimensions of frequency, time and location. Ultimately, this model will provide the means to meet the increasing demand and, where appropriate, to assure dynamic spectrum access to bandwidth, wherever required, whenever required. This new spectrum management model will provide Federal agencies with the bandwidth and agility the Federal agencies identified as requirements in their agency plans, while at the same time ensuring access to spectrum for private sector growth and innovation.

This Federal Plan further recognizes that Federal agencies will need access to up-to-date, low cost, interoperable, and spectrally efficient technology, solutions that may only be found in commercial services. Meeting these needs will require greater coordination and cooperation among Federal agencies, the NTIA, the FCC, state and local public safety entities and private sector spectrum users and technology innovators.

II. TODAY'S SPECTRUM ENVIRONMENT

Sixty-nine Federal agencies and departments further their missions by using radio frequency spectrum for communications, navigation, broadcasting and other purposes. The radio-frequency spectrum is allocated to specific radio services, operating in specified frequency bands, and subject to technical and service rules. The Federal agencies use over 40 specific radio services and their frequency assignments are recorded in the Government Master File maintained by NTIA. These frequency assignments are coordinated via a collaborative Executive Branch review. The FCC licenses non-Federal spectrum use through a public process.

The current spectrum management system at times lacks the flexibility to rapidly accommodate new operational requirements and innovative technologies. The *Presidential Initiative* and ongoing NTIA efforts will enable the existing Federal agency spectrum management system to be more responsive to Federal agency needs. For example, NTIA is implementing extensive information technology (IT) improvements that will streamline the process of obtaining spectrum authorizations and improve access to information concerning Federal agency spectrum use. To the extent possible, obtaining frequency authorizations and coordination among Federal agency systems, and between Federal agency and non-Federal agency systems, will be automated. Several Federal agencies already share frequencies and networks.[6] Some Federal agencies also share facilities and frequencies with state and local entities. Many Federal agencies have revamped and centralized their spectrum management functions, integrating them with their agency's strategic and capital planning processes. In some Federal agencies, strategic spectrum planning is encompassed within the agency's IT activities. Further details on this spectrum management evolution are discussed in Section IV.

---

[6] For example, USDA runs the National Interagency Fire Center, where emergency supplies, including 8000 land mobile radios, can be used during emergencies wherever they are needed. Treasury operates the "Federal Common," an interoperable frequency assignment which can be shared among all Federal agencies for law enforcement, as well as in coordination with State and local police in emergencies.

III. FUTURE FEDERAL SPECTRUM REQUIREMENTS

A. More Data/ Higher Speeds

1. Overall. Federal agencies have identified a widespread demand for greater data throughput, which often translates into a need for more bandwidth. The agencies underscore a heightened need for wireless broadband applications. For example, DOD projects a substantial, but not yet quantified, requirement for broadband communications-on-the-move. DOD envisions an IP-based flexible, ad-hoc mobile network providing constant connectivity and situational awareness.[7] Faced with increased complexity in crime fighting, DOJ forecasts increased demand for new spectrum-dependent technologies and systems. These requirements may mean wider operating bandwidths and/or spectrum access in higher frequency bands, although most requirements for mobile communications focus on use of spectrum below 5 GHz. Some Federal agencies project increases in the use of wireless broadband access for desktop and mobile computers and for public safety broadband applications.

2. Public Safety. The DHS Spectrum Needs Plan outlines the utility of broadband in a number of public safety scenarios.[8] These range from fire services situational awareness to medical high-speed resolution video transmission, to mobile surveillance emergency response video and images. The Spectrum Needs Plan recommends that NTIA, the FCC and DHS study the use of additional spectrum below 1 GHz for public safety broadband applications.

3. Unmanned Systems. Agencies foresee more unmanned systems applied in military, law enforcement and public safety missions. Unmanned aerial and ground systems often require a number of frequencies for functions ranging from control of the vehicle to communications relay and mission functionality (*e.g.*, sensor data transfer, weapons functions and situational awareness). Compression techniques may assist in reducing the amount of bandwidth needed for some data links. Nevertheless, agencies project substantial demand for spectrum for unmanned vehicles, with large bandwidths necessary for data transfer.

B. Satellite and Space Services

1. Increased Demand for Satellite Capacity. Agencies, such as DOD, project an increased demand for satellite capacity for defense, backup for disaster relief and remote area communications. In the past decade, commercial satellite service providers have often met such requirements. Consolidation in the commercial satellite industry could affect the future availability of such services. If commercial satellite capacity is insufficient to meet agency missions, additional Federal satellite systems may be required, along with additional spectrum allocations. Also, current regulatory mechanisms do not automatically provide Federal use of

---

[7] "Situational awareness" with respect to communications enables devices and personnel to have accurate and up-to-date information concerning their operational environment.

[8] The DHS Spectrum Needs Plan addresses state, local and tribal public safety needs. The COG Annex addresses continuity of government operations requirements. In addition, agencies have commented on emergency preparedness and continuity of Government operations issues in their agency-specific plans.

fixed-satellite earth stations in conjunction with commercial satellites with the same regulatory status as commercial users for purposes of protection from interference.[9]

2. Global Positioning System (GPS). DOD developed and operates GPS, a satellite constellation that provides radionavigation worldwide supporting its military aviation, maritime and terrestrial operations. The civilian community now uses GPS tracking and direction-finding extensively in civil aviation, automobiles, cell phones and other applications. Continued growth in use of GPS-enabled devices will be facilitated by the additional frequencies allocated to the radionavigation satellite service at the World Radiocommunication Conference in 2000 (WRC-2000). As the full civil potential of GPS services and its augmentations are realized, the demand for services provided by other Federal radionavigation systems is expected to decrease.

3. Remote Sensing Operations.

a) Meteorological Satellite (MetSat) Service. The Department of Commerce, National Oceanographic and Atmospheric Administration (NOAA), uses satellites to collect information about weather and conditions on the Earth, supporting a variety of economic interests in addition to disaster relief operations. NOAA projects additional spectrum needs for MetSat data transmission, passive sensing, radar, telemetry links for control and programming of autonomous vehicles and for marine and wildlife tracking.

b) Climatic research applications. The Department of Interior, United States Geological Survey and NASA use active and passive sensing satellites for research into a variety of areas including earthquakes, volcanoes and climate modeling. This research directly contributes to disaster prediction/detection on a global basis.

Near-term, NASA will require additional spectrum to provide global observations of soil moisture under substantial vegetation canopies and at subsurface depth. This information can aid understanding of the global environment.

---

[9] NTIA petitioned the FCC to address this matter. *See*, Amendment to the National Table of Frequency Allocations, RM-11341, *Petition for Rulemaking*, National Telecommunications and Information Administration, filed Aug. 4, 2006. NTIA also cited the National Space Policy as support for NTIA's petition in a letter to the FCC stating that the U.S. should "seek spectrum regulatory status under U.S. domestic regulations for United States Government owned and operated earth stations operating through commercial satellites, consistent with the regulatory status afforded commercial operations and with the allocation status of the satellite service." *See*, Letter of John M.R. Kneuer, Assistant Secretary of Commerce for Communication and Information to Kevin J. Martin, Chairman, Federal Communications Commission, dated Nov. 16, 2006. *See also*, U.S. National Space Policy, at 9 (August 31, 2006), *available at* http://www.ostp.gov/html/US%20National%20Space%20Policy.pdf.http://www.ostp.gov/html/US%20National%20Space%20Policy.pdf. The FCC has developed some mechanisms for providing such protection, on a case-by-case basis.

4. Space Policy and Research.

a) Overall. The President has authorized a new overarching national space policy.[10] The policy aims to strengthen the nation's space leadership and ensure that space capabilities are available when needed and free from harmful interference in order to further U.S. national security, homeland security and foreign policy objectives, to increase the benefits of discovery and environmental activities, and enable a dynamic, globally competitive domestic commercial space sector.

b) Research. President Bush has made space travel to the Moon and Mars a priority for NASA. NASA identifies specific additional spectrum requirements to meet the large bandwidth necessary to fulfill these missions. NASA has also developed a "Space Communications Architecture" for implementing the Presidential vision for space exploration.

C. High Frequency (HF)

Continued and growing demand for HF spectrum stands out in agency forecasts for defense, homeland security, public safety and continuity of Government operations, both fixed and mobile. Also known as "shortwave" radio, HF encompasses radio frequencies between 3 and 30 MHz. HF can achieve over-the-horizon communications at relatively low cost.[11] HF can serve as a main communications system, and as a backup for satellite communications. DOD notes that HF can be a "common denominator," achieving interoperable communications in multi-service and multi-national operations, especially with coalition partners that have limited communications capabilities.

Several Federal agencies use HF for emergency communications. The National Communications System has established the SHARES HF program for national security and emergency preparedness.[12] The BBG and the Coast Guard identify additional specific requirements for HF spectrum. The BBG uses HF for international non-military broadcasting. The Coast Guard uses HF for maritime mobile communications, and is also exploring use of HF radar systems. The Public Safety Spectrum Needs Plan underscores public safety's reliance on HF in disaster and emergency scenes when commercial and other terrestrial systems are disrupted.

NTIA recognizes the continued and potentially growing need for HF spectrum and will work with the Federal agencies and the FCC to further refine needs and identify possible solutions.

---

[10] *See*, National Space Policy, *supra* note 9 at 5.

[11] HF waves can transmit to the other side of the earth because they are refracted by the Earth's atmosphere, a phenomenon known as ionospheric skip propagation.

[12] SHARES or SHAred RESources HF radio communications program provides a single, interagency emergency message-handling system. SHARES brings together existing HF radio resources of Federal, state and industry organizations when normal communications are unavailable. *See* http://www.ncs.gov/shares/.

D. Radar

Agencies use radar for air and maritime navigation. In addition, the Federal Government, particularly the DOD, uses radar for location, targeting, tracking and surveillance.

Defense and security use of radar systems will continue to grow and evolve. Agencies have projected future radar demand in the HF and VHF bands. Many spectrum bands for radar are not fungible. Rather, radar systems present particular engineering cases and require propagation qualities that are suited to specific missions and purposes vital to national security. However, these Federal uses face increased competition for spectrum from expanding commercial services, as well as services that can serve both Federal and non-Federal users. For example, RFID technologies are heavily used by certain agencies but the technology operates within UHF spectrum allocated for the radiolocation service. Commercial interest in the radar bands for non-Federal applications often begins overseas, but as international implementation becomes successful, interest in U.S. market implementation grows.

E. Air Traffic Control

The FAA projects steady increases in demand for aeronautical mobile capacity. Many of these demands will be met through equipment upgrades. However, flight safety and efficient aircraft movement require greater and timelier information, which could create a need for more spectrum.

F. Above 30 GHz

There are several emerging applications for radar in the upper regions of the spectrum. DOD's study of millimeter wave bands (30-300 GHz) includes radar ground-mapping applications such as precise resolution and target identification. In addition, there is developing interest in the above 300 GHz region for applications such as radio astronomy and remote sensing. Scientists anticipate using these upper frequency ranges to study galaxy and star formation with giant telescopes like the Atacama Large Millimeter Array in Chile. Researchers also are applying "T-rays," or radio waves in the terahertz range above 1000 GHz, to medical imaging and explosive detection.

IV. THE FEDERAL STRATEGY

While the Federal agencies have provided extensive information on their current and projected future spectrum use, this information is primarily qualitative in nature. Only a few have been able to supply quantified estimates of future spectrum uses. Furthermore, while agencies are motivated to utilize effective systems in order to meet their missions, further improvements to the Federal spectrum management framework are needed to improve spectrum efficiency. Agencies have taken some actions to utilize more spectrally efficient systems, for example, by implementing narrowband equipment and taking initial steps to consider the economic value of spectrum. However, more action is needed to meet growing spectrum demand. Further integration of spectrum management into agency capital planning and budget processes is needed to provide a mechanism for consideration of the value of spectrum when investing in new major spectrum-dependent systems. Mechanisms that enable agencies to factor in the value of spectrum or provide other means to use it more efficiently, along with assessment of system effectiveness in meeting mission requirements, could result in investment in more spectrum-efficient systems.

With respect to future non-Federal spectrum requirements, such needs generally are driven by market forces as well as state and local public safety requirements, which are difficult to project over the long run. Moreover, pending collaboration with the FCC on development of a National Strategic Spectrum Plan, information concerning future non-Federal agency spectrum requirements can only be inferred by the rapid growth of new wireless technologies and services over the past few years. In order to accommodate these trends, this Federal Strategic Spectrum Plan seeks to incrementally improve the Federal spectrum management processes through: automation and advanced analytical tools; standardized generation of spectrum requirements; and methods to forecast spectrum trends. These improvements will lead to a better understanding of existing and intended spectrum use and a comprehensive operational picture of the spectrum environment. This increased understanding will enable development of policies and standards which support the introduction and use of adaptive and dynamic means of utilizing spectrum. Improvements to Federal spectrum management must foster promising technologies that improve efficiency and effectiveness and ultimately result in the flexibility, agility and adaptability of spectrum-dependent systems required by Federal and non-Federal entities in the future.

A. Near–Term

For the next five years, NTIA expects the Federal agencies to continue many of the spectrum management improvements they have already instituted in response to the *Presidential Initiative,* including more strategic spectrum planning linked to overall agency strategic and capital planning processes as well as more rigorous analyses of alternative solutions to meeting mission requirements. The Federal Government and the nation will continue to reap the benefits of these and several other ongoing *Presidential Initiative* projects.

The Spectrum Needs Plan identifies the need for further study of public safety requirements.[13] In addition, the Spectrum Needs Plan encourages state and local public safety agencies to formulate long-term strategic spectrum plans that foster interoperability.[14]

NTIA will continue its program to streamline and integrate spectrum management processes through enterprise-wide information services which will reduce the time required to perform

[13] In 1995, the FCC and NTIA convened experts from local, state, and Federal user communities, as well as staff of their respective agencies, and private industry to form the Public Safety Wireless Advisory Committee (PSWAC). The goal of the PSWAC was to determine comprehensively the public safety spectrum requirements through 2010. The 1996 PSWAC Final Report stands as the first and only study of public safety spectrum requirements at all levels of government. *See*, Final Report of the Public Safety Wireless Advisory Committee to the Federal Communications Commission and the National Telecommunications and Information Administration, Sept. 11, 1996, http://www.ntia.doc.gov/osmhome/pubsafe/pswac_al.pdf.

[14] The Spectrum Needs Plan specifically recommends that non-Federal public safety agencies address how they intend to use all available spectrum efficiently, and to maximize the use of new technology, in public safety Tactical Interoperable Communication Plans (TICP), as required by the fiscal year 2005 Homeland Security Grant Program guidance.

operations, eliminate duplicative steps encountered with spectrum management processes, increase information sharing, and encourage consideration of adaptive technologies and efficiency measures. NTIA will continue to work with the Federal agencies in this effort so that the spectrum management community optimizes its human capital and investments as it improves operational effectiveness.

1. Use of Commercial Services Where Feasible. Federal regulations require Federal agencies to use commercial communications and spectrum-dependent services where possible.[15] The rapid deployment of improved commercial technologies, their decreasing costs, and tight Federal budgets can provide incentives to use such services.[16] The COG Annex acknowledges that, as a general rule, the Federal Government should make better use of commercial services.[17] The COG Annex, however, underscores that emergency services require higher standards of reliability and redundancy and that commercial networks may not be designed to this level.

Commercial communications services and networks nevertheless are an important adjunct to dedicated government systems. DOD, in particular, relies heavily on capacity on commercial communications satellites but cannot control the availability of such commercial capacity on an on-going basis. Thus, a rational plan is needed to balance commercial use, involving multiple commercial providers, with availability of government-dedicated systems, to ensure access to satellite capacity, whenever and wherever needed.

2. "Smart" Technologies. Many agencies plan to implement "smart" radio technologies such as software-defined radio (SDR) to improve adaptability and flexibility within an operational environment. Ultimately, these and other technologies will provide more rapid access to needed frequencies, wherever needed, whenever needed.

Through automatic reprogramming, an SDR device can transmit and receive on a wide range of frequencies, and operate pursuant to changing technologies and service rules and standards. "Cognitive" radios are programmed to "perceive" and "learn" their radio environment. By tracking and adapting to their electro-magnetic environment, cognitive radios can dynamically use whatever spectrum is available in any particular moment, and at the same time prevent interference to co-existing systems. NTIA is monitoring the development of such spectrally efficient approaches and encourages additional technology developments, particularly in the area of dynamic spectrum access. NTIA will look to both the government and private sector for assistance and support in devising the necessary plans and strategies that will allow evolution of the spectrum management system to support use of these technologies and minimize human-directed processes.

3. Flexible Approach to Incentives. Currently, regulatory hurdles prevent Federal and non-Federal spectrum users from efficiently sharing spectrum. New policies could allow Federal agencies to benefit from making available underutilized spectrum to non-Federal entities. More

[15] *See e.g.,* NTIA Manual, supra note 39 § 8.2.48A ("Federal agencies implementing new land mobile communication systems and replacing aging ones should use available commercially offered land mobile services, or share land mobile services operated by other Federal, state or local government agencies whenever possible.")
[16] NTIA authorization is required for Federal entities operating on spectrum allocated to non-Federal users.
[17] COG Annex, at 2-7.

flexible spectrum sharing could allow both Federal and non-Federal users to more efficiently utilize the spectrum resource through economic and non-economic incentives. NTIA is studying various incentive approaches and methodologies to promote the use of spectrum-efficient technologies to satisfy Federal and non-Federal spectrum needs. These studies will identify policy changes required to implement these incentive mechanisms, possibly including secondary markets, property rights, sharing, and fees. NTIA expects to develop recommendations relating to these policy changes, as appropriate, develop legislative proposals as required, and implement such policies within the Federal Government.

4. Interoperability and Other Public Safety Issues.

a) Regulatory Flexibility. The lack of communications interoperability among public safety agencies is a complex and key concern. Several agencies have called for rule changes and policy reforms to improve interoperability and sharing in emergencies. NTIA, with the advice of the Interdepartment Radio Advisory Committee (IRAC), recently took steps to address the need for non-Federal entities to use public safety spectrum in appropriate situations.[18]

b) Federal/Non-Federal Public Safety Demonstration. Pursuant to the *Presidential Initiative*, NTIA tested the operational and cost effectiveness of sharing spectrum and communications infrastructure among Federal, state and local governments, and other non-Federal users.[19] This test utilized the Washington, DC Wireless Accelerated Responder Network (WARN), a pilot program operating on a dedicated public safety network in the 700 MHz band under an FCC experimental license. WARN provides real-time video for city-wide remote surveillance, chemical and biological detection and other emergency-related services. NTIA published a report on the results and observations of the demonstration project and associated recommendations in 2007.[20]

c) Microwave Backhaul. The Spectrum Needs Plan anticipates requirements for expanded microwave backbone networks to accommodate new public safety services, as contemplated in the 700 MHz band. The Spectrum Needs Plan recommends that the FCC, in coordination with NTIA and DHS, work with the public safety community to assess this need, as well as opportunities for sharing within the public safety community.

5. COG Considerations. The COG Annex to the Spectrum Needs Plan advises that, as new frequencies are assigned or re-allocated, spectrum managers consider how to support alternative communications in emergencies. NTIA will take these concerns into account, as appropriate.[21]

---

[18] *See*, NTIA Manual, *supra* note 39 § 4.3.16.

[19] *See*, *Spectrum Policy for the 21st Century -- The President's Spectrum Policy Initiative: Report 2, Recommendations from State and Local Governments and Private Sector Responders*, U.S. Dep't of Commerce, National Telecommunications and Information Administration (June 2004) (Report 2), http://www.ntia.doc.gov/reports/specpolini/presspecpolini_report2_06242004.pdf.

[20] *See*, *A Public Safety Sharing Demonstration*, U.S. Dep't of Commerce, NTIA (May 2007), http://www.ntia.doc.gov/reports/NTIAWARNReport.pdf. This report fulfilled Recommendation 9(b) of Report 2. *See, supra* note 19, at 26.

[21] *See generally*, section III.C, *supra* at page 6.

6. IT Upgrades to the Federal Spectrum Management System. The *Presidential Initiative* underscores the criticality of information technology to reaching the ultimate goal of real-time processing of requests for new or additional frequency assignments. NTIA and the FCC have worked together in the past to automate frequency coordination. Future automation could build upon the success of 70-80-90 GHz coordination, where millimeter wave bands, once exclusively used by Federal agencies, can now be approved for non-Federal use in a matter of minutes. NTIA also is working to streamline the work of Federal spectrum managers through IT innovations such as single portal access to both classified and non-classified systems, electronic access to the IRAC documents and creation of a "Data Dictionary" that will standardize the terminology used in frequency applications.

7. Spectrum Valuation and Economic Efficiency. As directed by the President, the Office of Management and Budget has instructed the Federal agencies to consider the economic value of radio spectrum when developing justifications for new systems.[22] NTIA's *Presidential Initiative* program is considering methods of valuing Federal spectrum as well as incentives for more efficient spectrum use within the Federal Government.

The 2004 Executive Memorandum also directed the NTIA to develop a plan to identify and establish possible incentives for both the Federal and non-Federal sectors to use spectrum more efficiently and effectively. NTIA has created a project plan for this task, and begun its implementation. NTIA convened a public-private workshop on incentives in 2006 and inventoried international spectrum management "best practices". NTIA continues to focus on spectrum valuation, possible levying of user fees for Federal spectrum use, increased sharing and other, market and non-market-based approaches to stimulate the most efficient use of this important natural resource.

8. Technical Efficiency. NTIA's engineers are developing more precise methods to improve management of scarce spectrum. For example, NTIA is developing models for optimizing efficiency and effectiveness in land mobile systems. The Commerce Spectrum Management Advisory Committee (CSMAC) is studying technical and operational sharing efficiencies. DOD is developing a spectrum evaluation mechanism, the "spectrum scorecard", which provides a spectrum efficiency and effectiveness trade-off analysis for program managers. Further programs will develop automated spectrum management tools that also will promote dynamic frequency use, increasing the amount of time frequency assignments are in use.

9. Forecasting Trends. Development of new spectrum management tools will improve quantification of Federal spectrum use, and refine estimates of future requirements. NTIA will continue to collaborate with the Federal agencies, and other entities, as appropriate, on how to make projections of spectrum usage as accurate as possible. These efforts include exploring how to better predict both Federal and private sector spectrum use, including study of scenario-based simulation methods. These new approaches will improve forecasts of spectrum trends, and new tools will enable tracking spectrum usage in the dimensions of both time and space.

---

[22] The Office of Management and Budget (OMB), Circular A-11, § 33.4 (2006), *available at* http://www.whitehouse.gov/omb/circulars/a11/current_year/s33.pdf (last visited, Feb. 7, 2008).

10. Improved Interagency and Federal/Private-Sector Coordination. The Policy and Plans Steering Group (PPSG), an advisory group of senior, political-level Federal officials advising NTIA's Administrator on spectrum policy and strategic plans, will continue to serve as a forum for issue resolution and harmonization on *Presidential Initiative* tasks.[23] The CSMAC will provide valuable input from the private sector. In addition, the working partnership between NTIA and the FCC on automation will reduce the need for staff to handle individual spectrum requests. Finally, NTIA's collaboration with the FCC on a National Strategic Spectrum Plan will promote full integration and execution of *Presidential Initiative* recommendations.

B. Mid-Term

1. Median Objectives. NTIA's five-to-ten-year goal is achieving a unified approach to improved spectrum situational awareness and adaptive spectrum use and control. Improved processes will increase the accuracy and fidelity of Federal spectrum requirements data. NTIA and FCC coordination will be automated, eliminating the "man in the loop" for most aspects of spectrum assignment and frequency coordination. DOD also is taking steps now to achieve automated coordination of its internal spectrum assets.

2. NTIA/FCC New Technology Testbed. The test bed proposal is a key recommendation of the President's Initiative.[24] It will enable Federal and non-Federal users of spectrum to explore new technologies and methods to share the finite radio spectrum. Both the NTIA and the FCC have solicited comment on the proposal. Each agency will identify 10 MHz of spectrum to be used in the test. NTIA expects that this project will drive future innovation and increased sharing to benefit government and commercial users, and serve as a proving ground and catalyst for advancing technologies important to dynamic spectrum access.

C. Long-Term

Because the agency-specific strategic spectrum plans contain limited information regarding future requirements and technology, NTIA's long-range assumptions are necessarily also limited. At this time, NTIA cannot predict the precise technologies, services and processes that will be utilized a decade from now. Current allocation and authorization methods and low-power unlicensed underlays will continue in use. For many bands and services, NTIA also envisions increased spectrum sharing through cognitive, self-adjusting spectrum use. This will provide a higher level of confidence of increased spectrum access for Federal, public safety and commercial users, providing an overall framework for meeting increasingly complex spectrum needs. Spectrum access on a dynamic basis will be realized only through effective planning by the spectrum management community to define and take the steps necessary to achieve this long-term vision. It is NTIA's goal within the next two-to-five years to identify the spectrum management framework required for the Federal Government to keep pace with the dramatic changes in technology and to achieve this vision of spectrum use. NTIA expects to execute this new framework within Federal spectrum management and related processes by 2012.

---

[23] *See* Report 1, Recommendation 13, *supra* note 4, at 29.

[24] *See*, Recommendation 11, Report 1, *supra* note 4, at 28.

<u>V. RECOMMENDATIONS</u>

This Federal Plan sets in motion an evolutionary strategy for an overarching national spectrum policy for the 21st Century. The goal of this strategy is to provide access to spectrum for Federal and non-Federal users alike on an increasingly dynamic basis. In charting this course, both Federal and non-Federal sectors must work together to create a unified vision for this future state. The overarching, high-level vision, architecture, and steps to achieve the goals of the President's Spectrum Policy for the 21st Century will be articulated in this policy. A Federal or National Strategic Plan for Spectrum Management must embody this vision, architecture and steps and provide a blueprint for spectrum management for the Federal Government. Each Federal agency should then formulate a corresponding strategic plan for spectrum management to ensure that all agencies are consistent and unified in realizing this holistic vision. Finally, NTIA will continue to work with the Federal agencies to collectively and collaboratively establish the foundation, incremental steps, actions and milestones necessary to move the United States forward to achieving this goal. The National Telecommunications and Information Administration invites the Federal agencies, the Federal Communications Commission, and the spectrum-using American public, with input from technology and equipment developers and service providers, to work together to achieve this future of dynamic spectrum access.

Appendix A

PRESIDENTIAL MEMORANDUM

the White House
President George W. Bush

For Immediate Release
Office of the Press Secretary
November 30, 2004

Presidential Determination: Memorandum for the Heads of Executive Departments and Agencies

MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

SUBJECT: Improving Spectrum Management for the 21st Century

In May 2003, I established the Spectrum Policy Initiative to promote the development and implementation of a U.S. spectrum management policy for the 21st century. This initiative will foster economic growth; promote our national and homeland security; maintain U.S. global leadership in communications technology; and satisfy other vital U.S. needs in areas such as public safety, scientific research, Federal transportation infrastructure, and law enforcement.

The existing legal and policy framework for spectrum management has not kept pace with the dramatic changes in technology and spectrum use. Under the existing framework, the Federal Government generally reviews every change in spectrum use. This process is often slow and inflexible and can encourage the introduction of new technologies. Some spectrum users, including Government agencies, have argued that the existing spectrum process is insufficiently responsive to the need to protect current critical uses.

As a result, I directed the Secretary of Commerce to prepare recommendations for improving spectrum management. The Secretary of Commerce then established a Federal Government Spectrum Task Force and initiated a series of public meetings to address improvements in policies affecting spectrum use by the Federal Government, State, and local governments, and the private sector. The recommendations resulting from these activities were included in a two-part series of reports released by the Secretary of Commerce in June 2004, under the title Spectrum Policy for the 21st Century - The Presidents Spectrum Policy Initiative (Reports).

Therefore, to the extent permitted by law and within existing appropriations, I hereby direct the heads of executive departments and agencies (agencies) to implement the recommendations in the Reports as follows:

Section 1. Office of Management and Budget.

Within 6 months of the date of this memorandum, the Office of Management and Budget (OMB) shall provide guidance to the agencies for improving capital planning and investment control procedures to better identify spectrum requirements and the costs of investments in spectrum-dependent programs and systems. Within 1 year of the date of this memorandum, agencies shall implement methods for improving capital planning and investment control procedures consistent with the OMB guidance, including making any modifications to agency capital planning procedures necessary to ensure greater consideration of more efficient and cost-effective spectrum use.

Section 2. Other Executive Departments and Agencies.

(a) Within 1 year of the date of this memorandum, the heads of agencies selected by the Secretary of Commerce shall provide agency-specific strategic spectrum plans (agency plans) to the Secretary of Commerce that include: (1) spectrum requirements, including bandwidth and frequency location for future technologies or services; (2) the planned uses of new technologies or expanded services requiring spectrum over a period of time agreed to by the selected agencies; and (3) suggested spectrum efficient approaches to meeting identified spectrum requirements. The heads of agencies shall update their agency plans biennially. In addition, the heads of agencies will implement a formal process to evaluate their proposed needs for spectrum. Such process shall include an analysis and assessment of the options available to obtain the associated communications services that are most spectrum-efficient and the effective alternatives available to meet the agency mission requirements. Heads of agencies shall provide their analysis and assessment to the National Telecommunications and Information Administration (NTIA) for review when seeking spectrum certification from the NTIA.

(b) Within 6 months of the date of this memorandum, the Secretary of Homeland Security, in coordination with the Secretary of Commerce and, as appropriate, the Chairman of the Federal Communications Commission, and considering the views of representatives from: (1) the public safety community, (2) State, local, tribal, and regional governments; and (3) the private sector, shall identify public safety spectrum needs.

(c) Within 1 year of the date of this memorandum, the Secretary of Homeland Security, in consultation with the Secretary of Commerce, the Director of the Office of Science and Technology Policy, the Director of the Office of Management and Budget, the Attorney General, the Secretaries of State, Defense, Transportation, Agriculture, and the Interior, the heads of other appropriate agencies, and, as appropriate, the Chairman of the Federal Communications Commission, shall develop a comprehensive plan, the Spectrum Needs Plan, to address issues related to communication spectrum used by the public safety community, as well as the continuity of Government operations. The Spectrum Needs Plan shall be submitted to the President through the Assistant to the President for Homeland Security, in coordination with the Assistant to the President for Economic Policy and other relevant components of the Executive Office of the President.

Section 3. Department of Commerce.

(a) Within 6 months after receiving the agency plans developed in section 2(a) of this memorandum, the Secretary of Commerce shall integrate the agency plans and Spectrum Needs Plan, based upon a Department of Commerce framework, into a Federal Strategic Spectrum Plan and shall assist in the formulation of a National Strategic Spectrum Plan. The Secretary of Commerce, in consultation with the Chairman of the Federal Communications Commission, as appropriate, shall update the National Strategic Spectrum Plan on a biennial basis thereafter.

(b) Within 1 year of the date of this memorandum, the Secretary of Commerce, in coordination with other relevant Federal agencies identified by the Secretary, shall develop a plan for identifying and implementing incentives that promote more efficient and effective use of the spectrum while protecting national and homeland security, critical infrastructure, and Government services.

(c) Within 6 months of the date of this memorandum, the Secretary of Commerce shall establish a plan for the implementation of all other recommendations included in the Reports. Not more than 1 year from the date of this memorandum, the Secretary of Commerce shall provide to the President a report describing the progress on implementing the recommendations in the Reports. The report shall include a section prepared by the Secretary of Homeland Security that describes the progress made with respect to public safety spectrum issues. This report shall be updated on an annual basis, until completion of the actions required by this memorandum. The heads of agencies shall provide the Secretary of Commerce and the Secretary of Homeland Security with any assistance or information required in the preparation of the annual report.

(d) The plans in sections 3(a)-(c) and the annual report developed in section 3(c) of this memorandum shall be submitted to the President through the Assistant to the President for Economic Policy, in coordination with the Assistant to the President for National Security Affairs and other relevant components of the Executive Office of the President.

(e) As appropriate, the Secretary of Commerce and heads of other agencies shall consult with the Chairman of the Federal Communications Commission regarding the implementation of the recommendations in the Reports.

Section 4. General.

(a) Nothing in this memorandum shall be construed to impair or otherwise affect the functions of the Director of the Office of Management and Budget relating to budget, administrative, or legislative proposals.

(b) This memorandum is intended only to improve the internal management of the Federal Government and is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity, by a party against the United States, its departments, agencies, entities, instrumentalities, its officers or employees, or any other person.

(c) This order shall be implemented in a manner consistent with existing statutes, treaties, Executive Agreements, and Executive Orders affecting the operation of any of the departments, agencies, or instrumentalities of the Federal Government.

GEORGE W. BUSH

# # #

Appendix B

CURRENT FEDERAL SPECTRUM USE AND FUTURE REQUIREMENTS

INTRODUCTION

This Appendix describes the current and expected future uses of the spectrum for radiocommunication based on the submissions of the fifteen Federal agencies selected by the Secretary of Commerce in accordance with the direction of the President. This compendium is based on the National Telecommunications and Information Administration's (NTIA) review, compilation, and synthesis of these submissions so that the Federal Government's current and future spectrum needs could be described in the context of agency missions and functions. In preparing this Appendix, NTIA sought, as requested by the various Federal agencies, to ensure that the descriptions and subject matter presented would not jeopardize the sensitivity of government operations. This Appendix: (1) summarizes Federal agency spectrum use on a service-by-service basis; (2) addresses the specific needs of the public safety community; (3) discusses the impact of new technologies on Federal agency spectrum use; and (4) provides summaries of the Federal agency-specific strategic spectrum plans submitted to NTIA.

SPECTRUM ALLOCATIONS

Radio frequency spectrum allocations are a result of domestic and international spectrum planning processes in which parts of the spectrum ("frequency bands" or simply "bands") are set aside or allocated to the different radio services in a table of radio frequency spectrum allocations.[25] Most allocations result from the collective activities of the member nations of the International Telecommunication Union (ITU), a United Nations specialized agency. An international Table of Frequency Allocations is necessary because radio transmissions can transcend national borders. Furthermore, some services, such as aeronautical radionavigation, require the international commonality that such a table provides.

The ITU Table of Frequency Allocations is part of the ITU Radio Regulations, which has international treaty status. Each country, however, retains national sovereignty with respect to operation of wireless devices within its boundaries, and can adopt its own allocations. However, most ITU signatory countries, including the United States, use the ITU table as the basis for their national table. Many nations consider their table of frequency allocations as their national spectrum plan, since it provides guidance as to where in the radiofrequency spectrum to operate radio systems, including those under development. The ITU Table of Frequency Allocations not

---

[25] Three key terms "allocation," "allotment," and "assignment" have precise legal definitions based on international telecommunications treaty law. These are incorporated into the U.S. regulations and are:

> An allocation (of a frequency band) is "entry in the Table of Frequency Allocations of a given frequency band service under specified conditions. This term shall also be applied to the frequency band concerned."
>
> An allotment (of a radio frequency or radio frequency channel) is "entry of a designated frequency channel in an agreed plan."
>
> An assignment (of a radio frequency or radio frequency channel) is "authorization given by an administration for a radio station to use a radio frequency or radio frequency or a radio frequency channel under specific conditions."

See, ITU Radio Regulations, art. 1, sec. II, at 1.16-1.18 (Geneva 2004).

only pertains to current uses but provides allocations which can address many future needs. In some cases, individual country allocations may differ slightly from the ITU table, depending upon the spectrum needs of that nation. The United States further divides its allocation table into Federal and non-Federal allocations.[26]

The allocation table structure, both international and domestic, often allows multiple radio services in a frequency band. This provides flexibility within a country to use location, time or another aspect of a radio operation to allow sharing the same spectrum without harmful interference. In many cases, a country takes a band allocated to multiple services and separates those services into specific subbands to prevent interference or simplify assignment. The table of frequency allocations is changed as needed to accommodate new technologies and radio services, and to accommodate additional spectrum requirements created by growth in existing services. Similarly, spectrum allocations may no longer be required for some obsolete technologies or services that are no longer used, freeing that spectrum for other uses. The ITU changes the Table of Frequency Allocations via decisions made during World Radiocommunication Conferences (WRC). With the exception of changes in the bands allocated exclusively to Federal Government users, spectrum allocation changes in the United States are made in accordance with administrative law procedures.[27] For example, if a new service or system does not "fit" into an existing service category or allocation, a lengthy domestic, and often international process, is required to define the new service and provide allocations for such service. These processes, when they require changes to the international table of frequency allocations, can take many years.

[26] For the purposes of this Federal plan, Federal frequencies or allocations are those allocated for the Federal Government and NTIA authorization is required for federal entities operating in the radio frequency spectrum. Those allocated for use by state and local governments, commercial and private entities are non-Federal allocations and FCC authorization is required for non-federal entities operating in the spectum. It should be noted that there also are shared Federal and non-Federal allocations.
[27] *See*, Administrative Procedures Act, 5 U.S.C. § 553 (1946, as amended).

SECTION B-1

RADIOCOMMUNICATION SERVICES

APPROACH

The discussion within this plan regarding the major radiocommunication services has been divided as follows, with some services grouped within one section, based on similarities in function:

- Mobile Service and Land Mobile Service;
- Aeronautical Mobile Service;
- Maritime Mobile Service;
- Mobile-Satellite Service;
- Aeronautical Mobile-Satellite Service;
- Maritime Mobile-Satellite Service;
- Fixed-Satellite Service;
- Fixed Service;
- Radiodetermination Service and Radiodetermination-Satellite Service, including Radionavigation Service, Radionavigation-Satellite Service and Radiolocation Service;
- Earth Exploration-Satellite Service, Space Research Service, and Meteorological-Satellite Service
- Meteorological Aids Service;
- Radio Astronomy Service;
- Space Operations Service and Inter-Satellite Service;
- Broadcasting Service and Broadcasting-Satellite Service;
- Miscellaneous Services; and
- Unspecified Services.

The following sections describe current Federal Government use of the radiofrequency spectrum, by radio service. These sections describe frequency bands used, the types of systems operated, and the Federal missions supported by these systems. The sections also address projected future requirements for spectrum to the extent addressed in the agency plans, Federal use of commercial systems, and how new technologies are being employed and are expected to be deployed in spectrum-dependent systems.

MOBILE SERVICE AND LAND MOBILE SERVICE

INTRODUCTION

This section addresses the mobile and land mobile services. The mobile service includes stations used for communications purposes while in motion on various platforms such as handheld, automobiles, ships, and aircraft. The land mobile service includes mobile stations that operate only on land. The aeronautical mobile service, the maritime mobile service, and the mobile-satellite service are considered in separate sub-sections.

The mobile service is defined as "a radiocommunication service between mobile and land stations, or between mobile stations."[28] Any mobile station operating on the surface of the Earth, including operations in the air or on ships may operate in spectrum allocated to the mobile service. However, spectrum allocated specifically to the land mobile service can be used only for stations operating on land.

The land mobile service is defined as "a mobile service between base stations and land mobile stations, or between land mobile stations." Furthermore, a "land mobile station" is a "mobile station … capable of surface movement within the geographical limits of a country or continent." A mobile station is used "while in motion or during halts at unspecified points."[29]

The land mobile service has the largest number of Federal assignments of all the radio services. Federal agencies operate stations in the land mobile service in many frequency bands throughout the spectrum. Because of the physics of radio propagation and readily available equipment, the greatest land mobile usage is concentrated in the 30-300 MHz (VHF) and 300-3000 MHz (UHF) frequency ranges. In addition to using Federal Government frequencies and dedicated systems for mobile communications, Federal agencies make extensive and growing use of commercial services such as cellular communications.

Recognizing the critical importance of land mobile communications, NTIA has conducted a number of analyses and planning studies, including long-term spectrum requirements for the land mobile service and the 3-30 MHz (HF) bands. These studies are discussed and referenced in the sub-sections that follow.

Federal land mobile spectrum serves many functions. These include conventional mobile voice communications used for facilities operations, administration, maintenance or security, scientific, medical or meteorological uses, supporting the electrical power grid at Federally-operated electric utilities, security and maintenance of our national parks, security and law enforcement, highway safety and administration, public safety, homeland security, continuity of government operations, interoperability with other agencies, military equipment testing and training, and national defense. Agency requirements with respect to public safety uses are addressed in the Public Safety Section.

---

[28] *See*, ITU Radio Regulations, art. 1, sec. III, at 1.24 (Geneva 2004). A land station is formally defined as "a station in the mobile service not intended for use while in motion," *i.e.*, a base station or repeater.
[29] *See*, ITU Radio Regulations, art. 1, sec. IV, at 1.67 (Geneva 2004).

Land Mobile Service – Related NTIA Spectrum Planning

In 1995, NTIA published its national long-range spectrum requirements report titled "U.S. National Spectrum Requirements Projections and Trends" that addressed all of the then current and projected ten-year spectrum needs.[30] The land mobile service was a significant part of the study, and the report concluded that a total of 204 MHz would be needed for Federal and non-Federal land mobile operations through 2005. Later in 1995, NTIA produced a subsequent planning report devoted solely to the land mobile service, "Land Mobile Spectrum Planning Options."[31] This land mobile planning study identified several communications modes that required additional spectrum: 1) conventional or trunking dispatch requirements; 2) wide-area land mobile; 3) wide-area and wide-bandwidth public safety, industrial, and business; 4) mobile video; and, 5) intelligent transportation systems.

NTIA currently has two land mobile communications studies underway with the overall objective of improving spectrum-use efficiency and usage effectiveness.[32] The studies focus on: 1) developing standardized methods for evaluating the efficiency obtained by the Federal Government in its use of the land mobile spectrum; and 2) proposing improvements in efficiency though use of new technologies, spectrum management practices, technical standards, and policies. Both of the current NTIA studies examine the use of the 162-174 MHz Federal land mobile frequency band in the Washington, D.C. metropolitan area, considered to be a spectrally congested land mobile radio environment. These efforts are reviewing:

1. Adopting a frequency assignment method based on improved interference analysis methodology and detailed equipment characteristics;
2. Using digital trunking technology in facility-shared land mobile communications systems in areas where there are many users; and
3. Reducing or rearranging the existing frequency allotments[33] and the use of area frequency assignments.[34]

Currently, NTIA also is investigating how frequency allotments and area frequency assignments are used by the Federal agencies. NTIA is developing proposals to reduce the number of channels allotted to individual agencies and to limit the use of area frequency

---

30 *U.S. National Spectrum Requirements: Projections and Trends*, U.S. Dep't. of Commerce, NTIA (March 1995) (NTIA 1995 Report).

31 *Land Mobile Spectrum Planning Options*, NTIA Special Publication 95-34, NTIA (Oct. 1995) (NTIA Land Mobile Report).

32 Spectrum effectiveness refers to how well a resource satisfies the overall service requirements of the users. Using more accurate standardized interference analysis methodologies for assigning frequencies will increase the effectiveness of the Federal agencies obtaining frequency assignments in spectrally congested areas and in performing their missions.

33 Frequency allotments are designated radio frequencies in a channel plan within an allocated band for use by specific agencies. *See generally*, NTIA Manual, supra note 39 at 6.1.1 (for the definition of "allotment of a radio frequency or radio frequency channel"). In the NTIA spectrum management process, channel allotments essentially provide a structure within which agencies select frequencies. However, these allotments do not convey a right to or ownership of the allotted channel. Moreover, Federal agencies must obtain assignments from NTIA to use allotted channels.

34 An area assignment of a frequency provides an agency with access throughout a specified geographic area (*e.g.*, a specific state or portion thereof, or indeed the United States and its Possessions).

assignments unless the agency can show a very high level of use throughout the region covered by the assignment.[35] For example, in place of the area frequency assignments, an NTIA-managed pool of frequencies could be created from which agencies could obtain assignments where and when they need them in a timely and efficient manner. If NTIA decides to manage a pool of frequencies, reducing or eliminating the specified channel allotments to Federal agencies, an automated capability based on commercial interference calculation methodologies, such as that contained in the Telecommunications Industry Association's TSB-88-B methodology, would be employed to ensure that the spectrum is used efficiently.[36]

Federal jurisdictions and their communications operations can be broad depending upon the nature of their authority and mission, and the frequency reuse reflects the larger geographic operating areas. The Federal system capabilities must meet the demands of the larger Federal missions and associated communications requirements. These demands are not static, and in many cases are constantly evolving and necessitate deployment of systems in new locations. Therefore, the fundamental methods of assigning frequencies and reuse have been significantly different between the Federal and non-Federal sectors.

Improving Spectrum Efficiency by Narrowbanding Land Mobile Channels

NTIA recognized in 1993 that the critical land mobile communications bands of 162-174 MHz and 406.1-420 MHz were becoming congested and that future spectrum requirements would not be likely to be met under the 25 kHz channel plans.[37] NTIA concluded that the spectrum efficiency could be almost doubled if the channelization was halved to 12.5 kHz thereby enhancing the possibility of satisfying future requirements. This reduction in channel size is called narrowbanding.[38]

With the advice of the IRAC, NTIA adopted 12.5 kHz channel plans for the 138-150.8 MHz, 162-174 MHz, and 406.1-420 MHz bands. For the latter two bands, conformance was required by 2005 and 2008 respectively, providing a transition period of ten years.[39] Because of fiscal and administrative constraints, not all of the Federal agencies expect to comply with these mandates. For example, narrowbanding is one of the Department of Homeland Security's (DHS) three major spectrum-related issues. New, narrowband equipment suitable for Federal missions has been slow to reach the market, and there is potential for interference from the not-yet transitioned 25 kHz systems.

The U.S. Department of Agriculture's (USDA) Forest Service (FS) completed all of its migration to VHF narrowband equipment in 2005. These assignments represented 90 percent of

---

[35] Allotments are discussed in more detail in the sub-section "Land Mobile Service Allotment Plans." Each agency must request frequency assignments from NTIA for use of channels allotted for use by that agency.

[36] TIA TSB-88-B-1 *Wireless Communications Systems - Performance in Noise and Interference - Limited Situations - Recommended Methods for Technology - Independent Modeling, Simulation, and Verifications*, May 1, 2005.

[37] *Land Mobile Spectrum Efficiency: A Plan for Federal Government Agencies to Use More Spectrum-Efficient Technologies*, NTIA Report 93-300, NTIA (Oct. 1993) (1993 NTIA Efficiency Report).

[38] *Id*. at 52.

[39] *See, Manual of Regulations and Procedures for Federal Radio Frequency Management*, U.S. Dep't. of Commerce, NTIA, May 2003 Edition, September 2006 Revision at §§ 4.3.7 and 4.3.9 (NTIA Manual).

the USDA's VHF infrastructure. However, agencies such as the Agricultural Research Service (ARS), the Animal and Plant Health Inspection Service (APHIS), and the Food Safety and Inspection Service (FSIS) have not been able to obtain funding for new narrowband equipment to replace the 25 kHz legacy systems. This is a particular challenge for APHIS, which operates the next largest number of radios outside of the Forest Service.

The Broadcasting Board of Governors (BBG) is moving to comply with the narrowband mandate by migrating out of the 162-174 MHz band into the 406.1-420 MHz band. BBG is working to upgrade its headquarters' 406.1-420 MHz system to narrowband. BBG is reviewing its systems in the 406.1-420 MHz band at two locations to decide if they should be upgraded, merged, or deleted.

The Department of Justice (DOJ) expects to meet the NTIA narrowband mandates by transitioning many operations into the Integrated Wireless Network (IWN) in the 162-174 MHz band. The IWN program and network will also serve DHS and the Department of Treasury (Treasury). However, the DOJ's encryption needs are increasing and it may have to rely on technological advances to use narrowband channels for these purposes, possibly delaying transition.

The Department of Interior (DOI) will meet NTIA's narrowband goal in all bureaus and offices by October 1, 2010. The National Aeronautics and Space Administration (NASA) will replace older land mobile systems and assignments in accordance to the channel plans presented in the NTIA Manual Sections 4.3.7 and 4.3.9. Three Treasury bureaus have complied with NTIA's narrowbanding mandates (the largest users included) and others are complying. The Department of State (DOS) expects to comply with narrowbanding in the 406.1-420 MHz band by January 1, 2008.

The mandate to migrate from technology that operates on 25 kHz channel bandwidths to technology that supports 12.5 kHz channel bandwidths will continue to affect the Department of Energy (DOE) for the foreseeable future.

Improving Spectrum Efficiency and Management Flexibility with Land Mobile Service National Frequency Allotment Plans

The 162-174 MHz and 406.1-420 MHz bands are the backbone of Federal land mobile communications and are used for critical law enforcement, national security functions, and many other purposes. The 162-174 MHz and 406.1-420 MHz bands are channelized via national channeling plans, and many of the channels are allotted to specific agency use. The allotment plan, originally established over fifty years ago as an extension of the allocation plan, allows the users to make deployment decisions using the channels allotted to them with a high degree of confidence of interference free operation. In Federal Government allotment plans, specific channels are allotted to individual Federal agencies and others are allotted for all Federal agencies. For example, a channel such as 162.4250 MHz may be allotted nationally to the Department of the Navy (Navy) and the adjacent channel at 162.4375 MHz may be allotted nationally to the USDA. Subject to agreement, channels may be made available by one agency for use by another agency. These allotment plans require precise technical standards for equipment operation, and the equipment is generally compliant with these standards.

In this process, an agency may use another agency's allotment with the permission of the agency "allotted" that channel. Such use allows for cooperative use of specific frequencies between the two agencies. For example, the Navy may need more channels than it is allotted in an area with extensive Navy activities such as the Norfolk, Virginia Naval base. The Navy could arrange to use another agency's allotted channels in Norfolk, but there is no assurance that the other agency will be willing to relinquish its use to the Navy. Since all agencies face this situation from time to time, they are usually willing to make such allotment sharing arrangements.

Spectrum management computer models are now widely available, including models that can select available channels in heavily congested areas. These models differ in complexity and accuracy. Some are built using simple and practical rules that have been in use for decades and offer only more rapid calculation and selection of frequencies. They do not increase spectrum–use efficiencies. Others use accurate system and terrain characteristics to predict the interference levels expected in each receiver in the existing and planned systems. These latter systems offer both increased speed in identification of usable frequencies as well as increased spectrum efficiency. When these more advanced spectrum management models are used, Federal spectrum managers no longer need to be as heavily reliant on allotment plans because the models can easily identify an available channel. However, some models can select only the agency's allotted channels, and other models are very conservative in their frequency reuse interference calculations. Models are continually being modernized and improved so that they can be used to enable more spectrum sharing and frequency reuse to improve the overall spectrum-use efficiency.

However, allotments do allow a specific agency to maximize the agency reuse of frequencies and more readily plan for caches of equipment that can support nationwide contingency operations. Furthermore, the effective use of both interference models and channel plans is dependent on an accurate and reliable up-to-date national database of current spectrum use that provides the foundation for frequency selection.

National allotment plans have the appearance of not being a spectrally efficient method of spectrum management because channels may remain fallow in some parts of the country, *e.g.*, the Navy's light use in Iowa, Nebraska, and other interior United States areas that are far removed from Navy facilities, where the channels could easily be used by other agencies. However, balancing this concern are the advantages associated with allowing the agencies to work with each other to meet shifting demands. Greater spectrum management flexibility could be achieved by reviewing the current allotment plans to determine what, if any, restructuring or re-designating of specific allotments would provide more effective spectrum use.

On the other hand, the missions of the Federal agencies undergo major changes over the years and these changes need to be considered when developing communications requirements. In the post-9/11 environment with the increased emphasis on national and homeland security, the Federal agencies' spectrum needs should be reassessed, especially those agencies that have a greater mission today than they had fifteen years ago. Any new rearrangement of the allotments with new procedures could be problematic if done without reassessing the agencies' missions and operational requirements.

A study of allotment plans could result in revising the allotments of these frequencies based on current and anticipated trends in these bands. However, some nationally allotted channels may still be required for uses such as national security because law enforcement agents may be required to operate anywhere in the United States on very short notice, requiring immediate communications capabilities that can be most easily satisfied by readily available allotment channels. Thus, some channels are needed to remain readily available to satisfy emergency law enforcement needs.

To communicate classified information, DOJ requires Type 1 encrypted land mobile communications that meet National Security Agency (NSA) encryption standards. Type 1 NSA-certified equipment is available and is used by DOJ on 25 kHz channels in the 162-174 MHz and 406.1-420 MHz bands. However, there currently is no Type 1 NSA-certified equipment that operates on the 12.5 kHz narrowband channels in the 162-174 MHz or 406.1-420 MHz bands. NSA has approved a commercial Digital Encryption Standard (DES) on the wider 25 kHz channels, but it does not meet Type 1 encryption standards. The lack of suitable encryption technology presents operational problems on the narrowband channels and new technology must be developed. DOJ recognized this problem during the development of the narrowband allotment plans and the required implementation date was selected to allow industry to develop the required equipment. However, Type 1 encrypted equipment still is not available.

The Federal Aviation Administration (FAA) is experiencing difficulties in locating suitable frequencies in the 162-174 MHz and 406.1-420 MHz bands in metropolitan areas and in the Canadian and Mexican border areas. There are a limited number of FAA-allotted channels in these bands but FAA would support an NTIA study to review the allotment plans in these bands.

The frequencies in the 162-174 MHz band allotted specifically to DOE in the western United States, where many DOE facilities are located, are insufficient in number to meet DOE requirements. The border areas with Canada and Mexico provide significant challenges where there are fewer frequencies available because of international agreements. DOE utilizes the allotments of other Federal agencies to meet its frequency requirements in these areas.

In the past, the Federal Communications Commission (FCC) also used allotments in the land mobile radio bands, based on the type of activities or entities using the spectrum. However, in a rulemaking proceeding, the FCC developed an overall strategy for using the spectrum allocated to the land mobile radio service more efficiently to meet future communications requirements. In June 1995, the FCC adopted a new narrowband channel plan in the public land mobile radio (PLMR) bands below 800 MHz.[40] The FCC adopted a Second Report and Order in February

---

[40] Replacement of Part 90 by Part 88 to Revise the Private Land Mobile Radio Services and Modify the Policies Governing Them, PR Doc. No. 92-235, *Report and Order and Further Notice of Proposed Rulemaking*, 10 F.C.C.R. 10,076 (1995).

1997, which eliminated twenty discrete radio services and replaced them with two frequency pools: the Public Safety Pool and the Industrial/Business Pool.[41]

NTIA has on-going a project to improve spectrum efficiency in land mobile systems that includes the investigation of the use of national frequency allotments by the Federal agencies. As part of the *President's Spectrum Policy Initiative*, NTIA is investigating options that could be used to reduce the number of channels allotted to individual agencies.

ALLOCATION ASSETS

There are numerous frequency bands allocated to the mobile service or land mobile service throughout the spectrum. There are five bands allocated to these services in the 1705-3000 kHz band, twenty-three bands in the 3-30 MHz HF region of the spectrum, and forty-eight bands allocated to these services in the 30 MHz to 20 GHz region of the spectrum.

Current Mobile Service and Land Mobile Service Usage And Future Spectrum Requirements

The largest Federal users of spectrum with the mobile service station class are the USDA, DOJ, Department of Army (Army), DOI, and DHS. Following the creation of the DHS, some units of Treasury were transferred to DHS, accounting for major changes in the number of Treasury assignments. The number of DOJ assignments has declined in recent years as they have consolidated assignments to United States and its possessions (US&P) or regional assignments resulting in fewer numbers of assignments. The Departments of the Air Force (Air Force), Army, and Navy have increased assignments due to deployment of more systems. The largest Federal users of the land mobile service are the DHS, Army, Air Force, Navy, DOI, and DOJ.

In the mobile service, the Federal agencies, especially the Department of Defense (DOD), operate many systems that fall under the mobile service allocation rather than the more specific land, maritime, or aeronautical mobile service allocations. Many of the mobile systems provide communications such as networking of land units with airborne units, air-to-air communications, or air-to-ground data links. Data links are becoming increasingly critical in military applications since the use of precision-guided munitions and unmanned aircraft systems and the like is increasing.

This section is arranged from lower to higher frequency bands, except that the DOD is broken out in a separate sub-section because of the extensive DOD use of land mobile communications, recognizing that much of the DOD land mobile use is on the battlefield and in training.

Use of Bands in the 1705-3000 kHz Range. There are five bands allocated to the mobile service in the 1705-2850 kHz part of the spectrum: 1705-1800 kHz; 2000-2065 kHz; 2107-2170

[41] Replacement of Part 90 by Part 88 to Revise the Private Land Mobile Radio Services and Modify the Policies Governing Them, PR Doc. No. 92-235, *Second Report and Order*, 12 F.C.C.R. 14,307 (1997).

kHz; 2194-2495 kHz; and 2505-2850 kHz. These bands are used to achieve over-the-horizon communications via ionospheric skip propagation, normally at distances up to 400 km. Reliable ground-wave communications can also be achieved at distances up to 60-100 km, depending on transmitter power and other technical factors.

The DOD is the primary user of these five frequency bands. The DOE has frequency assignments in the 2505-2850 kHz band that are used for nationwide “aerial tracking” communications with aircraft. The Department of Veterans Affairs (VA) uses the 2-3 MHz part of the spectrum for emergency long-haul communications.

In summary, spectrum usage and requirements of the bands in the 1705-3000 kHz region of the spectrum for mobile communications are expected to continue for at least the next ten years, although there is an overall decline in spectrum usage as agencies satisfy their spectrum needs in other frequency bands.

Use of Bands in the 3-30 MHz (HF) Range. There are twenty-eight frequency bands in the 3-30 MHz (HF) spectrum range allocated to the mobile service. Many of the bands are shared with the fixed service on a co-primary basis, thus permitting the establishment of communications networks with both fixed stations and mobile stations on various platforms. The HF bands can achieve over-the-horizon communications via ionospheric skip propagation at a relatively low cost.

The Federal agencies make extensive use of the HF bands for land mobile communications, which is frequently the preferred mode of operation when communications are required at distances over 200 kilometers using ionospheric skip propagation. In many communications applications, there are both fixed and mobile stations within the same network, and thus both the fixed service and land mobile service allocations are used.

The most significant advance in HF communications over the past twenty years has been the development of Automatic Link Establishment (ALE) technology that enables systems to automatically select usable frequencies to overcome the vagaries of ionospheric propagation. The ALE system uses automated techniques and ionospheric sounding to automatically determine and select the best operating frequencies from a pre-determined group. Once the communications link has been established, any normal type of traffic such as voice or data can be passed. Reliable HF communications requires a number of frequency assignments to a specific communications link, in a number of different HF bands, only one frequency of which may be usable for reliable communications at any one time.[42] A typical frequency assignment group would consist of five or six frequencies, each in widely separated HF bands.

HF bands can be a “common denominator” in achieving interoperable communications in multi-service and multi-national operations, especially with coalition partners with limited communications capabilities. DOD uses the HF bands extensively for mobile and fixed service communications, and it has developed and published HF communications technical and operating standards.

---

[42] *High Frequency Radio Automatic Link Establishment (ALE) Application Handbook*, U.S. Dep’t. of Commerce, NTIA, Institute of Telecommunications Sciences (Sept. 1998).

The National Communications System (NCS) has also established a number of HF and ALE operational standards. For example, the NCS standard FED-STD-1045A, "Telecommunications: HF Radio Automatic Link Establishment" supports interoperability between telecommunications facilities and systems and interface with data processing equipment.[43] The NCS also has seven other HF communications technical and operating standards.

DOI uses the HF bands to provide communications in its various bureaus. The VA uses the HF spectrum for emergency long-haul communications.

NCS has established the SHAred RESources (SHARES) HF radio communications program for national security and emergency preparedness. The SHARES system includes ninety-three Federal, state, and industry entities as resource contributors, with over 1000 HF stations located in every state and at twenty overseas locations. Over 150 frequencies have been authorized for use in the SHARES program.[44] In addition to using the HF bands for SHARES, the VA will implement a department-wide HF emergency communications system called the Trans-America Radio Program (TARP) to provide end-to-end survivable communications among all VA sites. In addition, DHS expects a growing need for access to HF spectrum by both fixed and mobile services.

Over the past ten years, Federal access to HF spectrum for mobile stations has decreased. The Federal agencies cannot afford further loss of HF spectrum to services other than communications if they are to support these growing Federal requirements for HF spectrum sufficient to support communications operational requirements.

In summary, there are many current as well as projected increased future requirements for access to HF bands for critical mobile and land mobile communications, both for primary communications and for emergency and back-up communications. In particular, HF systems can be used as a backup for satellite communications. New applications are being developed which will use HF communications links for e-mail and compressed multimedia communications that combine voice and data services.

Use of Bands in the 30-88 MHz Range. The physics of radio propagation make the 30-88 MHz bands ideal for land mobile communications at distances normally within a 50-70 km radius, but occasionally at longer distances up to 170 km. The Federal agencies use the 30-50 MHz band for operations within the properly allocated bands in the US&P. The 50-88 MHz bands that are not available in the United States may be used in other parts of the world. The largest Federal users of the 30-50 MHz band for the mobile and land mobile services are the DOD, DOI, USDA, DOJ, Tennessee Valley Authority (TVA), Treasury, and the Department of Commerce (DOC).

The number of DOD assignments has substantially increased over the past ten years in the mobile service as more tactical systems have been fielded. Most of the DOD's spectrum usage

---

[43] *Telecommunications: HF Radio Automatic Link Establishment*, Federal Standard, FS-1045A, U.S. General Services Administration (Oct. 18, 1993), http://www.its.bldrdoc.gov/fs-1045a/45-scop.htm.
[44] *Shared Resources (SHARES) High Frequency Radio Program*, National Communications System, http://www.ncs.gov/shares.

in the 30-88 MHz range is in the bands exclusively allocated to the Federal Government below 50 MHz. Parts of 30-88 MHz band above 50 MHz are allocated to the amateur service, television broadcasting, and other services in the United States, and are not available for DOD use. However, the DOD units may use some of the bands in the 30-88 MHz bands in overseas locations that have different allocations. The DOD uses parts of the 30-88 MHz band for tactical and tactical-exercise communications, and non-tactical communications such as Mobile Subscriber Equipment (MSE).

TVA operates communications systems in these bands for security communications along its electrical grid. The National Oceanic and Atmospheric Administration (NOAA) has spectrum requirements in the 30-40 MHz band for mobile radio for law enforcement, geodetic field communications and telemetry for fish tags. NOAA also uses the 40-42 MHz band for meteor burst communications for meteorological and hydrologic operations. VA uses the 30-56.32 MHz band for hospital paging systems.

Use of Bands in the 138-150.8 MHz Range. Three frequency bands in the 138-150.8 MHz range are allocated to the mobile service on a shared primary basis to the Federal Government: 138-144 MHz, 148-149.9 MHz, and 150.05-150.8 MHz. DOD is the primary user of the 138-150.8 MHz band.[45] The military agencies use these bands for voice communications in tactical operations, using both land and airborne units under the mobile allocation. Operations in the United States are for training purposes. The U.S. Coast Guard (Coast Guard), NASA, and the Federal Emergency Management Agency (FEMA) are the other users but their usage is much less. In addition to the military agencies, DOJ uses the 148-150.8 MHz bands for interoperability communications by their law enforcement units with military law enforcement units.

Use of the 162-174 MHz and 406.1-420 MHz Bands. The 162-174 MHz band (the band is divided into two segments consisting of 162.0125-173.2 MHz and 173.4-174 MHz) and the 406.1-420 MHz band have the most Federal frequency assignments of any bands allocated to the Federal Government. The two bands are used extensively for land mobile communications and the majority of Federal non-military mobile communications are conducted in the two bands.

USDA's frequency assignments may increase in the 162-174 MHz and 406.1-420 MHz bands as the Department transitions from narrowband analog to narrowband digital technology because of a potential need for additional repeaters in locations where the signal strength is weaker using new digital equipment than in the legacy analog mode. As USDA transitions to more spectrally efficient digital technology, interoperability with state and local agencies and cooperating entities still operating in an analog mode will be achieved by installing backward compatible systems.

The law enforcement agencies or those with law enforcement units report continuing land mobile needs. For the short term through 2010, DOJ's most significant requirement for spectrum is in direct support of law enforcement tactical communications, mainly within these two major Federal land mobile communications bands. Although DOJ does not expect to seek additional

[45] NTIA Manual, supra note 39 at § 4-160. Footnote G30 states that "the fixed and mobile services are limited primarily to operations by the military services."

allocations, it will intensify its use of these bands. New technologies will be needed to meet increased requirements for tactical communications and surveillance.

The Coast Guard projects an overall 300 percent growth in its assignments, including the 162-174 MHz and the 406.1-420 MHz bands, for Rescue 21, the maritime emergency response system for the coastal United States as well as for the infrastructure supporting all Coast Guard coastal missions. Overall, the Coast Guard envisions land mobile growth in the 162-174 MHz, and 406.1-420 MHz bands, (and in the 700-800 MHz spectrum range) for fixed and mobile services, as well as in multi-band interoperability and aeronautical frequencies. Since the 162-174 MHz and 406.1-420 MHz bands have been channelized into narrowband 12.5 kHz channels, Coast Guard communications in this band are generally limited to voice. Coast Guard broadband data requirements would require other spectrum resources.

DOC's NOAA has spectrum requirements for tracking of marine mammals via data telemetry in the 162-174 MHz band, and the use will be expanded. NOAA also has mobile communications requirements in the 406.1-420 MHz band for: 1) satellite fish tracking, specifically to uplink fish data to satellites; 2) the Physical Oceanographic Real Time System (PORTS) to measure ocean currents; and 3) water level stations to measure tide levels. NOAA also uses the 406.1-420 MHz band for an Automated Surface Observing System (ASOS) to support meteorological operations from aircraft.

The United States Fish and Wildlife Service (USFWS) manages the wildlife telemetry program in the 406.1-420 MHz for the DOI and other Federal agencies. There are interstitial channels between 162 MHz and 174 MHz for dedicated wildlife telemetry use. The USFWS and eight DOI bureaus in almost every state use these assignments to track migratory birds, wolves, bears, caribou, and other wildlife. The transmitters are very low power, but the receivers are very sensitive. This usage will continue to increase every year for at least the next ten years.

DOE also uses land mobile spectrum at its national laboratories, area offices, and throughout the regions served by the power marketing administrations. DOE also uses land mobile spectrum at its national laboratories and area offices. Looking to the future, DOE expects that its tracking of radioactive materials will be done with commercial or Federal Government satellites, radar, and a variety of multi-service commercial and Federal voice and data mobile systems in the 162 MHz to 2 GHz bands. Incident prevention and control will require ultra-wideband technology and robot-controlled and secure communications systems in these bands to communicate with other public safety units. Nuclear storage and lab control will require robust Federal communications systems using secure voice and data and commercial wireless services for administrative and operations functions. Security sensors may be deployed using land mobile radio systems in this band.

DOE has experienced difficulties locating available frequencies in the 162-174 MHz band in the Mexican and Canadian border areas. The U.S. Postal Service (USPS) will need access to additional spectrum in the 162-174 MHz and 406.1-420 MHz bands where it projects a requirement for an aggregate 413 kHz in the 162-174 MHz band and an aggregate 588 kHz in the 406.1-420 MHz band. The DOS anticipates that over the next ten years, it will have an approximate three percent rise in assignments in existing bands, except for 406.1-420 MHz, where it projects that 100 new assignments will be needed.

BBG uses the 406.1-420 MHz band for security, operations, maintenance, and computer help desk support, for administration, maintenance, and journalists. The FAA also uses these bands to operate various fixed stations at airports. These fixed stations are an integral component in support of the National Airspace.

A number of frequencies in the 162-174 MHz band are authorized for non-Federal use, such as for public safety services, and in some cases, non-public safety services, by the U.S. Table of Frequency Allocations.[46] In addition, Part 90 of the FCC Rules lists numerous channels allocated for Federal use in the 162-174 MHz band, including the entire 169-172 MHz band, as available for use by non-Federal entities through the FCC public safety pool frequency table.[47] Within the 162-174 MHz band, the 173.2-173.4 MHz band is allocated exclusively to the non-Federal sector. There are a significant number of non-Federal assignments in the 162-174 MHz band, many of which are for public safety communications.

The Multi-Agency Integrated Wireless Network (IWN)

DOJ is developing the IWN, an interoperable, narrowband VHF trunked land mobile system operating in the 162-174 MHz band. The IWN system is planned to be shared by DOJ, Treasury, and DHS. IWN is a first-of-its kind joint initiative led by the DOJ, DHS, and Treasury to provide a consolidated Federal wireless communications service with voice, data, and multimedia capabilities and opportunities for interoperability with state, local, and tribal public safety agencies. The IWN will reduce the total spectrum needs in this band. However, certain Treasury Bureaus, such as the Bureau of Engraving and Printing, and the U.S. Mint, may not participate directly in the IWN because they have very specific communications requirements, including in-building coverage for a campus environment that might not be supportable by the IWN.

In conjunction with IWN, Treasury's campus facilities will transition from the 162-174 MHz band to the 406.1-420 MHz band, reducing the need for using the 162-174 MHz band. For several Treasury Bureaus including the Bureau of Engraving and Printing, the U.S. Mint, and the Internal Revenue Service (IRS) facilities, to interface with the IWN, access to the 162-174 MHz band will be required. Treasury plans to provide gateways to access the IWN for emergencies and law enforcement incidents that involve multi-agency communications. The Integrated Treasury Network frequencies that were transitioned to DHS when the Department was created could be integrated into the IWN.

For DOJ and other agencies which use the system, the IWN, when fully implemented, is expected to provide a unified system for law enforcement officers. Together with its narrowbanding efforts, and based on the initial IWN implementation in Seattle, DOJ will achieve a fifty percent reduction in spectrum use, a sixty-five percent reduction in its 162-174 MHz band assignments. Participating agencies plan to use the IWN to further their interoperability goals.

[46] *See*, U.S. Table of Frequency Allocations, 47 C.F.R. § 2.106, U.S. footnotes 8, 11, 216, 223, 300 and 312.
[47] *Id.* at § 90.265.

Several other agencies have expressed an interest in utilizing IWN. USDA's Office of Inspector General plans to join the IWN system. USPS wants to merge its Inspection Service land mobile system into the IWN. DOI has joined the IWN to build interoperable networks in the metropolitan areas of Washington, D.C. and New York City. Some agencies, however, experience challenges presented by joining this system. DHS was created after IWN's formation. Issues such as the need to support new technologies such as voice-over-IP, potential system congestion, especially in metro areas, and border issues with Mexico and Canada must be addressed. Conversion to the IWN may require Treasury to have access to additional spectrum so that a parallel system (*i.e*., legacy system) may run during a transition period. It is not clear whether the transition to narrowband channels at the same time may meet these additional requirements.

Use of Bands in the 225-399.9 MHz Range. There are six bands within the 225-399.9 MHz range of the spectrum, five of which are allocated to the mobile service. The exception is 328.6-335.4 MHz which is allocated to the aeronautical radionavigation service. The military agencies are the heaviest users of the band, and substantial growth is noted for both the mobile service and the land mobile service. The growth is attributed to deployment of more communications systems, especially by DOD.

DOD operates critical air-to-air and air-to-ground communications systems in the 225-399.9 MHz band, which since the 1950s has been preserved for military operations by the North Atlantic Treaty Organization (NATO) and within the individual member countries. The military nature of this band has also been maintained by certain allied and friendly nations outside the NATO alliance such as Australia, Israel, New Zealand, and Saudi Arabia, and most recently by the European Cooperation Partner nations and the Partners for Peace nations. (In addition to terrestrial mobile communications, parts of the 225-399.9 MHz band are also used for the aeronautical radionavigation service for aircraft landing systems and by mobile satellite systems, as discussed in the sub-sections on those services.)

One major DOD system operating in the 225-399.9 MHz range is a radiocommunication system used for air-to-air, air-to-ground, and ground-to-air communications. It allows the Army to communicate with Air Force, Navy, and NATO units.

The Coast Guard uses the 225-399.9 MHz band for tactical operations such as ship-to-air and ship-to-ship clear and secure voice communications.

The DOD has begun to use the 380-399.9 MHz band for non-tactical land mobile communications using digital trunking systems. Widespread national use is likely on military bases to provide communications to support various base activities such as security, maintenance, medical applications, and other communications.

Use of the 420-450 MHz Band. In the United States, the 420-450 MHz band is allocated to the radiolocation service on a primary basis. There are no mobile or land mobile allocations in the United States, although the ITU Table of Frequency Allocations allocates the mobile service on a primary basis in the 420-430 MHz and 440-450 MHz bands in all three ITU Regions. Thus, some of the military usage for mobile and land mobile services in the United States must be on a non-interference basis (NIB).

Use of the 902-928 MHz Band. The DOD uses the 902-928 MHz band for communications for drone control and other land and air vehicles at military test ranges. The BBG uses the 902-928 MHz band for wireless microphones and for communications from the studio to reporters for live coverage of news events.

Use of the 960-1215 MHz Band. The 960-1215 MHz band is allocated to the radionavigation service and partially to the aeronautical radionavigation-satellite service, both on a primary basis. The DOD also operates the Joint Tactical Information Distribution System (JTIDS), which includes a major communications subsystem, in this band. JTIDS is a military system used by United States and NATO forces to provide tactical, secure, jam-resistant voice and data communications and general situation awareness information. It has been operational since 1981 and deployed aboard aircraft and ships of all three military Departments with man-transportable versions available. The Multifunctional Information Distribution System (MIDS) is a major international program that also operates in the band.

JTIDS is authorized on the condition that no harmful interference will be caused to current or future aeronautical radionavigation users authorized to operate in the band. Extensive use of the 960-1215 MHz band is made by aeronautical radionavigation service and radionavigation satellite service systems including the ATCRBS, Mode-S, TCAS, DME, TACAN and the planned 2006/2007 Global Positioning System (GPS) civil-use L5 signal. A test program was conducted to assure that JTIDS, employing spread spectrum modulation (frequency hopping and phase coding) techniques, could operate compatibly with other navigation systems operating in the band. A Memorandum of Understanding (MOU) was implemented between the Department of Transportation (DOT) and DOD to further greater technical and operational compatibility between civilian navigation systems and the JTIDS/MIDS, including placing possible limitations on the JTIDS/MIDS operating frequencies.[48]

The JTIDS/MIDS system is expected to operate well into the middle of this century, and thus, the long-range spectrum requirements for its operation in the 960-1215 MHz band are expected to continue.

Use of the 1429-1435 MHz Band. The 1432-1435 MHz band has been reallocated from the Federal Government to non-Federal sector use following Title III of the Balanced Budget Act of 1997.[49] However, essential Federal operations will be protected indefinitely. The military uses the band for a number of mobile communications applications such as test range aeronautical telemetry, the flight test telemetry of aircraft, remote telecommand of aircraft guided weapons

---

[48] *2005 Federal Radionavigation Plan*, Departments of Defense, Homeland Security and Transportation, DOT-VNTSC-RITA-05-12/DOD-4650.5 at pp. 61, 62 (Dec. 2005) (2005 FRP). The GPS L5 channel will operate on 1176.45 MHz, providing an additional civil use signal. The L5 satellite is scheduled to launch in 2009. *See* GPS Program Office Website, http://www.losangeles.af.mil/library/factsheets/factsheet.asp?id=5325. GPS is discussed in more detail in the Radionavigation Section of this report.

[49] *Spectrum Reallocation Report, Response to Title III of the Balanced Budget Act of 1997,* NTIA Special Pub. 98-36, NTIA (February 1998).

systems, and other operation.

The USPS has a spectrum requirement for 10 kHz in the 1429-1435 MHz band for future communications for radio frequency identification (RFID) tracking and asset management systems.

Use of Bands in the 1435-1525 MHz and the 1525-1535 MHz Ranges. The 1435-1525 MHz band is allocated to the mobile service (aeronautical telemetry) on a primary basis, while the 1525-1535 MHz band is allocated to the mobile-satellite (space-to-Earth) service on a primary basis. Both bands are allocated for Federal and non-Federal users.

Furthermore, footnote US78 states: "In the mobile service, the frequencies between 1435 and 1535 MHz will be assigned for aeronautical telemetry and associated telecommand operations for flight testing of manned or unmanned aircraft and missiles, or their major components. Permissible usage includes telemetry associated with launching and reentry into the Earth's atmosphere as well as any incidental orbiting prior to reentry of manned objects undergoing flight tests. The following frequencies are shared with flight telemetry mobile stations: 1444.5, 1453.5, 1501.5, 1515.5, 1524.5, and 1525.5 MHz."[50]

Use of the 1755-1850 MHz Band. DOD currently uses the 1755-1850 MHz band for a broad range of mobile or transportable and advanced wireless systems applications such as mobile video control links. Almost all of the Federal assignments in the band are used by DOD with mobile service assignments in the band. The DOD has substantially increased its use of the band in the 1995-2005 period. Furthermore, DOD's Training and Test and Evaluation (TT&E) needs are increasing, corresponding to an increase in its tactical spectrum needs.

Use of Bands in the 2290-2700 MHz Range. The 2310-2320 MHz band falls within the 2310-2360 MHz band allocated on a primary basis to the non-Federal mobile service and to the Federal Government on a secondary basis. The non-Federal allocation includes a primary allocation to the non-Federal mobile service in 2310-2320 MHz, shared with broadcasting and radiolocation. Footnote US339 pertains to both the Federal and non-Federal allocations and addresses aeronautical telemetry activities. The 2360-2395 MHz band is allocated to the mobile service on a primary basis, with footnote US276 authorizing aeronautical telemetry and telecommand in the 2360-2395 MHz band.

These bands within the 2290-2700 MHz range can be used by the mobile service or the land mobile service. The most extensively used band is 2345-2390 MHz with a large number of assignments in the mobile service. There are very few land mobile assignments in the bands.

The 2310-2320 MHz and 2345-2390 MHz bands are used extensively for aeronautical telemetry and telecommand functions.

The 2290-2700 MHz band is used for DOD's communications for aircraft and missile flight-testing telemetry, the operation of simulators during combat aircrew training for surface-to-air

[50] NTIA Manual, *supra* note 39 at 4-131.

missile operations, and the scoring of air-to-air missiles against targets. The Army uses, on a non-interference basis, the 2400-2483.5 MHz portion of the band, the “unlicensed” band used by Wireless Fidelity (WiFi), for tactical communications and for wireless local area networks (WLANs).

Use of the 4400-4940 MHz Band. This band includes three sub-bands: 4400-4500 MHz, 4500-4800 MHz, and 4800-4940 MHz. Footnotes US203, US342, and 5.149 apply to some of the bands to protect radio astronomy observations, which may limit the use of parts of the bands for communications, especially airborne operations.

In the 4400-4500 MHz range, the Federal agencies have both land and mobile service with the DOD having the most usage. The DOD is the largest user of the 4500-4800 MHz range. In the 4800-4940 MHz range, the DOD is the largest user.

The Navy operates a wideband data link in the 4400-4940 MHz frequency range.

The USPS is developing vehicle telemetry and vehicle location and tracking systems for use in conjunction with GPS. These systems will utilize 8 MHz in the 4800-4990 MHz band for mobile and stationary networks in support of these activities.

Use of the Bands in the 14.4-15.35 GHz Range. This range of spectrum is allocated to six frequency bands for the mobile service either on a primary or secondary basis. Some of the bands are shared between the Federal and non-Federal sectors. The Coast Guard uses this band for a mobile tactical data link. Other services using the bands are fixed, space research, non-Federal fixed-satellite uplinks, and the non-Federal mobile-satellite service.

Use of the 25.25-27.5 GHz Band. The three Federally-allocated bands that make up this band are 25.25-25.5 GHz, 25.5-27 GHz, and 27.0-27.5 GHz, which contain no Federal assignments for the mobile service or the land mobile service. The DOD has future communications systems requirements for this band.

Future DOD Mobile Spectrum Usage and Requirements

DOD is reforming its communications strategy with the goal of “net-centric” and seamless real-time military voice, data and video across U.S. military services, and bridging coalition forces and allies. DOD sees its future shaped by “Network-Centric Warfare.” Network-Centric Warfare would link sensors, communications systems and weapons systems in an interconnected grid. The new tactical communications infrastructure will include modular, software-defined, multimode radios to replace existing inventory and ultimately satellite communications terminals. These radios will have cross-banding and networking capabilities to allow mobile forces to stay connected to an Internet Protocol (IP)-based network. Bandwidth requirements for such new programs will alter projected spectrum usage.

DOD sees spectrum use as a principal component of the Global Information Grid (GIG) foundation layer. The GIG is the globally interconnected end-to-end set of information capabilities that manage and provide information, on demand, to war fighters, defense policy makers and support personnel. The Global Electromagnetic Spectrum Information System (GEMSIS) is both a near and long-term initiative to unify and improve DOD spectrum operations in anticipation of network-centric operations and associated spectrum requirements.

DOD anticipates significant additional requirements through 2015 and beyond, regardless of modernization efforts, with the biggest growth in the frequency bands below 3 GHz. The addition of the new Joint Tactical Radio System (JTRS) radios and unmanned intelligence, surveillance and reconnaissance and combat delivery platforms will all require additional spectrum.

DOD's transformational agenda, particularly its use of unmanned and Future Combat Systems (FCS), drives its future spectrum needs. DOD expects a very substantial rise in the need for unmanned systems, resulting in a continuing need for spectrum in all frequency bands used today, with growth in selected bands. Unmanned ground system control links, most often operating in VHF or UHF bands, require as much spectrum as unmanned air systems. Increases in the number of frequencies needed, in bandwidth required to support data transfer, and in the operation time for longer mission requirements are expected. To meet this demand, improved spectrum management schemes and scheduling that will promote frequency sharing are required. Without significant spectrum reuse and spectrum-efficient technologies, unmanned systems will be constrained, and may require highly refined scheduling plans.

Pending budget approvals, the Army anticipates that fielding the FCS elements will commence in 2010, with first operations expected in 2014. Several homogenous communication systems such as JTRS, Wideband Network Waveform and Soldier Radio Waveform, will combine to form the FCS.

The FCS requires a fully mobile tactical communications infrastructure that can conduct combat operations on the move, at the quick halt and during sustained operations. Information must safely cross the wireless network regardless of environment and arrive within identified timelines. This means using omni-directional systems, and limiting reuse and sharing. The FCS requires very high bandwidth capability for large numbers of forces over a dispersed area. This translates into large blocks of contiguous spectrum. DOD may specify spectrum requirements for FCS in future revisions to its strategic spectrum plan.

DOD may need access to more mobile-service spectrum use after 2014 to bolster the joint transformational concepts of Army and Marine Future Combat Systems, Air Force Command and Control Constellation, and Navy FORCEnet. The Wideband Network Waveform (WNW) wireless networks are expected to drive spectrum requirements beyond 2014. These networks will provide increased situational awareness, timely dissemination of intelligence, and direct high-bandwidth communications to all battlefield users.

Spectrum Requirements for Aeronautical Flight Test Telemetry

Although not a specifically allocated radiocommunication service, *per se*, Aeronautical Mobile Telemetry (AMT) and telecommand are extensive spectrum uses falling within the mobile service allocation. The major AMT applications are for flight test data collection of manned and unmanned aircraft, missiles, and rockets. Flight telemetry systems currently operate in several frequency bands, but the most used bands are the previously discussed 1435-1535 MHz, 2310-2320 MHz, and 2345-2390 MHz bands. Footnote US339 authorizes aeronautical telemetry and associated telecommand operations for flight-testing in the 2310-2320 MHz and 2345-2360 MHz bands.[51] The telemetry systems are used by both Federal agencies and non-Federal entities, frequently in cooperative working arrangements.

The Aerospace and Flight Test Radio Coordinating Council (AFTRCC), an organization of aerospace companies, coordinates flight testing operations and planning, in the United States.[52] Furthermore, the International Foundation for Telemetering (IFT) serves the telemetering "community."[53] Another international organization called the International Consortium on Telemetry Spectrum (ICTS) ensures the future availability of spectrum for telemetering. The ICTS is concerned with all types of telemetry, including applications such as meteorology and industry.

The ITU has recognized the need for additional spectrum for aeronautical telecommand and telemetry via Agenda Item 1.5 of the 2007 World Radiocommunication Conference (WRC-07), which charges the WRC-07 "to consider additional spectrum requirements and possible additional spectrum allocations for aeronautical telecommand and high bit-rate aeronautical telemetry, in accordance with Resolution 230 (WRC-03)."[54] Resolution 230 adopted at WRC-03 calls for: "[c]onsideration of mobile allocations for use by wideband aeronautical telemetry and associated telecommand."[55]

The United States preparations for WRC-07 include several aeronautical telemetry-related documents for submission to the ITU-R Working Party (WP) 8B. United States input document, Document 8B/139-E, addresses potential candidate bands for wideband aeronautical telemetry, concluding that, "[o]f the bands considered, the potential for success in meeting the short to near term spectrum requirements seems greatest in the 4400-4940 MHz and 5925-6700 MHz bands."[56] For long-term requirements, where technology advances are necessary, the preferred bands are 22.5-23.6 GHz, 24.75-25.5 GHz, and 27.0-27.5 GHz.[57] However, the five preferred bands have incumbent users with potential spectrum sharing problems, and the document acknowledges "each of the candidate bands identified in this document would appear to warrant further study in WP 8B to determine the ability to share the bands between AMT and the incumbent services in these bands."[58]

---

[51] NTIA Manual, *supra* note 39 at 4-144.

[52] *See* Aerospace and Flight Test Radio Coordinating Council website, http://www.aftrcc.org/ (last visited, Feb. 7, 2008).

[53] *See* International Telemetering Conference website, http://www.telemetry.org/ (last visited, Feb. 7, 2008).

[54] Agenda of the 2007 World Radiocommunication Conference, Resolution 802, Final Acts of the 2003 World Radiocommunication Conference (Geneva, 2003).

[55] *See* Final Acts of the 2003 World Radiocommunication Conference, Resolution 230 (Geneva, 2003).

[56] *Potential Candidate Bands for Wideband Aeronautical Mobile Telemetry (AMT),* U.S. Input Document 8B/139-E submitted to ITU-R Working Party 8B, at 3 (March 30, 2005). *See*, ITU Website, http://www.itu.int/md/R03-WP8B-C-0139/en.

[57] *Id.* at 3.

[58] *Id*. at 7.

The United States submitted Document 8B/143-E to address the future spectrum requirements for airborne telemetry. Using a queuing analysis and various scenarios, the document concludes that "even if the most advanced spectrally-efficient modulation techniques were used for telemetering, by the end of 2017, a single aerial vehicle would not have sufficient spectrum to send its data, even assuming all others in the area ceased operation." The study also showed that, "given current trends, no less than 650 MHz would be required for a single test vehicle by the year 2024."[59] The 650 MHz spectrum will be used for safety-related and time-critical information, networked downlink telemetry, video downlinks, and uplink traffic.[60]

In summary, there are increased spectrum requirements for the mobile service for aeronautical telemetry and telecommand operations. Some of these requirements may be satisfied via an allocation to the aeronautical mobile service.[61]

Spectrum Requirements for Medical Telemetry

Medical telemetry represents another use of the radio spectrum of interest to Federal agencies. Medical telemetry transmits patient information to a medical center for observation by medical staff. The telemetry operations can be short range such as on a hospital floor, or longer-range transmissions such as from a medical emergency vehicle. Medical telemetry communications can assist in saving lives by providing critical medical data to medical personnel. The operating frequencies are usually used by both Federal agencies and non-Federal entities. The primary Federal users are military and VA hospitals.

The shorter-range systems are frequently unlicensed and operate under NTIA Manual Section 7.8 and 7.9 which are based on Part 15 of the FCC Rules, while Medical Implant Communications (MICS) falls under Part 95 of the FCC Rules. Many licensed and unlicensed operations are located in the 608-614 MHz band, where television (TV) channel 37 would normally operate, but is precluded by radio astronomy observations in that band. Footnote US246 provides for licensed or authorized medical telemetry operations but they must be coordinated with radio astronomy operations. The US246, US345, US350, US351, and US352 footnotes authorize medical telemetry operations. Furthermore, footnote US216 provides for "medical radio communications" on a number of VHF and UHF frequencies and small sub-bands. The frequencies are authorized for "… the purpose of delivering or rendering medical services to individuals (medical radiocommunications systems)."[62] The operations are authorized for both Federal and non-Federal operations. These operations are in conventional land-mobile bands where longer distance communications can be achieved, for example, to transmit an injured person's medical data from an emergency ambulance to the emergency room of a hospital. The medical operations are not exclusive to these frequencies and sub-bands, and the operations are in land mobile and mobile bands used by land mobile and other systems.

---

[59] *Spectrum Requirement for Aeronautical Mobile Telemetry*, U.S. Input Doc. 8B/143-E at 5 (March 31, 2005).
[60] *Id.* at § 8B/139-E.
[61] For more information on aeronautical telemetry, see sections entitled "Aeronautical Mobile" and "Aeronautical Mobile-Satellite Service," *infra* at B-32 and B-53.
[62] NTIA Manual, *supra* note 39 at 4-135.

The VA currently operates in the 460-470 MHz band for telemetry in coronary care cases, but the band must be vacated and operations moved to the 608-614 MHz band. However, the medical telemetry operations in the 608-614 MHz band have been experiencing interference from TV transmitters operating on the adjacent TV channels 36 and 38. Additional allocations in the 1395-1400 MHz and 1427-1429.5 MHz band were provided about five years ago, but the equipment has been slow to develop, and users have not been driving the demand to the new bands. Furthermore, the VA has rejected the use of the 1395-1400 MHz and 1427-1429.5 MHz bands because equipment is not available.

Federal Use of Exclusive Non-Federal Frequency Bands

Federal agencies are authorized to use frequencies assigned by the FCC to non-Federal public safety agencies and for emergency operations. Section 7.12 of the NTIA Manual, "Use of Frequencies Authorized to Non-Government Stations under Part 90 of the FCC Rules," provides for the Federal use of frequencies authorized to non-Federal stations under Part 90 of the FCC Rules when such operation is necessary for inter-communication with non-Federal entities.[63]

Section 7.3.4 of the NTIA Manual provides for the Federal agency emergency use of non-Federal frequencies. This section permits such operations when emergency inter-communication is necessary between Federal and non-Federal entities and a verbal or written agreement is provided.[64]

Federal Use of the Non-Federal 150.8-156.2475 MHz and 157.1875-162.0125 MHz Bands. These bands are allocated to non-Federal land mobile service, and are used extensively by private sector units. Federal agencies, especially the law enforcement and public safety agencies, use these bands to communicate with state and local law enforcement agencies under the provisions of Section 7.12 of the NTIA Manual. There is an upward trend in band usage, especially by the agencies with public safety missions such as DHS, DOI, and DOJ. The VA uses the 152.855-157.0375 MHz and 157.1875-161.575 MHz for emergency communications with VA medical facilities and local police, fire, and emergency medical units.

DOJ uses the 150.8-162 MHz non-Federal bands extensively for cooperative support with non-Federal law enforcement agencies. DOI uses the band to coordinate public safety and mission support activities with non-Federal agencies with similar missions.

Federal use of the Non-Federal 450-470 MHz Band. The 450-470 MHz band is used extensively by the private sector, and is one of the main land mobile frequency bands regulated by the FCC. Federal agencies, especially the law enforcement and public safety agencies, use the 450-470 MHz band to communicate with state and local law enforcement agencies under the provisions of Section 7.12 of the NTIA Manual, "Use of Frequencies Authorized to Non-Government Stations under Part 90 of the FCC Rules."[65]

---

[63] NTIA Manual, *supra* note 39, Part 7.12, at 7-17. (Part 90 of the FCC Rules deals with private land mobile radio services, including public safety communications).
[64] NTIA Manual, *supra* note 39 at 7-3.
[65] NTIA Manual, *supra* note 39, Part 7.12, at 7-17.

The VA uses part of the 450-460 MHz band extensively for emergency communications with local public safety and emergency medical units. The VA also uses the 460-470 MHz portion of the band in its medical facilities for telemetry of coronary care patients. DOC uses 458.54 MHz for animal tracking telemetry data as part of a fish tracking system. These operations have been coordinated with the FCC.

DOJ's most significant spectrum requirements are in support of tactical law enforcement communications. DOJ is an extensive user of the 420-512 MHz band that it uses for cooperative support with non-Federal law enforcement agencies. Moreover, the DOJ has a critical spectrum requirement for interoperability with non-Federal units operating in the 150.8-162 MHz and 420-870 MHz bands.

In summary, there are critical spectrum access requirements for Federal agencies to interoperate with non-Federal entities. Such interoperability as well as ongoing use by Federal entities of non-Federal spectrum requires agreements between the Federal and non-Federal entities.

ADDRESSING FUTURE MOBILE SERVICE SPECTRUM REQUIREMENTS

Satisfying future communications and spectrum access requirements can be accomplished in a number of ways such as increased spectrum sharing, network or facilities sharing, and using commercial services.

Spectrum Sharing

Federal agencies can "share" spectrum in various ways. They may use a technical solution such as a distance separation that enables frequency reuse without interference. Several agencies stressed the need for improvements in the use of the spectrum-sharing management techniques. DOJ advocates regulatory changes, such as technology-based assignment procedures, that would foster improved spectrum sharing. DOJ also advocates changes to NTIA Manual Sections 7.12 and 4.3.16, governing the procedures, respectively, for Federal users to obtain commercial spectrum and for non-Federal users to obtain Federal spectrum for public safety interoperability purposes. VA wants to find better ways to share spectrum and increase the efficiency of the spectrum currently in use. Many agencies have acknowledged that sharing in some form will increase in the future.[66] However, even supporters acknowledge that sharing is not always possible, especially for critical communications in areas where propagation anomalies are common.

NTIA supports more efficient and effective use of spectrum for land mobile, as well as other radio services. In particular, with respect to land mobile systems, agencies should: (1) continue to implement narrowbanding where appropriate; (2) utilize better spectrum management and interference analysis tools; (3) utilize trunking technology; (4) share frequencies, infrastructure and systems where feasible; (5) use commercial systems and services wherever possible; and (6) plan for the use of cognitive and adaptive techniques in their future systems.

---

[66] 1993 NTIA Efficiency Report, *supra* note 37, at 43.

Furthermore, the current allotment channel plans used in the 162-174 MHz and 406.1-420 MHz bands could be revised, or eventually phased out, providing more flexibility in assigning frequencies and supporting more channel sharing by Federal agencies.

Network or Facilities Sharing

Digital trunking communications systems provide spectrum access via network sharing and are spectrally efficient in dense user environments. Trunking systems can establish "talk groups" for several groups of users so that they automatically "time share" the same group of frequencies in a virtually transparent way. The NTIA Efficiency Report generally estimates that a five-channel trunking system, appropriately loaded, is about 3.5 times as efficient as a non-trunking system.[67] Moreover, agencies may enter into formal or informal arrangements to share channels with other Federal agencies, or with local and state groups. For example, DOC participates in the DOD Pacific Mobile Emergency Radio System. Many agencies endorse this practice.

The 406.1-420 MHz band is used for digital trunking operations by the Federal Radio Service Corporation under contract to NTIA under the Federal Specialized Mobile Radio Program (FedSMR). The frequencies are assigned for operation in five urban areas on the East Coast. The purpose of FedSMR is to provide spectrum-efficient trunked radio communications to a number of Federal users that can benefit from multiple talk groups and other features.

Many agencies use digital trunking systems as part of their operations, and several use the NTIA-administered FedSMR system, which supports Continuity of Operations (COOP) requirements for various agencies as well as for day-to-day communications. The FedSMR systems will be transitioned to narrowband by the end of 2007. DOC's Patent and Trademark Office, for example, meets its land mobile needs through the DOC FedSMR trunking radio system. The number of subscribers is growing, with the number doubling from 2002 to 2004. In Washington, D.C., the main users are the Smithsonian Institution, the National Archives, the National Zoo and the U.S. Holocaust Memorial. However, the Treasury's U.S. Mint finds that the monthly cost per subscriber unit of using the FedSMR Federal trunking system in Washington, D.C. and Philadelphia would be cost prohibitive.

FedSMR growth is expected to be twenty percent per year for at least the next five years, requiring about three additional channels per year. Use of technologies such as CDMA could permit more efficiency and reduce the requirements for additional channels. The FedSMR contractor is working with an equipment manufacturer to develop a digital system operating on 6.25 kHz channels.

Land-mobile networks can also be shared among agencies with common missions. For example, USDA infrastructure is shared with other agencies. The Forest Service maintains fire-fighting supplies, including land mobile radios, at the National Interagency Fire Center, located in Boise, Idaho. These radios are used during emergencies wherever they are needed for battling remote wildland fires, and performing emergency support functions under the National Response Framework.

[67] *See supra* note 37.

Treasury operates an interoperability frequency assignment called the Federal Common, which can be shared among all Federal agencies for law enforcement, as well as in coordination with state and local police in emergencies.

A number of DOE's sites and facilities share spectrum with other Federal agencies and local public safety units. The DOE Nevada Operations Office, which oversees nuclear test sites, shares with the Air Force at Nellis Air Force Base and with other Federal agencies for incident-response purposes.

DOI's Bureau of Land Management plans to continue reengineering and consolidating with partners to reduce spectrum demand in the HF, VHF and UHF bands and support and improve interoperability. Some agencies see an increased emphasis on sharing in the future.

Use of Commercial Services

Federal agencies increasingly use commercial spectrum through use of non-Federal communications systems and services. These include cellular phone service for routine or conventional uses such as facility maintenance. Non-tactical Treasury missions are mainly supported by commercial services and unlicensed devices. DOC uses commercial services where they fully support mission requirements and save money. USDA's Office of the Inspector General uses commercial land mobile services but will be transitioning to IWN. DOJ uses commercial services (Blackberries, cellular phones, satellite communications terminals) to augment its day-to-day law enforcement activities. For example, cellular phones are frequently used for non-tactical purposes; whereas agency dedicated land mobile networks are used in mission-critical for sensitive or tactical applications.

In some cases, however, due to remote locations or unique requirements, use of commercial services may not be possible. For example, DHS's law enforcement and homeland security functions require rapid push-to-talk types of connections, security and broadcast capabilities in land mobile service, which Federal 162-174 MHz frequencies can satisfy. DOC may not be able to use commercial services during emergencies when operations must be assured or simultaneous transmission to multiple users is needed. With respect to electric power plant operation, the commercial cellular and satellite communications services do not provide the reliability, availability, and ease of control needed for DOE's missions. Commercial land mobile lacks the encryption needed for DOE's Nevada operations, including the Yucca Mountain test site and DOE assets located at Nellis Air Force Base.

USDA's perspective is that continued access to Federal spectrum is needed because much of its operations are in isolated areas where cell coverage is not available. To maintain communications for safety and emergency communications, USDA requires access to Federal radio-based systems.

Even if commercial cellular service were available in 100 percent of USDA's operating areas, the requirements for simultaneous broadcast voice messages across the entire operating territory cannot currently be met with existing commercial products and services. However, some cellular service providers are developing capabilities that USDA plans to explore as coverage becomes available across the USDA's broad operational footprint.

Several agencies expect to increase their reliance on commercial services in the future. The requirements of today's law enforcement demand unencumbered access to spectrum far exceeding those associated with voice operations in Federal exclusive bands. DOJ's operations cannot be frequency band or assignment limited. It plans to use commercial services to meet these needs. Commercial alternatives will be a large factor in DOI's spectrum planning through 2010. DOI assumes that wireless voice, data, and video transmission integration will be maximized through use of commercial as well as dedicated Federal systems. The potential for increased use of commercial applications to enhance DHS communications systems will also have a significant impact on the DHS's spectrum needs. NOAA may be able to use cellular telephones where cell coverage is adequate in the future. DOS will seek to use commercial sources of communications services.

Increased use of commercial services for non-secure activities to improve cost effectiveness and efficiency is foreseen by Treasury. However, demand may increase for commercial land mobile and unlicensed spectrum beyond Treasury's current level of usage. The U.S. Mint, for example, is investigating the feasibility of moving to a completely wireless desktop environment in the future. The IRS has considered the feasibility of using wireless broadband for computer connectivity in the field.

Additional requirements for cellular and paging services from DOE's field offices are projected. With respect to its power plant operations and support of the nation's electrical power grid, DOE predicts that sharing and interoperability will result in commonality of Federal and private utility systems.

LAND MOBILE SERVICE REQUIREMENTS SUMMARY

The Federal agencies make extensive use of many frequency bands to satisfy numerous mobile communications requirements. The military makes extensive use of HF networks on many platforms, and it will continue to do so for at least the next fifteen to twenty years. Federal agencies operate HF emergency communications networks, and they plan to implement more such networks for emergency back-up. The Federal agencies anticipate a need for 100 kHz of additional spectrum for the mobile service to accommodate uses such as emergency communications networks that permit interoperability.

Greatly expanding use of unmanned vehicles and spectrum-intense technologies is projected for military, law enforcement, and public safety applications.

There are increased spectrum requirements for aeronautical telemetry used for in flight-testing of manned and unmanned aircraft, rockets, and missiles.

With minor exceptions, most agencies expect to use the entire land mobile spectrum they currently use for at least five to ten years, and possibly fifteen years.

Although no specific quantities are provided, substantial growth is predicted for land mobile communications in defense and homeland security missions. Most of DOD's domestic assignments are below 6 GHz because this spectrum is conducive to terrestrial mobile operations with reliable, moderate capacity communications links and with excellent propagation characteristics through dense foliage. DOD's expected growth through 2015 may not be supportable without advances in spectrum utilization technologies and changes in spectrum management approaches. Furthermore, any loss of spectrum nationally or internationally will make it more difficult to satisfy DOD's requirements.

DOJ needs increased assignments in the 162-174 MHz and 406-420 MHz bands where the majority of DOJ's land mobile communications are located. Expanded activities and needed access to spectrum in the non-Federal bands 150-162 MHz, 450-470 MHz, and 800 MHz may also be necessary. Some agencies such as DOC-Census Bureau, DOC-NOAA and the BBG, do not foresee any major increases in demand.

Treasury is reviewing its use of frequency assignments, and releasing any that are no longer needed. USDA's total number of frequency assignments will decline as Federal systems are replaced with commercial services, such as in the bands USDA has relinquished to the FCC for public auction for advanced wireless communications. During FY2006, USDA released 1,027 frequencies for auction in the 1710-1755 MHz band. USDA will use its current frequency assignments more intensively to provide additional service in the same amount of spectrum.

The effects of techniques meant to increase spectrum efficiency are unclear during the transition period to narrowband, shared systems such as IWN and use of more trunked systems. In particular, with respect to agency participation in the IWN, several agencies caution that there may be a short-term need for more spectrum because both the legacy system and the new system will be in use for a transition period. Furthermore, the adaptation of narrowband land mobile spectrum to meet the expanding requirements for broadband applications is unclear. Agencies will consider new technologies or commercial systems that can be used for such purposes, and several agencies have identified software-defined radio (SDR) and radio over IP as future technologies to be considered.

Satisfying Future Land Mobile Service Spectrum Requirements

Several changes to the United States allocations in the 162-174 MHz spectrum region could assist the agencies in meeting their requirements. As discussed above, the 173.2-173.4 MHz band, allocated for non-Federal use, is within the 162-174 MHz Federal band. Exclusive Federal access to the band would facilitate Federal planning and improve spectrum-use efficiency. In addition, relocation of wireless microphones which operate on eight frequencies in the 162-174 MHz band and are extensively utilized in fast-food restaurants would enhance Federal use of the band. These unlicensed operations cause interference to mobile systems used by Federal law enforcement agencies. The 162-174 MHz band is critical to law enforcement communications, and to preclude harmful interference and to provide for more Federal spectrum access, relocating wireless microphones from this band and reallocating the 173.2-173.4 MHz band to exclusive Federal use may be needed.

Most of the future spectrum requirements could be satisfied in the existing land mobile service frequency bands by: 1) using more spectrum sharing; 2) network or facilities sharing; and 3) use of more commercial services. Rearrangement of the allotment channel plans in the 162-174 MHz and the 406.1-420 MHz bands also could facilitate more sharing, and the re-use of the same channels could improve spectrum-use efficiency.

Network or facilities sharing, especially the use of digital trunking, would use less spectrum and improve efficiency, and could provide cost savings to the Federal agencies. The increased use of non-Federal Government spectrum and systems, especially for administrative traffic, would relieve demands on Federal spectrum. The development of a commercial secure, reliable network for government use at all levels, and using portions of the spectrum currently allocated to those purposes, would also provide great relief to the currently crowded spectrum.

AERONAUTICAL MOBILE SERVICE

INTRODUCTION

The aeronautical mobile service (AMS) is a communications service that provides for the safety and regularity of aircraft flight. This service is a critical component of our nation's transportation communications infrastructure providing service to commercial, military, and private aircraft. There are a large number of Federal VHF frequency assignments in the United States to aeronautical communications, with approximately 50,000 air and ground VHF and UHF transmitters and receivers, and when counting both main and standby transmitters and receivers the figure rises to about 65,000.

The aeronautical mobile service is defined as: "A mobile service between aeronautical stations and aircraft stations, or between aircraft stations, in which survival craft stations may participate; emergency position-indicating radiobeacon stations may also participate in this service on designated distress and emergency frequencies."[68] There are two subcategories within the broader aeronautical mobile category:

1. Aeronautical Mobile (Route) Service or AM(R)S, defined as: "An aeronautical mobile service reserved for communications relating to safety and regularity of flight, primarily along national or international civil air routes."[69]

2. Aeronautical Mobile (Off Route**)** Service, or AM(OR)S, defined as: "An aeronautical mobile service intended for communications, including those relating to flight coordination, primarily outside national or international civil air routes, (mostly for military aircraft use)."[70]

The aeronautical mobile services are considered to be safety services, a term that also has a definition: "Any radiocommunication service used permanently or temporarily for the

[68] *See*, ITU Radio Regulations, art. 1, at § 1.32 (Geneva, 2004).
[69] *Id.* at § 1.36.
[70] *Id.* at § 1.37.

safeguarding of human life and property."[71] The aeronautical mobile service does not include personal communications to or from the passengers, such as telephone calls by passengers.

The aeronautical mobile service supports voice and data communications between ground stations and aircraft or between aircraft including flight testing, telecommunications, airdrome control, and route (R) and off-route (OR) services. Many of the communications within this service are used for Air Traffic Services (ATS) and Aeronautical Operational Control (AOC) safety communications.

ATS communications include Air Traffic Control (ATC) communications, communications providing alphanumeric and graphical weather data, and communications intended to notify appropriate organizations regarding aircraft in need of search and rescue, and to aid and assist such organizations as required.

AOC communications are used to initiate, continue, divert, or terminate a flight in the interest of the safety of the aircraft, and to ensure the regularity and efficiency of a flight. AOC functions operate via air-ground voice and data communications either through the cockpit crew or directly with airborne sensors or systems.

The AM(R)S operations, including certain frequency bands and technical standards used for this service, are coordinated internationally through the International Civil Aviation Organization (ICAO), a United Nations treaty organization, to ensure the worldwide interoperability of these services. Since the United States is an active member of ICAO, it incorporates the ICAO treaty, regulations, and standards into the relevant U.S. rules and regulations. Consequently, many of the aeronautical-related regulations found in Part 87 of the FCC Rules and the NTIA Manual are based on ICAO rules and standards. The AM(R)S supports voice and data communications between ground stations and aircraft or between aircraft operating within designated fight paths. As with other aeronautical mobile services, many of the communications within this service are used for ATS and AOC safety communications.

Aircraft operated by Federal agencies, the commercial airlines, and general aviation communities all depend on ATS and AOC radiocommunications services to foster the safe, economic, and efficient operation of aircraft. The FAA mission is to provide the safest, most efficient aerospace system in the world. In the spectrum management area, the mission of the FAA's ATC Spectrum Engineering Services spectrum management office is to:

1. Secure and manage the radio frequency spectrum;
2. Protect aeronautical spectrum domestically and U.S civil aviation interests internationally; and
3. Satisfy both present and future spectrum requirements for the flying public and the U.S. aviation community.

This mission is accomplished through optimization of resources and negotiation with other users of the radio spectrum at the national and international levels.[72]

[71] *Id.* at § 1.59.

Public participation with the Federal aeronautical-related regulatory and standards development processes is conducted through the Radio Technical Commission for Aeronautics (RTCA), Inc., a not-for-profit corporation that develops consensus-based recommendations regarding communications, navigation, surveillance, and air traffic management system issues. RTCA functions as a Federal Advisory Committee. Its recommendations are used by the FAA as the basis for policy, program, and regulatory decisions, and by the private sector as the basis for development, investment, and other business decisions.[73]

CURRENT AERONAUTICAL MOBILE SERVICE SPECTRUM USE AND FUTURE REQUIREMENTS

General

The aeronautical mobile spectrum is shared between Federal and non-Federal entities, enabling a Federal agency such as the FAA to communicate with aircraft operated by both Federal and non-Federal entities such as commercial airliners.

The FAA provides air-ground communications support for en route, terminal, and flight services to end users such as the commercial airlines, general and private aviation, the military services and other Federal agencies. En route services include the aircraft separation services, traffic advisories, and weather information to pilots en route between airports, etc. Terminal communications include the radio communications in the airspace that immediately surrounds the airport and on the ground. Flight services include flight plan filing, preflight and in-flight weather briefings, en route communications with pilots flying under visual flight rules, and assistance to pilots in distress.

The AM(R)S is used by both Federal and non-Federal entities in identical ways and operations are conducted in the 2-23 MHz (MF and HF) and 117.975-137 MHz (VHF) bands. Additionally, the FAA provides air traffic control services to military aircraft on allotted frequencies in the 225-399.9 MHz band. The FAA has many frequency assignments in the 117.975-137.0 MHz VHF band. DOD is the other Federal agency with extensive spectrum usage in the band.

The AM(R)S bands are mostly used for aeronautical communications. A large majority of Federal HF spectrum for the aeronautical mobile service use is accounted for by the military services, while the FAA accounts for over eighty-eight percent of the VHF spectrum use in its support to aeronautical mobile requirements of the commercial airlines and the flying public. Most of the FAA's HF communications requirements are satisfied by a private company, ARINC, Inc. (ARINC) under an FAA contract. The ARINC HF assignments are licensed by the FCC. ARINC provides civil aviation with communications services, planning and management.

---

[72] FAA ATC Spectrum Engineering Services, http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/spec_management/

[73] RTCA, Inc. Home Page, http://www.rtca.org/aboutrtca.asp. (last visited, Feb. 7, 2008).

Spectrum Use and Future Requirements in the MF and HF Bands

The 2-23 MHz bands include twenty-one distinct frequency bands that are shared equally by Federal and non-Federal users for ATS and AOC functions. The MF and HF bands, regulated by international agreement, have long provided the major means of communications with aircraft in transoceanic service, because the signals propagate over long distances, and in some developing countries. Because MF and HF propagation is dependent on time of day, time of year, sunspot cycles, and other factors, airborne MF and HF systems generally have multiple frequencies assigned during flight. MF and HF communications are not used over the continental United States, except in Alaska.[74]

DOD uses the MF and HF bands for a variety of functions, including tactical air-to-ground communications, command and control communications, and for communications supporting disaster relief operations. The Air Force uses MF and HF for global command and control stations, flight testing, tactical communications, data coordination and satellite recovery operations. One example of MF and HF aeronautical mobile service spectrum use is NASA's support of the space shuttle operations.[75]

Spectrum Use and Future Requirements in VHF Bands and in 960-1215 MHz

The 117.975-137 MHz VHF band provides the primary communications mode for ATS and AOC safety communications for all areas of the world where radio Line-Of-Sight (LOS) services can be established in a practical manner. Though VHF radio is limited to LOS, modern aircraft fly at altitudes where LOS can exceed 800 km. The 117.975-137 MHz band is used by civil aviation authorities to provide ATS safety communications and by the airlines, business aviation, and general aviation to provide AOC safety communications. Each communications frequency is re-used as often as possible due to the limited number of available frequencies.

The FAA and ARINC maintain an extensive network of VHF radio stations giving reliable coverage over the United States and off-shore areas. The communications in the 117.975-137 MHz band are via Double-Sideband Amplitude Modulation (DSB-AM), and since 1992 mostly on 25 kHz channels. In the United States, the 117.975-137 MHz band is divided into 760 (25 kHz) channels, with 524 available for ATS and the remainder used by AOC and general aviation. Although the band was narrowbanded to 25 kHz channels in 1977, there are many general aviation aircraft still operating on 50 kHz channels, requiring the FAA to have 50 kHz assignments for many operations. Furthermore, the 136-137 MHz segment was made available in 1977, but the expansion of the available channel capacity has been slow.[76]

The FAA estimated in 2004 that the channel requirements would grow and approximately 1230 frequency assignments might be needed to satisfy the air traffic control system needs until 2010. The present VHF communications system will be able to support the operation of the

---

[74] NTIA 1995 Report, *supra* note 30, at 41.

[75] *Spectrum Resource Assessment of Government Use of the HF (3-30 MHz) Band*, NTIA Technical Memorandum 89-141 at 67-68 (June 1989).

[76] *Radio Spectrum Plan for 2001-2010 (2004 Revision)*, FAA, at 1 and 2 (March 2005) (FAA Radio Spectrum Plan).

National Airspace System (NAS) until 2010 if FAA-identified improvements can be made.[77] The FAA Radio Spectrum Plan for 2001-2010 (updated 2005), states that "It was previously estimated that the Next Generation Air-to-Ground Communications (NEXCOM) concept would be implemented and used to satisfy new requirements in the United States in the 2010 time period. However, it is presently projected that a new system will not be implemented until 2015."[78]

DOT expects a future spectrum requirement for the 960-1215 MHz band for a satellite-based integrated communications and surveillance system. The band is currently allocated to aeronautical radionavigation, but is needed for the potential AOC and ATS communications applications.

The United States, within the ITU Radiocommunication Sector, submitted Document 8B/491-E to address the estimate of new aviation AM(R)S spectrum requirements. The study referenced in the document determined that new AM(R)S applications, like the Universal Access Transceiver (UAT) or Automatic Dependent Surveillance – Broadcast (ADS-B), "will require longer propagation distances *(e.g.,* out to radio line-of-sight), moderate bandwidth, and a number of distinct channels to allow for sector-to-sector assignments."[79] Based on technical characteristics of the radio spectrum, the study notes "it is expected that the former [UAT] applications will be accommodated in some portion of the 960-1164 MHz band."[80] The study considered evolving aeronautical applications and integration of a new system on an aircraft and estimated a need of approximately 60 MHz in some portion of the 960-1164 MHz band."[81]

Research continues into the use of the 960-1024 MHz radionavigation band as a communications band. Most recently, a NASA sponsored research paper was presented at the Working Group C of the International Civil Aviation Organization (ICAO) Aeronautical Communications Panel on propagation and interference modeling of communications and navigation systems via simulation.[82]

In conclusion, the transition from DSB-AM to a digital system in the 117.975-137 MHz band is a major spectrum management and engineering challenge to avoid interference and operating disruptions. The 960-1024 MHz band may be necessary to accommodate the future growth or to provide for the adoption of modern new technologies, but compatibility analyses are required.

---

[77] *Id*. at 1.
[78] *Id*.

[79] *Initial Estimate of New Aviation AM(R)S Spectrum Requirements*, U.S. Input Doc. 8B/491-E at 1 (March 31, 2005).
[80] *Id.*
[81] *Id*. at 5.
[82] *Future Communications Study Technology Assessment Activities and Progress*, ICAO Aeronautical Communications Panel, Working Group C, 10th Meeting, Paper ACP WGC10/WP6 (March 13-17, 2006).

Aeronautical Mobile Service Spectrum Use and Future Requirements of the 225-399.9 MHz Band

Federal agencies, such as DOD and the Coast Guard, make extensive use of the 225-399.9 MHz band for their aircraft operations. Within the IRAC, the 225-399.9 MHz band, excluding the 328.6-335.4 aeronautical radionavigation band, is managed by the Military Assignment Group (MAG). The Federal use of this band for aeronautical communications plays an important part in national defense and security. The military uses UHF for communications for training flights, combat, and ATC such as ground control, approach control, and en route separation services. The uses include coordination of in-flight refueling, vectoring of aircraft to targets, and large scale training exercises. The FAA, DOD, and Coast Guard account for nearly all of the mobile spectrum use in the 225-399.9 MHz band.

The FAA provides ATC functions for military aircraft essentially identical to the ATC communications in the VHF band. In fact, in most areas the FAA transmits ATC information simultaneously on VHF and UHF channels for military aircraft that are not VHF-equipped so that military and civilian aircraft are aware of each other.

Spectrum Use and Future Requirements of the 5000- 5030 and 5091-5150 MHz Bands

In the United States, DOD uses Microwave Landing Systems (MLS); however the FAA indicates that it "does not anticipate additional civil MLS development and that the phase-down of MLS is expected to begin in 2010."[83] Nevertheless, DOT requires spectrum for the MLS in the 5000-5250 MHz band to support existing DOD requirements.

The United States submitted Document 8B/491-E within the ITU Radiocommunication Sector with respect to estimating new aviation AM(R)S spectrum requirements. Surface spectrum requirements were estimated "based on a review of current surface communications requirements at a major airport in the United States."[84] The study assumed throughput requirements could be satisfied using "the candidate surface system technology (based on the Institute of Electrical and Electronics Engineers (IEEE) Standard 802.16e)."[85] The study showed that "approximately 60-100 MHz in some portion of the 5 000-5 150 MHz band" would be required.[86] The study pointed out that "it is important to note that those estimates are preliminary and closely tied to the assumptions made in the study."[87]

Additional functions supported in this band include satellite feeder links supporting integrated voice and data air-to-ground communications.

[83] 2005 FRP, *supra* note 46 at 3-9.
[84] *See supra* note 77 at 5.
[85] *Id.*
[86] *Id.*
[87] *Id.*

AERONAUTICAL MOBILE SERVICE REQUIREMENTS - SUMMARY

The available spectrum for aeronautical communications is adequate to support operations at the present time. However, it has long been recognized by the FAA that congestion will become a major spectrum management problem. This is being addressed domestically and internationally. One approach already identified is transitioning the 117.975-137 MHz VHF band from a DSB-AM technology to a digital technology to alleviate spectrum congestion.

In addition, the 108-117.975 MHz, 960-1024 MHz, 5000-5030 MHz, and 5091-5150 MHz bands have been identified as potential candidates to satisfy future AM(R)S communications requirements. Coordination with ICAO and allocations at future WRCs will be necessary.

MARITIME MOBILE SERVICE

INTRODUCTION

The maritime mobile service is defined as: "A mobile service between coast stations and ship stations, or between ship stations, or between associated on-board communications stations; survivor craft stations and emergency position-indicating radiobeacons may also participate in this service."[88]

The maritime community has been a pioneer in the use of wireless communications. As early as 1900, radios were being installed aboard ships to receive storm warnings transmitted from stations on shore. Today, the maritime mobile service provides a wide range of communication services to vessels operating in international waters, coastal areas, and inland lakes and waterways. The maritime mobile services provide a means of communications for the day-to-day activities of a multi-billion dollar industry as well as providing the critical safety link for the protection of life and property at sea. This section addresses only the Federal use of the maritime mobile service, and non-Federal use such as intercommunications and distress and safety.

Stations operating in the maritime mobile service provide a wide range of communication services to vessels operating in international waters, coastal areas, and inland lakes and waterways. These services provide a means of communications for the day-to-day activities of the maritime industry as well as providing a critical safety link for the protection of lives and property. The maritime mobile service serves a variety of functions, including command and control communications with cutters, aircraft, and shore facilities for search and rescue, homeland security and anti-terrorism activities and off-shore enforcement of laws and treaties.

Because safety-of-life is a worldwide concern, compatibility among stations authorized by all nations is essential. Therefore, many of the maritime standards are established by international agreements administered by the ITU and the International Maritime Organization (IMO). The ITU and IMO regulations are the basis for many of the regulations in the NTIA Manual and in the Part 80 of the FCC Rules. One example of an international requirement is the Global Maritime Distress and Safety System (GMDSS), a multi-unit system that operates in a number of frequency bands. Following the international law of the Safety of Life at Sea (SOLAS) convention, is a mandatory carriage requirement on vessels 300 gross tons and above.

Federal maritime mobile communications support the operation, movement and safety of shipping on navigable waters of the United States and on the surrounding seas. The Coast Guard has major responsibilities for maritime safety and navigation. Federal use of maritime mobile allocations is in compliance with international and domestic regulations to ensure interoperability with all shipping and to maintain the integrity of maritime distress and safety communications. Many other Federal agencies are active in the maritime mobile service, including DOD and DOC.

---

[88] *See*, ITU Radio Regulations, art. 1, sec. III, at 1.28 (Geneva, 2004).

CURRENT MARITIME MOBILE SERVICE SPECTRUM USE AND SPECTRUM REQUIREMENTS

Allocations to the maritime mobile service range from the MF (300-3000 kHz) through the VHF bands. Federal maritime mobile communications support the operation, movement and safety of shipping on navigable waters of the United States and on the surrounding seas. The Coast Guard has responsibility for maritime safety and navigation, both in United States' territorial waters and globally, with the Area of Responsibility (AOR) reaching far into the Atlantic and Pacific Oceans. The Federal use of maritime mobile allocations must be in compliance with international and domestic regulations to ensure interoperability with all shipping and to maintain the integrity of maritime distress and safety communications.

For most purposes, Federal and non-Federal users share the maritime frequencies and are accommodated in portions of the MF, HF (3-30 MHz), and VHF (156-162 MHz) bands. Frequency bands below 30 MHz are used for a wide range of services. Many of the channels are established and regulated by international agreement and are available for distress, urgency and safety, Digital Selective Calling (DSC), Narrow-Band Direct-Printing (NBDP), facsimile, public correspondence, private communications, etc. The Coast Guard and the DOD are the largest users of the maritime mobile service. The 156.2475-157.1875 MHz maritime mobile band is the heaviest used band by the Federal agencies. Another VHF band is the 161.575-162.0375 MHz band where the Coast Guard has the majority of the Federal assignments.

Current Use and Future Spectrum Requirements in the 300-3000 kHz (MF) Band

The NAVTEX shore-to-ship broadcasting system operates at 518 kHz to send messages such as gale warnings and other safety information. (NAVTEX is a text service for delivery of navigational and meteorological warnings and forecasts, as well as urgent marine safety information to ships approximately 200 miles from shore.) All SOLAS ships carry NAVTEX under the GMDSS requirement.

The Coast Guard uses parts of the 2-3 MHz spectrum for DSC and voice communications and for maritime distress communications. The Coast Guard also uses 2-3 MHz for NBDP and for Simplex-Teletype-Over-Radio (SITOR) for issuing messages such as storm warnings.

The frequency 2182 kHz is listed in Part 80, section G, paragraphs 80.301 and 80.304 of the FCC rules as a distress, urgency, and safety frequency. The FCC Rules require certain ship stations to retain watch times on 2182 kHz, and Coast Guard stations also monitor 2182 kHz.[89]

Current Use and Future Spectrum Requirements in the 3-30 MHz (HF) Bands

The maritime mobile use of the 4-26 MHz part of the HF band is channelized following the ITU Radio Regulations, Appendix 17. The channel plans have been incorporated into Annex H of the NTIA Manual, "Assignment Guide for Maritime Mobile Bands 4-26 MHz."[90] Since many

[89] 47 C.F.R. Part 80.

[90] NTIA Manual, *supra* note 39 at H-1.

bands are shared between Federal and non-Federal users and intercommunications is necessary, the channel plans are also contained in Subpart H, “Frequencies,” of Part 80 of the FCC Rules.

The Coast Guard relies on the HF bands for command and control communications with cutters, aircraft, and shore facilities for purposes including search and rescue, off-shore enforcement of laws and treaties (including drug enforcement). Because of the Coast Guard’s expanding role in drug enforcement, a significant increase in the use of HF systems for air-to-ground and ship-to-shore circuits has taken place in the last decade. They also rely on the HF band for such communications as distress and safety, broadcast of maritime safety information, emergency medical assistance communications, receipt of vessel position reports for safety purposes, and receipt of weather observation reports. HF communications play a vital role in relief efforts related to natural disasters or other emergencies threatening the safety of life and property, and in many cases, HF has been the only link with remote areas affected in a disaster. However, the variable ionospheric propagation characteristics of HF require access to multiple HF sub-bands to provide the assurance of reliable communications.

In addition to voice and low-speed data communications, the Coast Guard uses HF to provide WEFAX service, a facsimile service to transmit weather information to mariners. For example, information is provided on hurricanes or cyclones via text or graphical form. Coast Guard uses the 3-30 MHz band for SITOR to transmit marine forecasts and storm warnings. Based on new requirements, the Coast Guard may need an additional 1 MHz of HF spectrum to support the Integrated Deepwater Systems (IDS) and Maritime Domain Awareness (MDA) programs. The Coast Guard also needs additional spectrum for the increased ALE, dynamic frequency pools, expansion of HF data, and HF radar for long-range tracking.

The Navy also has HF communication systems that transmit between shore stations and ships, and ship-ship in the maritime mobile bands. These systems support hydrographic surveys, communications with jumbo tankers, weapon system testing, and secure tactical voice systems. Constant communications with individual ships and naval forces at sea is required. Therefore, the Navy has a large investment and heavy reliance on HF communication equipment at shore installations and shipboard. HF transmissions will continue to be very important for fleet-wide communications.

DOI uses HF for its U.S. Geological Survey (USGS) marine geology exploration and mapping tasks. The DOC has HF maritime mobile systems to support ships and boats used by the National Marine Fisheries Service and for communication links between major fishery centers and research vessels of the NOAA Corps fleet. NOAA uses the HF bands for maritime communications on board NOAA ships.

Reliable maritime mobile HF communications are necessary for the Navy’s Carrier-Strike-Group (CSG), and Expeditionary-Strike-Group (ESG). The Navy also uses HF to provide interoperability communications with coalition forces. In summary, the HF spectrum remains very valuable for maritime mobile communications, and more spectrum will be required in the future.

Use of The 30-300 MHz (VHF) Bands

The VHF channels in the 156-162 MHz band provide short-range ship-to-ship or ship-to-shore communications. Channels are made available according to the type of communication and the nature of the ship's operation. For example, channels are available for safety communications, distress and calling, control of ship movement, and other functions. Although not used extensively, data communications are also available on various channels, subject to special arrangement among interested and affected administrations. Many of these frequencies are specified on an international basis.

The 156-162 MHz band is a shared Federal and non-Federal band, channelized into a mixture of 25 kHz and 12.5 kHz channels. These channels are used by public correspondence, which has the option of using 12.5 kHz or 25 kHz channels.

The Coast Guard relies on VHF channels for ship-ship and ship-shore communications on a regular basis. The only exclusive Federal Government allocation for the maritime mobile service in the bands between 30-300 MHz is at 157.0375-157.1875 MHz. This band consists of six 25 kHz channels. Five channels are used to support the National VHF-FM Distress and Safety System operated by the Coast Guard. The remaining channel is used by Federal agencies as a working frequency for their maritime operations. The Coast Guard projects more than a ten percent growth of the maritime mobile assignments in the 156-162 MHz band over the next ten years. The projected growth in the number of assignments is due primarily to: 1) the implementation of the National Distress and Response System (NDRS) replacement (RESCUE 21); 2) additional Automatic Identification System (AIS) frequencies for vessel traffic and satellite detection; and 3) satisfying international interoperability requirements.

The Emergency Position-Indicating Radiobeacons (EPIRBs) are part of the GMDSS. Operating in the band 406-406.1 MHz, these devices are used by a vessel in distress to transmit its location via satellite to rescue coordination centers. Additional Coast Guard use of the VHF band includes monitoring channel 16 (156.8 MHz) for distress and channel 22 (157.1 MHz), for maritime safety broadcasts and liaison. The Coast Guard also uses channel 13 (156.650 MHz) for bridge-to-bridge navigational communications.

The 156-162 MHz band is used for AIS, a unique maritime navigation safety communications system that provides collision avoidance, vessel monitoring, and tracking to enhance maritime domain awareness. The AIS provides ship-to-ship, ship-to-shore, and shore-to-ship capabilities. The Coast Guard retains a spectrum requirement for frequencies allocated exclusively for AIS. The AIS is key element in the Coast Guard vessel traffic system, in conjunction with the radar displays to identify and track ships. The AIS operates on two frequencies: AIS 1 at 161.975 MHz (Channel 87B); and AIS 2 (Channel 88B) at 162.025 MHz, and it is a SOLAS requirement. On July 24, 2006 the FCC released a Report and Order and Further Notice of Proposed Rule Making and Fourth Memorandum Opinion and Order that designated the Channels 87B and 88B for AIS along the coasts and major waterways of the

United States.[91]

The Coast Guard forecasts a ten percent growth in frequency Coast Guard assignments in the 156-162 MHz band; an additional 25 kHz is needed for long range vessel tracking; 25 kHz for an additional AIS channel; and 25 kHz for Coast Guard force tracking.

The 156-162 MHz band is extremely critical to the maritime mobile service, especially for maritime safety and port and ship security communications. Furthermore, narrowbanding will not alleviate all of the maritime mobile spectrum requirements, especially the requirements for data and broadband data. NOAA ships require continued use of the 156.0-157.5 MHz spectrum for inter-ship communications.

In summary, there is a continuing and increasing need for interoperable communications in the 156-162 MHz band. Since this is the only internationally-interoperable maritime mobile service spectrum available above 30 MHz, its availability is critical to national maritime and security needs. Increased sharing of land mobile service spectrum may be required to satisfy critical maritime mobile service spectrum needs, especially for data communications requirements and for internationally-recognized narrowbanding arrangements for voice communications. Use of VHF maritime mobile bands for distress and safety is coordinated internationally. Availability of additional VHF land mobile bands for maritime mobile would require regulatory changes. Such changes could improve international operability and provide additional support for critical maritime mobile communications, especially maritime distress and safety communications.

Use of Commercial Services

The 216-220 MHz band is allocated to the Federal and non-Federal users for the maritime mobile service on a shared, primary, co-equal basis. Channels are made available within the 216-220 MHz band for a system called the Automated Maritime Telecommunications System (AMTS). Currently, there is only one AMTS in operation, with service being provided by Waterway Communications System, Inc. (WATERCOM), a corporation set up by a number of barge and towing operators. The system of fifty-five base stations (100-115 km spacing) tracks ship locations so that incoming calls are routed through the nearest base station. This system operates along the Mississippi, Illinois and Ohio Rivers, providing service primarily to the tug and towboat industry from New Orleans to Minneapolis/St. Paul, Chicago and Pittsburgh, and along the Gulf of Mexico Intracoastal Waterway from the Texas/Mexican border to the Florida panhandle.

Although not originally developed to provide maritime service, cellular telephone is becoming the service of choice, especially for small boat owners not required by law to carry a VHF maritime mobile radio. The Coast Guard permits certain fishing vessels required to carry radio equipment for safety purposes to equip themselves with a cellular telephone in lieu of other

[91] *See*, Amendment of the Commission's Rules Regarding Maritime Automatic Identification Systems, WT Doc. No. 04-344, *Report and Order and Further Notice of Proposed Rule Making and Fourth Memorandum Opinion and Order*, 21 F.C.C.R. 8892 (2006).

radio equipment. In the Gulf of Mexico, Petrocom operates an offshore cellular telephone service that provides voice and data services to vessels.

In many areas, dialing 911 on a cellular telephone will immediately connect to an emergency law enforcement and emergency operations center. While this has the great advantage of providing emergency help to boaters who have not purchased a marine communications radio, it has the disadvantage of not allowing other nearby boats to hear a distress call and respond more promptly. Furthermore, cellular telephone service has a more limited range than either of the other services (16 km versus 80 km). In addition, cellular telephone service tends to follow highways and population centers, rather than lakes, bays, rivers or coastlines. Thus, the cellular signal coverage in maritime areas is incidental and not the result of designed coverage, and large portions of many bodies of water are without coverage. There is also the possibility of unannounced coverage changes. Nevertheless, cellular telephone service is rapidly expanding and is expected to play a greater role in coastal and inland maritime mobile services. However, the Coast Guard does not endorse the use of cellular phones as a primary means of distress and safety related communications.

MARITIME MOBILE REQUIREMENTS SUMMARY

In summary, an additional 1 MHz for use by maritime mobile systems in the HF bands may be needed. There also is a continuing need for maritime mobile communications in the 156-162 MHz band for at least the next ten years. Narrowbanding the entire band to 12.5 kHz channels would provide additional channels, but for maritime mobile communications, such narrowbanding must take into account the need for international interoperability.

MOBILE-SATELLITE SERVICE

INTRODUCTION

The Mobile-Satellite Service (MSS) is defined as:

A radiocommunication service:

- between mobile earth stations and one or more space stations, or between space stations used by this service; or
- between mobile earth stations by means of one or more space stations. This service may also include feeder links necessary for its operation.[92]

This definition is for the generic MSS. There are more specific services such as the land MSS, the aeronautical MSS, and the maritime MSS, each with its unique definition. These specific services, other than distress and safety uses of the MSS, are not specifically addressed in this section. The use of mobile satellites for aeronautical mobile (route) service applications is discussed under the Aeronautical Mobile-Satellite sub-section.

The MSS may use satellites in the geostationary orbit (GSO), or the non-geostationary (NGSO) orbits. The feeder links providing communications from earth stations fixed in place to and from the satellite can operate in bands allocated either to the MSS or the Fixed-Satellite Service (FSS). Most of the MSS feeder links operate in FSS frequency bands.

As in the case of the FSS, MSS systems generally provide coverage to large areas of the Earth. Spacecraft weight and antenna technology currently limit the amount of frequency reuse possible in and between MSS systems. For example, operation of a geostationary MSS system over the North Atlantic may preclude the use of the same frequencies in most parts of the United States. Thus, the amount of spectrum required to support a given number of MSS users is large in comparison to the same number of users that can be served by highly developed terrestrial systems. MSS systems providing service to hand-held devices are further constrained in the amount of frequency reuse achievable. The lack of sufficiently high antenna gain and discrimination in mobile earth stations is a limiting factor in the spectrum efficiency achievable with these systems. However, the advantage of MSS is that it can accommodate traffic using very small earth terminals operating anywhere within the large coverage areas of the MSS satellite.

NGSO MSS systems operating below 1 GHz use considerably less spectrum than the NGSO systems using frequencies above 1 GHz because they are used for low data rate transmissions only. These systems should be capable of supporting large numbers of users in a few megahertz. NGSO systems can be in various orbits (low orbit, medium orbit, or elliptical orbit).

[92] *See*, ITU Radio Regulations, art. 1, sec. III, at 1.25 (Geneva, 2004).

ALLOCATION ASSETS

There are 40 frequency bands allocated to MSS in the United States below 100 GHz, but the majority of the Federal MSS systems operate in parts of the 235-322/335.4-399.9 MHz, 7 and 8 GHz, 20 and 30 GHz and 20 and 44 GHz portions of the spectrum. The MSS spectrum allocations below 3 GHz are narrow and crowded and contain significant regulatory constraints, especially for operations in other parts of the world. The majority of the MSS spectrum available for government satellites is above 3 GHz where propagation and foliage penetration losses are higher, making communications unreliable at times in certain locations.

However, the Federal agencies represent some of the largest users of commercial MSS services. Internationally, several frequency bands are used by commercial MSS systems. Additionally, there are several bands allocated to MSS by the ITU on a regional basis. However, only a subset of the worldwide allocated bands is currently available for commercial MSS systems in the United States.

The international footnote 5.457A states: "In the bands 5925-6425 MHz and 14-14.5 GHz, earth stations located on board vessels may communicate with space stations of the fixed-satellite service. Such use shall be in accordance with Resolution 902 (WRC-03)."[93] In the United States, footnotes NG180 through NG183 pertain to operations on board vessels. NG180 and NG181 authorize the operations of mobile earth stations on vessels in the 3700-4200 MHz and 5925-6425 MHz, respectively; and footnote NG182 authorizes such operations in the 10.95-11.2 GHz and 11.45-11.7 GHz bands; and footnote NG183 authorizes such operations in the 11.7-12.2 GHz and 14.0-14.5 GHz bands.[94] These footnotes address only non-Federal operations, and thus Federal operations are usually on a non-interference basis.

ITU footnote 5.199, incorporated in the U.S. Table of Frequency Allocations, provides that: "The bands 121.45-121.55 MHz and 242.95-243.05 MHz are also allocated to the mobile-satellite service for the reception on board satellites of emissions from emergency position-indicating radiobeacons transmitting at 121.5 MHz and 243 MHz."[95] The emergency position-indicating radiobeacons (EPIRBs) are part of the GMDSS. ITU Footnote 5.266 authorizes the EPIRBs in the 406.0-406.1 MHz frequency band.[96] There are also emergency-related MSS operations authorized at 1544-1545 MHz via ITU footnote 5.356 that is adopted by the United States: "The use of the band 1544-1545 MHz by the mobile-satellite service (space-to-Earth) is limited to distress and safety communications (see Article 31)."[97]

ITU footnote 5.353A further addresses the use of the 1530-1544 MHz and 1626.5-1645.5 MHz bands, providing priority spectrum requirements for the distress, urgency, and safety communications of the GMDSS.[98]

---

93 NTIA Manual, *supra* note 39 at 4-108.
94 *Id*. at 4-158.
95 *Id*. at 4-81.
96 *Id*. at 4-86.
97 *Id*. at 4-95.
98 *Id*. at 4-95.

Federal agencies make extensive use of the UHF bands for MSS under the regulatory provisions of footnote G100 that pertains to Federal operations: "The bands 235-322 MHz and 335.4-399.9 MHz are also allocated on a primary basis to the mobile-satellite service, limited to military operations."[99] In accordance with Footnote 5.254, the ITU allocation essentially provides the allocations on a secondary basis.

MOBILE-SATELLITE SERVICE SPECTRUM USE AND FUTURE REQUIREMENTS

General

The most extensive uses of MSS are for voice services with an increased demand for data. MSS will also likely transmit graphic and video data as the demand for these services grows. Mobile-satellite communications is a current and growing critical requirement to support military command, control, and communications activities, and has also proven to be an asset during disaster and emergency situations.

The Federal agencies have unique requirements for mobile-satellite communications to support their missions. DOD has been using mobile-satellite communications since the late 1970s, and has continuing and growing needs for worldwide mobile-satellite communications to support military operations.[100] Furthermore, there is significant need for mobile-satellite communications to support homeland security for search and rescue operations, tracking of criminals, disaster management communications, environmental monitoring, vehicle and cargo tracking and industrial monitoring control. DHS plans to use commercial MSS systems to meet most of their communications requirements, but that they cannot rely on the availability of commercial systems to meet all of their needs for the foreseeable future.

The DOD has requirements for additional MSS spectrum below 3 GHz because atmospheric and foliage penetration losses are relatively low, components are inexpensive, and small, efficient antennas can be used for handheld operations. Tactical and strategic military communications are essential to linking current and growing requirements of the military command, control, communications and intelligence. NTIA recognizes DOD's possible need for additional spectrum to be authorized for government use below 3 GHz, now limited to non-Federal satellites.[101] However, congestion by commercial MSS systems in the 1525-1559 and 1626.5-1660.5 MHz bands preclude their availability for Federal allocations. In an FCC Notice of Proposed Rulemaking (NPRM) proceeding, the bands 1610-1626.5 and 2483.5-2500 MHz bands were considered for expanded Federal use.[102] In its response to the FCC's NPRM, NTIA stated: "specifically, NTIA recommends that the Commission modify the table of frequency allocations to include Federal MSS in the bands 1615.5-1621.35 MHz, 2483.5-2492 MHz, and

---

[99] NTIA Manual, *supra* note 39 at 4-159.

[100] *Spectrum Reallocation Report: Response to Title III of the Balanced Budget Act of 1997,* NTIA Special Publication 98-36, at 2-6 (Feb. 1998).

[101] *See*, NTIA Manual, *supra* note 39 at 4-143. Currently under Footnote US319 to the Table of Allocations, Federal earth stations are allocated on a primary basis, for use with non-Federal satellites, in the 137-138 MHz, 148-149.9 MHz, 399.9-400.05 MHz, 400.15-401 MHz, 1610-1626.5 MHz and 2483.5-2500 MHz frequency bands.

[102] *Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, L Band, and the 1.6-2.4 GHz Bands*, IB Doc. No. 01-185, Report and Order and Notice of Proposed Rulemaking, 18 F.C.C.R. 1962 (2003) (MSS Order).

2498-2500 MHz to satisfy existing and growing Federal MSS spectrum requirements and to enhance communications for national defense, law enforcement, and emergency relief agencies."[103] The Commission did not support a Federal allocation but noted its intent to continue to work with NTIA and others in the Federal government to address spectrum issues in general.[104]

Mobile-Satellite Service Spectrum Use and Future Requirements in the UHF Bands

The military makes extensive use of mobile satellites operating in the UHF bands, because the signals can penetrate jungle foliage, inclement weather, and urban terrain. Although the UHF band is officially defined as the 300-3000 MHz band, discussions of the MSS, herein and in other documents, consider the 235-322 MHz band to be a UHF band. Small antennas can be used at the Earth stations making it easy to transport the stations. There are numerous UHF satellite earth terminals currently in use by the military, many of which are small and portable enough to be carried deep into theaters of operation. Federal assignments in the GMF cover hundreds and thousands of earth terminals within each MSS assignment. This is because each particular assignment may authorize numerous stations to operate anywhere within the US&P (a US&P frequency assignment is the typical practice for such mobile systems). Furthermore, the GMF does not contain assignments for deployments for systems operating outside of the US&P.

The Federal use of the UHF band for mobile satellites was initiated in 1978 with the Navy's Fleet Satellite Communications System (FLTSATCOM), a constellation of eight geostationary satellites providing worldwide coverage. The FLTSATCOM system is used by the Navy and Air Force, with the Air Force using it as part of its Air Force Satellite Communications System (AFSATCOM). The Coast Guard also uses the military satellites operating in this band.

The Navy began upgrading the FLTSATCOM in the 1990s with the UHF Follow-On (UFO) satellites. The UFO satellites offer increased communications channel capacity over the same frequency spectrum used by previous systems. Further, the Navy has awarded contracts for the next generation UHF satellites, termed the Multiple User Objective System (MUOS) that are expected to become operational in they near future. The capacity is 4 Mbps per beam. The MUOS will use Wideband-Code-Division-Multiple-Access (WCDMA) technology, the same technology as some forms of the Third Generation (3G) commercial cellular telecommunications technology. The MUOS will enable communications to various terminal devices such as handhelds, laptops, and personal communications units.

The Defense Satellite Communications System (DSCS)-III series of geostationary satellites that operate in the 7 and 8 GHz bands also carry a UHF transponder called the Single Channel Transponder (SCT) that provides a channel to communicate messages to the forces. The Military, Strategic, and Tactical Relay Satellite (MILSTAR) geostationary satellite also has UHF mobile-satellite capability, with a transponder that provides four AFSATCOM IIR channels and a fleet broadcast channel.

---

[103] NTIA Comments, IB Docket No. 01-185, at ii (filed, July 15, 2003).

[104] *Review of the Spectrum Sharing Plan Among Non-Geostationary Satellite Orbit Mobile Satellite Service Systems in the 1.6/2.4 GHz Bands,* IB Doc. No. 02-364, Fourth Report and Order and Further Notice of Proposed Rulemaking, 19 F.C.C.R. 13356 at ¶¶ 78-79 (2004).

In summary, the DOD has many critical communications satellites operating, or to be operated, in the UHF frequency bands of 235-322 MHz and 335.4-399.9 MHz, and these requirements will remain strong for at least the next ten to fifteen years.

Federal Mobile-Satellite Service spectrum Use and Future Requirements in the 3700-4200 MHz (4 GHz), 5925-6425 MHz (6 GHz), 11.7-12.2 GHz (12 GHz), and 13.75-14.5 GHz (14 GHz) Non-Federal Bands

Although not pertaining to MSS operations *per se*, footnotes NG180 through NG 183 authorize non-Federal mobile Earth Stations on Vessels (ESVs) operating with satellites in the FSS in the 4, 6, 10/11, 12, and 14 GHz bands. Since there are no Federal allocations, the Federal operations typically occur via commercial satellites on a non-interference basis. ESV operations may satisfy some of the DOD's mobile spectrum requirements. However, the 4 and 6 GHz bands are used extensively by point-to-point microwave radio relay systems, including electric and gas utilities, pipelines, railroads, and telephone companies as backup to their fiber-optic lines. There is interference potential in the 4 and 6 GHz bands if the ESVs operate in areas close to land, where the microwave antenna mainbeam can intersect the station on the vessel, and vice versa.[105]

DOD will use the 12/14 GHz bands for a tactical data link using commercial satellites. The Coast Guard will also use these bands for surveillance of coastal and ocean areas.

The Federal use of mobile platforms in the commercial satellite bands presents policy challenges. The Federal assignments in the exclusive non-Federal FSS bands used by commercial satellites do not have any regulatory allocation status, and Federal agencies may be forced to operate on a non-interference basis. Furthermore, operations on other mobile platforms may require that additional recognition would have to be sought in the ITU, as was done for the ESV operations.

The growing MSS requirements, especially for DOD and its need for satellite capacity for units on the move, require additional policy focus on:

1. Allocation categories and service definitions;
2. Status of Federal earth stations; and
3. Increased Access to non-Federal satellite capacity internationally.

Mobile-Satellite Service Spectrum Use and Future Requirements in the 7250-8400 MHz (7 and 8 GHz) Bands

Federal agencies operate MSS in the 7250-8400 MHz band since the channel bandwidth of the UHF satellites is too narrow to provide wideband communications, forcing the use of these higher capacity, higher frequency MSS bands. Of the bands with MSS allocations, some are secondary allocations, and some allocations authorize MSS but prohibit aeronautical

[105] *Procedures to Govern the Use of Satellite Earth Stations on Board Vessels in the 5925-6425 MHz/3700-4200 MHz Bands and 14.0-14.5 GHz/11.7-12.2 GHz Bands*, IB Doc. No. 02-10, Report and Order, 20 F.C.C.R. 674 (2005).

transmissions. Most of these bands are also allocated to and used by the fixed, fixed-satellite, and other satellite-related services. The MSS usage in the 7 and 8 GHz band is used by the military for airborne, shipborne, and transportable earth station terminals. The mobile earth station terminals in these bands are more technically complex than those in the UHF bands because the earth station antenna must remain "locked on" to the specific geostationary satellite to preclude interfering with other satellites.

The DOD DSCS-III series of geostationary satellites are deployed in various locations providing essentially worldwide communications coverage. The DSCS-III is primarily a strategic communications system with large fixed station terminals, but it can provide tactical communications via mobile-satellite terminals located on mobile platforms. The DSCS-III antenna design permits large area coverage, or multiple beam coverage. For the smaller mobile terminals, the satellite can use a spot beam with increased radiated power to provide adequate performance despite path losses which are greater than in the UHF band. The DOD makes extensive use of the 7250-8400 MHz bands for MSS communications, and these spectrum requirements will remain constant for at least over the next ten years.

Mobile-Satellite Service Spectrum Use and Future Requirements in the Bands above 20 GHz

The frequency bands above 20 GHz have higher propagation path losses than the 7 and 8 GHz bands and much higher than the UHF band, especially in precipitation such as heavy rain. Dense clouds can also substantially increase the propagation path losses. Nevertheless, there is considerable mobile satellite use of the spectrum above 20 GHz.

The MILSTAR and the Wideband Gapfiller satellites operate as both fixed satellites with larger fixed-satellite earth stations, and can also operate with mobile-satellite earth stations. These satellites can provide secure high-data rate communications to/from small transportable and mobile terminals providing tactical communications. The MILSTAR and its newer replacement, the Advanced-Extremely-High-Frequency (AEHF) satellite, are robust systems. The same frequency bands as MILSTAR are used but the AEHF has a higher data rate capability. The AEHF architecture supports transformational communications and network-centric warfare. These satellites will continue to operate over the near future, and the spectrum requirements will remain constant for at least the next ten years.

Mobile-Satellite Service Use for Emergency Communications

Emergency communications, for purposes such as locating vessels and people in distress, use satellite-based systems that operate as MSS. The DOC-NOAA operates the United States' component of the international COSPAS-SARSAT satellite search and rescue system, an international program operated by the United States, Canada, France, and the Russian Federation. The system is designed to precisely locate vessels or people in distress. It operates satellites that receive beacon signals from the vessel or person, and relay the signal to a central control station to locate the origin of the signal.

The systems currently consists of a both a Low-Earth Orbiting (LEO) segment and a GSO segment. The LEO segment consists of the U.S. Search and Rescue Satellite Aided Tracking (SARSAT) operated by NOAA, and the Russian COSPAS satellites. The Geographic Synthetic Aperture Radar (GeoSAR) constellation is comprised of satellites provided by the United States via the Geostationary Operational Environmental Satellite (GOES); India via the Indian National Satellite System (INSAT) series of satellites; and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) MSG satellite series.

The COSPAS-SARSAT operates EPIRBS at 121.5 MHz, 243 MHz, or 406 MHz that are allocated to these frequencies via ITU footnotes. However, in October 2000, the International COSPAS-SARSAT Program announced that it plans to terminate satellite processing of distress signals from 121.5 and 243 MHz emergency beacons on February 1, 2009.[106] All mariners, aviators, and individuals using EPIRBS on those frequencies will need to switch to the newer, more reliable, digital systems operating on 406 MHz to be detected by satellites. The decision to stop processing of the 121.5 MHz and 243 MHz satellite signals is due to problems with beacons on these frequencies, which inundate search and rescue authorities with numerous false alerts and provide inaccurate data, which adversely impacts the effectiveness of lifesaving services.[107]

NOAA operates the COSPAS-SARSAT system in the United States, and DOC has spectrum requirements for the SARSAT system at 121.45-121.55 MHz, 242.95-243.05 MHz; and 406.0-406-1 MHz. Short term spectrum requirements can be satisfied by the use of 121.45-121.55 MHz and 242.95-243.05 MHz. The Coast Guard is involved in the maritime search and rescue operations and uses the 121.5 and 406 MHz frequencies to make position determinations. NOAA operates the satellite system, routing maritime alerts to the responsible Coast Guard Rescue Coordination Centers. The spectrum requirements for the EPIRBS operating at 406 MHz should remain for at least the next ten years, but the operations at 121.5 and 243 MHz will be phased out by February 1, 2009.

USE OF COMMERCIAL MSS SYSTEMS

Beyond the use of federally operated MSS systems to support military operations, the growing demand for MSS by Federal agencies will be met by commercial MSS. This is especially true for communications during emergencies when conventional terrestrial wire and wireless communications services have been damaged or are otherwise inoperable.

The DOD uses a myriad of commercial satellites to provide communications to their mobile units, some of which may not be available in the Western Hemisphere.

The commercial Inmarsat system provides communications to ocean-going ships, communications which will tend to replace the use of long-range HF communications. The Inmarsat system also provides distress, safety and general communication services. Its use for distress and safety communications is part of the GMDSS. This international application is required by the international treaty resulting from the SOLAS Convention. Inmarsat had over

[106] COSPAS-SARSAT Website, http://www.cospas-sarsat.org/FirstPage/121.5PhaseOut.htm/ (last visited, Feb. 8, 2008).
[107] NOAA Satellite and Information Service Website, http://www.sarsat.noaa.gov/ (last visited, Feb. 8, 2008).

100,000 registered GMDSS-capable mobile terminals at the end of October 2004.[108] Furthermore, the Inmarsat Mini-M terminal is used extensively by small vessels. Future MSS provided by LEO satellites could provide service to smaller vessels, including those in Polar Regions. Commercial and non-commercial maritime users can be anticipated to increasingly use MSS as availability improves and costs are reduced.

In addition to the GMDSS, the Inmarsat satellite system is also used extensively by the Coast Guard as one of the main methods of communications. The Coast Guard also makes extensive use of leased Inmarsat services for data and secure and non-secure voice communications, and dial-up service to provide Integrated Services Digital Network (ISDN) data circuits.

Federal, state, and local government agencies require intermittent use of commercial MSS when other communications systems may be unavailable. The use of commercial MSS during Hurricane Katrina serves as a recent example of the important role of satellite communications when terrestrial commercial communications systems are inoperable. VA uses the Iridium satellite system for emergency communications by a growing number of VA medical centers, regional offices, and senior executives.

The DOC relies on commercial mobile satellite spectrum for satellite telephone applications in support of maritime operations, law enforcement, and COOP. MSS provides connectivity in areas where terrestrial networks are not available. DOC requirements for mobile-satellite phone services are not expected to increase significantly in the next ten years.

NOAA uses mobile satellite phone technology for a variety of operations. The Alaska Region (AR) of the National Weather Service (NWS) operates a single satellite telephone terminal to increase participation in the collection of marine observations under the Voluntary Observing Ship (VOS) program. Fishing vessels and some other craft chose to not broadcast their coordinates over VHF or UHF radio for competitive reasons. Use of satellite phone allows private contact with the Valdez Weather Service Office (WSO), avoiding cost of calls entering the Public Telephone Switched Network (PTSN). NOAA also uses twelve satellite phones for enforcement operations in remote areas and for ship-to-ship and ship-to-shore communications. Use of satellite telephone technology allows NOAA to increase participation in the collection of marine weather data and ensures safety during NOAA law enforcement operations and while NOAA ships are at sea. This directly contributes to all the NOAA activities, with emphasis on monitoring and observing the sea, managing ocean resources to optimize safety. This activity supports both the NOAA *Weather and Water Goal* and the Commerce and Transportation Goal. Satellite phone communications are provided by commercial services.

In summary, commercial MSS are widely used by the Federal agencies. Since many uses are for emergency situations, future specific requirements are difficult to determine because of the situational uncertainty, but in general will continue to be widely utilized.

---

[108] Satellite Services (INMARSAT and COSPAS-SARSAT), *Analysis and Assessment of the GMDSS performance of Inmarsat Global, Ltd.*, from the International Maritime Organization Communications and Search and Rescue Committee, COMSAR 9/XX at 3.3 (Dec. 4, 2004). *See* U.S. State Department Website, http://www.state.gov/documents/organization/51952.pdf.

MOBILE SATELLITE SERVICE REQUIREMENTS SUMMARY

The DOD is by far the largest Federal user of mobile-satellite spectrum, using both the federally-allocated frequency bands and commercial services. DOD's use of satellite communications has increased greatly over the past decade. Satellite communications resources are inherently flexible and well-suited to supporting dynamic mobile and communications-on-the-move operations required for military missions. Spanning distance, terrain, or hostile forces, satellite communications can provide a global reach for dispersed mobile platforms such as aircraft (both manned and unmanned), submarines, surface ships, vehicle and man-pack applications.

The DOD has unique operational requirements and commercial MSS services may not always be able to provide the needed service. DOD requires reliable communications in both normal and highly stressed communications environments such as severe multi-path, high ambient noise, scintillation, heavy rains, and in urban, rural, and heavily forested regions, on board ships, and in aircraft settings. The DOD MSS systems must be designed to meet certain performance requirements, including coverage, capacity, access and control, interoperability, types of service, mobility, reliability, encryption, and availability.

MSS systems operating in the bands below 3 GHz are the most likely to satisfy the unique Federal requirements to enhance communications for national defense, law enforcement, and emergency relief agencies. Commercial satellites operating in these bands are not designed to meet the majority of the DOD operational requirements.

However, DOD requirements for the use of commercial MSS are expected to continue to grow in the future. Except for the Coast Guard, the Federal uses of commercial satellites are usually intermittent, dictated by emergencies or geopolitical situations, rather than pre-planned or agreed-upon use, although the contract with Inmarsat may provide for access over the long term. Some situations will continue to require Federal access to the greater communications capacity that commercial systems may make available at the needed times.

The commercial MSS industry environment poses challenges with respect to future access for Federal agencies. Some firms operating commercial MSS have had major financial problems resulting in bankruptcies and others have gone through a number of corporate changes which have impacted their commitment to follow-on systems. Thus the possibility of limitations on availability of commercial MSS capacity must be considered when identifying methods of satisfying future communications requirements. Thus, to satisfy its critical communications requirements, the Federal Government may require additional spectrum allocated to the Federal MSS to enable the Federal agencies to operate their own satellites. The current allocations will also be required for at least the next ten years.

AERONAUTICAL MOBILE–SATELLITE SERVICE

INTRODUCTION

The Aeronautical Mobile-Satellite Service (AMSS) is defined as: “A mobile-satellite service in which mobile earth stations are located on board aircraft; survival craft stations and emergency position-indicating radiobeacon stations may also participate in this service.”[109]

As in the terrestrial counterparts, closely related are the subcategories of “route” and “off-route” services defined as:

- Aeronautical Mobile-Satellite Route (R) Service or AM(R)S, defined as**:** “An aeronautical mobile-satellite service reserved for communications relating to safety and regularity of flight, primarily along national or international civil air routes.”[110]

- Aeronautical Mobile-Satellite Off Route (OR) Service, or AM(OR)S, defined as**:** “An aeronautical mobile-satellite service intended for communications, including those relating to flight coordination, primarily outside national or international civil air routes.”[111]

The frequency bands allocated specifically to AMS(R)S are 117.975-136 MHz on a secondary basis via footnote 5.918; and 1610-1626.5 MHz and 5000-5150 MHz on a primary basis via international footnote 5.367.

Furthermore, international footnote 5.362A states:

> In the United States, in the bands 1555-1559 MHz and 1656.5-1660.5 MHz, the aeronautical mobile-satellite service shall have priority access and immediate availability, by preemption if necessary, over all other satellite communications operating within a network. Mobile-satellite systems shall not cause unacceptable interference to, or claim protection from, aeronautical mobile-satellite (R) service communications with priority 1 to 6 in Article 44. Account shall be taken of the priority of safety-related communications in the other mobile-satellite services.

International footnote 5.357A also applies to aeronautical mobile-satellite allocations and operations:

> In applying the procedures of Section II of Article 9 to the mobile-satellite service in the bands 1545-1555 MHz and 1646.1-1656.1 MHz, priority shall be given to accommodating the spectrum requirements of the aeronautical mobile-satellite (R) service providing transmission of messages with priority 1 to 6 in Article 44. Aeronautical mobile-satellite (R) service communications with priority 1-6 in Article 44 shall have priority access and immediate availability, by pre-emption if necessary, over

---

109 *See*, ITU Radio Regulations, art. 1, sec. III, at 1.35 (Geneva, 2004).
110 *Id.* at 1.36.
111 *Id.* at 1.37.

> all other mobile-satellite communications operating within a network. Mobile-satellite systems shall not cause unacceptable interference to, or claim protection from, aeronautical mobile-satellite (R) service communications with priority 1 to 6 in Article 44. Account shall be taken of the priority of safety-related communications in the other mobile-satellite services. (The provision of Resolution 222 (WRC-2000) shall apply.)[112]

While the priority access provisions to protect AMS(R)S currently apply to MSS systems operating in the bands 1545-1555 MHz and 1646.1-1656.1 MHz, the ITU Radiocommunication Sector has studied the "feasibility and practicality of prioritization and real-time pre-emptive access between different networks of mobile-satellite systems…while taking account the latest technical advances in order to maximize spectrum efficiency". [113] The studies concluded that "prioritization and intersystem real-time pre-emption is not practical and, without significant advance in technology, is unlikely to be feasible for technical, operational and economical reasons."[114] The spectrum requirements for MSS as well as AMS(R)S will continue to be studied within the ITU Radiocommunication Sector to meet commercial and government demand for these services.

DOT has ongoing and future requirements for satellite capacity available for aeronautical communications for ATS and AOC functions in the 1545-1559 MHz, 1610-1626.5 MHz, 1646.5-1660.5 MHz, and 2483.5-2500 MHz bands. These requirements will continue to be met by commercial satellite systems.

MARITIME-MOBILE SATELLITE SERVICE

The Maritime Mobile-Satellite Service is a mobile-satellite service in which mobile earth stations are located on board ships; survival craft stations and emergency position-indicating radiobeacon stations may also participate in this service.[115]

The use of mobile satellites for maritime applications is discussed in the Mobile-Satellite Service sub-section.

FIXED-SATELLITE SERVICE

INTRODUCTION

The fixed-satellite service (FSS) is defined as:

> A radiocommunication service between earth stations at given positions when one or more satellites are used; the given position may be a specified fixed point or any fixed point within specified areas; in some cases this service includes satellite-to-satellite links,

[112] NTIA Manual, *supra* note 39 at 4-96.
[113] ITU Report, ITU-R M. 2073 (2005).
[114] *Id.*
[115] NTIA Manual, *supra* note 39 at 6-9.

> which may also be operated in the inter-satellite service, the fixed-satellite service may also include feeder links for other space radiocommunication services.[116]

Communications satellites operating in the fixed-satellite service utilize a number of frequency allocations. Communications satellites operating in the FSS are predominantly geostationary, orbiting the earth at an altitude of approximately 35,800 km (22,300 miles) above the equator while providing continuous coverage to the geographic area within their coverage beams. Satellites in the FSS also operate in non-geostationary orbits (NGSO). These satellite systems can be more complex than GSO systems, to allow for co-frequency operation with GSO, NGSO and other systems (such as the Fixed Service).

The FSS usually involves communications between earth stations at fixed locations via a satellite, *i.e.*, uplinks and downlinks, although the service, as defined, can also include certain inter-satellite links and feeder links to satellites which operate in other radiocommunication services. The FSS can include communications to multiple, specified fixed locations.

The ubiquitous coverage, flexibility, wide bandwidths and relative security from disruptions due to natural disasters, intentional or unintentional physical or electromagnetic interference, make communications satellites, both dedicated government as well as commercial systems, a critical component of the U.S. government's telecommunications infrastructure.

Satellite systems increasingly are designed to be IP enabled, and interface with network communications on the ground. This IP-centricity will support the increasingly net-centric focus of Federal communications, especially that of the DOD, to ensure that missions are supported where needed, when needed, and with access to voice, data, and multimedia communications.

The greatest use of satellite communications by the Federal agencies is in the FSS. The largest users are the DOD, NASA, DOC, and the FAA. Most of these agencies have extensive on-going satellite communications programs in support of their critical missions and are developing more advanced systems with greater capacity to meet future communications requirements. The DOD uses its own dedicated FSS satellites as well as substantial amounts of capacity on commercial FSS satellites. Other Federal agencies also make extensive use of FSS capacity on commercial FSS satellites. The Federal agencies' use of commercial satellite systems is growing, and is becoming increasingly necessary to enable the agencies to fulfill their critical missions. Furthermore, the easy access to and use of large capacities of commercial satellites is becoming increasingly critical to national security interests.

CURRENT FIXED-SATELLITE SERVICE USE

The currently operational FSS systems are concentrated in the following frequency bands: 4/6 GHz, 7/8 GHz (for military systems), 11/14 GHz, and 20/30 GHz (used by both Federal and non-Federal systems). Non-Federal FSS systems are beginning to be implemented in the 20/30 GHz band, primarily for two-way broadband and direct-to-home television services. In addition, the FCC has allocated the 17.3-17.8 GHz (space-to-Earth) and 24.75-25.25 GHz (Earth-to-space)

---

[116] *See*, ITU Radio Regulations, art. 1, sec. III, at 1.21 (Geneva, 2004).

bands for commercial Broadcasting-Satellite Service (BSS), recognizing that the 17.7-17.8 GHz band may not be available for use in the United States. Although numerous bands above 30 GHz are allocated to the FSS, only one is presently used, and that is for military communications.

Federal Government Satellites Operating in the Fixed-Satellite Service

DOD is the largest Federal user of Federal FSS allocations. Military communications satellites, having both international and domestic applications, satisfy unique objectives. Since the success of the military forces depends upon their mobility, many of their requirements for communications between fixed points involve transportable systems. (Transportable, as distinguished from mobile, is defined as an operation from a fixed location that can be moved after a period of time.) The FSS accommodates many of these requirements because military units cannot quickly or economically connect temporarily-fixed locations with terrestrial wired communications.

Since the entire currently-used communications satellite spectrum is projected for continued or expanded use there is a growing competition for communications satellite spectrum. Future systems will use all of the existing communications satellite frequency bands and the associated orbital locations unless technology greatly increases data throughput on existing systems in currently allocated bands, other bands are made available for satellite service, or other non-satellite services can meet requirements. Consequently, sufficient nationally and internationally allocated frequency spectrum and orbital slots must be retained to continue to support military-unique systems and capabilities. Eliminating or reducing DOD's access to any portion of the satellite spectrum would reduce flexibility and jeopardize mission accomplishment. Satellite communications systems are absolutely essential in providing the assured and survivable communications demanded by the National Command Authorities (NCA) and strategic and non-strategic nuclear deterrence forces.

The Transformational Satellite System (T-SAT) is the Air Force's major initiative relating to space-based transformational communications to support requirements of the GIG. The GIG is DOD's integrated voice, video and data network and will enable the military to migrate its communications to an IP-based, or "network-centric" architecture. T-SAT will be DOD's international backbone communications system to support its net-centric warfighter system of the future and will be DOD's primary future military satellite communications constellation. While offering fully protected and secure communication services, it will also provide high data rates. The ability to provide high data rate protected services is made possible through the use of new technologies such as advanced RF-waveforms and IP switching. The multifunction capability of the T-SAT will require frequencies across all current satellite bands that are allocated to the Federal Government.

Over the longer term, the T-SAT will address DOD's future satellite communications needs for protected services. T-SAT will have the security features currently associated with the MILSTAR and AEHF constellations, but it will operate at much higher data rates. The T-SAT constellation will be capable of establishing circuit-based crosslinks with the AEHF constellation and also be backward compatible with AEHF circuit-based terminals. Accordingly, the T-SAT constellation will operate in the current MILSTAR and AEHF frequency bands, in addition to other frequency bands.

Over the mid-term, the Wideband Gapfiller Satellite (WGS) system will provide the next generation of wideband communications satellites for the DOD. The WGS constellation will supplement the DSCS and Global Broadcast System (GBS) systems while the DOD transitions to higher-capacity and higher-functionality systems. The WGS has the capability to support mobile and tactical battlefield forces and also will operate in the current spectrum bands used by DSCS and GBS.

In summary, the DOD expects major increases in its use of its dedicated federally owned-and-operated communications satellites operating in the FSS frequencies allocated for Federal use. Data and imaging communications, and broadband multimedia interactivity, which require large amounts of bandwidth, will require sophisticated and complex satellite systems with substantial capacity. The current spectrum allocations appear to be adequate to support the requirements for these dedicated Federal systems over the near and long term.

However, the conclusion that Federal spectrum is adequate for DOD-dedicated systems assumes that DOD will have ongoing ability to access commercial satellite spectrum and systems, as discussed in the following section. If commercial capacity is insufficient to meet DOD requirements, additional Federal-only allocations would be required to support DOD's requirements.

Federal Agency Use of Commercial Fixed-Satellite Service Communications Systems

A major trend indicated by the Federal Agencies is the extensive use of and continued increasing requirements for access to major capacity on non-Federal commercial satellite systems, particularly satellites operating in the FSS. DOD makes extensive use of the commercial satellite capacity, in the FSS, both in the United States and overseas and is likely to continue.

The FAA uses commercial satellite services as critical components of its navigation system. Their use includes satellites operating in the 12/14 GHz bands, which provide greater geographic coverage, higher power, and in the 4/6 GHz bands which provide communications service to the FAA for the Alaskan National Airspace Interfacility Communications System.

DOC relies on commercial FSS allocations for satellite connectivity between NOAA facilities and expects these requirements to increase over the next five to ten years.

NASA also makes extensive use of commercial satellite systems for its long-haul data and voice communications in support of its space missions. This use is discussed in the Space Research Service and Space Operations sections.

The USDA Forest Service uses commercial satellite capacity to provide broadband capabilities for transmission of data to assist with battling large fires. According to the USDA, the use of satellite technologies improves the efficiency of fire-fighting by accurately identifying hazardous areas; saving time and minimizing risks to humans by reducing the need for physical reconnaissance, and providing up-to-date information as additional fire management personnel join the fire-fighting and as the scope of the fire broadens across jurisdiction.

The BBG also uses commercial fixed satellite links to transmit digitized audio signals between its sites and also for global distribution of its broadcasting programming to its MF, HF, and FM terrestrial broadcasting stations located overseas.

Impact of Changes in the Commercial Satellite Industry on Present and Future Federal Government Operations

The principal ownership and system operators in the commercial fixed-satellite communications industry and the overall business philosophy have undergone dramatic changes over the past ten years. Former inter-governmental entity providers have been privatized, altering some of the established arrangements for provision of services. Because satellite communications allocations, technical, operational rules, and coverage are inherently international, the United States must continue to work within the international community to obtain access to capacity, to the geostationary orbit, and to ensure technical coordination and international recognition of U.S. satellites, both Federal and non-Federal. In addition, there has been substantial consolidation in the FSS industry, reducing the number of commercial providers.

There is an ongoing need to replenish FSS satellites, necessitating entering into regular satellite design, construction, and launch contracts. Commercial firms are focused on maximizing return on investment and may not make such long-term capital investment without firm customer commitments. When charges for use of FSS services and capacity increases (sometimes because of less capacity available as well as increased demand), firms may have the incentive to sell the satellite providers to other firms or conduct public stock offerings.

The consequences of these structural changes in the satellite industry for the Federal Government are that less commercial capacity may be available for Federal use in the next five to ten years, increasing the cost for the Federal Government or even worse, failing to provide the capacity that the Federal Government needs. Unavailability of sufficient commercial capacity could severely impact the ability of the Federal Government to meet its satellite communications requirements.

The U.S. procurement process for commercial satellite capacity is limited by the annual Congressional appropriations cycle. Every year, each agency must submit its budget proposal for upcoming fiscal years, including those for multi-year programs. This not only subjects dedicated Federal satellite systems to uncertainty regarding funding, but it also creates uncertainty as to funding for commercial satellite capacity. Thus, additional study of the impact of the procurement cycle and identification of alternative ways of assuring capacity for government systems as well as providing certainty for commercial suppliers is warranted.

Foreign acquisition and ownership of some commercial satellite systems operating in the United States has also occurred, although United States' subsidiaries have been created to comply with U.S. regulations. This reflects the FCC "Open Skies" policy and actions of the marketplace. Since critical national security communications supported by readily available commercial satellite capacity is essential, policy problems created by foreign control of the United States' domestic satellite industry may need to be addressed by Federal policy makers to the extent such problems are not adequately addressed by existing intergovernmental coordination procedures.[117]

Lack of Federal Government Allocations and Licensing Rights When Using Commercial Satellites

Federal agencies make extensive use of commercial satellites in the United States that operate in bands allocated exclusively to the non-Federal sector. In some frequency bands, when the Federal agency owns and operates the satellite earth stations, the Federal authorizations usually have no regulatory allocation or assignment status, unless specially arranged on a case-by-case basis, and thus have no "rights" when there are interference or sharing problems. Thus, in such bands, the Federal agencies usually operate on a non-interference basis, a status without any "rights" and in which there are no exclusively authorized spectrum-operating areas and all interference must be accepted unless there are negotiated agreements to provide higher status service. This lack of status means that the Federal agencies cannot claim protection from interference. Furthermore, a new non-Federal user in the immediate environment can claim protection from interference from the incumbent Federal user that may cause the Federal user to modify or cease operations. However, in general, Federal users are treated by commercial satellite operators on a basis equal to their non-Federal customers, for purposes of interference protection.

This regulatory situation can increase cost and can discourage government use of commercial satellite systems because for government operations employing the use of commercial satellite services to be protected, in addition to the satellite system, it may be considered necessary for the satellite ground station to be commercially licensed and operated, or protection of the earth station must be specially justified. This can result in the Federal Government entering into costly third party contracts with commercial providers to license and operate the ground stations. Changing U.S. spectrum regulatory policy to allow Federal Government operation of the ground stations on a protected basis, as is the case for non-Federal commercial satellite service customers operating their own earth stations, may reduce costs and encourage further use of commercial service providers. NTIA has petitioned the Commission to provide this protection.[118]

Other Fixed-Satellite Service Uses

Under the United States and international definitions, the FSS can include feeder links to other satellite systems as well as inter-satellite links. Spectrum requirements for feeder links are discussed in the chapters covering the services they support. None of the current allocations

[117] This policy issue is much broader than spectrum management, and may involve entities including the National Security Council, and the World Trade Organization, among others.
[118] *See supra* note 9.

provides for space-to-space (inter-satellite) links, although they can be accommodated in other services.

FUTURE FIXED-SATELLITE SERVICE SPECTRUM REQUIREMENTS

Spectrum Allocated to the Federal Government

The long-term spectrum requirements for federally owned-and-operated FSS communications satellites depend, among other factors, on the degree that spectrum reuse can be achieved and the extent to which jamming protection is employed. The spectrum reuse is a function of the capabilities of the earth terminals, including directionality and side-lobe design, and the satellite ability to focus more precisely on areas of service, through spot-beams and coding strategies. LEO and Medium-Earth-Orbit (MEO) satellites have a smaller field of view than GSO satellites and such satellite constellations can employ frequency reuse to a greater extent than GSO satellite systems. Satellites operating in highly elliptical (such as Molniya orbits) also offer some particular advantages in providing focused and high-power coverage with just a few satellites. The jamming protection afforded by satellites is primarily achieved through signal processing and requires an increased data overhead that results in wider basebands with corresponding increases in spectrum requirements in direct proportion to the processing gain supported. Factors also affecting spectrum reuse include: orbital location; power and modulation; satellite and terminal locations and antenna directionality; and time or operational limitations. All of these factors must be considered when identifying satellite spectrum requirements.

Due to operational capability requirements, the DOD must employ satellites across multiple, separate military and commercial frequency bands. No single frequency band or single satellite communications system can satisfy the full range of the diverse needs. Each satellite communications band in the International Table of Allocations has its own fundamental and essential utility to DOD due to capabilities not easily duplicated in other bands.

The ability to penetrate foliage or other obstacles is especially important for certain applications. For example, in general, the frequency bands below 3000 MHz penetrate foliage better than the higher bands, such as those operating above 10 GHz. However, the higher frequency bands provide expanded capacities through higher power, increased bandwidths, spot beams and coding. However, these systems are affected by increased rain and other precipitation attenuation effects and increased free-space loss.

As discussed above, to satisfy the increased demand for fixed-satellite communications associated with transformational warfighting and DOD's need for information, DOD is planning to field several new satellite constellations that will require access to satellite spectrum. While these systems are expected to operate in the current bands identified and allocated for satellite use, the increase in the number of constellations utilizing the same frequency bands will put great pressure on the frequency spectrum to satisfy the demand while providing necessary assurance of interference-free operations. There is increased research into the utility of higher bands above 40 GHz for these purposes, but their utility and ultimate use is not assured.

In summary, the Federal use of commercial satellite systems is extremely critical to national security and the issues identified herein should be addressed. The current Federal allocations appear to be adequate to support the federally owned-and-operated satellite systems spectrum requirements over the near and long term. However, this conclusion that the Federal spectrum allocations are adequate is highly dependent on the DOD's ability to access commercial satellite spectrum, as discussed herein. If adequate commercial satellite uses are not available to the DOD, then additional exclusive Federal spectrum would have to be obtained to support additional Federal (DOD) owned-and-operated satellites.

FIXED SERVICE

INTRODUCTION

The fixed service is "a radiocommunication service between specified fixed points."[119] This includes those services in which a stationary transmitter communicates with one or more intended stationary receivers. Transportable stations are in the fixed service and are defined as, "a station which is transferred to various fixed locations but is not intended to be used while in motion."[120]

The fixed service allocations include frequency bands ranging from the bands below 3 MHz to bands above 30 GHz. They can be analyzed according to broad frequency ranges, such as MF, HF, VHF, UHF, *etc.*, in which very different forms of communication can be supported. The lowest range is the MF or medium frequency range of 300 kHz to 3 MHz, which supports communication via ground wave propagation over relatively large geographic areas. The next higher range is the HF region of 3-30 MHz. HF signals are not restricted to LOS and can travel for thousands of kilometers via ionospheric propagation, providing a long-range narrowband service. At the 30-300 MHz (VHF) and 300-3000 MHz (UHF) frequencies, narrowband low-capacity fixed services can be achieved at ranges on the order of 70 km, often sharing frequency bands with mobile services. Point-to-point microwave radio-relay systems (often simply called "microwave systems") usually operate above 1 GHz to provide wideband communications over LOS paths. Tropospheric scatter-propagation systems use the UHF and 4 GHz parts of the spectrum to provide point-to-point service over paths up to 400 km, using highly directional antennas and high-powered transmitters.

CURRENT NTIA STUDIES OF THE FIXED SERVICE

NTIA is leading an effort to channelize certain microwave bands so that the channelization is consistent with standard international and domestic channel plans used in non-Federal systems. The opportunity for standardization arose because the transition of Federal systems in the 1710-1755 MHz band to other microwave bands required the purchase of new equipment for operations in the 4400-4940 MHz and 8500 MHz bands. Equipment for this transition based on the existing non-standard channel plans would cost significantly more than equipment available for use of standard channel plans. Thus, the use of standardized channel plans will result in: 1)

---

[119] *See*, ITU Radio Regulations, art. 1, sec. III, at 1.20 (Geneva, 2004).
[120] NTIA Manual, *supra* note 39 at 6.18.

lower Federal equipment procurement costs; 2) greater organization in use of the spectrum, facilitating identification of interference-free assignments; and 3) increased spectrum efficiency.

Initially, the new process will be developed for fixed service assignments, generally point-to-point microwave radio-relay communications, in the 4400-4940 MHz and 7125-8500 MHz bands. Standardized channel plans will be developed and used in conjunction with an improved interference analysis algorithm to assess the interference environment of the requested assignment. The FAA has released its database of current assignments in these bands to a government contractor. This database, because of its accuracy, will be used as the prototype for development of this computerized process. The result will be an automated process for frequency selection. After verification of the new process, it can be expanded to other bands and services.

ALLOCATION ASSETS

There are seven frequency bands below 535 kHz that are allocated to the fixed service, and five bands in the bands in the 1705-3000 kHz region of the spectrum. There are 45 bands allocated to the fixed service in the 3-30 MHz (HF) region of the spectrum. There are 93 bands allocated to the fixed service in the bands between 30 MHz and 100 GHz. Most of the bands are shared with other services, with the mobile service and land mobile service the most prevalent shared services.

CURRENT FIXED SERVICE SPECTRUM USE AND FUTURE REQUIREMENTS

Introduction

The sub-sections that follow will be grouped into four categories by ascending frequency order: 1) below 30 MHz; 2) 30-1000 MHz; 3) 1-10 GHz; and 4) above 10 GHz. Most of the frequency bands allocated to the fixed service are also allocated and used by other services, frequently the mobile service, enabling the development of networks with both fixed and mobile operations and equipment. The uses of the bands by the other services are discussed in the other sections of this Appendix.

Fixed-Service Use and Future Spectrum Requirements in the Bands below 30 MHz

Use of Spectrum below 190 kHz. There are seven bands below 190 kHz that are allocated to the fixed service. The Navy is the most intensive user of these bands for transmissions to stations on ships and submarines.

Use of Spectrum in the 3-30 MHz (HF) Range. Fixed stations operating below 30 MHz generally provide voice and low-speed data communications, generally using emission bandwidths of approximately 3 kHz. Under certain conditions, 3-30 MHz communications circuits can be established over long distances, including transoceanic routes, as the signals are reflected back to Earth by the ionosphere. Users of 3-30 MHz communication must consider the constantly changing nature of the ionosphere and the related sunspot cycle, high levels of ambient noise, severe crowding and interference, and in some cases, the need for relatively large antennas. Nevertheless, because of the long-range capability using relatively inexpensive equipment and its portability, 3-30 MHz is valuable for many long-range fixed applications. Fixed communications in the 3-30 MHz range are also necessary as a back up to satellite communications.

The DOD and many other Federal agencies use 3-30 MHz fixed systems because they can be set up quickly to support priority communications after hurricanes, earthquakes, or other natural disasters that have disrupted the existing communications infrastructure. DOD uses 3-30 MHz for command and control communications. Furthermore, 3-30 MHz communications are often the only way to communicate with developing nations via radio links.

The development of 3-30 MHz ALE technology has improved operational performance in this domain. An ALE system continually monitors the ionospheric propagation between all stations in the network over a range of frequencies. This monitoring allows the best frequency to be automatically selected for each message, substantially improving performance and reliability over conventional 3-30 MHz systems. Many Federal agencies have joined the SHARES Program, which uses 3-30 MHz voice network assets and ALE technology during emergency conditions. ALE and SHARES are discussed further in the Mobile Service and Land Mobile Service section and in the Public Safety section.

Federal agencies use many fixed 3-30 MHz links to Federal facilities outside the United States, partly as backup for sometimes unreliable commercial communications services. ALE techniques have made 3-30 MHz communications much more reliable and useful. The main Federal users are DOD and the DOS, which maintain many 3-30 MHz links to overseas bases, embassies, and offices. The 3-30 MHz bands are very crowded because they are the only bands that provide very long-range communications coverage with low investments in infrastructure. In past years, 3-30 MHz systems operated by the Federal Government, industry, and private and common carriers provided the majority of long range fixed radio circuits, including most of the transoceanic circuits. The 3-30 MHz band is extremely crowded today, with strong competition for spectrum by various services and systems and a substantial backlog of demand to absorb any frequencies that become available.

In summary, the 3-30 MHz fixed service spectrum requirements will remain very important for emergency use within the United States, and for satellite and wireline backup communications between the United States and foreign countries. The 3-30 MHz bands will continue to be used extensively over the next ten years and beyond.

Use of Spectrum in the 300 kHz to 3 MHz (MF) Range

Travelers Information Stations.   Travelers Information Stations (TIS) are low power stations that broadcast traffic and other information to travelers. A TIS is defined as "a base station in the land mobile service used to transmit non-commercial voice information pertaining to traffic and road conditions, traffic hazard and traveler advisories, directions, availability of lodging, rest stops and service stations, and descriptions of local points of interest."[121] TIS initially operated on 530 and 1610 kHz, just below and above the standard AM broadcasting

[121] NTIA Manual, *supra* note 39 at 6-18.

band of 540-1600 kHz. The broadcasting band was expanded to include frequencies up to 1705 kHz, and the TIS stations were permitted to operate anywhere within the entire 530-1700 kHz band, subject to the conditions of Part 90.242 of the FCC Rules where the band is considered as part of the public safety frequency pool.

NTIA rules on TIS are contained in Annex N of the NTIA Manual, addressing operations only on 1610 kHz.[122]

The FCC considers the TIS a mobile service. However, most Federal agencies operate TIS as a fixed service station. Federal agencies such as the DOI use TIS for traffic information in National Parks, and the USDA uses it in National Forests.

Fixed Service Spectrum Use and Future Requirements in the 30-1000 MHz Spectrum Region

Most of the fixed service allocations in the 30-1000 MHz spectrum region are shared with the land mobile service, although often as a secondary service or only in a limited geographical area. Most of the fixed services share frequencies with the mobile and land mobile services, frequently using directional antennas, but otherwise similar technology to the mobile and land mobile communications systems. Agencies with important sites located over a wide geographic area with many remote locations and no commercial communications available use fixed service communication links to interconnect land mobile radio repeaters in remote locations to communicate with mobile units.

DOE currently uses the 406.1 – 420 MHz band for Supervisory Control and Data Acquisition (SCADA) applications, but will migrate this function to alternate bands. This migration is required because narrowband channels are not able to support the data rates of SCADA applications. The DOE SCADA applications include monitoring and control of gas pipelines and electrical power lines. Other Federal agencies, such as the Army Corps of Engineers, use SCADA systems for control of dams and locks for flood control and river navigation and irrigation projects. In many SCADA applications, the data rate is quite low, although high reliability and quick response may be needed. SCADA applications often follow a solitary power line or pipeline through remote areas, where few alternative telecommunication services are available. DOE, for example, has over four million miles of telecommunications circuits for SCADA applications. DOE has SCADA links in the 406.1-420 MHz band, but states that the narrowbanding will make the band unusable for the SCADA data rates. The BPA is considering moving its SCADA operations from the 406.1-420 MHz band to bands higher in the spectrum.

Federal agencies such as DOI and USDA use point-to-point radio relay communications links in the fixed service to support and interconnect with their mobile radiocommunication repeater sites in federally-controlled remote areas such as National Forests and National Parks. These networks are used for natural resource management, firefighting, law enforcement, tourist information, environmental and wildlife control, search and rescue, and general administrative communications. The DOJ maintains extensive urban and wide-area radio networks to support

---

[122] *See*, NTIA Manual, *supra* note 39 at N-1, *Special Considerations for Federal Travelers Information Stations Operating on 1610 kHz*, Annex N, http://www.ntia.doc.gov/osmhome/redbook/N.pdf.

national law enforcement and security. The TVA also uses a single channel with 22 transmitters in the 162-174 MHz band for a direct load control system for the remote control of systems such as hot water heaters and air conditioners in private dwellings home to conserve electricity. Approximately 45,000 receivers are installed in homes and apartments to receive the energy control signals.

NOAA's NWS makes extensive use of the 162-174 MHz, and 406.1-420 MHz bands for short range fixed service communications in hydrological applications such as river and lake water level measurements and rain-level gauges. The system uses store-and-forward technology with a master station periodically querying the gauge station. Thus, the same frequency can be re-used many times. The only identified change in fixed service spectrum requirements for NOAA over the next ten years is the deployment of the Near Real Time Observing Network (NERON). NERON may add approximately 8,000 to 10,000 hydrologic assignments in the 162-174 MHz band.

The USDA uses the 406.1-420 MHz band for fixed communications that connect fixed stations to distant land mobile repeaters that operate in the 162-174 MHz band.

In the 900 MHz region of the spectrum, the Federal agencies have numerous frequency assignments for fixed service communications in 902-928 MHz, with the heaviest use by the DOD, DHS, DOE, and DOI. In the 932-935 MHz and 941-944 MHz bands, there are assignments for the FAA, DOE, and USDA. The DOD uses the 932-935 MHz band for communications for controlling base utilities and for data links which also use the 941-944 MHz band. TVA has assignments in the 932-955 MHz band used for analog microwave communications that it plans to upgrade to digital systems, either in this band or another band. FAA uses the 932-935 MHz and 941-944 MHz bands for communications links connecting FAA sites to its backbone network, and for data links for weather sensors. DOE uses the 932-935 MHz and 941-944 MHz for SCADA operations. DOI uses the 930-960 MHz band for microwave backbone and water meter interrogation.

DOD is digitizing battlefield communications with high capacity LOS radio. The radio has a feature that provides a spectrum scan to detect spectrum congestion to maximize link availability. Some of the bands used for this application are not available for military use in the United States, but may be used in foreign deployments.

In summary, the fixed service operations in the bands below 1000 MHz are generally not expected to grow rapidly, though some bands may see moderate growth. In many of these bands, the fixed service shares frequencies with the mobile service, although the fixed stations may usually have to meet additional restrictions. The fixed service operations in the bands below 1000 MHz can be supported by existing allocations for at least over the next ten years.

Fixed-Service Spectrum Use and Future Requirements in 1-10 GHz

The Federal agencies use the fixed service allocations above 1000 MHz for fixed service communications that are called microwave radio relay systems, or more simply, microwave links. Federal agency use of microwave, point-to-point communications systems grew following the advancement of the technologies. The military use of fixed and transportable systems expanded, as did applications such as the FAA's use for transmission of remote air-traffic radar video information to a central controller; and the Coast Guard's use for transmission of remote radar video in its harbor vessel traffic management systems. Many of the Federal agency microwave networks are in remote or mountainous areas precluding the use of fiber optics or commercial services.

Many Federal agencies use the fixed service for both point-to-point and point-to-multipoint systems to communicate with a wide range of sensors that keep track of weather, stream flow, geophysical, agricultural, and pollution phenomena. Microwave systems are also used to provide more economical communications between nearby offices, as well as providing high-reliability backup in case of commercial system failures. In some cases the fixed systems are stand-alone systems; in other cases, they provide backhaul for mobile and other types of communications systems.

The Federal use of microwave radio-relay communications at fixed installations in the future might be expected to decrease because of the increased use of fiber optics. Moreover, many future Federal communications services will be implemented with fiber optics or furnished by commercial networks using fiber. However, much of the military use of "fixed service" is for transportable stations that are used to extend wideband communications to any part of the globe rapidly. Military operations and training make extensive use of transportable microwave terminals that are designed to be transported to an overseas combat or support area, set up rapidly, configured into a communications network, and used for critical operational command and control communications for the duration of the mission. These capabilities are also used domestically to support training and to provide support of disaster relief and similar missions.

The transportable stations generally cannot be replaced by fiber optics systems. Furthermore, the reduction in permanent overseas bases will tend to increase the amount of temporary communications needed when military forces are deployed overseas. Today's military operations depend on a highly mobile force with increased use of communications as a "force-multiplier," where communications enable the forces to be more effective in carrying out their missions. This includes increased transmission of high-resolution digital imaging data used for reconnaissance and intelligence purposes from the collection centers to the command centers.

Military test and training ranges use fixed microwave systems to support range safety and security; to relay telemetry data received from airborne, mobile, and stationary platforms to central control sites; for closed circuit TV for safety, security, and performance evaluation; to provide radar tracking and air traffic control information; to observe other test and training results; and to support logistics and administrative support activities on these ranges. The need for extensive communication backbones on some ranges includes the relay to central monitoring sites of real-time updates on the status and exact location of thousands of individual vehicles and soldiers during realistic exercises that cover hundreds of square kilometers of test range.

Fixed Service Use of Spectrum in 1700-1850 MHz

The 1700-1850 MHz band is divided into three bands: 1700-1710 MHz, 1710-1755 MHz, and 1755-1850 MHz.

The 1700-1710 MHz Band. The 1700-1710 MHz band is allocated to the fixed service and the meteorological-satellite (space-to-Earth) service on a shared primary basis. Footnote G118 specifies that "fixed stations may be authorized in the band 1700-1710 MHz only if spectrum is not available in the band 1755-1850 MHz." [123]

There is very little use of the 1700-1710 by the Federal agencies for the fixed service, although there is considerable use by the meteorological-satellite service. Footnote G118 is limiting and the non-Federal advanced wireless services will operate in the 1710-1755 MHz band, including operations on the1710 MHz band edge. Since the fixed service transmitters usually have emission bandwidths of at least 1 MHz, the avoidance of adjacent band interference to the advanced wireless systems also constrains Federal use of the 1700-1710 MHz band.

The 1710-1850 MHz Region of the Spectrum. Before the reallocation of the 1710-1755 MHz band to non-Federal advanced wireless services, the 1710-1850 MHz band was used extensively for low to medium capacity microwave point-to-point radio relay communications systems. Such microwave communications systems require transmitters and receivers with specific frequency separations between the transmitters and receivers. For example, one site may transmit on 1720 MHz and receive on 1840 MHz. Since the 1720 MHz frequency is no longer usable, its pair at 1840 MHz is also no longer usable for this link.

Transition of the 1710-1755 MHz Band to the Private Sector for Advanced Wireless Services. Responding to the spectrum needs of the private sector, NTIA identified the 1710-1755 MHz band for reallocation to non-Federal use for Advanced Wireless Services (AWS), sometimes referred to as 3G cellular communications.[124] Because the band was used extensively by the Federal agencies for fixed and mobile communications, the Commercial Spectrum Enhancement Act (CSEA) was enacted in November 2004 to provide for a relocation trust fund to be set aside from the proceeds of the auction to reimburse the Federal agencies for relocating Federal stations to other frequencies upon transfer of spectrum to the private sector. NTIA worked with the Federal agencies that operate microwave radio-relay and other communications systems in the 1710-1755 MHz band to identify the systems requiring relocation and the alternatives (*e.g.*, other microwave bands or non-spectrum systems using fiber optics or commercial services), and to determine the relocation costs.

NTIA and the agencies identified 2,240 microwave radio-relay systems that need relocation, at a cost of nearly $936 million, which will come from the monies received from the FCC

---

[123] NTIA Manual, *supra* note 39 at 4-160.
[124] *The Potential for Accommodating Third Generation Mobile Systems: Federal Operations, Relocation Costs, and Operational Impacts,* U.S. Dep't. of Commerce, NTIA Report No. 1-46 (March 2001).

auction that began on August 9, 2006.[125] Spectrum currently used exclusively by the Federal Government will become available by this process, and American consumers and businesses will reap the benefits of more robust mobile technology. For business, this means greater productivity; and for the consumer, improved services. Moreover, Federal agencies will be able to upgrade their services and equipment, and utilize new, standardized channel plans which will reduce equipment costs and improve spectrum efficiency.

Use of the 1755-1850 MHz Band. The Army Corps of Engineers makes extensive use of the 1755-1850 MHz band for a nationwide system providing connectivity for monitoring water levels, remote alarms, and communications at waterways. The systems are used where commercial services do not exist, and are essential for remote monitoring of critical locks and dams. The communications systems ensure the safety and integrity of the nation's waterways and help prevent catastrophes. Other, non-fixed service Federal systems operate in this band. These are discussed in other sections of this Appendix.

Use of the 4400-4940 MHz Band. The DOD uses the 4400-4940 MHz band extensively to satisfy many of its requirements for high-capacity, multi-channel, point-to-point communications, including LOS and trans-horizon tropospheric scatter propagation modes. DOD has thousands of frequency assignments in the band for both fixed and transportable systems supporting the military and National Guard units. Many of the transportable units are used for tri-service tactical area communications. The tropospheric scatter systems employ high-power transmitters to provide communications up to about 400 km. Many of the systems are digital and are used for voice, data, and video communications.

The DOJ has numerous assignments in this band, a substantial increase over the use in 1995. The growth is attributed to migration from the 1710-1855 MHz band, the 1710-1755 MHz part of which was reallocated for the AWS.

As indicated previously, the DOE is migrating systems from the 1710-1850 MHz band to the 4400-4900 MHz band for SCADA use. FAA currently uses the 4400-4490 MHz band for high-capacity communications links between ground facilities. However, no future civil aviation uses have been identified for this band.

Use of the 5090-5150 MHz Band. FAA requires additional spectrum for its microwave radio relay communications systems operating in the fixed service, and it is developing a proposal to use the 5090-5150 MHz band for fixed service operations with channel plans similar to the 900 MHz band.[126]

Use of the 7125-8500 MHz Band. The FAA makes extensive use of regional microwave networks operating in the 7125-8500 MHz band to monitor and control the national airways, bringing air traffic information from remote navigation radar sites and navigation sensors, and providing two-way voice and data communications between air traffic controllers and aircraft.

---

[125] *Commercial Spectrum Enhancement Act—Report to Congress on Agency Plans for Spectrum Relocation Funds*, OMB, at 3 (Feb. 16, 2007), http://www.ntia.doc.gov/reports/2007/OMBSpectrumRelocationCongressionalNotification_final.pdf.

[126] 2005 FRP, *supra* note 46, at B-64.

The 7125-8500 MHz band is essential for the modernized air traffic control system with applications such as the Low-Density-Radio-Communications Links (LDRCL) and the Radio-Communications Links (RCL) backbone. The FAA uses the LDRCL for voice and data communications to support the National Airspace System. The FAA uses the RCL network to inter-connect the Air Route Traffic Control Centers in major cities throughout the United States and uses the Television Microwave Link (TML) for one-way transmission of ATC radar display data comprised of video signals. Existing allocations will continue to be required to meet the requirements of these services.

The 7125-8500 MHz band is heavily congested in metropolitan areas and for this reason the FAA is looking to meet future fixed-service needs in the 5090-5150 MHz band. The FAA has experienced difficulties in identifying assignments in the 7125-8500 MHz band near major metropolitan areas. Further, DOE's WAPA has experienced difficulties in identifying clear frequencies throughout the state of California, near military installations in Arizona, and near all metropolitan areas, especially Denver. DOE's BPA has noted difficulties in identifying available frequencies near major metropolitan areas and the Canadian border. The TVA also makes extensive use of the 7125-8500 MHz band for its communications network.

The Coast Guard provides monitoring and control of maritime traffic in major U.S. harbor areas, using microwave communications to interconnect multiple local Vessel Traffic Systems (VTS) radar and radio communications sites. The large emission bandwidths used can present frequency assignment challenges in congested areas.

Since these critical FAA and Coast Guard communications are safety-of-life services, both the FAA and Coast Guard use operational equipment redundancy to maintain very high reliability circuits. Achieving operational redundancy and high reliability sometimes requires frequency diversity where two channels are used, on separate frequencies. Many of the radar and communications sites are in remote locations without commercial service.

Federal agencies have frequency assignments in the 1710-1755 MHz band that will be displaced for the AWS, as discussed earlier. Of these assignments, a large number from the USDA, DOE, DOJ, DOD, DHS, and FAA will relocate to the 7125-8500 MHz band.

The DOE currently has numerous assignments in the 7125-8500 MHz band. DOE's BPA operates 156 sites in the 7125-8500 MHz band in Idaho, Montana, Oregon, and Washington to support the electric utility operations and maintenance. Although BPA considered using other technologies or commercial systems to meet its microwave communications needs, BPA found that the limited availability of commercial fiber and microwave links makes commercial options infeasible. WAPA has replaced some of its 7125-8500 MHz microwave links with government-owned fiber. It considered replacing other systems at other sites, but a lack of availability or unreliability has largely precluded a transition to fiber technology.

DOJ also has numerous assignments in the 7125-8500 MHz band that it uses for voice and video communications to support its field office operations.

Fixed-Service Spectrum Use and Future Requirements Bands Above 10 GHz

There are many frequency bands above 10 GHz that are allocated to the fixed service and to the Federal Government. For example, there are ten distinct fixed service bands between 20 and 30 GHz. However, the use of the frequency bands above 10 GHz for fixed-service is limited at times and at certain locations by increased propagation path losses due to rain, snow, water vapor, and oxygen absorption. These higher frequencies, however, can provide excellent short-range (up to 20 km) broadband communications between urban facilities, and the use of these bands should be expected to increase as Federal agencies implement IP-based communications.

The 14.5-15.35 GHz part of the spectrum is divided into four contiguous bands that are allocated to the fixed service; and the 21.2-23.6 GHz spectrum is divided into seven contiguous bands allocated to the fixed service. The 14.5-15.35 GHz band is used extensively for fixed service microwave communications links for the DOD, DOE, FAA, DOJ, and the VA.

The FAA uses the 14.5-15.35 GHz band for point-to-point microwave links called TML. The FAA uses the 24.25-27.5 GHz band and the 36.0-38.6 GHz band for high-capacity communications links between ground facilities. At DOI, fixed point-to-point networks will be moved into the highest frequency bands feasible to support its mission requirements. DOD in the future may require communications in the 38 GHz band for data networks.

Use of Unlicensed Devices for Fixed Service Applications

TVA uses unlicensed single channel spread spectrum radio for SCADA and metering. TVA also uses unlicensed spread spectrum microwave radio to serve as a “last mile” to substations and other facilities.

Network Facilities Sharing

Some Federal agencies may have excess capacity in their fixed service microwave links. If another agency requires fixed service communications over the same or nearly the same path, arrangements may be possible for the existing agency to provide network access to the second agency. This type of network facility sharing results in spectrum conservation and improved efficiency and cost savings to the Federal Government.

SUMMARY– FIXED SERVICE

The use of the 3-30 MHz bands for fixed communications services provides long-range communications with a minimum of infrastructure and low cost. The Federal use of fixed 3-30 MHz systems will continue to be important for emergency and military communications throughout the foreseeable future. Many Federal civilian agencies use or are planning to use 3-30 MHz for communications restoration after natural disasters.

There are extensive Federal agency uses of microwave radio-relay systems. The DOD and other agencies make extensive use of 1755-1850 MHz band and other bands allocated to the fixed service. These microwave communications systems generally operate where commercial services are not available and installing fiber optic communications is not feasible. Military uses of transportable systems in the fixed service are critically important in establishing military communications in overseas deployments, and equipment that operates in several bands provides the operational flexibility that is necessary for unknown foreign deployments.

While the Federal agencies have ongoing need for the fixed-service bands above 10 GHz, they do not have substantial future spectrum requirements for the fixed service in these bands.

RADIODETERMINATION SERVICE AND RADIODETERMINATION-SATELLITE SERVICES

INTRODUCTION

The radiodetermination service is defined as: "a radiocommunication service for the purpose of radiodetermination." Furthermore, radiodetermination is defined as: "the determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to these parameters, by means of the propagation properties of radio waves." [127]

The radiodetermination service is a broad radio service including the radionavigation service and the radiolocation service and several subclasses of both. The space-based counterpart, the radiodetermination-satellite service, also has several service subclasses. The radiodetermination service consists of two subcategories: 1) the radionavigation service; and 2) the radiolocation service.

The radionavigation service is: "a radiodetermination service for the purpose of radionavigation" and furthermore, radionavigation is defined as: "radiodetermination used for the purposes of navigation, including obstruction warning."

Systems in the radionavigation service include ATC radars, navigation radars onboard ships, and radio beacons that aid in aircraft and maritime navigation. These services are in the sub-categories of radionavigation service for aeronautical and maritime navigation and they are safety services. As such, they generally cannot share the spectrum with other radio services because of the potential that interference could result in loss of life or property.

The radionavigation-satellite service is the satellite counterpart, and it is defined as: "a radiodetermination-satellite service used for the purpose of radionavigation."

The radionavigation service is a safety service, and a safety service is defined as: "any radiocommunication service used primarily or temporarily for the safeguarding of human life and property." Radionavigation systems used in aeronautical landing scenarios warrant an aeronautical safety margin to give added protection from interference.

The radiolocation service is: "a radiodetermination service for the purpose of radiolocation;" and radiolocation is defined as: "radiodetermination used for purposes other than

[127] The definitions in this subsection are from Section III of the ITU Radio Regulations.

those of radionavigation." Stations operating in the radiolocation service include military radars used for detecting hostile aircraft, *etc*., and systems used for determining position coordinates rather than for navigation.

There are forty-seven frequency bands allocated to radiolocation service in the spectrum up to 50 GHz, eight of which are shared with the aeronautical or maritime radionavigation services. Up to 50 GHz, ten bands are allocated to the generic radionavigation service; thirty-four bands are allocated to the aeronautical radionavigation service; and twelve bands are allocated to the maritime radionavigation service.

RADIONAVIGATION SERVICE

INTRODUCTION

Stations operating in the frequency bands allocated to the radionavigation service can be either in the maritime or aeronautical radionavigation services, and the radionavigation signals can be transmitted from either the ground or from satellite-based systems. Some bands are allocated specifically to the maritime radionavigation or aeronautical radionavigation services.

The Federal Government provides radionavigation services for the safe transportation of people and goods, and to encourage the flow of commerce. The DOD also develops and uses the radionavigation services for national defense purposes. The use of the radionavigation service in the United States is jointly planned by DOD, DOT, and DHS. The DOD, DOT, and DHS jointly issue major navigation policy statements every two years, and publish a strategic radionavigation plan titled the Federal Radionavigation Plan (FRP).[128] The FRP is the official source of radionavigation policy and planning for the Federal Government, as directed by the National Defense Authorization Act for Fiscal Year 1998 (10 U.S.C. § 2281(c)).

The FRP presents the major radionavigation goals of the DOD, DOT, and DHS, and reflects the mixture of common-use civilian and military systems meeting the diverse national user requirements, which vary widely, *e.g*., from single-engine aircraft to large commercial airliners and from small pleasure boats to large ocean-going vessels, and military ships and aircraft. There are many user requirements, but the most significant ones are accuracy, reliability, and cost.

The Coast Guard and the FAA provide the majority of the radionavigation services in the United States, and NASA provides navigation for some space applications. The Coast Guard is responsible by statute to provide for safe and efficient maritime navigation; and the FAA is similarly responsible for aeronautical navigation. Some modern navigation services are used by both the maritime and aviation communities, so there are some common, overlapping interests. The FAA is responsible for the development and implementation of aeronautical radionavigation systems for safe and efficient air navigation, as well as control of all civil and military aviation within the national airspace; and for international airspace under the control of the United States.

[128] 2005 FRP, *supra* note 46.

The DOD develops and operates its own navigation systems in various frequency bands, a number of which are used by both the military and civilian communities. Furthermore, DOD ensures that all military ships and aircraft have the necessary civilian and military navigational capabilities.

Many radionavigation services require international approval and standardization to provide for the orderly and safe movement of ships and aircraft around the world. Equipment and operating standards are established in the ITU, in the IMO pursuant to the SOLAS Convention for maritime systems, and in the ICAO for aviation systems. Although the IMO and ICAO address some radio spectrum matters, their main emphasis is in the international standardization and interoperability of equipment and operating procedures. The United States participates in these organizations to plan and provide for the international standardization of navigation for ships and aircraft.

The FAA's national air traffic control system is primarily a ground-based system. However, it is planning a transition to a new satellite-based system using the GPS satellites.[129] The 2005 FRP states:

> As the full civil potential of GPS services and its augmentations are implemented, the demand for services primarily provided by other Federal radionavigation systems is expected to decrease. However, backup capabilities to GPS will require that some existing systems in use today remain available on a limited basis. While some operations may be conducted safely using a single radionavigation system, it is Federal policy to provide redundant radionavigation service where required.[130]

Furthermore, the FAA is developing the Automatic Dependent Surveillance-Broadcast (ADS-B) system that is intended to enhance existing radars capability. The ADS-B system integrates terrestrial systems and GPS information, providing air traffic controllers and pilots with much more accurate information that will help keep aircraft safely separated in the sky and on runways.[131] The ADS-B system also uses information obtained from existing radar systems.

CURRENT RADIONAVIGATION SERVICE USES AND FUTURE SPECTRUM REQUIREMENTS

This section presents a brief description and spectrum use of the major radionavigation systems currently operating, in addition to the long-term spectrum requirements of these operating and future planned systems. Older systems that have been overtaken by modern technologies and systems and thus are scheduled for phase-out are described, resulting in freeing up spectrum that could be reallocated for other uses.

---

[129] N*ational Airspace System: Persistent Problems in FAA's New Navigation System Highlight Need for Periodic Reevaluation*, General Accounting Office, GAO/RCED/AIMD-00-130 (June 12, 2000).
[130] 2005 FRP, *supra* note 46 at 2-1.
[131] *Automatic Dependent Surveillance-Broadcast (ADS-B)*, U.S. Dep't. of Transportation, FAA, Fact Sheet (May 2, 2006).

Although there is a trend towards more GPS use, a joint DOT and DOD assessment report indicates that there is some GPS vulnerability for civilian users.[132] The assessment was ordered by Presidential Decision Directive 63,[133] indicating the high level of concern about the vulnerability issue. The assessment report states that care must be taken to ensure that adequate back-up systems or procedures can be used when needed. Thus, not all of the conventional radionavigation systems can be decommissioned because some of them provide the necessary backup to the GPS systems.

Radionavigation Service Spectrum Use and Future Requirements for the Spectrum Range Below 535 kHz

The LORAN-C system, a long-range radionavigation system possessing an inherent high degree of accuracy at ranges up to 1,900 kilometers, operates on 100 kHz in the 90-110 kHz band that is allocated to the radionavigation service. It is funded by DOT and operated by the Coast Guard to provide maritime and aeronautical radionavigation. In 1992, the Coast Guard operated twenty-seven LORAN-C transmitters with some joint United States and Canadian operations. LORAN-C was originally developed for military use, but was selected for civil maritime use because of its high accuracy and relatively inexpensive receiving equipment. However, the portability, low cost, and accuracy of the GPS receivers has overtaken the LORAN-C in many applications.

The 2005 FRP indicates that "the Government continues to operate the LORAN-C system in the short term while evaluating the long-term need of the system."[134] The 2005 FRP also states that "The Department of Defense has determined that LORAN is no longer needed as a positioning, navigation, or timing aid for military users."[135] Thus, DOD ultimately may not have future spectrum requirements below 3 MHz for this system. However, DOT and DHS are considering an enhanced LORAN system (eLORAN) as a possible enhancement or backup for GPS utilizing its precise timing capability.

In summary, the LORAN-C radionavigation system continues to be operated and is being considered as a backup system to satellite-based radionavigation systems. At least in the near term, there continues to be a requirement for the 90-110 kHz band.

SUMMARY OF THE CURRENT AND FUTURE SPECTRUM REQUIREMENTS FOR THE RADIONAVIGATION SERVICE IN THE SPECTRUM BELOW 535 KHZ

The LORAN-C radionavigation system has been overtaken by the GPS technology as the primary radionavigation systems. Except for the use of aeronautical radiobeacons in Alaska, and the LORAN-C usage as a GPS timing backup, there are no present or future Federal radionavigation spectrum requirements for the spectrum below 190 kHz.

---

[132] *Vulnerability Assessment of the Transportation Infrastructure Relying on the Global Positioning System*, U.S. Dep't. of Transportation, Volpe Center (Sept. 2001).
[133] Presidential Decision Directive 63, *Critical Infrastructure Protection*, The White House, May 22, 1998.
[134] *Id*. at 2-4.
[135] *Id*. at 3-6.

AERONAUTICAL RADIONAVIGATION SERVICE

AERONAUTICAL RADIONAVIGATION NON-DIRECTIONAL RADIOBEACONS (NDBS)

Aeronautical Radionavigation Non-Directional RadioBeacons (NDBs) operate in the 190-535 kHz part of the spectrum and serve the civilian aircraft and DOD user communities with low-cost non-precision navigational aids. They are used for transition from enroute to precision terminal approach facilities and as non-precision approach aids at many airports. The NDBs also have some communications capability and provide weather information to pilots. In Alaska, the NDBs are used for enroute navigation.

The 2005 FRP indicates that the FAA has begun decommissioning stand-alone NDBs as users transition to GPS. However, the 2005 FRP also states that "most NDBs that define low-frequency airways in Alaska or serve international gateways and certain offshore areas like the Gulf of Mexico will be retained."[136]

The 190-435 kHz and 510-535 kHz bands are not identified for continued use by DOT. Except in Alaska, where the NDB system is projected to continue indefinitely, these bands will cease to be needed by civil aviation upon termination of the non-Alaska segments of the system. Termination of the NDB systems was originally scheduled for 2006, but it is not certain when all of the NDBs will be decommissioned. DOD does not expect any present or future need for the 190-535 kHz band.

RADIONAVIGATION SYSTEMS OPERATING IN THE VHF (30-300 MHZ AND UHF (300-3000 MHZ) BANDS

VOR System and Spectrum Use

The FAA operates the VHF Omnidirectional Range (VOR) system which provides azimuth readings to aircraft. The VOR system operates in the 108-118 MHz band. VORs are usually collocated with Distance Measuring Equipment (DME) used by civilian aircraft. The TACAN system is the military counterpart to the combined VOR/DME. The VOR/DME or TACAN provides the bearing and distance from the aircraft to the transmitter. Both the DME and TACAN operate in the 960-1215 MHz band. The VOR/DME and VOR/TACAN (VORTAC) are the main radionavigation aids in the NAS, and the VOR/DME is the internationally designated standard radionavigation aid for air carrier, business aviation, and general aviation instrument flight operations. Its use is an integral part of the air traffic control procedures. At some sites, the DME function is provided by the TACAN system which also provides azimuth guidance to military users. The azimuth service of TACAN serves military users whereas the DME serves both military and civil users.

The 108-117.975 MHz band is used for VOR, and the VOR will serve as a limited backup to satellite-based systems for DOT. The 2005 FRP indicates that as the transition to satellite-based

[136] *Id.* at 3-9 and 3-10.

services continues, the FAA plans to reduce VOR services based on the anticipated decreased use of VOR for en route navigation and instrument approaches.[137]

Although the GPS technology has overtaken some radionavigation technologies, the VOR and the associated DME will be used as a backup system to the GPS. This may continue even after GPS is fully integrated into the radionavigation process and becomes the main radionavigation service. Thus, the VOR operations in the 108-118 MHz band will remain essential to aircraft radionavigation in the United States in the near term. However, the requirements for more aeronautical mobile (R) communications spectrum are growing, and one possible solution is using the 112-118 MHz portion of the 108-118 MHz aeronautical radionavigation band for communications. The need for air-ground voice and data communications is expected to require the use of potential future spare capacity in the adjacent VOR navigation band as the requirements for VORs may decrease. This approach has been considered in the ICAO.

Instrument Landing Systems (ILS) (Multi-Band)

The Instrument Landing System (ILS) provides aircraft with precision vertical and lateral navigation guidance information during approach and landing. The ILS consists of a localizer operating in the 108-112 MHz band; a glide slope system operating in the 328.6-335.4 MHz band; and associated inner, middle, and outer marker beacons operating at 75 MHz. Federal regulations require that all air carrier aircraft be equipped with ILS avionics. ILS is also extensively used by general aviation and military aircraft. ILS is the ICAO standard landing system, and is used extensively worldwide.

The ILS will be phased out as the satellite-based Local Area Augmentation System (LAAS) is implemented. (See the LAAS section under GPS.) The FAA also plans to phase down marker beacons in favor of published distances to a DME site, or by using navigation waypoints.[138]

The Navy uses parts of the 30-88 MHz band for marker beacons and runway lighting controls. DOD also uses portions of the 108-150 MHz band for navigational aids, and the 328.6-335.4 MHz band is required for the glide slope ILS.

In summary, some ILS installations may be decommissioned within the next ten years when they are replaced by GPS-based systems. The ILS frequencies of 75 MHz, 108-112 MHz, and 328.6-335.4 MHz may then be considered for other aeronautical services.

SYSTEMS USING THE 960-1215 MHZ BAND

The 960-1215 MHz band is a critical band for many civilian and military radionavigation systems. The DME System operates in the 960-1215 MHz band and is usually collocated with a VOR (VOR/DME) operating in the 108-118 MHz band (discussed above) to provide the distance and azimuth from the aircraft to the DME transmitter. The DME and its military version, TACAN, operate in the 960-1215 MHz band.

---

[137] *Id*. at 2-4.
[138] *Id*. at 2-5.

The VOR/DME system is the primary radionavigation aid in the U.S. airspace and the internationally-designated standard radionavigation aid for air carrier, business aviation, and general aviation instrument flight operations. Its use is an integral part of the air traffic control procedures worldwide.

The 2005 FRP indicates that the FAA operates approximately sixty VOR, 405 VOR/DME, and 590 VORTAC stations, plus another 30 DMEs that are collocated with NDBs. The FAA owns and operates approximately 900 of these facilities, and other Federal agencies, states, local governments, and private entities own the rest. Furthermore, the DOD operates approximately 15 VOR, 18 VOR/DME, and 24 VORTAC stations, located predominately on military installations in the United States and overseas. These facilities are available to all users. The current VOR/DME services will be maintained at their current level until 2010 to enable aviation users to equip aircraft with GPS or GPS/WAAS avionics and to become familiar with the new system.[139]

The 2005 FRP indicates that the FAA plans to install additional low-power DMEs to support ILS precision approaches as recommended by the Commercial Aviation Safety Team.[140] The 960-1215 MHz band is a subset of the DME system for use as a backup to GPS. DOD's use of TACAN will continue as a backup to GPS even if GPS is certified to meet the Required Navigation Performance (RNP) and all aircraft are fitted. DOD operates the TACAN ground-based beacons throughout the United States in support of DOD flight operations.

SYSTEMS OPERATING ON 1030 MHZ AND 1090 MHZ

Air Traffic Control Radar Beacon System (ATCRBS)

The FAA's ATCRBS operates on 1030 MHz and 1090 MHz at stand-alone sites or in conjunction with long-range air traffic control and airport control radars to provide identification and other flight information about the aircraft to facilitate tracking and management by air traffic controllers. The ATCRBS is a Secondary Surveillance Radar (SSR), and consists of ground-based interrogators and airborne transponders. The Mode-3A and 3C version of ATCRBS interrogates all transponders in its surveillance area and displays target information such as the aircraft identified and altitude on the flight controller's radar screen or computer display.

The FAA's Mode Select, or Mode-S system, is a newer capability that provides more accurate position information and minimizes interference by reducing the number of transmissions required to obtain the necessary data. Mode-S is a discrete-address beacon system that selectively interrogates only those aircraft in the antenna beamwidth. The Mode-S also provides the means for a digital data-link that will be used to exchange information between the aircraft and various air traffic control functions and weather data bases. It is anticipated, however, that the FAA will have to continue to support the less efficient ATCRBS Mode-3A and 3C to provide support to aircraft that are not equipped with the more expensive Mode-S transponders.

[139] *Id*. at 3-7 and 3-8.
[140] *Id*. at 2-4.

The military agencies also operate ATCRBS. In addition, the DOD and Coast Guard use 1030 MHz and 1090 MHz to conduct air-to-air surveillance.

Traffic Alert and Collision Avoidance System (TCAS)

TCAS is required for installation aboard aircraft with a capacity of thirty or more passengers. The TCAS operates on 1030 MHz and 1090 MHz and is used by general, business, and commercial aviation. The DOD also uses the TCAS in conjunction with secondary surveillance radars on 1030-1090 MHz.

TCAS is a family of airborne devices that operate independently of the ground-based ATCRB system. Two different TCAS control levels have evolved. TCAS I is intended for commuter and general aviation aircraft; and it provides proximity warning only, assisting the pilot in visually acquiring intruder aircraft. TCAS II is intended for commercial airliners and business aircraft; and it provides traffic and resolution advisories (recommended escape maneuvers) in a vertical direction. The TCAS II, also called Version 7, is the same as the Airborne Collision Avoidance System (ACAS) which is the international standard.[141]

Automatic Dependent Surveillance-Broadcast (ADS-B) and the Universal Access Transceiver

The FAA operates the ADS-B system which generates onboard position information from onboard navigation systems, and transmits such position information to the ground. The ADS-B technology consists of the aircraft avionics broadcasting the aircraft's type, identification, GPS position, altitude, heading, speed, intent (climbing, descending, level, *etc*.) and other data autonomously without the need for ground interrogation. Among other features, the ADS-B provides in-flight traffic awareness for pilots plus cockpit displays of key uplinked flight information. Furthermore, no action to initiate the broadcasts is required by the pilot. ADS-B is also endorsed by ICAO.

The ADS-B operates on 1090 MHz and 978 MHz.[142] The 1090 MHz component of ADS-B is predominantly used by commercial aircraft that are equipped with Mode-S. The 978 MHz component of ADS-B is to support aircraft equipped with a Universal Access Transceiver (UAT). UAT is primarily used by general aviation. The two systems are integrated so that UAT and 1090 MHz equipped aircraft receive uplinked information on all aircraft within their geographic area.

The FAA conducted a major review of three future ATC surveillance options: 1) secondary radar (Mode-S or ATCRBS); 2) multilateration; and 3) ADS-B. The FAA study concluded that the secondary radar option was the least effective, and the ADS-B was the preferred system because it offers the best performance.

The UAT operates on a center frequency of 978 MHz with a 1 MHz bandwidth. The UAT supports multiple broadcast services including Flight Information Services (FIS-B) and Traffic

---

[141] The RTCA SC-186 ADS-B Website, U.S. Dep't. of Transportation, FAA, http://adsb.tc.faa.gov/ADS-B.htm

[142] *What is ADS-B?* ICAO Publication ADS-B/SITF/WP/9, Brisbane, Australia (March 24-26, 2003).

Information Services (TIS-B) in addition to ADS-B. The ICAO has approved the UAT and has developed detailed technical specifications.[143]

Multilateration Systems and Precision Runway Monitoring

Multilateration is another technology that uses the 1030 MHz and 1090 MHz frequency pair. Surface multilateration is a component of the Airport Surface Detection Equipment (ASDE) system that is used to support the runway incursion reduction program. By placing several multilateration units around an airport, the system can triangulate and obtain the precise location of aircraft on the airport surface. This information is fused with the information from the Surface Movement Radar (SMR) part of the ASDE (described later), and is used by air traffic controllers to prevent accidents between aircraft maneuvering on or getting ready to land on the airport surface. Multilateration is also used to prevent runway incursions between aircraft and vehicles operating on the airport surface.

Multilateration is expected to be used to reduce the separation between aircraft on parallel approaches. The increased update rate of aircraft locations provided by the multilateration systems permit this technology to also be used for this type of Precision Runway Monitoring (PRM).

Wide Area Multilateration (WAM) is an expanded version of the basic multilateration system that is being used on the airport surface. The operational concept of WAM is the same as that used for surface multilateration, but involves the use of multilateration units spread over a wide area. This technology is currently being tested for use around airports, and also as a supplement to the ADS-B coverage.

SUMMARY OF THE SPECTRUM REQUIREMENTS OF THE 960-1215 MHZ BAND

In summary, spectrum requirements for the ATCRBS, Mode-S, and Identification Friend or Foe (IFF) on 1030 MHz and 1090 MHz are expected to continue for more than ten years. Critical radionavigation and identification data is communicated on the 1030 MHz and 1090 MHz frequencies, and the access to the frequencies is essential, and the operations need to be protected from interference. New technology is also being tested and is expected to be integrated into the NAS that will make the interference free operation of 1030 MHz and 1090 MHz even more critical. The UAT use of 978 MHz is an additional critical spectrum requirement.

Overall, the 960-1215 MHz band is used extensively by the military and civilian communities for critical safety-of-life radionavigation services. The spectrum requirements will continue into the future.

---

143 *Manual on the Universal Access Transceiver (UAT): Detailed Technical Specifications, Edition 1, Revision 4.1*, ICAO Document ACP-WGW01/AI-1, Appendix C (June 22, 2005).

MARITIME RADIONAVIGATION SERVICE

MARITIME RADIONAVIGATION RADIOBEACONS

Maritime radiobeacons in the past provided a backup to more sophisticated radionavigation systems, and in 1992, they were the primary low-cost, medium accuracy system for ships equipped with only minimal radionavigation equipment.[144] The beacons are used for direction finding.

The maritime radiobeacons were also being used to transmit Differential GPS (DGPS) signals to vessels to provide a more accurate maritime use of the GPS for precision navigation. In 2005, some radiobeacons were being used in the interior of the United States only for transmitting the DGPS signals. As other means of providing differential enhancement to GPS have been implemented, the use of these radiobeacons has declined. (The use of maritime radiobeacons for the DGPS is discussed further in the GPS section in this appendix.)

The Coast Guard operates the maritime radiobeacons for transmitting the DGPS signal to provide more accurate navigation and positioning. The DGPS signal is transmitted on beacons in the 285-325 kHz band.

MARITIME RADIONAVIGATION RADARS

The IMO SOLAS Convention requires that ships with large displacements be equipped with a radionavigation radar system that enables them to navigate in coastal areas and near docks. The 2900-3100, 5460-5650, and 9300-9500 MHz bands are allocated for this purpose. The 9300-9500 MHz band radars provide a very high target resolution while the 2900-3100 MHz band radars provide long-range navigation capabilities. The 2900-3100 MHz and 9300-9500 MHz radars use interference-rejection circuitry to mitigate harmful interference even though several radars may be operating on or near the same frequency in the same geographical area.

In summary, the 2900-3100 MHz and 9300-9500 MHz radars are expected to continue operating for at least the next ten years, and thus, the long-range spectrum requirements are expected to continue.

MARITIME RADAR TRANSPONDER BEACONS

Radar Transponder Beacons (RACONs) are short-range navigation devices that provide target images on a vessel's maritime navigation radar operating in the 9300-9500 MHz band. RACONs are used to identify specific locations such as hazards. Although most RACONs are operated by the Coast Guard, private users are permitted to operate RACONs. The Coast Guard currently operates seventy-five RACONS in the 2900-3100 MHz band, and 117 RACONS in the 9300-9500 MHz band. RACONs provide important navigation information that is difficult to provide by other means, and spectrum requirements for RACONs in the 2900-3100 MHz and 9300-9500 MHz bands can be expected for at least the next ten years.

---

[144] 1992 FRP, *supra* note 46 at 2.2.

Coast Guard Maritime Vessel Traffic Systems

The Coast Guard operates VTS around harbors and coastal areas with a large amount of ship traffic. There are eight VTS locations including New York, Puget Sound, Houston, and San Francisco. The radars serve port management and vessel control functions by providing "video pictures" of ship activity at various locations, which are then transmitted to a central port control facility. The VTS coastal surveillance radars operate in the 2900-3100 MHz band or the 9225-9500 MHz band, although many operate in the 9300-9500 MHz band. The use and corresponding spectrum requirements are expected to continue for at least the next ten years.

RADIODETERMINATION-SATELLITE SERVICES

The Radiodetermination-Satellite Service (RDSS) is defined as: "a radiodetermination service for the purpose of radiodetermination involving the use of one or more space stations."[145]

Following the proposals of the United States and other nations, the ITU allocated frequency bands to the RDSS at the 1987 Mobile World Administrative Radio Conference (WARC) and at WARC-92. The United States proposals advocating RDSS allocations resulted from industry requirements.

The RDSS can provide both radionavigation and radiolocation services, and its long-term spectrum requirements are considered separately from that of the radionavigation-satellite service. There has been considerable private sector interest in developing and operating a radiodetermination-satellite or a radiodetermination-satellite type of service that could provide position locating services. A typical application would be for long-haul trucking so that the headquarters or central control facility could easily determine the precise location of its trucks.

Although not a true RDSS system or service, one approach uses a separate radionavigation service to determine position which is then communicated to a central location. For example, a remote unit calculates its position from a GPS navigation system, and then transmits its location via a communications satellite system operating in either the fixed-satellite or mobile-satellite services to the headquarters station. A true RDSS system would be a self-contained navigation and satellite system using the frequency bands allocated to the RDSS.

True RDSS systems use the timing provided by radio signals transmitted by multiple satellites and a participating vehicle (or remote ground station) to a central control point. In a supplementary service, using appropriate frequencies, the positions can be communicated to the vehicle or remote station for navigation and/or locating.

The relatively low cost of and widespread use of GPS receivers has reduced the impetus for dedicated RDSS satellites. Thus, no additional RDSS spectrum requirements are anticipated for at least the next ten years.

---

[145] *See*, ITU Radio Regulations, art. 1, sec. III, at 1.41 (Geneva, 2004).

RADIONAVIGATION-SATELLITE SERVICE

CURRENT SPECTRUM USE AND FUTURE REQUIREMENTS OF THE RADIONAVIGATION-SATELLITE SERVICE

Global Positioning System (GPS) and GPS-Related Systems. GPS is a DOD-developed, worldwide, satellite-based radionavigation system that will be the DOD's primary radionavigation system well into the future. Although originally developed as a military system, the system has evolved to where there is now extensive worldwide use by the civilian community. A National Security Presidential Directive designated the Secretaries of DOD and DOT as co-chairs of an Executive Committee to oversee all aspects of GPS, which now makes GPS a joint military-civilian system.[146] Furthermore, the NSPD identifies DOT as the focal point for representing and assuring civil GPS requirements.[147]

There are over 60 million GPS users worldwide, with civilian uses in automobiles growing the fastest. New applications also include GPS receivers in cellular phones. New signals are added specifically for civilian community use, and complementary augmentation methods improve its accuracy for critical navigation functions. As an international system, it is a principal element of a Global Navigation Satellite System (GNSS), and at this time, the only full constellation component of the ICAO GNSS. GPS is registered in the ITU as operating in the Radionavigation-Satellite Service (RNSS).

The GPS consists of a minimum twenty-four-satellite constellation operating on its L2 signal at 1227.60 MHz in the 1215-1240 MHz band; and on its L1 signal at 1575.42 MHz in the 1559-1610 MHz band. Encrypted signals are used by the United States and allied military forces. Unencrypted or civil signals are used by the public in many different applications. A new civil-use L5 signal at 1176.45 MHz in the 1164.45-1188.45 MHz band is planned. The L5 signal will enhance the ability of the GPS to support aviation and other civil users. Expansions include the addition of an L2C signal at 1227.60 MHz with a new civil code. A secure and spectrally separate military code will be added in the L1 and L2 bands.[148]

The other operating component of the GNSS is the Russian Federation Global Navigation Satellite System (GLONASS). Planned future systems include the European Union's Galileo system, the Japanese Quasi Zenith system, and the People's Republic of China's COMPASS regional system. These are discussed below.

The GPS as officially integrated into the United States NAS on February 17, 1994. This paved the way for satellites to eventually become the primary if not the sole means navigation system in U.S. airspace.[149] Although DOD and other users of navigation systems increasingly rely on GPS, systems such as LORAN-C, TACAN, Omega, and to a limited extent, VOR/DME

---

146 The National Security Presidential Directive is not available publicly. *See*, U.S. Global Positioning System Policy Fact Sheet, White House Office of Science and Technology Policy and National Security Council (March 29, 1996), http://clinton4.nara.gov/textonly/WH/EOP/OSTP/html/gps-factsheet.html.

147 *Detailed Justification for Nationwide Differential Global Positioning System (NDGPS) Program*, Dept. of Transportation, Research and Innovative Technology Administration, at 1 (2006).

148 2005 FRP, *supra* note 46 at 3-3.

149 "Satnav Sanctioned," Aviation Week and Space Technology, at 31 (Feb. 21, 1994).

will continue to operate as back-ups to GPS. For example, DOD will continue to use the TACAN system aboard Navy and Coast Guard ships.[150]

The FAA's WAAS uses geostationary satellites to provide a satellite-based augmentation system to GPS. The augmented L1 and L5 signals can provide precision approach navigation worldwide, precision navigation operations in certain areas of the world, and interference mitigation. Users within the communications-satellite footprint will have precision-approach capability. For example, once the L5 signal is implemented an aircraft can be outside the WAAS footprint and still be inside the "unaugmented" GPS footprint and able to execute a Category One (CAT 1) precision approach. (The WAAS is discussed in greater detail later in this section.)

DOC typically uses the GPS and the Russian Federation GLONASS system for navigation and position determination. In addition to the typical uses, NOAA uses the GNSS for observation systems. In a meteorological application, NOAA's Radiosonde Replacement System (RRS) will rely on GPS receivers integral to the radiosondes for improved wind measurement accuracy over its legacy system that relies on radio direction-finding for tracking radiosonde movement. NOAA is also researching the use of GNSS for measuring atmospheric parameters such as refractivity, correction factors for remote sensing and radar, and integrated precipitable water vapor. These applications using GNSS support all four NOAA mission goals.

Consistent with the Presidential Directive, NTIA, in coordination with the Federal agencies, is developing a GPS spectrum protection plan that, when completed, will help to protect current and future GPS operations.

The GPS implementation program is directed by a Joint-Program-Office (JPO), composed of the Air Force, DOT, Army, Coast Guard, and several other nations. The spectrum sharing and electromagnetic compatibility aspects of the GPS are led by the Air Force.

GPS Augmentation Systems and their Spectrum Requirements. DGPS improves the accuracy of the basic GPS. The DGPS process uses differences between the accurately-surveyed ground location of the DGPS station and the derived location from the GPS signal received at that location. A differential correction factor is then calculated and transmitted to users over a separate radio link. DGPS is necessary for some civil applications such as very accurate position location requirements; for example, off-shore oil drilling. In these position location activities, the GPS is actually providing a radiolocation type of service rather than radionavigation.

There are two types of differential signals: wide area, and local area. The wide area DGPS can achieve improved accuracies over large areas. Local differential signal areas could be used, for example, by a ship navigating towards the exact location to drill for oil. Several methods are being considered for delivering the differential signal. A geostationary satellite could be used for the wide area differential correction signal; and an FM broadcasting station sub-carrier could be used for the local area differential correction signal in those cases where integrity, continuity, and availability are not important factors.

---

[150] DOD Comments at 9, Docket No. 920532-2132, *Current and Future Requirements for the Use of Radio Frequencies in the United States*, Notice of Inquiry and Request for Comments, 57 Fed. Reg. 25010 (1992).

National Differential GPS (NDGPS). DOT, in coordination and cooperation with the DOC, has implemented an expanded LF/MF (30-300 kHz and 300-3000 kHz) beacon system modeled after the Coast Guard system. The Coast Guard's Maritime DGPS (MDGPS) system was slated for expansion into a National (NDGPS) system through an initial Congressional appropriation.[151] Several Federal agencies, states, and scientific organizations commenced work on installation of NDGPS through the United States; however, as of the end of 2007, the project was placed on hold pending Congressional review of future project funding.[152]

Radiobeacons operated in the frequency bands below 530 kHz by the Coast Guard provide the differential signal necessary for the required accuracy for Harbor Entrance and Approach (HEA) functions. Coast Guard has a spectrum requirement for the DGPS in the 285-325 kHz band.

Wide Area Augmentation System (WAAS). NTIA/ITS published a study in 1994 recommending that the FAA implement its WAAS.[153] The WAAS uses a network of precisely located ground reference stations that collect and process the GPS signals and send the processed signals to WAAS master stations. The WAAS master stations develop a WAAS correction signal that is then transmitted to a geostationary satellite and made available to all users who receive it on the satellite's downlink.

The FAA's WAAS is a major step towards modernizing critical navigation systems to a satellite-based system. The WAAS is designed to provide horizontal and vertical navigation for en route navigation, airport departures, and airport landing approaches. The key part of the WAAS is the augmentation of the GPS civil signals from their normal 20-meter accuracy to 1.5-2 meters in both horizontal and vertical directions. Although the WAAS was developed for aviation, it is being used in non-aviation applications such as agriculture, surveying, recreation, and automotive and maritime surface transportation.[154] The WAAS satellite-based augmentation system commenced in 2004 using Inmarsat satellites. To ensure adequate coverage in the mid-United States, and to ensure that follow-on systems would be available, the FAA contracted with Lockheed-Martin to provide WAAS through dedicated payloads onboard the Canadian Anik F1R commercial satellite operated by Telesat and the U.S. Galaxy XV commercial satellite operated by Intelsat. Galaxy XV is located at 133 degrees west longitude and operates at GPS signal L5 on 1166.20-1186.70 MHz, and at GPS signal L1 at 1565.17-1585.67 MHz. Lockheed-Martin operates the RNSS payloads on-board Galaxy XV and Anik F1R to "provide valuable

---

[151] *Department of Transportation and Related Agencies Appropriations Act of 1998*, P.L. 105-66, Art. 346, 49 U.S.C. § 301 (October 27, 1997).
[152] *See*, Coast Guard Website, http://www.navcen.uscg.gov/ndgps/default.htm.
[154] *A National Approach to Augmented GPS Services*, U.S. Dep't. of Commerce, NTIA Special Publication No. 94-30, at xv (1994).
[154] *Wide Area Augmentation System*, Fact Sheet, Satellite Navigation Product Teams, Dep't. of Transportation, FAA, http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/library/factsheets/#q2.

augmentation services to the existing U.S. global positioning system."[155] These augmentation systems are known as the Regional Positioning System (RPS).

Numerous manufacturers have developed WAAS-enabled GPS receivers for the aviation as well as the consumer market. The FAA indicates that there are millions of non-aviation WAAS-enabled GPS receivers in use.[156]

Local Area Augmentation System (LAAS). The FAA's LAAS is expected to provide pilots with safe vertical instrument guidance to heights ranging from less than 200 feet down to the runway surface. While LAAS is independent of WAAS, it will complement WAAS and provide precision approaches at airports where WAAS does not provide sufficient geographic coverage.[157] The LAAS is expected to augment the GPS and with an end-state configuration that will pinpoint an aircraft's position to one meter or less. The LAAS is also expected to be used by controllers for surface-area navigation to determine the accurate position of all approaching and taxiing aircraft and airport surface vehicles.

The overall LAAS system consists of three segments: 1) the LAAS Ground Facility or LGF, which provides differential corrections, integrity parameters, and precision approach path point data transmitted to aircraft over a VHF frequency; 2) the space segment, which provides the LGF with the GPS signals; and 3) the airborne subsystem, which applies the GPS corrections to the GPS signals.[158]

The FAA may use the new L5 navigation signal at 1176.45 MHz for both the WAAS and LAAS. The LAAS will broadcast GPS corrections and integrity data pertinent to both L1 and L5, and in the event of interference on either L1 or L5, the system will be able to automatically select the unaffected frequency.[159]

The LAAS is in the research and development stage. The LAAS will transmit its GPS-corrected signal to aircraft on frequencies in the 108-117.975 VHF frequency band.[160]

OTHER RADIONAVIGATION-SATELLITE SYSTEMS

Other nations and multi-national organizations operate or plan to operate radionavigation-satellite systems. These are the Russian Federation's currently operational and soon-to-be-modernized GLONASS; the European Union's planned Galileo; Japan's planned Quasi Zenith

---

[155] *In the Matter of Lockheed Martin Corp. Application to Launch and Operate a Geostationary Orbit Space Station in the Radionavigation Satellite Service at 133 degrees W.L.*, DA 05-1747, Order and Authorization, 20 F.C.C.R. 11023 (2005). *See also*, *In the Matter of Lockheed Martin Corp. Application to Launch and Operate a Geostationary Orbit Space Station in the Radionavigation Satellite Service at 107.3 degrees W.L.*, DA 05-2424, Order and Authorization, 20 F.C.C.R. 14558 (2005).

[156] *Wide Area Augmentation System*, *supra* note 155.

[157] *National Airspace System: Persistent Problems in FAA's New Navigation System Highlight Need for Periodic Reevaluation*, General Accounting Office, GAO/RCED/AIMD-00-130 (June 12, 2000).

[158] *Local Area Augmentation System*, Specification FAA-E-2937-A, Category I, Ground Facility, at 1 (April 17, 2002).

[159] *GPS Modernization*, Satellite Navigation Product Teams, U.S. Dep't. of Transportation, FAA, at 3 (May 10, 2006).

[160] 2005 FRP, *supra* note 46, at 4.2.1.1.

system; and China's planned COMPASS system. Receivers can be designed to use more than one satellite system, increasing performance accuracy and redundancy. The 2005 FRP points out that "a critical aspect of system interoperability is ensuring compatibility among radionavigation services."[161] The FRP also states that "the United States government has concerns about radionavigation signal structures that could adversely impact the military and civil use of GPS."[162]

TRENDS IN THE RADIONAVIGATION SERVICE AND THE RADIONAVIGATION-SATELLITE SERVICE

There are several major technology-driven trends in radionavigation. The first is towards increased use of satellite-based systems, especially the GPS, for many navigation applications. The GPS is expected to be used for even more applications in the future as the more accurate DGPS becomes available throughout the United States. The GPS is emerging as the main radionavigation service throughout the world, and its augmented forms provide the accuracy necessary for precision approach landings and other navigation and positioning movements requiring accuracy. The increased use of GPS should promote long-term reductions in the use of traditional radionavigation systems. Systems such as ILS, VOR, and MLS are expected ultimately to be replaced by GPS-based systems.

The FRP indicates a trend towards a GPS-based navigation system and away from the use of radars. However, the radars are used jointly by the FAA and the Air Force, and the military necessity for radar use in air defense is likely to continue beyond ten years.

DOC expects increasing applications of GPS in the meteorological data collection activities.

There are many radionavigation systems currently providing service to over a hundred million users. There are tens of thousands of radionavigation systems deployed on ships, aircraft, and other mobile platforms. The civilian users of the GPS, especially in personal automobiles, are extensive. Most of these systems will continue to have spectrum requirements for ten years and beyond.

Improved radionavigation systems are being developed using new technologies emphasizing satellite-based technologies. Although some of these new systems are expected to supplant many of the older systems, the transition may take at least ten years. The GPS is critical to U.S. national security interests, and its spectrum must be free of any potential problems. There are foreign interests in operating and developing radionavigation satellites, but the allocations for such services are limited and sharing is required. Cooperative sharing agreements have been signed, and more may be necessary as other systems move forward.

The spectrum used by radionavigation satellites is being analyzed in various U.S. domestic forums and in the ITU. Furthermore, some of the satellites operate in parts of the spectrum that are used by long-range air traffic surveillance and control radars, and sharing analyses must continue to assure that all systems are compatible.

---

[161] *Id.* at 1-10.
[162] *Id.*

FUTURE SPECTRUM REQUIREMENTS FOR THE RADIONAVIGATION-SATELLITE SERVICE

The long-term spectrum requirements for the radionavigation service are driven by requirements to support specific radionavigation systems. Trends towards more accurate and reliable satellite-based technologies are making some older systems obsolete, reducing the current and future spectrum needs in several frequency bands.

The large GPS-user growth projections together with the general trend away from other navigation and positioning systems to the GPS indicate that spectrum requirements for the following GPS frequencies and operating bands will continue well into the future: 1) the L5 signal at 1176.45 MHz in the 1164.45-1188.45 MHz band; 2) the L2 signal at 1227.60 MHz in the 1215-1240 MHz band; and 3) the L1 signal at 1575.42 MHz in the 1559-1610 MHz band. There is adequate spectrum available for the FAA's WAAS GPS-augmentation system. RNSS systems are operated or planned by other nations, and it is critical that the agreements and cooperation continue to allow systems to operate compatibly.

There is a continuing requirement for the 285-325 kHz band to provide the differential signals necessary for increased GPS accuracy in critical maritime navigation applications, and national coverage NDGPS system. Except for the 90-110 kHz LORAN-C band and Alaska, the spectrum below 190 kHz is no longer needed to support future radionavigation activities. The spectrum below 190 kHz could be studied further with the objective of reallocating it to other services, and the spectrum below 190 kHz, except for 90-110 kHz.

The current use and requirements of the 5000-5250 MHz band, or major parts of it, for navigation are light, making it an excellent candidate for planned future uses for aviation or other uses. Analyses may develop policies and sharing procedures that would allow other services to use the band.

RADIOLOCATION SERVICE

INTRODUCTION

This section addresses the radiolocation service. The radiolocation service is defined as "Radiodetermination used for purposes other than those of radionavigation."[163] Radiodetermination is "the determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to these parameters, by means of the propagation properties of radio waves."[164] Radiolocation systems, commonly called radar systems, can be either fixed or mobile.

A wide variety of pulsed and continuous wave (CW) radar systems perform a variety of location functions, many of which are critical to national security. The functions of such systems include: determining precise location; search or surveillance; target tracking; weapons control; ground mapping; and target identification; and combinations of these functions. The radars can be fixed or transportable, operating on ships, aircraft, missiles or land vehicles, or on space platforms.

The DOD is by far the largest Federal user of radar systems in the radiolocation service. Other agencies that use radars in the radiolocation service are the Coast Guard, DHS's Immigration and Customs Enforcement (ICE), FAA, and NASA. Unlike some other radio services that can fulfill their mission by using alternative means such as commercial or non-spectrum techniques, the radiolocation service, especially radar, has few, if any alternatives to the use of the radio spectrum.

New military radar systems require a lengthy period between the identification of the operational requirement, development of the conceptual design and prototypes, production of the hardware, and deployment. For a 1995 NTIA spectrum requirements study, radar experts were interviewed. These experts determined that new radars have a fifteen to twenty year concept to deployment life cycle.[165] However, rather than develop entirely new radars, the Federal agencies users generally maintain and upgrade their legacy systems. In many cases, the original radar "shell" and frequency assignments are retained but modern new technologies are introduced into the main radar circuitry and signal processing sections.

The most recent major advancement of the state of the art of radar development is the perfection of the solid-state Gallium Arsenide (GaAs) Monolithic Microwave Integrated Circuits (MMICs). The MMIC technology has advanced phased-array antenna technology by enabling the development of transmit-receive modules that contain an antenna element, a low noise receiver, a power amplifier, and digitally controlled elements. This has led to the development of Active Electronically-Steered Arrays (AESAs). The AESAs provide for rapid radar beam steering, and have already been deployed as weapons control radars on many aircraft.

---

[163] NTIA Manual, *supra* note 39 at § 6-13.
[164] *Id*.
[165] NTIA 1995 Report, *supra* note 30 at 141. The experts interviewed were Dr. Merrill Skolnik, then Superintendent of the Radar Division, Naval Research Lab; Robert Hill, Consultant and former Navy Senior Radar Scientist; Dr. David Barton, Senior Radar Scientist, ANRO Co.; and Dr. Eli Brookner, Senior Radar Scientist, Raytheon Corp.

RADIOLOCATION SERVICE AND RADAR APPLICATIONS

Within the radiolocation service, radar applications can be generally grouped into the following categories:

1. **Air Surveillance Radars.** These radars search for airborne targets and can be located on land or on an aircraft or ships. These can be 2-Dimensional (2-D), providing distance and azimuth, or 3-Dimensional (3-D) systems, providing distance, azimuth and elevation angle. The airborne application is usually called Airborne Early Warning (AEW).

2. **Anti-air fire control and Multi-Function Radars.** The Army and Navy use the Patriot and Aegis anti-air search and fire control radars, which have weapons guidance and control functions. A “compromise” frequency band is usually selected that is too high for the best search function, and too low for the best guidance function.

3. **Airborne Multi-Purpose Radars.** These radars are used by military fighter and attack aircraft and usually operate in bands above 9 GHz because the driving parameter is the small available space for the antenna; and excellent antenna directive performance can be achieved with small antennas operating above 9 GHz. The radars are called multi-purpose because they are used for search, fire control, navigation, and mapping functions, and are sometimes used in conjunction with radar-guided missiles. New technologies such as AESA are now used.

4. **Anti-Ballistic Missile (ABM) Radars.** The military operates Ballistic Missile Early Warning Systems (BMEWS) to detect and provide early warnings of missiles. The BMEWS grew out of the older Distance Early Warning (DEW) line system that was an aircraft surveillance system. New Anti-Ballistic Missile (ABM) radars are being (and have been) developed as part of the Strategic Defense Initiative, now called the Ballistic Missile Defense Program.

5. **Surface, Battlefield and Homeland Surveillance Radars.** Surface surveillance radars are used by the Coast Guard to detect ships near the U.S. coastlines. Battlefield applications include hostile battery locations and minefield detection. Homeland security applications include location of drug traffickers and detection of illegal border crossing.

6. **Instrumentation Radars.** Instrumentation radars are used to track targets at test ranges and rocket launch facilities, such as Cape Canaveral.

In general, for pulsed radars, the shorter the duration of the pulse, the greater the target resolution. Shorter pulses cause larger emission bandwidths, but NTIA has found that interference due to the wide bandwidths tends to be mitigated in other radar receivers by the low duty cycles (typically 0.1 percent) associated with the short pulses.[166]

DOD increasingly uses Synthetic Aperture Radars (SARs) and Moving Target Indicator (MTI) radars for applications on Unmanned Aircraft Systems (UASs) and other airborne platforms. These radars provide greater resolution and imaging capability, but also require greater emission bandwidth to achieve the detail associated with SAR and MTI images. To enhance radar performance, the DOD's Naval Research Laboratory has conducted research on a radar operating with simultaneous transmissions from 850 to 1400 MHz. The research results of the radar, called the Senrad, showed that the very wide bandwidth provided improvements in 1) target detection and tracking performance; 2) MTI; 3) height-finding accuracy; 4) target recognition; and 5) reduced vulnerability to countermeasures.[167]

RADIOLOCATION SERVICE USE AND FUTURE SPECTRUM REQUIREMENTS IN THE 3-30 MHZ (HF) BAND

Although there are no current allocations, the HF spectrum in 3-30 MHz also is used for radiolocation, and NTIA has authorized such use. Ionospheric skywave propagation permits signals to propagate for long distances, frequently thousands of miles. HF radars use ionospheric propagation or surface waves for detecting targets over long distances and require very large antennas for good performance. Since the HF bands are highly congested with many users and numerous radio services, the possibility of signals propagating over long distances increases the possibility of interference to other users such as the aeronautical mobile service used by airliners for transoceanic communications. DOD, however, uses HF Over-The-Horizon (OTH) radars for long-range target detection, up to 8000 km. In order to avoid interference, the radars employ interference-minimizing methods, selecting transmitting frequencies by monitoring for other signals and avoiding frequencies that are in use.

Coast Guard has emerging spectrum requirements for both HF Relocatable over-The-horizon Skywave Radars (ROTHR) and for HF Surface Wave Radars (HFSWR). Large-aperture ROTHR systems are used for wide-area maritime and coastal surveillance in maritime and law-enforcement applications. The HFSWR systems can use small compact-aperture antennas, and are used for remote sensing of ocean surface roughness and currents. Research is being conducted into the use of HFSWR systems to detect and track vessel targets.

DOC is conducting research into the meteorological applications of HF surface wave radars, especially to collect oceanographic data for meteorological applications. These radars may also support Coast Guard requirements.

DOD expects to increase HF radar use over time, as does the Coast Guard. Since there are no HF allocations for the radiolocation service and new allocations in the HF bands are unlikely,

---

[166] *Effects of RF Interference on Radar Receivers*, U.S. Dep't of Commerce, NTIA, Institute for Telecommunications Science, NTIA Report TR-06-444 (Sept. 2006).

[167] M. Skolnik, G. Linde, and K. Meads, *Senrad: An Advanced Wideband Air-Surveillance Radar*, IEEE Transactions on Aerospace and Electronic Systems, vol. 37, no. 4, at 1163 (Oct. 2001).

future HF radars must be carefully designed with a dynamic channel occupancy analyzer to minimize harmful interference to other systems.

RADIOLOCATION SERVICE USE AND FUTURE SPECTRUM REQUIREMENTS IN THE 30-300 MHZ (VHF) BAND

The use of the VHF band for radiolocation systems is limited because the radiolocation allocations are very narrow. Moreover, high performance is difficult to achieve because very large antennas are required for good target resolution. The only allocations to the radiolocation service in the VHF band cover a few discrete frequencies in the 154-161 MHz part of the spectrum; and provide secondary status in the 216-225 MHz band. Over the next five to ten years, new radiolocation service allocations are unlikely even though new radar spectrum requirements may develop because of the DOD advanced research activities. Therefore, these systems would have to be able to operate on a non-interference basis.

The Navy operates the Space Surveillance (SPASUR) system in the band. United States footnote US239 provides for protection of the SPASUR operating in the frequency band 216.88-217.08 MHz.[168] The SPASUR was originally installed in 1965 in several southern states and is used to collect data on satellites and other space objects as they pass over the United States. DOD has a requirement for continued DOD use of the 216-225 MHz band for its radiolocation service operations.

RADIOLOCATION SERVICE USE AND FUTURE SPECTRUM REQUIREMENTS IN THE 420-450 MHZ BAND

The 420-450 MHz band is excellent for long-range search and surveillance operations, and to lesser extent, the associated target tracking. The large antennas required for good resolution of targets generally limit operations to large land-based installations, although shipborne and airborne installations have been made.

The 420-450 MHz band is used for national airspace surveillance and early warning radars, shipborne and airborne early warning radars, as well as systems employed during tactical operations and exercises for three-dimensional positioning, navigation, and friendly force identification. The DHS/ICE operates search and surveillance radars in the 420-450 MHz band.

Wind-Profiler Radars

The wind profiler radar system provides real-time wind speed and direction values as a function of altitude for use in weather forecasting and identification of severe wind conditions. Wind profilers will provide real-time wind speed and direction information, while also providing long-term costs savings through automated use, not requiring expendable equipment such as radiosondes. Wind profilers will not fully replace radiosonde systems, but may augment radiosonde operations by providing additional data, allowing operation of a reduce number of radiosonde stations.

[168] NTIA Manual, *supra* note 39 at 4-137.

The selection of an appropriate frequency band(s) for long-term operation, both nationally and internationally, remains an issue. The propagation characteristics of the atmosphere require that the wind profiler systems operate within the 50-1000 MHz range. Currently, there are three frequency ranges of particular interest: 1) around 50 MHz; 2) the 200-500 MHz range; and 3) around 1000 MHz. Each of the aforementioned bands best accommodates a particular profiler application. Most wind profiler operations have been conducted at research facilities for experimental purposes. Nationally, the majority of effort has focused around the 200-500 MHz range to accommodate the DOC national network. NTIA has investigated various candidate frequency bands to accommodate Wind Profilers and selected the frequency 449 MHz.[169]

NOAA's Profiler Demonstration Network (NPDN), in operation since 1992, consists of thirty-five unmanned Doppler radar sites located in eighteen central states and Alaska, and was designed to operate on an experimental basis on 404.37 MHz. The NPDN provides hourly vertical wind profile data, and the data is distributed to the NWS, environmental research groups, and universities. The NWS is planning for deployment of an operational network at 449 MHz, replacing the NPDN.

DOC/NOAA's Profiler Network (NPN), in operation since 1992, consists of thirty-five unmanned Doppler radar sites located in 18 central states and Alaska. The NPN provides hourly vertical wind profile data, and the data is distributed to the NWS, environmental research groups, and universities. The NPN currently operates on 404.37 MHz, but NOAA is transitioning the operating frequency to 449.0 MHz.

The FAA requires wind profiling radars, operating in the 448-450 MHz band, for measuring winds aloft at altitudes up to 65,000 feet, and for measuring the jet stream.

DOD and DHS are expected to continue their extensive use of the 420-450 MHz band for critical national security applications such as long-range search radars, missile and aircraft surveillance radars, and associated radar target tracking applications. The DOD will increase use of the 420-450 MHz band in the future. Furthermore, the DOC and FAA will continue to expand their use of wind profilers for meteorological and aeronautical applications. Thus, continued access to the 420-450 MHz band is critical to national defense, safety, and security.

RADIOLOCATION SERVICE USE AND FUTURE SPECTRUM REQUIREMENTS IN THE 902-928 MHZ BAND

The 902-928 MHz band allocation is shared by the Federal and non-Federal radiolocation service, the fixed service, the amateur service, Part 15 unlicensed devices, and the Industrial, Scientific and Medical equipment (*e.g.*, microwave ovens and heaters).

DOD has two radars operating in the band and expects to continue its use of the 902-928 MHz band through the year 2020. These provide long-range, two-dimensional automatic detection and reporting of targets within their surveillance coverage.

---

[169] *Assessment of Bands for Wind Profiler Accommodation,* U.S. Dep't. of Commerce, NTIA Report 91-280 (Sept. 1991).

DOC operates a limited number of wind profiler radars in the 902-928 MHz band to conduct atmospheric research.

RADIOLOCATION SERVICE USE AND FUTURE SPECTRUM REQUIREMENTS IN THE 932-935 MHZ AND 941-944 MHZ BANDS

DOD shares the 932-935 MHz band with non-Federal users, and the Navy uses these bands for air defense radars. Footnote US268 provides for use of the 928-942 MHz band by the radiolocation service, with operations limited to Federal ship stations operating in offshore ocean areas.[170] The Navy radar is used for long-range air surveillance. Continued DOD use of the 932-935 MHz and 941-944 MHz bands for the radiolocation service at the present level is expected through the year 2020.

RADIOLOCATION SERVICE USE AND FUTURE SPECTRUM REQUIREMENTS IN THE 1215-1390 MHZ BAND

Physical propagation conditions and availability of antennas with good performance provide for extensive radar use of the 1215-1390 MHz band for long-range search, surveillance, and tracking. The main users of this band are the Air Force and the FAA. Often, the frequency authorizations are to the FAA when they are joint Air Force and FAA operations. This system primarily operated and maintained by the FAA, and it provides data to the FAA, Air Force, and other Federal control centers. The system operates in both the aeronautical radionavigation service and the radiolocation service.

Prior to 2001, this military application was for outward-looking border surveillance. However, since the 9/11 terrorist attacks, the military coverage has been expanded to provide additional information to the North American Aerospace Defense Command (NORAD) on internal air traffic. An extensive program is currently underway to extend the service life of those radar systems providing coverage of the interior of the United States. The data is shared by the FAA, DOD, DHS/ICE, and others, while the 1215-1390 MHz band is used for long- and short-range air defense radars for North American border surveillance and for an intercontinental ballistic missile detection surveillance radar.

NOAA has a future spectrum requirement for meteorological radars in the 1215-1400 MHz band for air turbulence and meteorological research.

Radars using the 1215-1390 MHz band are critical to national security and defense and to the national commercial air transportation system. The band was formerly the 1215-1400 MHz band, but the 1390-1400 MHz portion was relinquished to the private sector. This compressed the existing operations into the reduced 1215-1390 MHz band, and a further erosion of this critical band could jeopardize national security and air transportation safety.

[170] NTIA Manual, *supra* note 39; Table of Frequency Allocations, footnote US268. *See also*, footnote US116 which provides other limitations.

The 1215-1390 MHz spectrum space is adequate to satisfy future systems requirements for at least ten years. However, studies have shown that the RNSS systems may cause some compatibility problems with the radars in the band. Within the United States, the matter is being investigated by experts from the DOD, FAA, NTIA, and radar manufacturers known as the "L-Band Working Group," and internationally by ITU-R Working Parties 8B and 8D. Some of the studies have shown that the radars may have to avoid specific parts of the 1215-1390 MHz band.

Air Route Surveillance Radars (ARSRs)

The FAA and the Air Force jointly operate the ARSRS for air defense and air traffic control. Thus, the ARSRS operates in both the radiolocation service and the aeronautical radionavigation service. The ARSRS was upgraded via the ARSR-4 radar located at the periphery of the United States, which provides long-range surveillance for air traffic control centers to monitor en route aircraft. The ARSRS is also used by air traffic controllers to guide aircraft to smaller airports that do not have their own radar systems. In addition, the FAA maintains an extensive network of radars supporting the FAA's air traffic surveillance requirements.

The long-term air traffic surveillance requirements and the availability of large frequency bandwidth make the 1215-1390 MHz band very attractive for air traffic control radars. The ARSR-4 and all of the older ARSR radars operate in the 1215-1400 MHz band, with radionavigation services confined to the 1240-1370 MHz band, and with the older radars limited to 1350 MHz. The ARSR-4 radars are expected to operate for more than twenty years, and the older upgraded radars could operate for at least ten years. Thus, long-term spectrum requirements for long-range air traffic control radars within the 1215-1370 MHz band can be expected for at least ten years. (See the Radiolocation Section for additional information on the use of the 1215-1390 MHz band.)

The 1215-1390 MHz band will remain essential for operating long-range surveillance radars. The joint FAA and Air Force radars are critical to the nation's air traffic control and national defense. Although the spectrum is adequate to satisfy future systems requirements, there is an ongoing need for sharing analyses with radionavigation satellites to preclude any sharing problems that may require the radars to avoid specific parts of the 1215-1390 MHz band. The sharing issue is under study in several international and domestic U.S. forums.[171] The military requirements for radar in these bands are likely to continue beyond 10 years.

RADIOLOCATION SERVICE USE AND FUTURE SPECTRUM REQUIREMENTS IN THE 2-4 GHZ SPECTRUM RANGE

The 2-4 GHz range of the spectrum has a number of bands allocated to the radiolocation service. The radiolocation service is allocated on a primary or secondary basis in the lower part, 2300-2450 MHz, and to five bands in the upper part, 2700-3700 MHz. Portions of these

---

[145] *See e.g.*, ITU, Resolution 6-8 (WRC-03), *Use of the Frequency Band 1215-1300 MHz By Systems of the Radionavigation-Satellite Service (Space-to-Earth)* (Geneva, 2003); and *Resolution 609 (WRC-03), "Protection of Aeronautical Radionavigation Service Systems from the Equivalent Power Flux-Density Produced by Radionavigation-Satellite Networks and Systems in the 1164-1215 Frequency Band* (Geneva, 2003).

radiolocation bands, 2390-2400 MHz and 2402-2417 MHz, are now allocated for non-Federal use.

Adequate spectrum is available in the bands within 2900-3700 MHz, and radars with reasonably sized antennas in this band can obtain good performance and angular resolution. The external noise level is low, enabling long-range air search and surveillance radars to operate in the band. The good angular resolution and narrow antenna beams make the band attractive for military radars for the ability to reduce hostile jamming. The band can be used for multi-function radars for medium-range aircraft detection and tracking. The overall good radar performance and the reasonable-sized antennas make the band very attractive for transportable military radars used for air search and surveillance.

The FAA is highly dependant on the 2700-2900 MHz frequency band to support the 277 airport surveillance radar systems (described in detail below) operating throughout the United States. The DOC/FAA/DOD tri-service program operates 171 Next Generation Weather Radar (NEXRAD) systems that are critical to providing state-of-the-art weather forecasting and for air traffic control. A study conducted prior to World Radiocommunication Conference (WRC)-2000 concluded that operation of meteorological radars in higher frequency ranges (5600-5650 MHz or 9300-9500 MHz) would not provide radar performance necessary for severe weather detection in conditions typical for the United States.

There are pressures internationally from both International Mobile Telecommunications (IMT) and 802.16 Worldwide Interoperability for Microwave Access (WiMAX) systems in the 3.4-3.65 GHz band which is allocated to radiolocation in the United States. Furthermore, DOD is experiencing pressure from industry with regard to radar systems and bands, in general. Due to the long development times and the special characteristics of radars, systems cannot move from band to band. Overall, DOD requires the existing radiolocation allocations for ten years and beyond.

The DOE field offices plan to strengthen security by using more radars operating in the 1.3 GHz, 3 GHz, and 5 GHz bands. Furthermore, DOE is addressing security concerns and considering several protective measures using different types of radars.

The DOD uses the 2900-3100 MHz band extensively for transportable land-based three-dimensional air search and surveillance radar systems.

Additionally, DOD uses the 2900-3100 MHz band for transportable radars used to provide accurate information on artillery or rockets. The radars are expected to be in use for at least the next ten years. The Navy uses the 3100-3600 MHz band for a shipborne radar system.

The DOD also plans to develop and deploy the Navy’s new volume search radar, operating in the 2-4 GHz band, on the next generation destroyers. The Coast Guard plans to use the 2900-3200 MHz band for Tethered Aerostat Radar Systems (TARS).

In summary, the DOD, FAA, DOC, DOE, NASA, and other Federal agencies use the bands within 2-4 GHz that are allocated to radiolocation for many critical uses, and many billions of dollars have been invested in these systems. These are critical national security applications, and the associated spectrum requirements to support classified and unclassified systems will continue for the next ten years and beyond.

Airport Surveillance Radars (ASRs)

The FAA operates 277 airport surveillance radars (ASRs, also called terminal radars) at over 250 airports for management and control of the aircraft as they approach the airport for landing. Each radar operates on two frequencies to increase performance, and for redundancy and diversity. All of the ASR radars operate in the 2700-2900 MHz band. They are the mainstay of air traffic management around major airports, and spectrum requirements are expected to continue for more than 10 years. This spectrum is currently shared with meteorological radars such as the NEXRAD and a variety of DOD radars. The FAA has modernized the system by procuring 122 new ASR-11 radar systems to replace the older ASR-7s and ASR-8s.

DOT uses the 2700-3000 MHz band for ASRs and long-range weather radars. However, ASRs operate in the 2700-2900 MHz portion; and the NEXRAD weather radars operate in the 2700-3000 MHz portion. DOD uses the 2700-2900 MHz band extensively for military airfield surveillance radars, and Ground Control Approach (GCA) radars.

DOT also utilizes the 3500-3650 MHz band for ASRs. Although the 3500-3650 MHz band is not required for modernized ATC systems, the inability to use this band for radar services could limit future expansion of the airport surveillance radar system.

RADIOLOCATION SERVICE USAGE AND FUTURE SPECTRUM REQUIREMENTS IN THE 4-8 GHZ SPECTRUM RANGE

Airborne Radar Altimeters

Many aircraft use radar altimeters during flight to determine height above the Earth. Most of the radar altimeters operate in the 4200-4400 MHz band reserved exclusively for this function by international agreement. Because of the capability to achieve increased precision and accuracy at altitudes of 1,000 ft. or less, they are used as a height controlling function in aircraft automatic approach and landing systems. In many aircraft, radio altimeters are also directly coupled to Ground Proximity Warning Systems (GPWS) designed to give warning when an aircraft falls dangerously below its desired descent path. Frequency modulated CW altimeters are used in practically all civil aircraft, including many general aviation aircraft. For higher altitude measurement, pulsed type radio altimeters are in extensive use.

In response to a formal Question adopted at the ITU 1987 Mobile WARC, the ICAO studied the issue and concluded that the whole 4200 to 4400 MHz band currently allocated for radio altimeters is required up to at least the year 2015.[172] The ITU's Radiocommunication Sector also

---

[172] *U.S. National Spectrum Requirements: Projections and Trends*, U.S. Dep't. of Commerce, NTIA Special Publication No. 94-31 at fn. 391 (March 1995) (1995 NTIA Report), *citing* ICAO COM/MET/OPS/90, Report of the Communications Meteorology, and Operations Divisional Meeting, Appendix A to Agenda Item 1 (1990).

conducted a study of the altimeter use of the 4200-4400 MHz band and made a similar conclusion.[173]

THE 5000-5250 MHZ BAND, MICROWAVE LANDING SYSTEMS (MLS), AND ASDE-X

Microwave Landing System (MLS)

The Microwave Landing System (MLS) was a joint development of DOT, DOD, and NASA under FAA management, and it provides a civil/military, Federal and non-Federal standardized airport approach and landing system with improved performance using the 5000-5250 MHz band. The MLS has a number of advantages over the ILS because the MLS signals are minimally affected by surrounding terrain, structures, and weather; and MLS signals can be used to support curved approaches. In 1978, the ICAO selected the MLS as the international standard precision approach system, with implementation at all international airports targeted for 1998. The MLS was expected to gradually replace the ILS in national and international civil aviation.

The Air Force Mobile Microwave Landing System (MMLS) operates in the 5000-5250 MHz band. MMLS is a tactical transportable all-weather guidance system that provides highly reliable localizer glide slope functions for aircraft approaching airfields. MMLS augments existing Air Force ATC and landing systems allowing its aircraft to operate at airfields with limited or no navigational aids in adverse weather.

While there are some FAA-operated MLS systems that require protection, there are no plans for the implementation of additional MLS systems. The FAA does not anticipate additional civil MLS development but rather a phase-down of MLS beginning in 2010.[174] The FAA is considering new aeronautical applications for portions of the 5000-5150 MHz band, including airport communications via a wireless Local-Area Network (LAN) in the 5091-5150 MHz band, called the Airport Network and Location Equipment (ANLE). The ANLE would operate in the aeronautical mobile service, and it would support the multilateration component of the ASDE system. The ASDE is a traffic management system for the airport surface that provides seamless coverage and aircraft identification to air traffic controllers. The FAA plans to install the ASDE-X at thirty-five airports in the United States. (The ASDE is covered in greater detail in the Radiolocation Section.) The ANLE system would protect existing MLS operations by not utilizing the primary MLS band. As discussed above, FAA use of this band for fixed service operations, using channel plans similar to those in the 900 MHz band, by the FAA also is under consideration.

DOT also has a requirement for the 5150-5250 MHz as an expansion band for terminal weather radars currently in the 5600-5650 MHz band.

In the 5000-5250 MHz band, the civilian MLS will be phased out beginning in 2010. The majority of military MLS systems are overseas, and these systems operate only in the portion of the band below 5100 MHz. The 5091-5150 MHz band is being proposed for an additional

---

[173] *Supra* note 172 at fn. 392, *citing* Int'l Radio Consultative Committee, International Telecommunication Union Report 1186, *Use of the Frequency Band 4,200 to 4,400 MHz by Radio Altimeters* (1990).
[174] 2005 FRP, *supra* note 46 at 3.1.8.

allocation of the aeronautical mobile service for operation of airport communications via a wireless Local-Area Network (LAN), ANLE, as discussed above. While the 5091-5150 MHz portion of the band currently is used for feeder links to non-GSO MSS systems, operating pursuant to a non-Federal fixed-satellite service allocation, studies are ongoing as to how other services may be able to use the band.

Other Uses in the 4-8 GHz Range

The 5250-5925 MHz frequency range is allocated to the radiolocation service on a primary or secondary basis in six bands. These bands have some physical limitations that reduce their usefulness for long-range air search and surveillance. However, they are used extensively for test range instrumentation radars to track rockets, missiles and other targets.

The 5850-5925 MHz band is allocated to the FSS (Earth-to-space), and the radiolocation service on a shared primary basis. Footnote US245 limits the satellite activities in the United States to international intercontinental systems and such activities are subject to case-by-case electromagnetic compatibility analysis.[175]

The 5250-5350 MHz band is used extensively by an air defense system. This surface-to-air missile defense multi-function radar system can detect and track hundreds of targets, and respond to threats by quickly establishing defensive measures. The band is also under consideration by the Navy for its next generation major shipborne radar. It also is allocated for use by unlicensed wireless networks operating in the mobile service. These unlicensed devices must employ Dynamic Frequency Selection (DFS) to detect radar operations and vacate any channel where they detect a radar emission above a specific threshold level. The unlicensed devices are permitted to operate in the 5250-5350 and 5470-5725 MHz bands.

The 5350-5650 MHz band is used by the DOD for radars that are part of an advanced ground-based air defense missile system.

The 5400-5900 MHz band has been a mainstay for test range instrumentation radars since the early days of the space age. The radars have provided service for many years on the Eastern Test Range, the Western Test Range, White Sands Missile Range, New Mexico, Wallops Island, Virginia, on tracking ships and other test ranges.

The Navy uses a shipborne radar system and its variations for surface search and navigation. Operations and spectrum requirements in the 5450-5850 MHz band will likely continue for the next ten years.

In summary, the 5250-5925 MHz band is used extensively for DOD systems, and these spectrum requirements are likely to continue for at least ten years.

175 NTIA Manual, *supra* note 39 at 4-137.

RADIOLOCATION SERVICE USE AND FUTURE SPECTRUM REQUIREMENTS IN THE 8.5-10.55 GHZ SPECTRUM RANGE

Good radar performance is achieved in the 8.5-10.55 GHz band with small antennas permitting many mobile applications on aircraft, missiles, ships, tanks, and other vehicles, including extensive use of small hand-held radar systems. The band is well suited for short-range search applications. The frequency band allocations are wide, permitting the use of narrow pulses with wide emission bandwidth to achieve good target resolution.

The 8.5-10.55 GHz spectrum range contains eight separate bands. Over 2 GHz of spectrum is available for radar use. Some of the bands are used extensively for radionavigation by both the Federal Government and the private sector. For example, the 9300-9500 MHz band is used by both aircraft weather navigation radars, and by shipborne navigation radars. Since almost all commercial aircraft and larger ships employ such radars, 5,000-10,000 are estimated to be in use. There are also some experimental ground based meteorological radars operating in the band that are transportable for rapid deployment during severe weather.

The MMICS solid-state technology has been used to develop new radars and to modernize and upgrade older radars operating in the 8-10.55 GHz band, especially for installations as weapons control radars onboard fighter aircraft where antenna space is very limited. The MMICS technology is used in the development of AESAs that do not require any mechanical components. Since the AESAs are all electronic as opposed to older mechanical or planar array antenna systems, the AESAs permit extremely rapid radar beam steering, an important capability in search, surveillance and weapons control applications. These fighter aircraft and their radars will be used for at least the next ten years.

DOD uses the band for transportable ground-based radars for weapon locating. The units have been modernized with new technology, and operations are likely to continue for the next ten years. Additionally, DOD uses the band for radar fire control systems on frigates and small ships. Operations will likely continue for at least the next ten years.

DOD uses the 9.5-10.45 GHz band extensively for airborne fire control radar systems. The fire control radars are used for air-to-air combat and air-to-surface attack, frequently operating in conjunction with an advanced missile system. These operations and spectrum requirements will continue well into the 21st century.

DOD uses the 8.5-10.55 GHz band for the radar component of a major defensive missile system. DOD also has constructed a Sea-Based X-band (SBX) radar that operates within the 8.55-10.55 GHz band and has an emerging requirement for a multi-function fire control and surveillance radar operating within 8.55-10.55 GHz.

Military land-based radars also use the 8.5-10.55 GHz bands for search and surveillance. Many new radar systems are also being developed that use the band. Given a typical life cycle of fifteen to twenty years between concept and deployment, spectrum requirements for these radar systems should continue for at least the next ten years. The Coast Guard may use these bands for SARs. In addition, DOC has spectrum requirements for meteorological radars and experimental radars in the 9300-9500 MHz band to conduct atmospheric research.

There is a requirement to provide contiguous spectrum in the bands around 9 GHz for the radiolocation service allocated on a primary basis worldwide, in order to provide adequate spectrum for new radar systems. Emerging operational requirements for increased image resolution and increased range accuracy necessitate wider contiguous bandwidths than are available in existing allocations.

AIRFIELD RADARS

Airport Surface Detection Equipment (ASDE, ASDE-X)

ASDE provides radar surveillance, by tracking ground targets moving on an airport surface. They are used primarily at high activity airports to prevent runway incursions. Such monitoring is critical to support the orderly movement of aircraft and ground vehicles on the airport surface, especially during periods of low visibility such as rain, fog, and night operations. The ASDE systems alert airport controllers of potential conflicts and impending collisions.

The older ASDE models operating in the 15.7-16.2 GHz band are radiolocation devices, authorized in the Table of Frequency Allocations via footnote G59:

> G59 In the bands 902-928 MHz, 3100-3300 MHz, 3500-3600 MHz, 5250-5350 MHz, 9200-9300 MHz, 13.4-14.0 GHz, 15.7-17.7 GHz, and 24.05-24.25, all Federal non-military radiolocation shall be secondary to military radiolocation, except in the sub-band 15.7-16.2 MHz airport surface detection (ASDE is permitted on a co-equal basis subject to coordination with the military departments.[176]

The NTIA Manual provides additional regulatory guidance for radar operations, albeit for ASDE without specifically mentioning ASDE, in Section 8.2.46:

> Section 8.2.4. Radiolocation Operations in the Band 15.7-17.3 GHz. Ground based and airborne radars, except those authorized before January 1983, shall have the capability to operate and perform their missions, when necessary, on a day-to-day basis in the sub-bands 15.7 to 16.2 and 16.2 to 17.3 GHz, respectively.[177] (Section 8.2.46 is Justification for Frequency Assignments.)

THE 9000-9200 MHZ BAND – AIRFIELD PRECISION APPROACH RADARS AND ASDE-X

The 9000-9200 MHz band is used extensively by the military for Precision Approach Radars (PARs). Newer technologies may eventually be developed that would supplant the PARs. However, the PARs can be expected to be used for at least the next ten years, and thus, long-range spectrum requirements will continue.

---

[176] NTIA Manual, supra note 39 at 4-161.

[177] NTIA Manual, *supra* note 39 at 8-4.

The new version of the ASDE, the ASDE-X, also operates in the 9000-9200 MHz band. The FAA has installed new SMR systems that are a component of the (ASDE-X) at 35 airports, operating in the 9.0-9.2 GHz band. The ASDE-X provides a lower cost surface surveillance system at smaller to medium size airports to complement the ASDE-3 system that operates in a different frequency band and is installed at larger airports. The ASDE-X offers significant improvement in radar performance in rain. Due to the success of the ASDE-X program, additional airports will receive an ASDE-X system in the future. The 9000-9200 MHz band is required for the ASDE-X. In the 9000-9200 MHz band, the ASDE has co-primary allocation status with other radiolocation service systems, but will not have any specific regulatory recognition.

In summary, the 8.5-10.55 GHz bands are prime bands for military weapons control radars installed on the ground and onboard ships and aircraft, and spectrum requirements for such systems and activities should continue well beyond ten years.

RADIOLOCATION SERVICE USE AND FUTURE SPECTRUM REQUIREMENTS IN THE 10.55-30 GHZ SPECTRUM RANGE

The major application of radars in the 10.55-30 GHz radiolocation bands is on airborne mobile platforms, where physical limitations require small antennas. Good performance can be obtained over short ranges, but substantial precipitation attenuation can limit the useful range.

There are six distinct frequency bands between the 10.55-30 GHz band that are allocated to the radiolocation service: 1) 13.4-14.0 GHz; 2) 15.7-16.6 GHz; 3) 16.6-17.1 GHz; 4) 17.1-17.2 GHz; 5) 17.2-17.3 GHz; and 6) 24.050-24.250 GHz. Some of these bands have a relatively large number of frequency assignments, with the 15.7-16.6 GHz band being the most used of the five bands.

Federal agencies make extensive use of the 13.4-14.0 GHz band for shipborne radars.

A segment of the 15.7-17.1 GHz band, 15.7-16.2 GHz, has been approved for use by the FAA for its ASDE on a coequal basis with military radars subject to prior coordination with the military. This use was authorized by the addition of government Footnote G59 to the allocation table. (The FAA also is installing new ASDE-X models operating in the 9.0-9.2 GHz band.) However, for an unspecified time period, the spectrum requirements for the older ASDE models operating in the 15.7-16.2 GHz band will continue.

The 24.05-24.25 GHz band is used extensively for automobile traffic speed measuring (speed guns) operating in the radiolocation service. Under Part 90.19, the FCC uses "blanket" authorizations to license speed gun operations regardless of whether the radar operates in the 10.5-10.55 or 24.05-24.25 GHz bands. Federal policy for authorization of speed guns is similar. Therefore, there are thousands of authorized Federal and non-Federal radar speed gun operations in the 24.05-24.25 GHz band. These activities are expected to continue for at least the next ten years, and thus, the corresponding radiolocation spectrum requirements will continue. The DOD uses the 24.05-24.25 MHz band for a number of other types of radars.

In conclusion, the military radar systems and their spectrum requirements in the 10.55 to 30 GHz range are likely to continue for at least the next ten years. The FAA's ASDE-3 will require the use of the 24.45-24.65 GHz band until it is phased out.

RADIOLOCATION SERVICE USE AND FUTURE SPECTRUM REQUIREMENTS IN THE SPECTRUM RANGE ABOVE 30 GHZ

The 30-300 GHz or EHF part of the spectrum is designated the Millimeter Wave (mmw) region. Advances in solid state and signal processing technologies in recent years have made the millimeter wave part of the spectrum more attractive for a number of applications. Small diameter antennas are possible offering some advantages such as narrow beamwidths. The narrow antenna beamwidth leads to other operational advantages such as increased immunity to interference and improved resolution.

The mmw radars have a number of military applications: surveillance and target identification and acquisition, tracking and fire control, seekers and terminal guidance on missiles, instrumentation and measurements and ground mapping. One of the major disadvantages to operations at millimeter wavelengths is the increased atmospheric attenuation, particularly from water vapor and oxygen. The atmospheric attenuation characteristics in the 10-300 GHz range vary widely and influence the choice of frequency bands. However, there are troughs or atmospheric "windows" of lower attenuation in the vicinity of 35, 90, 140, and 240 GHz, coinciding with some radiolocation service band allocations.

There is extensive research and development (R&D) on radiolocation service radars, and to a lesser extent, on radionavigation service radars, at mmw. Although the activities are primarily research rather than development, the research results may eventually lead to the development and production of equipment at some time in the future, and spectrum will be needed for equipment at the operational stage. The DOE is developing an Ultra High-Resolution Synthetic Aperture Radar (UHRSAR) that operates in the 28.5-38.5 GHz band.

DOD uses the bands 30.0-31 GHz, and 33.4-36.0 GHz. The 33.4-36.0 GHz band is used for aircraft control, navigation and mapping, terrain following and avoidance, and for multimode airborne radar. Although the 33.4-36.0 GHz band is allocated to the radiolocation service, the 30.0-31 GHz band is not allocated to the radiolocation service, and operations must be performed on a non-interference basis.

The Naval Research Laboratory has a major R&D radar program operating in the 93.27-95 GHz band. The technical breakthrough by this program occurred when the Naval Research Laboratory developed a new high power transmitter tube called the gyro-klystron that permits average power as high as 10 kW.

In summary, there is a great deal of DOD-sponsored radar R&D taking place in the mmw bands. The R&D applications focus on ground mapping, including precise resolution and target identification. Some of the radar R&D will most likely evolve into the production and deployment of radar systems.

RADIOLOCATION SERVICE USE AND FUTURE SPECTRUM REQUIREMENTS IN THE SPECTRUM RANGE ABOVE 300 GHZ

Although frequencies above 300 GHz are not allocated at the present time, research is taking place, and allocations may have to be considered in the future. A majority of the research in the 300-3000 GHz (3 THz) band emphasizes components such as oscillators, mixers, amplifiers, *etc*. As currently envisioned, the main applications are radio astronomy and remote sensing. The remote sensing application leads to radiolocation service applications. Long-range spectrum requirements for the radiolocation service above 300 GHz may evolve as R&D continues.

SPECTRUM REQUIREMENTS FOR ULTRA-WIDEBAND AND SYNTHETIC APERTURE RADARS

Although Ultra-Wideband (UWB) radars date back to the early 1960s, there has been a strong interest in UWB in recent years, particularly for military applications. UWB radars are characterized by very wide bandwidth and the commensurate fine range resolution.

UWB radars can be generally categorized into impulse radars or non-impulse radars. The non-impulse radars are generally extrapolations and extensions of conventional radar systems, while impulse radar is defined as radar with a waveform of a single-cycle sine wave that has a bandwidth of approximately 100 percent, or approximately equal to the numerical value of its center frequency.

There is no possibility of exclusive or even sufficient properly allocated shared spectrum for UWB radars, and thus, spectrum sharing is required. Support for these systems must be based on demonstrated electromagnetic compatibility.

There has been extensive research and experimentation on UWB radars over the past ten years. The results indicate that the UWB radars are useful for certain applications. It is possible that one or more of these systems may move forward to a production phase within the next five years. The wide emission bandwidth of UWB radars transcend many bands, including passive bands that are used by many services. UWB operations are permitted on an unlicensed basis in compliance with Parts 7.8 and 7.9 of the NTIA Manual. This aligns with Part 15 of the FCC Rules. Section 8.3.30 also allows for the coordination of fixed location UWB systems intended for use at higher powers than allowed pursuant to 7.8 and 7.9.

The Navy and NASA are experimenting with SAR systems that operate in several radiolocation bands simultaneously and may be able to accomplish many of the applications of UWB radars while operating within allocated radiolocation bands. There is considerable research into developing systems in the terahertz spectrum region above 300 GHz, some applications of may provide the same capability as UWB systems.[178]

---

[178] M. Fitch and R. Osiander, *Terahertz Waves for Communications and Sensing*, Johns Hopkins APL Technical Digest, vol. 25, no. 4 at 348-350 (2004).

RADIOLOCATION SERVICE REQUIREMENTS FOR MULTI-BAND RADAR SYSTEMS

Radar target identification is valuable in applications such as remote earth sensing or for military uses. Research has been conducted on radars that operate simultaneously in two or more bands to determine if the data provides more accurate target identification. The following provides brief descriptions of some of the recent research.

NASA operates an airborne tri-band SAR at the Jet Propulsion Laboratory (JPL) for research into ground mapping and collecting environmental data. The radar is the AIRborne Synthetic Aperture Radar (AIRSAR) operating at 420-450 MHz; 1220-1260 MHz; and 5270-5310 MHz.[179]

Multi-band radar systems have been studied via federally sponsored research. The Massachusetts Institute of Technology (MIT) Lincoln Laboratory conducted research and experiments on target identification in foliage using radars operating simultaneously in the 420-450 MHz, 1215-1400 MHz band, and in the 5 GHz band, fully polarmetrically.[180] Polarmetric radars process the polarization of the return signal to determine the type of target. The polarization of electromagnetic waves changes as they are scattered by the object. The changes are processed and compared with the characteristics of known objects. The MIT system was an airborne SAR.

In summary, the overall mission requirement for improved and very accurate target information is the driving force behind the increased interest in tri-band radars. This application is for airborne radar "mapping" the ground and identifying targets. Spectrum requirements for theses applications will likely be accommodated within existing allocated bands.

SUMMARY AND FUTURE SPECTRUM REQUIREMENTS FOR THE RADIOLOCATION SERVICE

Radars operating in the radiolocation service are critical to national defense and security. The radiolocation service allocations have been declining over the past 25-30 years, beginning with the ITU WARC-79. This is particularly the case for the exclusive radiolocation and radionavigation bands where there is a trend towards more sharing with communications services. Radar experts have concluded that most of the radar systems that will need spectrum ten years from now are currently in operation. Rather than developing entirely new radars, most Federal agencies like the Navy are modernizing existing radars with new electronics and signal processing technologies with the spectrum operating bands remaining the same. Although the modernized radars may use the same band and bandwidth, the upgraded radars are frequently fitted with more capable processors and the latest processing technology resulting in a much more sensitive radar system.

---

[179] Jet Propulsion Laboratory Website, http://airsar.jpl.nasa.gov/documents/engineering/specs/char_table.html (last visited, Feb. 8, 2008).

[180] Fleischman, et al., *Summary of Results from a Foliage Penetration Experiment with a Three-Frequency Polarmetric SAR*, J. Surveillance Technologies II at 151-60 (April 1992).

EARTH EXPLORATION-SATELLITE SERVICE, SPACE RESEARCH SERVICE AND METEOROLOGICAL-SATELLITE SERVICE

The Earth Exploration-Satellite Service (EESS), the Space Research Service (SRS), and the Meteorological-Satellite Service (MetSat) are somewhat similar in function and share many frequency bands, and are thus treated together in this section. The major Federal agency users of the services are the DOC's NOAA, the Army and Air Force, NASA, and the DOI. While other agencies also have a few assignments in these services, these primary user agencies operate facilities in these services to perform space research, observe and report on weather conditions, and issue forecasts and warnings of weather and flood conditions, as well as monitoring numerous activities and conditions of the Earth. Some of these functions are provided by systems used jointly by these agencies, and such use is expected to increase in the future.

EARTH EXPLORATION-SATELLITE SERVICE

INTRODUCTION

The EESS is defined as:

> A radiocommunication service between earth stations and one or more space stations, which may include links between space stations, in which: information relating to the characteristics of the Earth and its natural phenomena including data relating to the state of the environment, is obtained from active sensors or passive sensors on Earth satellites; similar information is collected from airborne or Earth-based platforms; such information may be distributed to earth stations within the system concerned; platform interrogation may be included. This service may also include feeder links necessary for its operation.[181]

EESS allocations and operations are utilized for active sensor or passive sensors as defined below. EESS transmissions can be from Earth-to-space, space-to-Earth, or space-to-space.

An active sensor is defined as: "A measuring instrument in the Earth exploration-satellite service or in the space research service by means of which information is obtained by transmission and reception of radio waves."[182]

A passive sensor is defined as: "A measuring instrument in the Earth exploration-satellite service or in the space research service by means of which information is obtained by reception of radio waves of natural origin."[183]

The EESS (active) uses transmitters as a source of radio waves to provide energy that is subsequently reflected back to the transmitting satellite for reception and data collection. The EESS (passive) relies on the radiations from the Earth, atmosphere, or space to provide the collectible data.

---

[181] *See*, ITU Radio Regulations, art.1, sec. III, at 1.51 (Geneva, 2004).
[182] *Id.* at 1.182.
[183] *Id*. at 1.183.

The communications links used to transmit the sensor data collected by the satellite are transmitted in the EESS (space-to-Earth).

While the Federal Government developed programs in the 1990s to encourage the implementation of commercial remote sensing satellites in the EESS, this industry has not flourished. A Rand Corporation study in 1998 addressed both the benefits to the Federal Government from use of commercial remote sensing data as well as challenges relating to the use of commercial resources for such programs as the Mission to Planet Earth.[184] These challenges include uncertainty as to the availability of needed data from commercial sources, data policy issues, including varying intellectual property rights around the world, pricing, military uses of commercial remote sensing data, and others.[185] However, commercial remote sensing data provides an important adjunct to the data obtained by government systems and the Federal Government acquires and uses data from a number of remote sensing systems around the world.[186] Thus, while the study supports the use of data from commercial remote sensing satellites, it indicates the continued need for Federal satellites to ensure that a range of government missions are supported.

ALLOCATION ASSETS

There are over seventy frequency bands allocated to the EESS in various forms such as primary, secondary, active, passive, space-to-Earth, and Earth-to-space. Many of the EESS allocations are for passive activities, and others are designated as bands where active sensing can be conducted with the satellite transmitting signals and collecting the return signals. Other EESS allocations are not designated as active or passive, and some are used transmitting EESS data. Examples of EESS allocations that are used for communications are the four bands in 8025-8400 MHz that are used to downlink EESS data to Earth stations. Many of the bands allocated to the EESS are shared with other services, especially the meteorological-satellite service.

CURRENT SPECTRUM USE AND FUTURE SPECTRUM REQUIRMENTS – EARTH EXPLORATION-SATELLITE SERVICE (ACTIVE AND PASSIVE)

Earth Exploration-Satellite Service (Active)

NASA makes substantial use of the EESS in the active mode. Table B-1 presents the bands that NASA uses for active sensors operating in the EESS, often shared with space research service and other allocations.

---

[184] S. Pace, B. Sponberg, and M. Macauley, *Data Policy Issues and Barriers to Using Commercial Resources for Mission to Planet Earth*, Rand Corp., Report to the U.S. Office of Science and Technology Policy, DB-247-NASA/OSTP (1999) (Pace Report).
[185] *Id.* at 33-67.
[186] *Id.*

Table B-1. NASA Uses of EESS (Active) Sensors[187]

FREQUENCY BAND
5250-5255 MHz
5255-5350 MHz
5350-5460 MHz
5460-5470 MHz
5470-5570 MHz
13.25-13.4 GHz
13.4-13.75 GHz
13.75-14 GHz*
35.5-36.0 GHz
94.0-94.1 GHz

*Note: even though used for EESS (Active) sensors, the 13.75-14 GHz band is not allocated to the EESS.

Federal agencies' use of the Cloudsat cloud profiling radar system in the 94-94.1 GHz band is an example of the use of active sensing devices. The Cloudsat radar collects return data from clouds to determine the mass of water and ice within the clouds.

NOAA National Polar-Orbiting Operational Environmental Satellite System (NPOESS) has future spectrum requirements in the EESS (active) band to perform active sensing via a radar altimeter. The radar altimeter operates in the 5250-5350 MHz and 13.4-13.75 GHz bands to measure sea surface topography to an accuracy of approximately 4.2 cm to support the NOAA weather and water, climate variability, and the NOAA mission goals, including monitoring global mean sea level.

The USDA also makes extensive use of data gathered by remote-sensing satellites to monitor, assess and manage agricultural and forestry resources. In particular, it utilizes the NOAA satellites and NASA's Earth Observing System (EOS) AM1 satellite, called Terra, to evaluate Earth surface heat flux.

Earth Exploration-Satellite Service (Passive)

There is extensive use of the EESS (passive) by numerous Federal agencies and systems, but, typical of passive operations, there are only a few frequency assignments listed in the GMF. Although these sensors are operated on only a few satellites, the use of this important data is very wide and far-reaching.

Although receiver-only assignments can be entered into the GMF and receive protection from interference under certain conditions, there are no official provisions in the NTIA Manual requiring agencies to enter such assignments. However, entry of their passive frequency usage as assignments in the GMF helps insure interference protection from transmissions in the same or adjacent bands; and helps to accurately depict the actual spectrum usage of the bands by the Federal agencies.

[187] NASA Plan, Appendix 2; and NASA Website on Clouds at http://science.hq.nasa.gov/missions/satellite_24.htm.

NASA utilizes spectrum in the EESS (passive) to support the following sensing instruments:

1. Advanced Earth Observing Satellite (ADEOS)
2. Advanced Microwave Scanning Radiometer (AMSR)
3. Earth Observing System-P.M. (EOP-PM)
4. Electronically Scanning Thinned Array Radiometer (ESTAR)
5. Microwave Humidity Sounder (MHS)
6. Special Sensor Microwave/Imager (SSM/I)
7. Special Sensor Microwave/Temperature (SSM/T1)
8. Special Sensor Microwave/Water Vapor Profiler (SSM/T2)
9. Tropical Rainfall Measuring Mission (TRMM)
10. TRMM Microwave Imager (TMI)

The various instruments are used to measure the Earth's parameters such as sea surface temperature, rainfall, surface winds, water vapor, cloud water, oxygen absorption, ice, and snow. Table B-2 presents the frequency bands used by the instruments, although each instrument may use three or four bands.

Table B-2. NASA Use of EESS Spectrum for Passive Sensors

Band		Band	
1	6425-7075 MHz	13	57.0-58.2 GHz
2	10.6-10.68 GHz	14	64-65 GHz*
3	10.68-10.7 GHz	15	86.0-92.0 GHz
4	18.6-18.8 GHz	16	116-119.98 GHz
5	21.2-21.4 GHz	17	148.5-151.5 GHz
6	22.21-22.5 GHz	18	182-190 GHz
7	23.6-24.0 GHz	19	190-191.8 GHz
8	31.3-31.8 GHz	20	200-202 GHz
9	33.4-34.2 GHz *	21	240 GHz*
10	36.0-37.0 GHz	22	640 GHz*
11	50.2-50.4 GHz	23	2400 GHz*
12	52.6-55.78 GHz		

* Used but unallocated. Footnote 5.565 provides for EESS experimentation in parts of the 275-1000 GHz band.

Extensive use is made of the EESS passive sensing bands for various purposes on polar-orbiting spacecraft. The current and planned passive sensors are the Conical Microwave Imaging Sounder (CMIS), the Advanced Microwave Sounding Unit (AMSU), and the MHS. Table B-3 presents the frequency bands either in use or planned for these sensors.

Table B-3. DOC Use of EESS Spectrum for Passive Remote Sensing

Band		Band	
1	6407.5-6792.5 MHz*	9	52.6-59.3 GHz
2	10.645-10.755 GHz	10	59.3-60.525 GHz**
3	18.6-18.8 GHz	11	86.0-92.0 GHz
4	23.6-24.0 GHz	12	148.5-151.5 GHz
5	31.3-31.5 GHz	13	155.5-158.5 GHz
6	36.0-37.0 GHz	14	164.0-167.0 GHz
7	50.2-50.4 GHz	15	174.8-191.8 GHz
8	51.4-52.6 GHz**	16	316-334 GHz***

* EESS authorized over oceans by footnote 5.458.
** Planned for use but unallocated.
***Footnote 5.565 provides for EESS experimentation in parts of the 275-1000 GHz band.

FUTURE SPECTRUM REQUIREMENTS – EARTH-EXPLORATION SATELLITE SERVICE (PASSIVE)

There are a number of frequencies in the bands above 275 GHz identified for passive sensing.[188] Moreover, additional allocations are likely to be considered at a future WRC to meet the needs of users of passive sensing, including NASA and the DOC. This would require the revision of the ITU Table of Frequency Allocations to provide for allocations for passive sensing at frequencies above 275 GHz.

The existing spectrum allocations to the EESS (passive), nevertheless, appear to be adequate to support the operational and planned EESS systems for at least the next ten years.

EARTH EXPLORATION-SATELLITE COMMUNICATIONS SPECTRUM USE AND REQUIREMENTS

EESS satellite systems collect large amounts of data via their sensors, which must be transmitted to earth stations which then forward the data to processing centers. As the sensors become more advanced, more data is collected requiring higher data transmission rates and spectrum bandwidth.

The operations of the Landsat series of Earth exploration-satellites were privatized in 1992 based on Public Law No. 102-555, the Land Remote Sensing Policy Act of 1992, and the Presidential Decision Directive NSTC-3, the Landsat Remote Sensing Strategy dated May 5, 1994. However, the privatization efforts were not successful, and the new replacement series system is entirely owned and operated by the Federal Government. Between 1994 and 1999, NASA, DOD, NOAA, and DOI/USGS were all involved with the Landsat program. However, the 1999 Landsat management plan assigned the responsibilities to NASA and the USGS, especially regarding Landsat 7 and future programs. NASA was tasked, among other things, to develop and launch Landsat 7, while the USGS was tasked to manage the spacecraft and ground

[188] *See*, ITU Radio Regulations, art. 1, sec. III, at 5.565. Radio Regulation 5.565 provides for "experimentation with, and development of various passive services and all other services" in these bands. *See also*, Resolution 950 (WRC-03) which states that "allocations in the bands above 275 GHz should be considered at a future WRC."

system, including command and control of the spacecraft.[189] NOAA had major responsibilities in the 1994 Landsat management plan, but none were prescribed in the 1999 management plan.

To clarify responsibilities further, the Office of Science and Technology Policy issued on December 23, 1995, a memorandum to provide managerial and administrative guidance for the Landsat program. Specifically, the memorandum established a plan whereby:

1) NASA will acquire a single Landsat data continuity mission (LDCM) in the form of a free-flyer spacecraft to collect land surface data and deliver its data to the Department of the Interior (DOI)/United States Geological Survey (USGS);
2) DOI, through the USGS, will be responsible for the operations of the LDCM and for the collection, archiving, processing, and distribution of the land surface data to U.S. Government and other users.[190]

NASA is developing the new generation of Earth exploration-satellites to replace the Landsat 5 and 7 generation, beginning with the Landsat Data Continuity Mission (LDCM). The USGS will operate the system after the 2011 launch. NASA is developing the procurement specifications and identifying the needed frequency bands.

The LDCM will have more advanced sensors, requiring greater data transmission rates that require much more bandwidth than Landsat 7. The actual technical parameters will not be available until the bids are received, but NASA expects that the required communications bandwidths will be about 230-320 MHz, indicating that much of the available 8025-8400 MHz downlink band may be used. The 25.5-27.0 GHz band may also be used. The Telemetry, Tracking, and Command (TT&C) signals will most likely operate in the usual 2025-2110 MHz and 2200-2290 MHz bands.

In summary, the EESS allocations in the 8025-8400 MHz band are used extensively to transmit data from space-to-Earth with the 25.5-27.0 GHz band also used. The planned LDCM satellite is expected to require bandwidths on the order of 320 MHz that would consume a large part of the available 8025-8400 MHz band.

---

[189] *Management Plan for the Landsat Program,* National Aeronautics and Space Administration and the U.S. Geological Survey, (Dec. 1, 1999), NASA Website, http://geo.arc.nasa.gov/sge/landsat/mgmtplan.html.
[190] Memorandum for the Secretary of State and Others, John H. Marburger, III, Director, Executive Office of the President, Office of Science and Technology Policy, Subject: Landsat Data Continuity Strategy Adjustment (Dec. 23, 2005), Federation of American Scientists Website, http://fas.org/irp/news/2005/12/ostp122305.pdf.

METEOROLOGICAL-SATELLITE SERVICE

METEOROLOGICAL-SATELLITE SERVICE

INTRODUCTION

The meteorological-satellite service (MetSat) is defined as: "An Earth exploration-satellite service for meteorological purposes."[191]

NOAA is the largest Federal Government user of MetSat systems. These systems can use EESS sensor spectrum from space or from data collection platforms on the Earth's surface to collect information about the weather and the condition of the Earth. NOAA requires access to EESS, MetSat, and other space-related spectrum to fulfill its mission by operating satellites with active and passive sensors for atmospheric and Earth surface sensing, transmitting the data to earth stations, transmitting processed data from such sensors to the satellites for retransmission back to Earth, and maintaining control of its satellites. Active and passive sensor operations are dependent on the relationship between the Earth's physical characteristics and radio frequencies that provide unique measurement of these characteristics.

CURRENT USE AND FUTURE SPECTRUM REQUIREMENTS

Federal agencies operate a number of MetSat systems to gather data from the Earth, and to collect and transmit atmospheric data. NOAA is the primary operator. However, DOD also operates a MetSat system. NOAA currently operates fourteen meteorological satellites in three separate constellations. Many Federal agencies, such as the TVA, transmit information to the NOAA satellites from the agencies' ground sensors, taking advantage of the capabilities of these satellites in support of specific agency missions.

The agencies with the most assignments in the MetSat service include NOAA, DOD, and the FAA. In addition, NASA, the National Science Foundation (NSF), USDA, and DOE each has a few MetSat assignments. These assignments primarily are for Earth stations operating in conjunction with the NOAA and DOD MetSat systems in support of meteorological operations and atmospheric research. DOD also operates systems in the 401-406 MHz band to collect weather data to support air traffic control functions and other DOD missions.

NOAA operates the two civilian operational environmental satellite systems: 1) the Polar-orbiting Operational Environmental Satellite (POES); and 2) the GOES systems, both of which provide vital data in support of the NOAA mission. The GOES and POES satellites are used for weather observation and prediction, operating in twelve MetSat frequency bands as well as several EESS bands, including those reserved for passive sensing use. These satellite networks provide essential information on severe storm development which is used daily in television and radio weather broadcasts to inform the public. A small amount of spectrum in the 460-470 MHz

[191] *See*, ITU Radio Regulations, art. 1, sec. III, at 1.52 (Geneva, 2004).

band (primarily a non-Federal land mobile band) is used for GOES satellite downlinks for interrogation of data collection platforms.

The GOES and POES networks, operated by the National Environmental Satellite, Data, and Information Service (NESDIS) of NOAA, make day and night observations of weather (clouds, temperature, winds, *etc.*), ocean state (sea surface temperature, *etc.*), geological and agricultural features over the entire Earth. This data and other environmental data are collected and then transmitted to Earth stations. The data is gathered and processed at the NOAA ground stations and then retransmitted generally via non-government commercial satellites to NOAA processing centers. The MetSat systems also provide for the collection and radio relay of data from fixed and mobile environmental observing platforms, including ships, aircraft, ocean buoys, and remote land surface sites.

The GOES system maintains a continuous data stream from a two-satellite operational system in support of the NWS mission requirements. These satellites send weather data and images that cover various sections in and near the United States. The current weather satellites transmit visible and infrared images and can focus, when necessary, on small areas to monitor severe storms or, most often, on large areas for synoptic scale, and maneuver in space to obtain maximum coverage. The GOES satellites operate in the GSO.

The POES satellites operate in a circular to slightly elliptical orbit to provide daily global coverage, with morning and afternoon orbits, to deliver global data for improvement of weather forecasting. Information is received on cloud cover, storm location, atmospheric and surface temperatures, and heat balance of the Earth's atmosphere. The data from GOES and POES are complementary, providing comprehensive information about conditions on the Earth and in its atmosphere.

The USGS carries out research on snow and ice studies using satellite passive microwave observations. Other uses by the USGS of data acquired through EOS systems involves climate research, analysis of geomagnetic data (to compute possible impact of Sun and Earth interactions on such systems as GPS), study of volcanoes, and others. DOI's Bureau of Reclamation gathers data to assist the USGS with its watershed and river system management program. The Bureau of Indian Affairs, the National Park Service and USFWS also use data collected via MetSats.

The NPOESS satellites will use many frequency bands, including frequencies in the 460-470 MHz, 1698-1710 MHz, 7750-7850 MHz, 8025-8400 MHz, 25.5-27.0 GHz, and the 20/30 GHz bands, to support many missions and requirements to transmit large quantities of data. However, NPOESS will no longer require the 137-138 MHz band.

Several other Federal agencies use information gathered by sensors and received by the NOAA satellites and have frequency assignments in bands allocated to the MetSat. DOI has frequency assignments in the 402-403 MHz band to transmit sensor data to the meteorological satellites. DOI utilizes the NOAA GOES satellites for support in fire monitoring, weather forecasting, lightning detection, and climate monitoring. The USGS Water Resources Division collects water resource and climate data for a number of projects relating to rainfall runoff, water quality and hydrologic processes. Data is collected at the USGS sites and transmitted to the

NOAA Wallops Island, Virginia control center via GOES. The information is then rebroadcast through U.S. commercial communications satellites to USGS ground station data collection and analysis sites.

The new GOES-R MetSat series will accommodate a significantly higher data rate for the satellites' atmospheric, imaging and sounding instrumentation. The imager and sounder data rates in the current generation GOES are 2.6 Mbps for the raw downlink and 2.1 Mbps for the global processed data. These data rates can be accommodated by the spectrum used in the current-generation system. However, for the GOES-R, NOAA/NESDIS requires significantly higher data rates, necessitating higher order modulations and other technologies to be used in the existing frequency assignments.

Table B-4 presents NOAA's MetSat current spectrum usage and future spectrum requirements. With both the planned new NPOESS and GOES-R networks likely being launched before 2015, DOC will have a significant increase in spectrum use within ten years. This is principally due to the sensors having much greater complexity (more sensitivity, higher resolution, both spectrally and spatially) more channels and resulting higher data rates. However, the use of additional spectrum is expected to result in a much better understanding of the Earth and its environment. NOAA plans to keep its increase in spectrum use to a minimum through application of technologies enabling more efficient modulation schemes, encoding, compression, and filtering.

Table B-4. Current MetSat Spectrum Use and Future NOAA MetSat Spectrum Requirements

Frequency Band	Function	Polar or Geostationary
137-138 MHz	Data Transmission Space-to-Earth	Polar, current only
401–403 MHz	Data Collection Platform Uplink	Polar and Geo., current and future
406-406.1 MHz	Search and Rescue, EPIRBs	Polar and Geo., current and future
460–470 MHz	Data Collection Platform Interrogation Downlink	Geo. (current and future) and Future Polar
1544-1545 MHz	Search and Rescue, downlink	Polar and Geo., current and future
1670–1710 MHz	Data Transmission Space-to-Earth	Polar and Geo., current and future
2025-2110 MHz	Spacecraft Command and Processed Data Uplink	Polar (Command only) and Geo., current and future
2200–2290 MHz	Telemetry Data Transmission to Earth	Polar and Geo., current and future
7190-7235 MHz	Processed Data Transmission to Spacecraft	Future Geo.
7750-7850 MHz	Data Transmission to Earth	Future Polar

The design of NPOESS is almost complete, thereby limiting the extent to which further improvements in spectrum efficiency can be accomplished. For GOES-R there is a very active radio frequency communications design effort in place that is expected to continue for several years. This effort has concentrated on examining the latest technologies available regarding efficient modulation, encoding and compression algorithms in order to achieve the maximum spectrum efficiencies which will result in the greatest data throughput in the least amount of radio frequency spectrum.

SPACE RESEARCH SERVICE

INTRODUCTION

The SRS is defined as**:** "A radiocommunication service in which spacecraft or other objects in space are used for scientific or technological research purposes."[192] Operations in the space research service include Earth-to-space links, space-to-Earth links, both near-Earth and deep space, space-to-space links, and either active or passive sensing. Both passive and active sensing is used for remote sensing to gather information from the earth as well as space.

NASA has a need for availability of properly protected electromagnetic spectrum to support the implementation of the agency's communication and remote-sensing systems.[193] Because of the nature of NASA's activities, its spectrum planning is geared to the missions it has planned for up to thirty years in the future. This includes the United States' vision for space exploration -- to implement a sustained and affordable human and robotic program to explore the solar system and beyond."[194]

Because the nature of space communications necessitates NASA operations above many countries in addition to the United States consistency in international allocations is critical. NASA participates actively in the Space Frequency Coordination Group (SFCG) in order to coordinate its worldwide spectrum requirements. (NTIA, DOC, and DOD also participate in the SFCG.) The SFCG is an international group of space agencies that work together to determine how best to use allocated frequency bands and how to provide cross-support to each other's mission.[195]

ALLOCATION ASSETS

There are ninety frequency bands allocated to the space research service, and operations also take place in the 275-2400 GHz part of the spectrum where there are no allocations, except recognition of the activities by footnote. NASA indicates that it is also using 33.4-34.2 GHz for the JASON-1 program and 64-65 GHz for the Upper Atmosphere Research Satellite (UARS) program, but there are no allocations for SRS or EESS in these bands.

[192] *See*, ITU Radio Regulations, art. 1, sec. III, at 1.55 (Geneva, 2004).
[193] NASA Long Range Electromagnetic Spectrum Forecast at 6 (Nov. 1, 2005).
[194] *Id*.
[195] *Id.* at 7.

CURRENT SPECTRUM USE AND FUTURE SPECTRUM REQUIREMENTS

Current Spectrum Use

NASA's scientific spacecraft must be tracked and controlled, and the health, condition, safety of the spacecraft monitored. Scientific data gathered by these spacecraft must also be transmitted to receive sites. Because most of its space activities are research-oriented, NASA has historically used the space research service for the bulk of its radiocommunication links to and from space. NASA operates a communications infrastructure that includes the Tracking and Data Relay Satellite System (TDRSS); the Ground Network (GN); and the Deep Space Network (DSN). The TDRSS uses communications satellites in geostationary orbit to relay data from scientific spacecraft to a fixed ground location. The GN operates a number of ground-based tracking facilities to provide direct support to the spacecraft without the need for a relay. The DSN is used to support scientific spacecraft whose missions are beyond 2-million kilometers from Earth, such as missions to other planets.

NASA re-uses many of the same frequency bands for its near space missions; and re-uses other bands for their deep space missions. For example, NASA has fifty-two near-Earth spacecraft that share the use of the 2025-2110 MHz for uplinks and the 2200-2290 MHz band for downlinks. There are also twenty-five NASA spacecraft that use either one of both of these bands for space-to-space links between spacecraft via TDRSS. At least fourteen of these NASA systems that use space-to-space frequencies re-use the same frequency. NASA also has twenty deep-space missions that share the use of the 8400-8450 MHz space-to-Earth or downlink band, and seventeen deep-space missions that share the use of the 7145-7190 MHz Earth-to-space or uplink band.

Future Spectrum Requirements

To augment the additional allocation to the space research service adopted at the WRC-03 in the 25.5-27.0 GHz band to support downlink transmissions from space-to-Earth, NASA has a need for another allocation of 500 MHz of nearby spectrum to support mission data communications and command and control links in the Earth-to-space direction. This estimate might increase with manned missions. It may be necessary to place this allocation change for additional space-research spectrum on an agenda of a future WRC.

In support of NASA's deep space mission and space-to-Earth communications, an additional 2.5 GHz is required in bands between 27.5-40 GHz. This requirement also would likely require an agenda item at a future WRC. The need for this large increase in spectrum requirements over the next ten to thirty years is needed to support future U.S. deep space missions which utilize data rate capability in the range of hundreds of megabits-per-second to support the large amount of on-board generated data. Downlink data rate predictions for future years are 2010-125 Mbps, 2020-150 Mbps and 2030-1500 Mbps. Moreover, the number of deep space missions is expected to increase as more space agencies explore the solar system and beyond.

An additional 1 MHz of spectrum in the 100-150 MHz range to support synthetic aperture radio (SAR) research has been identified. NASA is assessing whether this is a short term or long term requirement, and whether the use would be from an airborne or spaceborne platform. NASA is considering whether an additional allocation will be needed, or whether such operations could be conducted on a non-interference basis. If NASA pursues an allocation change, this would require consideration by the United States for a proposal to a future WRC.[196]

METEOROLOGICAL AIDS SERVICE

INTRODUCTION

The Meteorological Aids (MetAids) service is "a radiocommunication service used for meteorological, including hydrological, observations and exploration."[197] The major Federal agency users of MetAids frequency bands are the NWS of the DOC/NOAA and the DOD. The mission of the NWS includes observing and reporting of weather, issuing forecasts, and warning of weather and flood conditions affecting national safety, welfare and the economy.

The equipment employed in the MetAids service (*e.g.*, weather radars,[198] radiosondes, dropsondes and rocketsondes) perform some of these observing functions and provide critical data used in around-the-clock weather forecasting services, flood warning, and meteorological research studies. The data collected by the MetAids systems are shared with several Federal agencies, state and local governments, academic research programs, and commercial weather-forecasting firms.

The Federal Government is the largest user of meteorological aids equipment in the frequency bands allocated for this service, and it provides such data to private and commercial users including private sector meteorological organizations which prepare specialized forecasts for broadcast and to industry sectors such as agriculture.

---

[196] *Id.*

[197] *See*, ITU Radio Regulations, art. 1, sec. III, at 1.50 (Geneva, 2004).

[198] *See, e.g.*, discussion of NOAA's Profiler Demonstration Network, in the radiodetermination/radiolocation services section, *infra* at B-95. The profiler radars are a subset of weather radars.

SPECTRUM ALLOCATION ASSETS

Table B-5 presents a list of the frequency bands that are allocated to the meteorological aids service. The table includes the bands allocated to the Federal Government, and to the non-Federal or commercial sector. Many of the bands are shared with other services. The bands above 2700 MHz are radar bands and are not available for radiosondes, and many of the bands are also used in conjunction with passive sensors operating in conjunction with the EESS (passive) allocations.

Table B-5. Frequency Bands Allocated to the Meteorological Aids Service

Band (MHz)	Status
400.15-401.0	Shared
401-402	Shared
402-403	Shared
403-406	Shared
1668.4-1670.0	Shared
1670-1690	Shared
1690-1700	Shared
2700-2900	Federal
2900-3000	Federal
5600-5650	Shared
9300-9500	Non-Federal

CURRENT SPECTRUM USE AND FUTURE SPECTRUM REQUIREMENTS

Federal Government Systems Operating in the Meteorological Aids Service

NOAA is the largest Federal user of the systems operating in the MetAids service. Other Federal agencies including the DOD and the FAA are also major users. NASA, NSF, USDA and DOE each have a few assignments. The NWS operates a large number of radiosonde and dropsonde systems under the MetAids radio service.[199]

The primary types of systems in the MetAids service are radiosondes, including dropsondes**.** Radiosondes are sensor packages lifted through the atmosphere by a balloon or in the case of dropsondes, dropped from aircraft. Sensor data is transmitted to a ground station near the release point where the data is processed, and meteorological data products are produced. Radiosonde data are used by NOAA and the global meteorological community as an essential input to weather models and by NOAA researchers for atmospheric and climatologic research. NOAA operates a synoptic network of 102 radiosonde stations, each releasing a flight at 0000 and 1200 Coordinated Universal Time (UTC). In addition, NOAA researchers operate transportable radiosonde and dropsonde stations for atmospheric research. Radiosondes are the only devices capable of providing location-specific atmospheric measurements to an altitude of thirty

[199] A radiosonde is defined as "an automatic radio transmitter in the meteorological aids service usually carried on an aircraft, free balloon, kite, and which transmits meteorological data." *See*, ITU Radio Regulations, art. 1, sec. III, at 1.109 (Geneva, 2004). A dropsonde is a meteorological device designed to be dropped from an aircraft to collect meteorological data such as from a tropical storm.

kilometers. Dropsondes are capable of data collections from flight level to within a few meters of the earth's surface.

NOAA has also begun deployment of the RRS for the U.S. synoptic radiosonde network. Legacy synoptic radiosonde operations require on the order of 15 to 20 MHz of bandwidth in the range 1670-1690 MHz. Radiosondes are expendable items, where approximately 80,000 are flown in the United States per year for synoptic operations. Legacy radiosondes use a low cost transmitter based on a free running oscillator design to maintain low cost. The emission bandwidth was excessive and the transmitter frequency would drift as much as 4 MHz while in flight. The new RRS radiosonde uses a more efficient digital transmitter where drift is minimized. Through deployment of RRS, the U.S. synoptic radiosonde spectrum requirements are being reduced by fifty percent or more, albeit at a per-radiosonde cost increase.

Radiosonde data supports the NOAA Weather and Water, Climate Variability, DOC, and DOT mission goals. Synoptic data improves weather forecasters' ability to increase weather and water warning lead times and forecast accuracy, and improve the predictability, expected time and location, and potential impact of hazardous weather events. Data users include Federal and foreign meteorological activities, atmospheric research, and state and local governments. In addition, the NOAA radiosonde system data are critical to emergency missions by providing medium range information on weather related events (rainfall, wind speed and direction, severe weather events) and making the information readily available to all Federal agencies.

Radiosondes and dropsondes are operated by NOAA in the allocated bands 400.15-406 MHz and 1668.4-1700 MHz. With the deployment of the RRS most synoptic operations are conducted within 1675-1683 MHz, avoiding MetSat downlinks above 1683 MHz and commercial operations below 1675 MHz. Several synoptic stations and most NOAA research systems are operated in 400.15-406 MHz, which is shared extensively with other Federal agencies and non-Federal research institutions. NOAA requirements for radiosonde spectrum are anticipated to remain constant over the next five to ten years.

The DOC and DOI use data uplinks to the GOES and POES satellites in the 401-403 MHz band, and there are thousands of transmitters called Data Collection Platforms (DCPs). The DCPs collect measurements such as temperature and then transmit them, via GOES and POES satellites, to a receiving station that forwards the data to processing centers. DOD also operates systems in this band to collect weather data to support air traffic control functions and other DOD missions.

NWS also operates a number of systems, including approximately 120 weather radars, 102 weather balloon stations, the fire-weather program, the hurricane backup communications program, the weather reconnaissance aircraft program, and other miscellaneous radio requirements. Some of these systems are operated in conjunction with state and local governments. NWS also provides other services, in frequency bands not allocated for MetAids, such as 503 NOAA Weather Radio Stations, 3,437 hydrological data collection and warning stations, and the hydrologic telemetry program.

Meteorological radars and radiosondes are the traditional methods for the collection of weather observations for which spectrum has been allocated in the United States and throughout the world. The NEXRAD radar system operating in the 2700-3000 MHz band is the most critical meteorological radar system in the United States. The FAA operates the NEXRAD systems in Alaska, Hawaii, Puerto Rico, and Guam; and NOAA operates all of the NEXRAD systems in the continental United States. The NEXRAD program is managed by the tri-agency Radar Operations Center (ROC) in Norman, Oklahoma. DOC/NOAA, FAA, and DOD provide ROC staff and funding support to the NEXRAD program

The NEXRAD radars have added to the spectrum congestion in the 2700-3000 MHz band in many geographic areas of the United States because the 2700-3000 MHz band is also extensively used by airport surveillance radars in the aeronautical radionavigation service. Furthermore, the NEXRAD system is no longer in production, and a new program will have to be initiated for the future generation meteorological radar system. The FAA plans to use the 2900-3000 MHz and 3500-3650 MHz bands when spectrum becomes unavailable in the 2700-2900 MHz band.

Non-Federal Uses in the Meteorological Aids Bands

Non-Federal use of the MetAids bands is in the 400.15-406 MHz and 9300-9500 MHz bands; however, many licensees also use the 5350-5600 MHz band on a non-interference basis. State and local governments primarily use the 400.15-406 MHz band for hydrologic data collection, fire weather forecasting, and water runoff predictions, with the data sent back and collected via the GOES satellite. Many colleges and universities perform research in the areas of carbon monoxide studies and global atmospheric assessments. Many meteorological weather radars operate in the 5350-5600 MHz and 9300-9500 MHz bands and are owned and operated by state and local governments, private weather forecasting businesses, utility companies, cable television companies, broadcast stations, and college and universities.

Future Spectrum Requirements

Table B-6 presents NOAA's current and future spectrum requirements.

Table B-6. NOAA Current and Future Spectrum Requirements

Band	System	Current Use	Projected Change in Requirements In Next 10 Years
400.15-406 MHz	Radiosondes	Meteorological Operations and Atmospheric Research	None
	Wind Profiler Radar	Wind Profiler Radar Experimental Network	Use of 401-406 MHz for this system to be discontinued; new Wind Profiler Radar systems in 449± MHz under development
	MetSat Data Transmission	Data Collection Platform Transmission to Satellite	None
1675-1683 MHz	Radiosondes	Meteorological Operations	None (Deployment of modernized system underway- spectrum efficiency increased reducing requirements 50%)
2700-3000 MHz	Meteorological Radar	Forecast and Warnings Operations	None
5600-5650 MHz	Meteorological Radar	Atmospheric Research	Ongoing research to assess future potential requirement
9300-9500 MHz	Meteorological Radar	Atmospheric Research	May be used for Gapfiller radars. Number of systems to be determined.

RADIO ASTRONOMY SERVICE

INTRODUCTION

The radio astronomy service is defined as: "A service involving the use of radio astronomy,"[200] and radio astronomy is defined as: "astronomy based on the reception of radio waves of cosmic origin."[201]

Radio astronomy operations are mostly terrestrially based, but some allocations via footnotes authorize space-based radio astronomy activities. The passive nature of radio astronomy is similar in some respects to the passive sensing activities of the EESS. However, radio astronomy activities gather data from space by looking away from the Earth and within space, in contrast to remote sensing activities which primarily gather data from the Earth.

The radio astronomy service uses radio waves to study celestial phenomena through measurement of the characteristics of radio waves emitted by physical processes occurring in space. Radio astronomy complements observations of objects and phenomena at other wavelengths, such as infrared, optical, ultraviolet, and x-ray wavelengths. Radio astronomy has resulted in substantial increases in astronomical knowledge, including the discovery of several classes of new objects, including pulsars, quasars, radio galaxies and new planets. Some of these objects are among the most extreme and energetic physical processes in the universe. Because radio astronomy is used to study objects and phenomena that occur at very large distances from the Earth, large diameter antennas or arrays of smaller antennas are needed. Radio astronomy telescopes use large antennas to reflect the radio signals received from space to a receiver, placed at the focus of the antenna that amplifies and transforms the signals into usable data.

The NSF, a Federal agency, is the major supporter of radio astronomy research in the United States, and it funds the operations of numerous radio astronomy facilities located both within the United States and its possessions and in some other countries. Two national centers are dedicated to radio astronomy research: the National Radio Astronomy Observatory (NRAO), headquartered in Charlottesville, Virginia; and the National Astronomy and Ionosphere Center (NAIC), operated by Cornell University. Both facilities are operated under cooperative agreements with the NSF.

The NRAO operates facilities at twelve sites in the continental United States, Hawaii and St. Croix and is building, in conjunction with international partners, a major millimeter/sub-millimeter wave array (the Atacama Large Millimeter/sub-millimeter Array, or ALMA) in Chile. NAIC operates the Arecibo Observatory in Puerto Rico, with the world's largest single-antenna radio telescope at 305 meter (1000 feet) in diameter.

Effective use of the Green Bank, West Virginia radio astronomy facilities is made possible by the National Radio Quiet Zone, which facilitates coordination of spectrum use within a 13,000 square mile area around the Green Bank observatory.

---

[200] *See*, ITU Radio Regulations, art. 1, sec. III, at 1.58 (Geneva, 2004).
[201] *Id.* at 1.13.

New and upgraded radio astronomy facilities are planned, including advanced telescopes with the ability to observe over a wider range of frequencies. A number of new telescopes are under construction: ALMA and other telescopes in Chile; a millimeter-wave telescope in Puebla, Mexico being constructed as a partnership between Mexico and the University of Massachusetts; the South Pole Telescope, a specialized telescope that will study the origin of the universe using millimeter wave bands; and the Allen Telescope Array (ATA) in northern California, which will demonstrate a new class of radio telescope that uses a large number of relatively inexpensive, smaller antennas.

In addition to using spectrum in a passive manner to gather data from space, radar astronomers use transmitters to beam signals toward solar system objects such as planets, asteroids, and comets, and collect the return signals that are then used to produce detailed radar images of the objects.

In addition to astronomical users of the spectrum, NSF also funds upper and lower atmospheric scientists who make use of active devices such as specialized radars, operating in the bands allocated to the radiolocation service in the 40 MHz to 100 GHz range, to study atmospheric and ionospheric phenomena.

SPECTRUM ALLOCATION ASSETS

There are over seventy frequency bands allocated to the radio astronomy service. The bands have primary and secondary allocations to the Federal Government radio astronomy service, and there are frequency bands for which the radio astronomy service is authorized via footnotes to the table of frequency allocations. Furthermore, footnote US342 requests consideration for the use of the bands by the radio astronomy service.[202]

Most of the frequency bands that are allocated in the United States to radio astronomy are also allocated to other passive services (non-transmitting). In most cases, no fundamental emissions from other spectrum users should be evident in these bands at any location in the United States and possessions. However, unwanted (spurious and/or out-of-band) emissions[203] can impact these bands. In some bands, the radio astronomy service shares primary status with other services. Shared primary services may coordinate with one another to avoid interference.

The radio astronomy service also has a secondary allocation in some bands. In these bands, the radio astronomy service cannot claim interference protection from primary services, but may coordinate spectrum use with other services allocated on a secondary basis. Finally, radio astronomy operations are recognized in some bands via footnote US342 to the table of frequency allocations. Some of these bands encompass sub-bands in which the radio astronomy service is already allocated on a primary or secondary basis. In those sub-bands, the level of protection for the radio astronomy service is based upon its primary or secondary allocation. Outside of those sub-bands (*i.e.*, within the bands that radio astronomy is mentioned only by footnote), footnote US342 requests that other users of the spectrum take into consideration the use of the bands for radio astronomy, but are not otherwise required to protect the radio astronomy service.

---

[202] NTIA Manual, *supra* note 39 at 4-144 and 4-145.
[203] Unwanted emissions are emissions outside the transmitter or receiver bandwidth.

There are very few frequency assignments for radio astronomy or other passive services in the GMF as passive services are not required to obtain frequency assignments. However, as discussed above, these operations should consider entry into the GMF to provide information to other systems concerning the need to protect the radio astronomy passive activities.

CURRENT SPECTRUM USE AND FUTURE SPECTRUM REQUIREMENTS

Current Spectrum Use for the Radio Astronomy Service

Radio astronomy observations enable scientists to discover and study phenomena that are not observable by other means, such as radiation from various phenomena in the universe, many occurring billions of years ago and whose radio emissions are just now reaching Earth. The vast majority of cosmic signals are exceedingly weak and therefore difficult to detect. Cosmic sources also are very distant, so propagation losses are extreme — at 1400 MHz, the free space propagation path loss over forty trillion kilometers (the cosmically short distance to the closest star to the Sun) is very large (367 dB); the loss over ninety-five billion trillion kilometers (the distance to the edge of the observable universe) is a daunting 555 dB. Radio astronomy research is therefore conducted with extremely sensitive instruments located mostly at sites far removed from predictable sources of ground-based radio interference. In spite of the isolation of most radio telescopes, the intensive use of the spectrum terrestrially, in the air, and by satellite systems, means that access to spectrum for radio astronomy observations is very constrained.

Research in radio astronomy is conducted with a number of antenna types, including single antenna telescopes and multiple-antenna systems called arrays. When used as an interferometer[204], two or more antennas (now considered “elements” of the interferometer) are pointed at the same object, and the data received by each are cross-correlated. An interferometer achieves an angular resolution equivalent to the resolution that would be achieved by a single antenna, the same diameter as the separation between elements of the array.

Scientific research through radio astronomy often requires access to specific, well-defined parts of the spectrum. For example, radio astronomers cannot always choose the frequencies of their observation arbitrarily, as many of the cosmic signals they study take the form of spectral lines covering a limited frequency range. These lines are generated at characteristic frequencies associated with transitions between quantized energy states of atoms or molecules, and in order to obtain the information that the astronomer seeks they must be observed at these specific frequencies. Moreover, radio astronomers cannot limit their observations to a few bands. For example, establishing the chemical composition and dynamics of interstellar matter requires

---

[204] An **interferometer** works on the principle that two waves that coincide with the same phase will add to each other while two waves that have opposite phases will cancel each other out, assuming both have the same amplitude. The highest-resolution astronomical images are produced using interferometers (at both optical and radio wavelengths). In order to perform interferometric imaging in optical astronomy at least three telescopes are required (more are preferred).

measurements of many spectral lines across the millimeter wave part of the spectrum. In addition, international observation programs, in which the United States is an active participant, may necessitate the use of common equipment, and dictate the choice of frequencies for a given experiment.

Many radio astronomy allocations are based on the list of spectral lines of greatest importance to radio astronomy. This list is maintained by the International Astronomical Union (IAU) and updated periodically. For example, the 1400–1427 MHz band is allocated to radio astronomy for observations of the 1420.406 MHz spectral line emitted by hydrogen, the element that comprises over ninety percent of the presently observable contents of the universe. Some important spectral lines were discovered only after the band had been allocated to an active service (for example, the 12.178 GHz methanol lines, in a band allocated to satellite downlinks). Lines outside allocated bands may occasionally be observed as circumstances permit (*e.g.*, when there are no satellite transmissions), but at greatly reduced efficiency.

Other frequency bands are allocated to the radio astronomy service for continuum observations. These allocations are loosely made in approximately one-octave steps, to allow astronomers to study the variation of broadband emissions with frequency. Some broadband sources emit strongly at low frequencies and hardly at all at higher frequencies, while others do the opposite; the details of the spectrum provide important information about the sources and physical processes operating in them.

Using terrestrial radio telescopes, radio astronomers can observe cosmic phenomena at frequencies ranging from 15 MHz to over 1,000 GHz. To meet the needs of radio astronomy, frequencies at regular intervals across this range must be protected from interference in the vicinity of the radio observatories. The basic plan of spectrum management for radio astronomy is to protect small bands across the range for continuum observations, while choosing those bands so they contain the spectral lines of greatest interest.

Scientists continue to pioneer the use of ever-higher radio frequencies, going well beyond the 1,000 GHz (1 THz) region. Some of the highest frequency radio instruments have begun to blur the line between radio and infrared detection techniques.

Observations outside a radio astronomy band are made possible by the fact that radio astronomy is a passive service, and therefore such observations do not cause harmful interference to allocated services. Out-of-band observing, however, means generally a greatly reduced efficiency, since significant periods of interference can occur due to other services transmitting in the band. Radio astronomers are devoting a great deal of effort into developing hardware and software solutions that may allow them to observe in the midst of varying levels of interference. Such solutions can only be partially effective, however, result in reduced efficiency and, sometimes, to failure in acquiring usable data, in spite of best efforts.

Future Spectrum Requirements for the Radio Astronomy Service

The existing allocations to radio astronomy do not take into account the wide range of Doppler shifts at which spectral lines can be observed. For example, the 1420 MHz hydrogen line can be “redshifted” to frequencies as low as 200 MHz at the largest cosmological distances, and thus astronomers are forced to observe outside of the allocated radio astronomy bands. Furthermore, astronomers increasingly are using bandwidths wider than the specifically allocated bands. Increased observing bandwidths can allow fainter broadband (non-spectral line) signals to be detected.

Observations in bands outside allocated radio astronomy bands increasingly can be useful using a combination of interference mitigation techniques, geographical separation, and regulations, including coordination zones around observatories. However, these techniques do not obviate the continued need for dedicated radio astronomy allocations.

Radio astronomy requirements are expected to be satisfied during the next decade within the range of currently allocated spectrum through interference mitigation and other techniques. NSF does not anticipate a requirement for new radio astronomy allocations at frequencies up to 275 GHz. However, new allocations in the 275 GHz to 1 THz region of the spectrum to radio astronomy and other science services may be needed by NSF within a decade, due to the intense interest of the astronomy community in mmw observations and given the large international investment that is currently going into facilities to observe this spectral region. Spectrum allocations above 1 THz may also become necessary beyond the next decade.

SPACE OPERATION, INTER-SATELLITE AND SPACE-TO-SPACE SERVICES

SPACE OPERATION SERVICE

The Space Operation Service (SOS) is defined as: "A radiocommunication service concerned exclusively with the operation of spacecraft, in particular space tracking, space telemetry and space telecommand. These functions will normally be provided within the service in which the space station is operating."[205] The operations within the SOS allocation can be either in the Earth-to-space, space-to-Earth, or the space-to-space directions.

The typical Federal uses of the space operation service are monitoring the locations and condition of spacecraft in the space-to-Earth direction and for transmitting telecommand signals in the Earth-to-space direction to control the spacecraft, including moving it to other locations. Most space operations are referred to as TT&C. Different TT&C communications are required for the various phases of a spacecraft's mission. The TT&C can consist of: 1) long-term in-orbit TT&C; or 2) short-term TT&C communications required for satellite positioning or ascertaining spacecraft health. An example of a long-term TT&C would be support of a spacecraft sent to Mars or the continuous monitoring of spacecraft health for a geostationary spacecraft. An example of a short-term TT&C would be a ten minute duration communication to check the health of a geostationary or non-geostationary satellite.

NASA, DOD, and DOC are the predominant Federal users of the space operation service, although some space operation types of activities may be taken in bands that are allocated to other satellite services or services such as space research.

SPACE-TO-SPACE OPERATIONS

Some space-to-space communications and other operations take place in frequency bands that are allocated to services other than the ISS. Space-to-space operations are authorized in the table of frequency allocations. For example, the 410-420 MHz band is allocated to the SRS (space-to-space) on a primary basis, with footnote 5.268 limiting operations to communications within 5 km of an orbiting, manned space vehicle.[206]

SPECTRUM ALLOCATION ASSETS

There are ten frequency bands allocated to the space operation service. In 1995, the allocations to the Federal Government also included the 136.0-137.0 MHz and 1427-1429 MHz bands, so the allocations to the space operation service declined by 3 MHz in the ten year period.

CURRENT SPECTRUM USE AND FUTURE SPECTRUM REQUIREMENTS

Current Spectrum Use

[205] *See*, ITU Radio Regulations, art. 1, sec. III, at 1.23 (Geneva, 2004).
[206] NTIA Manual, *supra* note 39 at 4-87.

NASA, DOC, and DOD are the primary Federal users of the SOS. The DOC and NASA had the greatest percentage growth in the past ten years. The growth in both cases is attributed to the launching of new spacecraft requiring additional frequency assignments.

Rather than using systems in bands allocated to the SOS, the TT&C communications for a spacecraft frequently occur in the same frequency band as the spacecraft communications frequency band related to its mission. For example, satellites operating in the SRS communications bands will frequently multiplex the TT&C tracking and telemetry signals onto a transponder that operates in the communications part of the SRS bands; or satellites operating in the FSS communications bands will assign specific frequencies for TT&C tracking and telemetry signals onto a transponder that operates in the communications part of the FSS bands, the same as the satellites main function. This practice results in considerable cost savings and improved reliability as the same equipment can be used for both functions.

However, in some cases, the TT&C links operate in a separate band because the bands differ widely in frequency. For example, a TT&C system operating in the 2 GHz band can use an omnidirectional antenna to communicate with the control stations on the Earth at various locations rather than to the location of the spacecraft downlink which may use a satellite antenna spot beam. Furthermore, communications in the 2 GHz spectrum area are not as susceptible to precipitation fading as operations in the higher bands, such as those above 20 GHz. The separate and lower frequency TT&C links also allow direct communications between LEO satellites and Earth stations for emergencies and contingencies.

Future Spectrum Requirements

The future spectrum requirements for the SOS should be satisfied by the existing allocations.

INTER-SATELLITE SERVICE

The Inter-Satellite Service (ISS) is defined as: "A radiocommunication service providing links between artificial satellites."[207] Satellites and other spacecraft often require communications among themselves, communications that are sometimes relayed to ground stations. Non-geostationary satellites and other spacecraft in low-Earth orbit sometimes relay their signals to the ground through geostationary relay satellites.

The manned space missions involving multiple spacecraft or extra-vehicular activities also require "inter-satellite" radiocommunications links. Some of these activities take place in frequency bands that are allocated to services other than the ISS.

NASA is the predominant Federal user of the ISS.

[207] *Id.* at 1.22.

SPECTRUM ALLOCATION ASSETS

There are twelve frequency bands that are specifically allocated to the ISS; and two bands are allocated to various other space-related services that also authorize space-to-space operations, such as in the SRS, the EESS, or the SOS. The allocation table specifically authorizes the space-to-space direction for these services.

CURRENT SPECTRUM USE AND FUTURE SPECTRUM REQUIREMENTS

Current Spectrum Use

NASA and the DOD are the only Federal agencies with space-to-space operations. NASA uses the TDRSS for communications for tracking and data acquisition services between GSO spacecraft and NASA and specific user control stations or data processing facilities. The TDRSS space segment consists of nine satellites in GSO, with the constellation distributed to provide global coverage. Command data is uplinked from the ground segment to the TDRSS and relayed from the TDRSS to other spacecraft. Conversely, telemetry data is relayed from various user spacecraft via the TDRSS and downlinked to the ground segments near Las Cruces, New Mexico or at Guam, and then on to data collection locations via terrestrial communications services. Scientists collect and analyze the experimental and sensor data, and operations personnel use satellite engineering data to manage the satellite itself. Data relayed through TDRSS is critical to scientists investigating both near and deep space phenomena and Earth science.

Table B-7 depicts bands that are used for space-to-space operations by NASA and by non-U.S. space agencies in joint projects with NASA.

Table B-7. Additional NASA and NASA-Related Space-to-Space Operations

Band	Function
410-420 MHz	astronaut extra-vehicular activity (EVA)
139.208 MHz	support Russian docking station
143.625 MHz	support Russian docking station
3230-3300 MHz	Russian docking radar
24.45-24.75 GHz	GRACE project, joint US/Germany
32.3-33.0 GHz	GRACE project, joint US/Germany

Future Spectrum Requirements

The Federal future spectrum requirements to support space-to-space operations and the ISS can be satisfied within the existing allocated spectrum for at least the next ten years.

BROADCASTING AND BROADCASTING SATELLITE SERVICES

BROADCASTING SERVICE

INTRODUCTION

The broadcasting service is defined as: "A radiocommunication service in which the transmissions are intended for direct reception by the public. This service may include sound transmissions, television transmissions or other types of transmissions."[208] Similarly, the broadcasting-satellite service is defined as "A radiocommunication service in which signals transmitted or retransmitted by space stations are intended for direct reception by the general public."[209]

A large majority of the broadcasting by United States Federal agencies is conducted by the BBG, which became the independent Federal agency responsible for all U.S. government and government-sponsored, non-military, international broadcasting on October 1, 1999. This resulted from the 1998 Foreign Affairs Reform and Restructuring Act (Public Law 105-277). While the BBG is the legal name given to the Federal entity encompassing all United States international broadcasting services, the day-to-day broadcasting activities are carried out by the individual BBG international broadcasters: the Voice of America (VOA), Alhurra Television, Radio Sawa, Radio Farda, WORLDNET Television, Radio Free Europe/Radio Liberty (RFE/RL), Radio Free Asia (RFA), and Radio and TV Martí, with the assistance of the International Broadcasting Bureau (IBB). The BBG has many facilities overseas, and two in the United States that broadcast to overseas locations. The BBG overseas operations are licensed by the host nation under various agreements and other provisions and are not under the control of the NTIA. The BBG adheres to the Smith-Mundt Act of 1948, which provides that information produced for audiences outside the United States shall not be disseminated within the United States.

CURRENT SPECTRUM USE AND FUTURE SPECTRUM REQUIREMENTS

High Frequency (3-30 MHz) Broadcasting Spectrum Use

HF or shortwave broadcasting uses ionospheric propagation modes and very high-powered transmitters to achieve reliable broadcasting coverage over large distances. The ionospheric propagation is a function of the frequency, the date within an eleven year sun spot cycle, and the time of year and the time of day. Transmitting simultaneously on a number of frequencies is a common practice to overcome propagation uncertainties to provide reliable broadcasting. The BBG, the only Federal agency operating HF broadcasting stations, has major HF transmitting facilities in the United States at Delano, California; and Greenville, North Carolina. The Delano site transmits to the Far East, Southeast Asia, the Pacific Ocean region, and Central America; and the Greenville location transmits to Europe, the Middle East, Africa, Central and South America.

---

[208] *See*, ITU Radio Regulations, art. 1, sec. III, at 1.38 (Geneva, 2004).
[209] *Id.* at 1.39.

The Delano and Greenville locations use the HF bands allocated to broadcasting within the 5-26.1 MHz part of the spectrum. The BBG has assignments in the 5-26.1 MHz bands at the Delano and Greenville locations. The large number of assignments is necessary to assure reliable broadcasting service via ionospheric propagation modes at any time during the eleven year sun spot cycle; and in various months and at various times of the day. Furthermore, to assure reliable broadcasting, transmitter powers as high as 500 kW are used with highly directive Sterba curtain and other types of antennas.

The BBG/IBB participates in the High Frequency Coordination Conference (HFCC), formerly known as the High Frequency Coordination Committee, to coordinate HF frequency usage. The HFCC is a group of about sixty organizations from more than thirty nations that informally coordinates broadcasting frequency usage.[210]

Other BBG Broadcasting Operations Within the United States Spectrum Use

The BBG operates Radio Martí at Marathon, Florida to broadcast to Cuba. Radio Martí consists of an AM-band transmitter operating at 1180 kHz; and TV Martí operates at Cudjoe Key, Florida using a tethered aerostat transmitter operating on TV channels 18, 50 and 64. NTIA authorized Radio Martí on 1180 kHz, while the FCC-licensed TV Martí in accordance with the Television Broadcasting to Cuba Act.[211] Radio Martí programs are also broadcast on some HF channels from the Greenville site.

Broadcasting by Other Federal Agencies

A number of other Federal agencies operate stations in the broadcasting service, but the operations are typically low-powered, serving only a small area. Examples are the Navy operating a 10-watt FM broadcasting station on the campus of the United States Naval Academy in Annapolis, Maryland; the USDA operating a low-powered TV translator to provide television broadcasting to forest rangers in remote locations; and the Army operating a TV station limited to supporting operations of the Joint Readiness Training Center located in Fort Polk, Louisiana.

Future Spectrum Requirements

Future HF broadcasting needs are difficult to predict because they depend on the current political environment of a given geographical area. The HFCC approximates that 850 kHz of additional spectrum between 4 and 10 MHz is required to alleviate the co-channel interference that currently exists. The United States will not pursue this issue during the upcoming WRC-07 as other Federal agencies have HF requirements for services other than HF broadcasting. Current shortwave spectrum is vitally important to the BBG to continue its mission, so it needs international cooperation within ITU guidelines to minimize interference and keep background noise environment low to ensure sustainability of this radio delivery media.

---

[210] High Frequency Coordination Conference Website, http://www.hfcc.org/

[211] *Request of United States Information Agency*, Memorandum Opinion and Order, 10 F.C.C.R. 4514 (1995). *See also*, Foreign Relations Authorization Act, Pub. L. No. 101-246, Title II, Part D, § 241, 104 Stat. 15 (1990).

The BBG has conducted tests of digital shortwave broadcasting technology, namely the Digital Radio Mondiale (DRM), and is waiting for digital receivers to become a realistic option for listeners within appropriate target areas before significant investments are made in this technology. The impact of DRM on spectrum requirements is unknown, but if it becomes popular, the demand for additional HF spectrum will increase proportionally.

BROADCASTING SATELLITE SERVICE

There are no current or planned Federal uses or future requirements for broadcasting satellites.

MISCELLANEOUS SERVICES

STANDARD FREQUENCY AND TIME SIGNAL SERVICE AND THE STANDARD FREQUENCY AND TIME SIGNAL-SATELLITE SERVICE

The Standard Frequency and Time Signal (SFTS) service is defined as: "A radiocommunication service for scientific, technical and other purposes, providing the transmission of specified frequencies, time signals, or both, of high precision, intended for general reception."[212] There is also a space counterpart called the standard frequency and time signal-satellite service that is defined as: "A radiocommunication service using space stations on earth satellites for the same purposes as those of the standard frequency and time signal service."[213] Scientific researchers, network managers, and ordinary consumers use the standard frequency and time signal service and its satellite counterpart to ensure precise standards, such as accurate time (UTC) and frequency calibration.[214]

SPECTRUM ALLOCATION ASSETS

The SFTS service is allocated to eleven frequency bands most of which have small bandwidths. The bands are centered around 20 kHz, 60 kHz, 2.5 MHz, 5 MHz, 10 MHz, 15 MHz, 20 MHz, and 25 MHz. There are larger bands in 400.05-400.15 MHz, 4200-4204 MHz, and 6425-6429 MHz.

The SFTS satellite service is allocated in the bands 13.4-14.0 GHz (Earth-to-space), 20.2-21.2 GHz (space-to-Earth), 25.25-27.0 GHz (Earth-to-space), and 30-31.3 GHz (space-to-Earth).

There are no frequency assignments to the SFTS satellite service.

CURRENT SPECTRUM USE AND FUTURE SPECTRUM REQUIREMENTS

The DOC National Institute of Standards and Technology (NIST) had fourteen SFTS service assignments in the service in 1995 and fifteen in 2005. NIST operates SFTS HF radio stations, WWV, located in Fort Collins, Colorado, and WWVH in Kauai, Hawaii. Both stations operate on 2.5, 5, 10, and 15 MHz, and WWV also operates on 20 MHz. WWVH had also transmitted on 20 MHz and 25 MHz, and NIST plans to retain the frequency assignments to resume operations in the future.

The stations broadcast time announcements, standard time intervals, standard frequencies, time corrections, a BCD (Binary Coded Decimal) time code, geophysical alerts, marine storm warnings, and GPS status reports. Although each frequency carries the same information, the HF signal quality reception varies with different factors such as location, time of year, time of

---

212 *See*, ITU Radio Regulations, art. 1, sec. III, at 1.53 (Geneva, 2004).

213 *Id*. at 1.54.

214 NTIA Manual, *supra* note 39 § 6.1.1. *See generally*, U.S. National Spectrum Requirements: Projections and Trends, U.S. Dep't. of Commerce, NTIA Report No. 94-31, Executive Summary (March 1995), http://www.ntia.doc.gov/osmhome/reports.html.

day, the frequency being used, and atmospheric and ionospheric propagation conditions. The use of multiple frequencies ensures greater reliability.[215]

NIST also operates station WWVB on 60 kHz at Fort Collins. WWVB broadcasts are used to synchronize consumer electronic products like wall clocks, clock radios, and wristwatches. In addition, testing laboratories use WWVB station to calibrate electronic equipment and frequency standards.[216]

NIST plans to add an east coast station operating at 40 kHz and another station at 77.5 kHz in Hawaii. The east coast transmitter would use 50 kW and would augment the Colorado signal by covering the eastern seaboard with a stronger signal to synchronize clocks, *etc*. NIST has submitted requests for funding the projects through the Federal budgeting process, and is waiting for Congressional approval. The U.S. Table of Frequency Allocations does not allocate the SFTS service at the 40 kHz and 77.5 kHz frequencies. However, DOC/NIST has applied for spectrum certification for these planned facilities.

In addition to the NIST stations, the DOD's GPS satellites deliver time signals, achieving accuracies to the micro-second on 1575.42 and 1227.6 MHz.[217] The telecommunications and power industries are major users of GPS service for these applications.

The Coast Guard's LORAN-C transmissions at 100 kHz also are often used as a reference for frequency calibrations. The LORAN-C signals cover very large areas because the ground wave signal is stable and easy to receive.[218] There is some support for development of an Enhanced LORAN (eLORAN) system with time signal service that would serve as a backup for GPS.[219] However, eLORAN has not been fully funded and it remains a long-range plan. DOT, in coordination with DHS, is evaluating whether to continue to operate or invest in the North American LORAN-C beyond FY2007 and to determine whether eLORAN provides enhanced capability complementary to GPS and/or useful GPS back-up capability.[220]

The current spectrum allocated to the SFTS and the SFTS satellite service, however, is required to satisfy the near term and long-term spectrum requirements. The SFTS allocations at 40 kHz and 77.5 kHz may be needed for these requirements.

---

215 *See generally,* NIST Radio Station WWV and NIST Radio Station WWVH, http://tf.nist.gov/stations/wwv.html; http://tf.nist.gov/stations/wwvh.htm; Reference Data for Engineers: Radio, Electronics, Computer, and Communications, 1-148 to 1-157 (Van Valkenburg, M. and Middleton, W., Editors. 9th Ed.)

216 *See generally,* NIST Radio Station WWVB, http://tf.nist.gov/stations/wwvb.htm; Reference Data for Engineers: Radio, Electronics, Computer, and Communications, 1-157 to 1-160 (Van Valkenburg, M. and Middleton, W., Editors, 9th Ed.).

217 *See generally,* Reference Data for Engineers: Radio, Electronics, Computer and Communications, 1-160-162 (Van Valkenburg, M.and Middleton, W., Editors, 9th Ed.); GPS Time Server, http://www.ntp-time-server.com/gps-time-server/gps-time-server.htm; One-Way GPS Time Transfer, http://tf.nist.gov/time/oneway.htm.

218 NIST LORAN-C Data Archive, http://tf.nist.gov/timefreq/service/lorantrace.htm.

219 "Coast Guard Auxiliary Provides Vital Support for Homeland Security Scientific Mission," http://teamcoastguard.org/2006/Aug/A060805/index.htm.

220 *See*, Long Range Aids to Navigation (LORAN) Program, Request for Public Comments, 72 Fed.Reg. 796 (Jan. 8, 2007).

UNSPECIFIED SERVICES

The NTIA Manual, § 6.1.4, Table A lists a number of services as "Unspecified Services." Some of these "unspecified" services should be reclassified as part of existing services.[221]

SOUNDER NETWORK AND SOUNDER PREDICTION

An ionosphere sounder is a device that transmits signals for the purpose of determining ionospheric conditions.[222] The military and other Federal entities use it to probe ionospheric conditions. The ionosphere reflects and refracts radio waves. By monitoring ionospheric conditions, the sounder can select the best HF frequency to use.

A sounder network station is a station equipped with an ionosphere sounder for real-time selection of frequencies for operational communication circuits.[223]

A sounder prediction station is a station equipped with an ionosphere sounder for real-time monitoring of upper atmosphere phenomena or to obtain data for the prediction of propagation conditions.

SPACE TELECOMMAND SPACE STATION AND SPACE TELECOMMAND EARTH STATION

Space telecommand is defined as: "the use of radio communication to transmit signals to a space station to initiate, modify, or terminate equipment functions on an associated space object, including the space station."[224] A space telecommand space station receives emissions used for space telecommand and a space telecommand earth station emits signals used for space telecommand. NASA and DOD have numerous space telecommand Earth station assignments.

SPACE TRACKING SPACE STATION AND SPACE TRACKING EARTH STATION

The NTIA Manual defines space tracking as the use of radiodetermination, excluding primary radar, to ascertain the orbit, velocity or instantaneous position of an object in space, in order to follow the movement of the object.[225] A space tracking Earth station transmits or receives emission used for space tracking. A space tracking space station transmits or receives and retransmits emissions used for space tracking. DOD, DOC, and NASA have numerous Earth station assignments.

---

221 DGPS, for example, is an "unspecified service" discussed in detail in the section on the Radionavigation Service. The need to reclassify DGPS as part of the Radionavigation Service is discussed at page B-84, footnote 148.
222 NTIA Manual, *supra* note 39 at § 6.1.1.
223 *Id.*
224 *See*, ITU Radio Regulations, art. 1, sec. V, at 1.135 (Geneva, 2004).
225 NTIA Manual, *supra* note 39 at § 6.1.1.

SPACE TELEMETERING SPACE STATION AND SPACE TELEMETERING EARTH STATION

The NTIA Manual defines space telemetry as the use of telemetry for the transmission from a space station of results of measurements made in a spacecraft, including those relating to the functioning of the spacecraft.[226] A space telemetering Earth station receives emissions used for space telemetering. A space telemetering space station is defined as a space station, "the emissions of which are used for space telemetering."[227]

Both DOD and NASA have assignments in this service.

EXPERIMENTAL STATIONS

The NTIA Manual lists a number of experimental station classes as having "no specific service." These are: Experimental Contract Developmental, Experimental Developmental, Experimental Export, Experimental Composite, Experimental Research, and Experimental Testing.[228]

---

[226] *Id.*
[227] *Id.*
[228] *See* NTIA Manual, *supra* note 39 at § 6.1.4 which provides the following definitions: An experimental station is "a station using radio waves in experiments with a view to the development of science or technique." An experimental contract developmental station is "an experimental station used for the evaluation or testing under Government contract of electronics equipment or systems in a design or development stage." An experimental developmental station is "an experimental station used for evaluation or testing of electronics equipment or systems in a design or development stage." An experimental export station is "an experimental station intended for export and used for the evaluation or testing of electronics equipment or systems in the design or development stage." An experimental research station is "an experimental station used in basic studies concerning scientific investigations looking toward the improvement of the art of radiocommunications." An experimental testing station is "an experimental station used for the evaluation or testing of electronics equipment or systems, including site selection and transmission path surveys, which have been developed for operational use." An experimental composite station is not defined in the NTIA Manual.

SECTION B-2

PUBLIC SAFETY SPECTRUM NEEDS

STATE AND LOCAL PUBLIC SAFETY SPECTRUM NEEDS

INTRODUCTION

When the President initiated the Spectrum Policy Reform Initiative in June 2003, he requested the Secretary of Commerce to prepare legislation and other recommendations to, among other things, develop means to address the critical spectrum needs of national security, homeland security, and public safety.

Subsequently, the President directed the Secretary of Homeland Security, in consultation with other Federal, state, and local agencies "to address issues related to communication spectrum used by the public safety community, as well as continuity of government operations" in a comprehensive plan, the "Spectrum Needs Plan."[229] DHS accordingly formulated a Public Safety Spectrum Needs Plan (Spectrum Needs Plan) after consulting with the NTIA, the FCC, and state, local, tribal and Federal public safety agencies. The President also directed the DOC to integrate the Spectrum Needs Plan and agency-specific strategic spectrum plans into a "Federal Strategic Spectrum Plan."[230]

DHS's plan addressed concerns of public safety spectrum users, identified the spectrum assets currently available and provided information concerning the public safety community's interest in spectrum in the 700 MHz band. Because the Spectrum Needs Plan was submitted prior to the FCC's actions in 2007 with respect to public safety use of spectrum in the 700 MHz band, it did not address the FCC's most recent decisions concerning public safety's access to narrowband and broadband allocations in that band. The FCC recently designated 10 MHz of spectrum in the 700 MHz band for a nationwide interoperable public safety broadband network to be provided by a public-private partnership.[231] This 10 MHz is part of the 24 MHz in the 700 MHz band already allocated to public safety (12 MHz for narrowband, 10 MHz for broadband,

---

[229] Presidential Determination: Memorandum for the Heads of Executive Departments and Agencies, Improving Spectrum Management for the 21st Century, §§ 2(c), 3(a) (Nov. 30, 2004) (2004 Executive Memorandum) http://www.whitehouse.gov/news/releases/2004/11/20041130-8.html.

[230] State and local public safety radio services fall under the regulatory authority of the FCC. Therefore, rules, procedures, and spectrum needs are developed and codified by them. It is anticipated that the FCC will provide additional information on behalf of the State and local public safety communities during the development of the National Strategic Spectrum Plan.

[231] *See*, *Implementing a Nationwide, Broadband, Interoperable Public Safety Network in the 700 MHz Band; Development of Operational, Technical and Spectrum Requirements for Meeting Federal, State and Local Public Safety Communications Requirements Through the Year 2010*, PS Docket No. 06-229, Second Report and Order, 22 F.C.C.R. 15289 (2007) (Second Report and Order). *See also*, Intelligence Reform and Terrorism Prevention Act of 2004, Pub.L.No. 108-458, § 7303, 118 Stat. 3638 (2004). *See also*, *FCC Revises 700 MHz Rules to Advance Interoperable Public Safety Communications and Promote Wireless Broadband Deployment*, FCC Press Release, http://fjallfoss.fcc.gov/edocs_public/attachmatch/DOC-275669A1.doc.

and 2 MHz for an internal guard band).[232] Thus, the following section contains information that in addition to that provided in the Spectrum Needs Plan, in order to accurately describe how spectrum will be made available for a nationwide interoperable broadband public safety system following the broadcast industry's return of analog spectrum in early 2009.

CURRENT NON-FEDERAL PUBLIC SAFETY SPECTRUM ASSETS

The FCC has allocated more than 97 MHz of spectrum for public safety service providers, including spectrum allocated prior to 2007. This includes 24 MHz of spectrum in the 763-775 and 793-805 MHz bands,[233] depicted in Table B-8, which will be available nationwide when terrestrial television broadcasters transition to digital television and release the spectrum currently used for analog transmissions. Congress mandated that non-Federal public safety entities will have nationwide access to all of the 24 MHz no later than February 17, 2009 when broadcasters must cease analog operations.[234]

[232] *Id*.
[233] These two bands were adjusted by 1 MHz in the downward direction (to 763-775 MHz and 793-805 MHz) by the FCC in its recent order on the 700 MHz band. *Infra* note 254 at 131.
[234] Digital Television Transition and Public Safety Act of 2005, Pub.L. No. 109-171, 120 Stat. 4, Deficit Reduction Act of 2005, Title III, *codified at* 42 U.S.C. §§ 309, 337 (2006) (Digital Television Transition Act).

Table B-8 depicts the existing allocations to Non-Federal public safety interests.

Table B-8. Existing Non-Federal Public Safety Frequency Bands*

Non-Federal Public Safety Frequency Band (MHz)	Voice	Narrowband Data		Broadband Data	National Interoperability[235]	Outside Interference	Conventional or Trunked
2–25	✓	✓					Conventional
25–50	✓	✓					Conventional
72–76	✓	✓					Conventional
150–162[236]	✓	✓			✓		Both
220–222	✓	✓			✓		Conventional
450–470	✓	✓			✓		Both
470–512[237]	✓	✓					Both
763–775 793–805[238]	✓	✓		✓	✓		Both
806–821 851–866	✓	✓				✓	Both
821–824 866–869	✓	✓			✓	✓	Both
4940–4990[239]	✓			✓			N/A

*Source: DHS Public Safety Spectrum Needs Plan with addition of broadband notation for 700 MHz bands

[235] Current national interoperability channels are:

0.25 MHz of the 150–174 MHz band, which includes five narrowband channels in the 162–174 MHz federal band.
0.2 MHz of the 450–470 MHz band
2.6 MHz of the 763–775–776 and 793–805–806 MHz band
0.125 MHz of the 821–824 and 866–869 MHz band.

[236] Fire departments tend to select the 150-162 MHz band because of its long-range propagation characteristics.

[237] All frequencies in this band are only available in 11 metropolitan areas.

[238] *Infra* n. 256.

[239] Allocations in 4940–4990 MHz are best suited for incident site communications, i.e., high-speed, short-distance transmissions.

Unencumbered Spectrum

The DHS Spectrum Needs Plan emphasizes that certain public safety communications, especially those supporting emergency situations, command and control, situational analysis, and other mission-critical functions require spectrum unencumbered by other users to ensure reliability and eliminate or reduce potential interference.

Interoperability

The requirement for interoperability is a major concern for public safety identified by DHS. Federal agencies primarily use the 162-174 MHz and 406.1-420 MHz bands for their public safety requirements. Local and state public safety agency systems operate in many different bands, ranging from 25 MHz to 4.9 GHz. Existing public safety communications systems operating below 512 MHz lack common and sufficient channels to support all interoperability requirements. Fewer than a dozen standardized state and local interoperability frequencies, set aside by the FCC, exist below 512 MHz.

DHS cites the following challenges to achieving interoperability: (1) inadequate interagency cooperation; (2) insufficient standard operating procedures; (3) lack of available interoperable equipment; (4) inadequate training; and (5) lack of sufficient interoperable spectrum. Interoperability gateways, such as IP switches, have demonstrated the ability to "patch" systems together in certain circumstances.

However, the Spectrum Needs Plan indicates that such techniques are insufficient to provide broad-based, reliable and robust interoperability because of high costs, requirements for technically-trained staff, and limitations on the ability of such systems to support direct unit-to-unit communications.

The Spectrum Needs Plan suggested that additional allocations of spectrum designated specifically for interoperability could assist agencies in local, state and Federal homeland security coordination. Contiguous frequency allocations also could permit efficient equipment design and allow public safety agencies to benefit from economies of scale in equipment purchases.

Broadband Operational and Spectrum Requirements

Public safety requirements for and use of bandwidth-intensive wireless technologies are increasing. These broadband services include: in-car video cameras, medical video, mobile surveillance, software downloads, and transmission of large data files. The FCC reallocated the 4940-4990 MHz band in 2003 from a Federal Government-only allocation for fixed and mobile non-Federal public safety services.[240] In its reallocation order, the FCC adopted rules "intended

[240] *See, The 4.9 GHz Band Transferred from Federal Government Use,* Third Report and Order, 18 F.C.C.R. 9152 (2003) (*Third Report and Order*). *See also, The 4.9 GHz Band Transferred from Federal Government Use,* WT

to accommodate a variety of new broadband applications such as high-speed digital technologies and wireless local area networks for incident scene Management, dispatch operations and vehicular operations." However, according to the Spectrum Needs Plan, the non-Federal public safety community has not extensively used the 4940-4990 MHz band because of propagation characteristics, limited geographic range, lack of available and affordable equipment, and susceptibility to adverse weather conditions. Within the context of the reallocation of the analog television spectrum in the 700 MHz band, numerous public safety organizations supported an allocation of 700 MHz band spectrum for broadband use, as part of the 24 MHz already identified for public safety use beginning in 2009.[241] The recent FCC action to create a nationwide interoperable public-safety broadband system in the 700 MHz band is intended to address these requirements.[242]

FCC Actions to Provide For a Nationwide Interoperable Broadband Public Safety Network

The FCC, in August, 2007, determined that 10 MHz of the spectrum from the D Block (758-763 MHz and 788-793 MHz) to be auctioned in early 2008, combined with 10 MHz of public safety's 24 MHz (763-768 MHz and 788-793 MHz), will be made available to form a nationwide shared public safety/private broadband network. The Commission concluded that a single nationwide Public Safety Broadband License would be issued for the 10 MHz designated for public safety. The "Public Safety Broadband Licensee will be responsible for implementing the 700 MHz public safety nationwide interoperable broadband network".[243] The broadband network (using both public safety's 10 MHz and the commercial 10 MHz) will be funded and built by the commercial D Block licensee.

The FCC decided that the "upper 700 MHz D Block Licensee will gain access to the 700 MHz public safety broadband spectrum on a secondary preemptible basis through a spectrum leasing arrangement with the Public Safety Broadband Licensee."[244] The basis for such access will be negotiated between the commercial D Block licensee and the Public Safety Broadband licensee.

The public safety licensee, as prescribed by the FCC, is comprised of a broad range of organizations representative of non-Federal public safety interests. Under FCC rules, no

---

Docket No. 00-32,Second Report and Order and Further Notice of Proposed Rule Making, 17 F.C.C.R. 3955, 3955 (2002).

[241] *See, Implementing a Nationwide, Broadband, Interoperable Public Safety Network in the 700 MHz Band; Development of Operational, Technical and Spectrum Requirements for Meeting Federal, State and Local Public Safety Communications Requirements Through the Year 2010*, PS Docket No. 06-229, Second Report and Order, 22 F.C.C.R. 15289 (2007) (*Second Report and Order*). *See also,* Intelligence Reform and Terrorism Prevention Act of 2004, Pub.L. No. 108-458, § 7303, 118 Stat. 3638 (2004). *See also,* *FCC Revises 700 MHz Rules to Advance Interoperable Public Safety Communications and Promote Wireless Broadband Deployment*, FCC Press Release, http://fjallfoss.fcc.gov/edocs_public/attachmatch/DOC-275669A1.doc.

[242] *Second Report and Order,* at 1.

[243] *Id*. at 142.

[244] *Id*.

commercial interest may be held in or participate in the management of the Public Safety Broadband Licensee.[245]

Because there are some existing public safety narrowband systems in portions of the 700 MHz band, the FCC determined that narrowband operations now operating in channels 63 and 68 (and the upper 1 megahertz of channels 64 and 69) must be relocated no later than the DTV transition date of February 17, 2009.[246]

These existing narrowband systems will have to be relocated to accommodate the new band plan and ensure that the 700 MHz nationwide interoperable broadband system can be implemented as soon as possible by the D block licensee. The FCC determined that the Upper 700 MHz D Block commercial licensee will be required to pay the costs associated with relocating public safety narrowband operations to the consolidated channels, "in recognition of the significant benefits that will accrue to the D Block licensee".[247]

NON-FEDERAL SPECTRUM USE AND FUTURE SPECTRUM REQUIREMENTS

Spectrum Requirements Below 512 MHz for Communications in Rural Areas

Outside the major urban areas, most public safety agencies operate below 512 MHz because the long-range propagation characteristics of VHF make it much more cost-effective to cover larger areas with fewer antenna towers. Furthermore, in rural areas, there is often insufficient capacity on existing public safety VHF channels, and DHS has recommended the identification of additional frequencies for rural-area communications.

Improving Spectrum Efficiency by Narrowbanding

Narrowbanding increases spectral efficiency by using technological measures to transport the same wireless information in a percentage of the spectral bandwidth (typically fifty percent). DHS recommends narrowbanding below 512 MHz for voice and low-speed data applications.

Spectrum Requirements for Point-To-Point Microwave Radio Relay Backhaul Links

The availability to non-Federal public safety entities of 700 MHz band spectrum will encourage deployment of wide-area, multi-agency radio systems that may require expanded infrastructure. Such infrastructure is likely to include point-to-point fixed microwave communications links. The non-Federal public safety community does not currently have dedicated allocations in the 6 GHz, 10-11 GHz, 12 GHz, 18 GHz, or 21-23 GHz microwave bands. Microwave radio relay link backhaul communications provide inexpensive and effective long-distance communication, especially when land-line (wire) systems are disrupted in an emergency.

---

245 *Id*. at 144-146*. See also, Implementing a Nationwide, Broadband, Interoperable Public Safety Network in the 700 MHz Band*, PS Docket No. 06-229, Order on Reconsideration, 22 F.C.C.R. 17935 (2007); and *Order*, 22 F.C.C.R. 20453 (2007).
246 *Id.* at 132.
247 *Id.* at 133.

Therefore, DHS suggests that it would be useful for the FCC, in coordination with NTIA and DHS, to work with the public safety community to perform an assessment of current public safety point-to-point microwave use to evaluate anticipated growth and a potential need for additional public safety exclusive microwave spectrum, as well as opportunities for sharing microwave spectrum within the public safety community and between public safety and other users of point-to-point systems.

USING COMMERCIAL SERVICES FOR PUBLIC SAFETY

Public safety agencies require readily available spectrum in emergency situations. Commercial services have a tolerated a level of non-coverage in some areas and at some times. DHS therefore does not view commercial services as an effective solution for mission-critical public safety spectrum use. However, guidelines and resources to aid public safety agencies in identifying appropriate commercial applications could be useful. This may free up dedicated public safety spectrum for mission-critical functions.

LONG-RANGE STRATEGIC SPECTRUM PLANNING

Public safety telecommunications needs continue to grow as homeland security responsibilities increase. Therefore, the DHS, in coordination with the FCC and NTIA, will have a key role in providing guidance for non-Federal public safety agencies to prepare long-range strategic spectrum plans.

DHS also recommends conducting a comprehensive examination of public safety communications, comparable to the 1996 Final Report of the Public Safety Wireless Advisory Committee (PSWAC).[248] Further, in coordination with DOC and the FCC, DHS suggests that the PSWAC findings be reviewed in light of the changes that have occurred in the public safety environment over the past decade.

CONCLUSION

While additional spectrum in the 700 MHz band will be made available to state, local and tribal public safety entities pursuant the FCC's recent action, the benefits from the public-private partnership will take a number of years to be realized. In addition, a number of technical, operational, financial and political issues will need to be addressed as this system is implemented. However, the public safety community and the public at large could reap significant benefits from the responsiveness of the Congress and the FCC to the requirements for spectrum for broadband interoperable public safety communications.

However, more spectrum in and of itself will not solve all of the challenges facing non-Federal public safety communications. To respond to these challenges, the non-Federal public safety community is working to develop common standards for certain radio systems, implement new technologies, interconnect with other networks, including IP networks, and develop back-up systems. Increasingly, the non-Federal public safety community is coordinating these efforts

[248] PSWAC Report, *supra* note 13.

across jurisdictional boundaries. With the additional 700 MHz spectrum available for a nationwide interoperable broadband public safety system, state, local and tribal public safety entities should be able to develop interoperable systems (both narrowband and broadband) which significantly improve the communications capabilities needed to safeguard life and property.

FEDERAL PUBLIC SAFETY SPECTRUM NEEDS

CURRENT SPECTRUM USE AND FUTURE SPECTRUM REQUIREMENTS

The 162-174 MHz and 406.1-420 MHz bands, the two most heavily used Federal bands, are the primary public safety bands for Federal agencies.[249] The general use of these bands is discussed in more detail in the mobile and land mobile sections of Section B-1.

Most Federal agencies note that their departments rely on spectrum for public safety and interoperability purposes. Many agencies see an even greater future need for spectrum for these uses, but have not yet quantified these needs.

DOE expects that incident prevention and control will require UWB technology, in addition to land mobile radio systems, in the 162 MHz and 406.1 MHz bands to communicate with public safety.

DOJ sees the need for rapid response, and thus, unfettered spectrum access as situations dictate. DOJ needs the ability to set up mobile land mobile repeaters where a mission may require, without the need for embedded infrastructure. DOJ's use of nationwide land mobile frequencies may be justified in such cases.

As the USDA's operational support requirements increase, National Interagency Fire Center (NIFC) operations would be vastly improved with the permanent assignment of additional national frequencies. The NIFC is the nation's support center for wildland firefighting. Through the NIFC, seven Federal agencies, along with state foresters, work cooperatively to fight fires and provide other natural disaster relief across the country. The NIFC maintains a cache of handheld land mobile radios for use in large scale disaster relief.

The USDA keeps accurate records on the annual use of permanently assigned spectrum and frequencies temporarily assigned from other agencies. Every year the USDA engages in sophisticated planning for the upcoming fire season, using historical information and data from the drought index, weather, water, and snow-pack programs to anticipate resources, including radio frequencies. Traditionally, other Federal agencies provide USDA with temporary assignments to make up for shortfalls in permanent USDA frequency assignments. This impacts firefighting operations because off-the-shelf equipment configured to operate on USDA's permanently assigned frequencies often has to be reconfigured to operate on temporary frequencies before it can be deployed.

---

[249] *Alternative Frequencies for Use by Public Safety Systems: Response to Title XVII, Section 1705 of the National Defense Authorization Act for FY2001,* U.S. Dep't of Commerce, NTIA Special Pub. 01-48 at 3-1 (Dec. 2001).

The Federal Government is increasingly looking to the NIFC to perform emergency support functions in addition to wildland firefighting, such as relief from weather-related natural disasters. Additional incident-command frequencies for large-scale incidents would improve overall operations. NIFC shares their existing frequencies with other Federal agencies for non-emergency operational needs when not in use.

INTEROPERABILITY

For DHS, interoperability means day-to-day, task force and incident (emergency response) communications both horizontally (Federal-to-Federal) and vertically (Federal-state-local-tribal). It sees an increased need for interoperation with other Federal agencies and non-Federal first responders.

DOJ expects an expanded presence in FCC-regulated spectrum at 150-162 MHz, 450-470 MHz, and 800 MHz region to support interoperability. There is a critical requirement for interoperability with non-Federal public safety users in these bands and DOJ expects interoperability needs to grow exponentially. These interoperability requirements are localized, and consequently, not amenable to a nationwide solution.

The VA also expects to join with other Federal, state, and local agencies to develop interoperable first responder capabilities. Treasury operates an interoperability frequency named the "Federal Common" which can be shared among all Federal agencies for law enforcement, as well as in coordination with State and local police in emergencies.

Many DOE field offices have established cooperative relationships with local and state public safety agencies.

DOI/Bureau of Land Management is reengineering and consolidating its land mobile systems with its partners to reduce spectrum demand and improve interoperability.

Several agencies acknowledge the importance of standardized equipment. DOC is developing a standard in LMR Project 25 for narrowband land mobile radios for public safety. The Coast Guard's uses for VHF high band (136-174 MHz) Project 25 include interoperability with Federal agencies. The Coast Guard's Rescue 21 system, an advanced search and rescue system that is replacing the Coast Guard's current system, the National Distress Response System, requires interoperability with public safety. Rescue 21 enhances line of sight coverage, increases position localization, increases the number of available voice and data changes and improves interoperability with Federal, state and local partners.

The new IWN acts as the core for some agencies' interoperability plans. The IWN is a collaborative effort of Treasury, DOJ, and DHS to create a consolidated Federal wireless network that can support interoperability with state and local public safety officials. IWN may be the future key to interoperability with other Federal agencies as well as state, local, and tribal partners. Interoperability could be improved through Treasury's participation in and connectivity to the IWN.

Public safety interoperability is a complex issue and a key concern of government entities at all levels. Policy and regulatory changes, some of which were recently made, are needed to facilitate interoperability and sharing in emergency situations. Standardized equipment, such as that being developed for narrowband land mobile radios under Project 25, can facilitate interoperability. Other technological approaches also are under development which may have significant impact on public safety interoperability.

Recent experimental programs, such as the WARN system in the District of Columbia, have demonstrated how partnerships among Federal, state and local governments which share spectrum and infrastructure facilitate interoperable communications.[250]

HF SPECTRUM REQUIREMENTS

DHS expects a growing need for HF bandwidth for both fixed and mobile uses. The existing and future plans of several Federal agencies, as well as local and state first responders, echo this. Both Treasury and VA have initiated deployment of HF networks.

BROADBAND SPECTRUM REQUIREMENTS

As did state and local public safety agencies, some Federal agencies underscore the growing need for broadband wireless networks for emergency uses. Broadband data networks might be needed for DHS's internal functions as well as interoperability. Broadband data networks may be a topic for additional deliberation with NTIA. Recent developments in using broadband in public safety incidents suggest that Federal agencies with similar missions should use this technology. No Federal spectrum is identified or structured specifically for this use.

COMMUNICATIONS SATELLITE SPECTRUM REQUIREMENTS

Commercial satellite services can provide very useful emergency communications, especially when terrestrial infrastructure is impaired or destroyed. Transportable earth stations can create an instant infrastructure in emergency situations. Yet, satellite infrastructure takes a great deal of time and money to implement. There are also some inherent delays in voice or data transmissions, which can cause communications difficulties.[251]

Several agencies use satellite telephones as a primary communications method for areas with a non-existent terrestrial communications infrastructure. For example, the USDA, and especially the USDA's Forest Service, utilizes commercial satellite services to provide coverage in remote areas where a land mobile radio system available 100 percent of the time may not be feasible or cost-effective for their fire-fighting and other public safety missions. Use of commercial satellite systems, however, also may be costly, on a per minute basis, but may support mission-critical

---

[250] *Supra* note 19. *See*, *Spectrum Policy for the 21st Century – The President's Spectrum Policy Initiative: A Public Safety Sharing Demonstration*, U.S. Dep't. of Commerce, NTIA, (June 2007), http://www.ntia.doc.gov/reports/2007/NTIAWARNReport.htm.

[251] Federal Communications Commission, *Report to Congress On The Study To Assess Short-Term and Long-Term Needs for Allocations of Additional Portions of the Electromagnetic Spectrum for Federal, State and Local Emergency Response Providers Appendix C* (December 19, 2005) (FCC Appendix C), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-262865A1.pdf..

functions. In addition, the NSF uses satellite communications to provide medical and logistical public safety support to the U.S. Antarctica scientific bases.

Agencies also use satellite communications as backup communications in the event of degraded or destroyed terrestrial communications infrastructure. In particular, the VA procured 154 satellite telephones for emergency communications use after the terrorist attacks of September 11, 2001. The Coast Guard also uses satellite communications for search and rescue operations when other communications methods are unsuited for the task.

Commercial services help to fulfill a great deal of the agency satellite needs. For example, the Treasury sometimes uses commercial satellite telephones during enforcement and investigative activities, especially during joint operations for interoperability purposes. In addition, the Forest Service is deploying commercial satellite broadband technologies to assist with battling large fires.

In the aftermath of the September 11, 2001 attacks and Hurricane Katrina, satellite telephones played a vital role in public safety communications. Often they were the only available communications link. Satellites also provide programming distribution for telemedicine and associated emergency medical services, situational analysis imaging of disaster and emergency areas, meteorological and scientific analysis for emerging weather threats that may affect fire-fighting or homeland security interests, maritime communication (including search and rescue missions and other maritime law enforcement tasks), and asset tracking and navigation for emergency responders.

OTHER ISSUES RELATING TO PUBLIC SAFETY SPECTRUM USE

DHS may advocate for additional spectrum and adequate policy, rules, standards, and coordination to enhance interoperability at and between all government levels. DHS seeks more flexible rules permitting timely use of spectrum and common FCC/NTIA interoperability standards. Flexible channel plans would allow all public safety agencies to use Federal and non-Federal emergency frequencies without the need to undergo a lengthy approval process. DHS's goal is a seamless, nationwide public safety and incident response channeling plan spanning all public safety bands.

DOI would like to eliminate legacy regulations that impede innovations, including enhanced receiver standards that allow transmitters and receivers in separate networks to operate closer to each other, and allowing public safety local agency procurement of radio equipment through current contracts, enhancing the effectiveness of public safety joint interoperability operations.

Reform of the existing regulatory framework, including fostering an environment to allow improved spectrum sharing and interoperability between Federal and non-Federal activities, creating more flexible access rights as real-time requirements dictate, and ensuring the budget process allows for adequate funding for modernization directives could benefit DOJ.

NTIA and the IRAC have recently taken significant measures to address the need for non-Federal entities to use Federal public safety spectrum in appropriate situations. NTIA revised

Section 4.3.16 of the NTIA Manual to allow greater flexibility to non-Federal agencies to use the 162-174 MHz and 406.1-420 MHz bands for interagency law enforcement and incident response operations in coordination with Federal partners.

CONTINUITY OF GOVERNMENT/CONTINUITY OF OPERATIONS NEEDS

The 2004 Executive Memorandum directed the DHS in developing a Spectrum Needs Plan to consider "the continuity of government operations."[252] In addition, NTIA asked the Federal agencies to address these issues in their agency-specific plans.

COOP planning is the internal effort of government organizations to ensure that essential operations continue despite potential operational interruptions. COOP is a segment of Federal contingency planning that provides for Continuity of Government (COG), the continuance of our Constitutional government and the continuity of essential Federal functions.

CURRENT SPECTRUM USE AND FUTURE SPECTRUM REQUIREMENTS

As essential communications requirements of the Executive Branch are being formulated, certain minimum requisites have emerged, including priority treatment, secure communications, low traceability, restorability, interoperability, mobility, global coverage, survivability and durability, voice services, data services, scaleable bandwidth, affordability, mobility, and reliability and availability. The need for survivability and durability of emergency communications systems, as well as the need for HF and satellite frequencies, should be noted. There is also a need for spectrum managers to ensure that new commercial wireless technologies do not interfere with COG capabilities. Mobility of government functions (with interactive video) is expected to soon become a requirement for COG communications.

Identifying COG Spectrum Requirements

Uncertainty exists to whether there is enough spectrum allocated to support current and future COG requirements. Existing allocations will need to be continued, and new, expanded services will require more spectrum. The requirements for COG spectrum will greatly expand during catastrophic events, when interoperability is even more essential. The Continuity Communications Working Group (CCWG), an interagency working group within the NCS Committee of Principals (COP) should: (1) address the COOP and COG communications spectrum requirements; (2) analyze the adequacy of select Executive Branch agency and Department spectrum assignments against various disaster scenarios; (3) work closely with NTIA in developing a complete COG spectrum analysis for all Federal agencies and Departments supporting the COG mission; (4) address COG and COOP interoperability through the development of the continuity communications architecture; and (5) establish a formal process to test and demonstrate interoperability with both commercial and government-unique COG systems before large investments are made in hardware, systems and networks.

Current Federal studies of possible reallocation and assignment of Federal spectrum should consider the impact these changes could have on spectrum requirements for COG. The Federal spectrum management process must fully take COG spectrum issues into account. This

[252] *Supra* note 2, at 1. In Section 2(c), the President directed DHS "to address…continuity of Government operations."

recognition is meant to ensure that any new allocations allow for sustainable spectrum access in an emergency and are factored into a COG plan. The CCWG should coordinate its products and deliverables with the NTIA and submit spectrum requirements or needs biannually to NTIA.

COG Spectrum Documentation

Although most Federal agencies now have developed documentation for COG and COOP communications capability, there is no single repository within the Federal Government where such plans are available. In order to develop a single source of such documentation, the CCWG has recommended that: 1) the CCWG team visit and guide departments and agencies to complete the communications assessment and requirements portion of their COOP and COG plans; 2) the CCWG produce a single source document to be titled: *COG Spectrum Assignments for the Federal Government*; (3) develop another document for all other spectrum requirements of COOP supporting COG; and (4) urge Federal agencies to "exercise" the document in every COOP and COG exercise and verify spectrum resources. This would include validating the quality and responsiveness, limitations and responsiveness of services at each path or link, as well as evaluating the efficiency and effectiveness of dedicated resources and point-to-point connectivity.

Use of Commercial Spectrum-Based Systems

Commercial spectrum-based systems should be tested for effectiveness in support of COG, but it should be noted that commercial wireless systems can become saturated during a crisis. Moreover, commercial systems and networks generally are not designed to the high standards of reliability and redundancy that Federal emergency response systems require. Without a priority capability (such as the Wireless Priority Service), they would be of little value during a COG implementation. Other commercial systems, such as certain satellite services used during Hurricane Katrina, might be very useful.

Forward Looking Spectrum Use Issues

The NCS COP should identify and evaluate forward-looking issues regarding the use of spectrum for COG spectrum purposes. These issues include development of spectrum efficient technology, innovative spectrum sharing, interference solutions, interoperability, and international considerations.

SPECIFIC COG NEEDS

The Federal agencies have a number of common goals regarding COG and COOP. Many agencies want internal planning to ensure that spectrum needs and use are incorporated into internal COG and COOP plans. Wireless communications serve as an essential backup for COG, including land mobile, HF, microwave, and satellite communications for DOE. Many agencies also have a need to plan for interoperability between Federal agencies within and between Federal, state, and local levels of government in an emergency situation.

A number of Federal agencies have a need for HF radio communications for emergencies. Several agencies currently host or participate in shared spectrum initiatives for COG and COOP emergency purposes, especially in regard to HF spectrum use. In particular, a number of agencies utilize the NCS SHARES HF radio program, which provides a single, interagency emergency, message handling system, and the NTIA FedSMR, trunked, shared, radio service. The SHARES system links existing HF radio resources of Federal, state, and industry organizations when normal communications are unavailable. (SHARES and FedSMR are discussed in greater detail in the Mobile Service and Land Mobile Service section.)

Government agencies at all levels also recognize the importance of land mobile radio systems for COG and COOP.

SUMMARY OF COOP AND COG REQUIREMENTS

CURRENT SPECTRUM USE AND FUTURE SPECTRUM REQUIREMENTS

COOP and COG functions will utilize existing Federal agency infrastructure, systems, and frequency bands providing mobile (VHF and UHF), high frequency (HF), satellite, cellular and other wireless communications. In addition, systems specifically dedicated for COOP and COG will be deployed. Design and use of both existing and new systems will be based on the overall COOP and COG policies and procedures. Identifying and ensuring availability of systems, ensuring access to spectrum, testing equipment and systems, and minimizing potential interference to and from such systems also are critical elements of the telecommunications component of COOP and COG.

COG spectrum needs will utilize the frequency bands currently in use by Federal agencies as well other bands identified by the CCWG) under the NCS Committee of Principals. In addition to wireless infrastructure already in place, COOP and COG operations will utilize readily deployable mobile, fixed, satellite and broadband wireless systems which can be easily transported to and operated at emergency sites, often under extreme circumstances. COOP and COG plans also will evaluate the use of non-Federal systems, including state and local government as well as commercial systems, to complement the systems operating in Federal bands. With respect to the use of commercial systems, agencies will need to ensure that the systems provide the reliability and redundancy that Federal emergency response systems require. Interoperability with state, local and tribal entities, as well as with commercial systems, also will be taken into consideration in identifying and designing spectrum-supported systems for COOP and COG.

IP-based and other broadband systems as well as HF systems have been particularly noted as critical for COOP and COG, and for overall public safety operations on the Federal, state and local levels.

Use of Commercial Services

Most public safety entities, whether Federal or non-Federal, are not confident that commercial services are an effective solution for mission-critical public safety communications systems, including for COOP and COG, because such commercial systems may not meet the reliability, security and coverage requirements of the public safety entity. As discussed in the Public Safety section above, experimental programs, such as the WARN system in the District of Columbia, did not utilize commercial services because these services did not meet all of the District of Columbia's requirements for mission-critical systems.[253] However, Federal agencies are designing their COOP and COG programs to utilize both Federal and non-Federal systems to provide the redundancy and back-up to address the contingencies of emergency situations.

Ongoing dialogue between governmental entities and the private sector can address some of these concerns as well as provide a mechanism for testing the effectiveness of commercial services in support of public safety communications, including COG. Many Federal agencies already use commercial satellite communications to support their day-to-day operations as well as a backup in the case of a degraded or destroyed terrestrial infrastructure, such as in COG and COOP situations.

CONCLUSION

Some non-Federal public safety agencies already have long-range strategic spectrum plans, and increasingly, more are developing such long-range plans and public safety organizations provide support for development of such plans.

Federal agencies, as they develop their future internal strategic spectrum plans, are taking into account COG spectrum requirements.

[253] *Supra* note 19.

SECTION B-3

NEW TECHNOLOGIES, EXPANDED SERVICES, AND NEW SPECTRUM MANAGEMENT APPROACHES

INTRODUCTION

The Presidential Memorandum called on the agencies to include in their Strategic Spectrum Plans, "the planned uses of new technologies or expanded services requiring spectrum over a period of time agreed to by the selected agencies."[254] This section presents the planned uses of new technologies and expanded services expected to have an effect in the near term and future spectrum assignments, spectrum management methods, and spectrum use by the Federal agencies.

Many agencies' spectrum requirements will change as new technologies emerge that can satisfy increases in agency missions, their breadth and their demands. Research into technologies by agencies such as DOD can reduce future system spectrum requirements. One example is the use of connectionless low-duty cycle radio which may improve the energy per bit over 1000 times greater than conventional uses. Connectionless network service is one that transfers information between end users without establishing a logical connection or virtual circuit between those specific users. Connectionless networking dynamically adapts network time synchronization, routing, and energy strategy to achieve high performance at a fraction of the energy required. DOD seeks to capitalize on emerging technologies which will improve spectrum utilization, such as: bandwidth-efficient modulation and coding schemes, smart directional antennas, and data throughput increases built upon multipath technologies such as multiple-input-multiple-output (MIMO) technologies.

Specific information on the use of new technologies and services that will have an impact on near term and future spectrum utilization are discussed below.

EXPANDED USE OF BROADBAND WIRELESS TECHNOLOGIES

Federal agencies plan to expand communication services and applications using broadband wireless technologies. The DOD has future spectrum requirements for broadband mobile-on-the-move technologies using both terrestrial and satellite units. As previously discussed, DOD expects that its requirements beyond 2014 will be driven by a transition to wideband networks as a part of the GIG. This shift in technology mirrors the DOD's desire to shift from a manual spectrum management plan to an autonomous electromagnetic spectrum management regime. Beyond 2014, DOD's spectrum use will be driven by the transition to Wideband Network Waveform (WNW) wireless networks that contribute to DOD's Network Centric Warfare model. The WNW is a next-generation IP-based waveform designed to provide *ad hoc* mobile networking for military users. Through such new technology, DOD plans a Future Combat System (FCS) that can link ground, maritime, aeronautical and space operations with layered redundancy and constant connectivity. The FCS will use the WNW, the Soldier Radio

[254] *Supra* note 2, at Section 2(a).

Waveform, Network Data Link and Warfighter Information Network-Tactical systems, together with Intelligence Reconnaissance and Surveillance sensors to create a flexible wireless broadband battlefield network with increased connectivity and situational awareness.

Increased complexity in crime fighting necessitates higher data capacity requirements with increased demand for wider operating bandwidths and spectrum access in higher frequency bands. The demand for data networking and higher bandwidth transmission will also grow while costs fall. Electronic document interchange through wireless means will be expanded; wireless fax will also grow. DOI believes low bandwidth, low cost, high quality wireless video conferencing will accelerate and the use of spectrum sharing will make this cost-effective. DOE recognizes the recent developments in the public safety broadband applications, and that this technology might have a near-term impact on DOE's spectrum requirements. They will continue to evaluate the applicability of broadband wireless technologies to satisfying future agency missions.

The U.S. Mint is investigating the feasibility of moving to a completely wireless desktop environment in the future. The IRS has studied the feasibility of using wireless broadband for computer connectivity in the field to update technical operations software and equipment during undercover operations.

UNLICENSED BROADBAND WIRELESS COMMUNICATIONS SYSTEMS

Many agencies acknowledge increasing needs for unlicensed wireless broadband communications. However, not all system developers and agency spectrum managers understand that the use of this commercial unlicensed technology operating in some frequency bands comes without interference protection, because these systems operate without the protection of a spectrum license. Numerous agencies are alerting their organizations to this fact and will be advocating for a conversion of these unlicensed systems to licensed wireless broadband systems in the future for critical operational applications where interference cannot be tolerated.

DOI plans to continue its evolution from wired networks to unlicensed wireless equivalents, such as 802.11 based systems. WiFi and WiMAX will provide the ability to monitor patient health conditions in VA facilities as well as provide interactive voice and video. These services are in accordance with VA's broader telemedicine and telehealth missions. The NSF Antarctic Project will also expand the use of commercial wireless such as WiFi for safety of life and scientific applications. TVA uses unlicensed systems, *e.g.,* in the "last mile" component of the SCADA system used to monitor and control the TVA electrical power grid.

MULTIPLE-INPUT-MULTIPLE-OUTPUT (MIMO) TECHNOLOGY

MIMO is a multiplexing technique for increasing bandwidth and range that uses the multiple paths created by the reflection of radio signals off objects to transmit greater information. Instead of causing interference and fading, multi-paths are recombined in a MIMO system to increase spectral efficiency. The use of MIMO in various types of wireless networks, including those conforming to Institute of Electrical and Electronics Engineers, Inc. (IEEE) standard

802.11, is being evaluated. For example, an IEEE task group is considering incorporating MIMO as part of a new 802.11n standard. Moreover, the IEEE 802.16e standard for WiMAX can support MIMO.

ULTRA-WIDEBAND TECHNOLOGIES

DOE may need to upgrade systems for UWB for monitoring and resolving radiological incidents. However, interference avoidance techniques may need to be developed for UWB to allay user concerns. DOJ requires spectrum for UWB use for detection and tracking, and as well as for ground penetrating radar because of unique propagation and penetration characteristics.

Several agencies are also planning to use UWB ground penetrating radar. The VA's National Cemetery Administration, for example, implemented a pilot program using UWB ground penetrating radar together with GPS to locate and identify the cemetery plots of veterans. USDA uses UWB ground penetrating radars to study subsurface soil. DOT's Federal Highway Administration uses a relatively new form of ground penetrating radar, a step-frequency version which has the potential to improve accuracy, in its new Digital Highway Measurement Vehicle. This project has the potential to improve the way highways are maintained, and to provide critical data for highway and rail replacement decisions.

Wall-penetrating radar, a similar UWB technology, can "see" through walls to locate people and objects on the other side in hostage situations for law enforcement agencies and in rescue operations for fire and safety officials.

RADIO OVER INTERNET PROTOCOL (ROIP)

There is a general trend in wireless networks towards an IP-based system, where every node in the network has a specific IP address. USDA's Forest Service is testing Radio Over Internet Protocol (RoIP) to replace microwave links. VA is evaluating voice-over-IP, as well as other new technologies such as WiFi and RFID. The overall transition of all DOD wireless networks from IPv4 to IPv6, the "Next Generation" Internet protocol, is mandated by 2008. IPv6 is designed to run efficiently on high performance networks (*e.g.,* Gigabit Ethernet) as well as on low bandwidth wireless networks. In addition, it provides a platform for new Internet functionality that will be required in the near future. Two Treasury Bureaus will relocate from the 1710-1755 MHz band to higher bands, and replace the equipment with digital IP-based video surveillance systems.

EXPANDED USES OF 3-30 MHZ HF BANDS

DHS uses HF for command and control purposes especially during times of national emergency, and it believes that emerging HF applications will increase demand for new HF spectrum access. These include electronic messaging systems (e-mail), interactive Internet applications such as instant messaging and web browsing, large file transfer access, and digital voice. Increased utilization of HF SDR, based upon multilayer interfaces (in addition to the physical layer), will produce additional future HF spectrum requirements. DHS acknowledges that Federal agencies do not have sufficient HF spectrum to back up other communications systems for national security applications, and that Federal agencies will need more HF spectrum to meet increased national security related mission requirements, specifically the requirement for operation of HF ALE networks. ALE, a specialized radio modem or ALE adaptive controller, automatically establishes the best links between HF radio stations without manual intervention.

The SHARES program will require two additional channels in the 2-30 MHz band for COG, COOP, and interoperability purposes to avoid sunspot disruption. Treasury will require additional HF spectrum for its planned HF network, "TreasNet" that supports continuing operations during emergencies. BBG also projects a need for increased HF spectrum for DRM. Moreover, the Coast Guard and DOC indicate future HF spectrum needs for surface wave radar systems. The Coast Guard plan is to use such radars to detect ships at long distances, and the DOC will use the radars to collect sea data for meteorological purposes.

HF AERONAUTICAL APPLICATIONS

The FAA plans HF-long-range air to ground datalink communications in the oceanic and Alaskan airspace in the 2.85-22 MHz band. It is estimated that an additional 180 kHz of spectrum is necessary in this band associated with sixty new channels for a planned oceanic air-to-ground datalink.

UNMANNED AIR SYSTEMS (UAS) AND UNATTENDED GROUND SYSTEMS (UGS)

DOD expects a very substantial rise in the demand for unmanned / unattended systems. This will lead to increases in: 1) spectrum necessary to support the growing use of unmanned vehicles; 2) the amount of bandwidth needed to support the necessary data transfer; and 3) operation time caused by longer on-duty requirements. These demands will require increased attention to spectrum management schemes and scheduling that promote frequency sharing.

A typical Unmanned Air Systems (UAS) may require spectrum in as many as fourteen different frequency bands to achieve various functions like: launch and recovery, platform control, payload functionality, sensor data transfer, navigation, weapons functions, and communications relay. Technologies that increase onboard processing and compression of sensor data will assist in reducing the amount of bandwidth needed for airborne data links. A typical Unattended Ground Systems (UGS) mission requires spectrum in seven frequency bands. Without significant spectrum reuse and spectrum efficient technologies, unmanned systems will be severely constrained and may require highly refined scheduling plans.

Spectrum to support airborne data links will be the single largest contributor to increased demand for spectrum among unmanned systems. Data link rates and processor speeds are rapidly evolving to enhance future unmanned capabilities.

UAVs and tethered aerostats (balloon-borne radar) will require spectrum for land mobile, command and control, sensor telemetry, imaging, radar, and video applications. Coast Guard has contracted for the development and design of forty-five Bell Eagle Eyes (HV-911) Vertical Takeoff-and-Landing (VTOL) Unmanned Aerial Vehicles (VUAVs).

The USDA Forest Service is collaborating with NASA to test the use of UAV remote sensing applications for locating and mapping forest fires. Currently, the Forest Service uses manned airplanes with infrared sensing equipment to spot fires. Maps of these fires are then transmitted directly down to the fire fighters using a 900 MHz unlicensed link. NASA is helping to test the feasibility of carrying the airborne repeaters in unmanned vehicles by using a coordinated USDA frequency and equipment in the San Jose, California area where the tests are taking place.

Monitoring and deterring radiological incidents, in addition to the use of UWB discussed above, will require secure, LMR systems in the 162, 406, and 800 MHz bands capable of communicating with various public safety organizations.

NOAA has one autonomous underwater vehicle for collecting oceanographic data and matching the data to foraging areas of tracked marine mammals. NOAA may acquire several additional vehicles in the future.

The 960–1215 MHz band, currently allocated to aeronautical radionavigation, is needed by DOT for potential critical support applications, as well as for various future communications and surveillance applications.

FUTURE DEVELOPMENT AND USE OF "SMART" TECHNOLOGIES

Many agencies are supporting or plan to implement SDR technologies, which describe a new type of radio communications equipment that can automatically be reprogrammed to transmit and receive within a wide range of frequencies, using any stored transmission format. SDRs rely on embedded and programmable software for modifying and upgrading functionality and configuration. In addition, SDRs are capable of altering software based algorithms used for baseband signal processing of multiple waveform types, as well as intermediate frequency processing alternatives.

DOD is developing programmable radio products, specifically under the Joint Tactical Radio System (JTRS) program umbrella. The JTRS is a family of modular, multi-band, multi-mode radios that will provide the basis for advanced IP-based networked communication systems.

DOI is interested in deploying software-defined radio in the future, as an efficient way to adapt, update, and enhance a system via software upgrades. DOI encourages increasing collaborative efforts with Federal partners and the vendor community to use new technologies to increase interoperability. Because "smart" technologies can shift frequencies as needed, they have the potential to use higher frequency ranges, which are more susceptible to interference.

DOJ will pursue "smart" technologies to adaptively exploit available resources. It envisions a technical state where radio frequency systems are no longer band dependent, allowing the DOJ to expand operations.

COGNITIVE RADIO

Cognitive radio is another version of the smart radio. Cognitive radios are designed to be able to "perceive" and "know" the radio environment in which they are situated. The cognitive radio "senses" its environment, has the ability to track changes and react to those electro-magnetic environmental findings and adapt its operation accordingly. Cognitive radios can dynamically use whatever spectrum is available in a particular instant of time.

DARPA'S XG PROGRAM

The Defense Advanced Research Projects Agency (DARPA) has been proceeding for the past few years on a Next Generation (XG) program based on "policy-defined" smart radios that can dynamically access available spectrum. XG is designed to operate on a software-defined platform. Presently, DARPA, however, is testing these "smart" radios using WiMAX protocols and Application Specific Integrated Circuits (ASICs) to demonstrate the concept of an adaptable cognitive smart radio concept. In this manner, the radios used for the demonstrations are not limited by software, which can add complexity and lead to integration problems. What the XG program does require are "policies" or regulatory, military and technical rules that dictate how and when to avoid interference.

XG program goals are to develop both the enabling technologies and system concepts to dynamically redistribute allocated spectrum along with novel waveforms in order to provide dramatic improvements for military communications in support of a full range of worldwide deployments. U.S. forces face unique spectrum access issues in each country in which they operate, due to competing civilian or government users of national spectrum within these countries, as well as complex coordination issues with allies. The main objective of the XG program is to develop and demonstrate a set of standard dynamic spectrum adaptation technologies for legacy and future emitter systems for joint service utility.

NEXT GENERATION RADIO ASTRONOMY SERVICES AND TERAHERTZ TECHNOLOGIES

NSF believes that new allocations in the 275 GHz to 1 THz region may be needed within a decade for radio astronomy and other science services. With respect to these higher frequency bands, NSF will likely use spectrum in the 275-2400 GHz range for radio astronomy research. The terahertz region of the spectrum lies between light and radio wave frequencies. Terahertz frequencies between 300 GHz and 3 THz are classified as mmw with wavelengths between sub millimeter (<1 millimeter) and 100 micrometers (ending edge of far-infrared light). Astronomers have begun to use millimeter waves to study galaxy and star formation.

NSF and multinational partners are building the ALMA in the Chilean Andes. This project will observe regions of the universe which are optically dark, yet shine in the millimeter portion of the electromagnetic spectrum. ALMA will image stars and planets in gas clouds near the sun and observe galaxies as they form at the edge of the universe, which we see roughly as they were ten billion years ago. The Atacama Cosmology Telescope began studying cosmic microwave radiation in Chile at the end of 2006 using the first sub-millimeter wave "CCD" (Charge-Couple

Device) detector, or chip, which registers light and transforms it into digital code, to help produce digital images. It operates in bands just beneath 275 GHz, at 145, 255, and 265 GHz.

NSF also has plans for a large millimeter telescope in Mexico designed for frequencies between 85 and 350 GHz. Construction is expected to be completed in 2007. At the South Pole, the NSF is constructing a new telescope, to be deployed by the start of 2007, capable of observations up to about 1.5 THz. The telescope would measure anisotropies (or changes in the temperature of the cosmic microwave background radiation that vary with direction) associated with the "Big Bang" theory.

Some scientific institutions, including the Rensselaer Polytechnic Institute and the Johns Hopkins Applied Physics Lab are researching the uses of "T-rays" in the terahertz range above 1000 GHz. These waves may supplant x-rays in 3-D medical imaging or allow detection of contaminants in incoming mail.

SECTION B-4

SUMMARIES OF AGENCY-SPECIFIC STRATEGIC SPECTRUM PLANS

This section of Appendix B presents summaries of the agency-specific strategic spectrum plans submitted to NTIA. Some of the plans and the summaries were supplemented by additional information provided by the agencies and/or by information obtained from other sources.

BROADCASTING BOARD OF GOVERNORS

AGENCY MISSION

The mission of the BBG is to ensure and safeguard the integrity, quality, and effectiveness of U.S. international broadcasters, and to promote and sustain freedom and democracy by broadcasting accurate and objective news and information about the United States and the world to overseas audiences. U.S. Federal Government international broadcasting promotes the open communication of information and ideas in support of democracy, and the freedom to seek, receive, and impart information worldwide. BBG supports broadcasts to more than 125 nations and areas in over sixty languages.

The shortwave spectrum in the 3-30 MHz HF bands is vitally important to the BBG to continue its mission. Thus international cooperation is needed to ensure that ITU allocations, regulations, and guidelines minimize interference and keep background noise environment low to ensure sustainability of the radio delivery media.

BBG SPECTRUM USE AND REQUIREMENTS

The BBG operates at four sites in the United States: (1) its studio and office headquarters in Washington, DC; (2) a VOA HF high power transmitter in Delano, California; (3) VOA HF high power transmitter in Greenville, North Carolina and (4) the Radio and TV Martí sites in Marathon and Cudjoe Key, FL. Except for TV Martí, the use of frequencies at the United States locations is authorized by NTIA. BBG operations at overseas sites do not fall under NTIA regulatory authority, but are subject to licensing authorization and other arrangements with host nations and other relevant authorities. The two BBG entities with frequency assignments and operations within the United States are the VOA and the Office of Cuba Broadcasting.

THE VOICE OF AMERICA SPECTRUM USE AND REQUIREMENTS

From United States and foreign facilities, the VOA broadcasts each week to an estimated worldwide audience of ninety-four million people. VOA programming is carried on shortwave, satellite, medium wave in the standard AM broadcasting band, and FM. These broadcasts are transmitted from the IBB stations and leased facilities around the world, and are rebroadcast through a global network of more than 1,300 affiliate stations. VOA's more than 1,000 hours of weekly programming also is available on the Internet and through satellite-delivered television. Television offerings include more than twenty hours weekly of original programs.

VOA HF broadcasting operations are at the Greenville and Delano sites, using the HF bands allocated to broadcasting within the 5-26.1 MHz part of the spectrum. The large number of assignments is necessary to assure reliable broadcasting service via ionospheric reflection propagation modes at all times during the eleven-year sun spot cycle; and during various months and at various times of the day. Transmitter powers as high as 500 kW are used, together with highly directional antennas.

THE OFFICE OF CUBA BROADCASTING SPECTRUM USE AND REQUIREMENTS

The Office of Cuba Broadcasting directs the operations of Radio and TV Martí, the broadcast services that provide Spanish-language news, features, and entertainment programs to Cuba from Marathon and Cudjoe Key, Florida. Radio Martí broadcasts seven days a week, twenty-four hours a day, on medium wave at 1180 kHz and shortwave in the HF bands from Greenville, North Carolina. TV Martí broadcasts from Cudjoe Key, Florida using an aerostat transmitter operating on TV channels 18, 50, and 64, twenty-four hours a day, including newscasts as well as public affairs, culture, music, sports, and entertainment programs. The commentary and information broadcast by the stations promote the free flow of information and ideas in Cuba. NTIA authorized Radio Martí on 1180 kHz, while the FCC licensed TV Martí in accordance with the Television Broadcasting to Cuba Act.[255]

BBG FUTURE SPECTRUM REQUIREMENTS

The future HF broadcasting needs are difficult to predict as they depend on the current political environment of a given geographical area. The BBG participates in the High Frequency Coordination Conference (HFCC), a multi-nation international organization that has analyzed the HF broadcasting spectrum and concluded that approximately 850 kHz of additional spectrum allocated to broadcasting is required between 4 and 10 MHz to alleviate the co-channel interference issues that currently exist. The United States will not pursue this issue during the upcoming WRC-07 as other Federal agencies have conflicting requirements. Current shortwave spectrum is vitally important to the BBG to continue its mission.

OTHER BBG SPECTRUM USAGE

The BBG uses land mobile communications in the 162-174 MHz and 406.1-420 MHz bands for security and maintenance personnel at its Washington, DC headquarters and Greenville, NC and Delano, CA locations. Remote broadcasting-to-studio links are used operating with 50 watts in the 902-928 MHz band; and low power, 0.10-0.50 watts. Wireless microphones are used at the studios which also operate in the 902-928 MHz band. The TV Marti aerostat uses a 1432 MHz uplink and a 2205 MHz downlink; and commercial satellites at 3700-4200 MHz (space-to-Earth) and 5925-6425 MHz (Earth-to-space) are used for distributing audio and video programming from the studio headquarters to the transmitting sites.

---

[255] S*upra* note 187.

NEW TECHNOLOGIES

The BBG's IBB has tested digital shortwave broadcasting, *i.e.*, DRM. The BBG is waiting for lower-cost digital receivers to become a realistic option for listeners within appropriate target areas before significant investments are made in this technology. The impact of DRM on spectrum requirements is unknown, but if it becomes popular, the demand for additional HF spectrum will increase.

DEPARTMENT OF AGRICULTURE

AGENCY MISSION

The USDA overall mission is improving and maintaining the agricultural viability of the nation, including the development and expansion of international markets for agricultural products; implementation of rural development projects; oversight of credit and conservation programs; and conducting agricultural research on crop production. The USDA, through the Forest Service and the Natural Resources Conservation Service (NRCS), protects the nation's soil, water, forests, and natural resources. The USDA also safeguards and ensures quality standards of the nation's foods.

There are nine USDA primary missions and major administrative offices that are supported by spectrum dependent systems. Their specific missions and uses of spectrum are summarized below.

USDA SPECTRUM USE AND REQUIREMENTS

FOREST SERVICE

The Forest Service mission is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations. Established in 1905, the Forest Service is a Federal agency that manages public lands in national forests and grasslands. The Forest Service is also the largest forestry research organization in the world, and provides technical and financial assistance to state and private forestry agencies.

In support of its mission, the Forest Service accounts for more than eighty-five percent of the USDA radiocommunications use and ninety percent of the spectrum use. The Forest Service's radio requirements and use are primarily for conventional land mobile radio systems. These requirements have been concentrated mainly in three bands: 162-174 MHz, 406.1-420 MHz, and 1710-1850 MHz. However, the Forest Service is vacating the 1710-1755 MHz band which was reallocated for non-Federal use and auctioned for advanced wireless services. The Forest Service has a small but growing requirement in the 30-50 MHz band. The Forest Service has more than 70,000 radios supporting its varied missions. More than 60,000 radios: repeater stations, base stations, mobiles, and portables operate in the 162-174 MHz band. These systems also support communications with the approximate 800 contracted and owned aircraft flying between 50,000 and 100,000 hours each year. The current inventory of Forest Service radio equipment includes 47,391 portable radios, 21,193 mobile radios, 2,378 repeaters, 617 cross band base stations, 717 licensed and unlicensed Part 15 microwave terminals, and 865 radios of other types, for an agency total of 75,630.

The Forest Service's activities include wildfire firefighting, law enforcement, search and rescue, and daily administrative and operational use supporting management of 140 million acres of public land. The critical functions of wild land fire fighting and law enforcement are highly dependent on radio technology.

Many other programs within the Forest Service depend upon radio technology. These include engineering, timber, recreation, and wildlife management. Radio technology supports remote weather stations which monitor snow pillows, stream flow, and wildlife tracking. Many of these activities utilize the GPS as well. Land-mobile networks are shared between the Forest Service and other Federal, state and local agencies with common missions. The Forest Service shares spectrum, infrastructure and other resources through the National Interagency Fire Center (NIFC) in Boise, Idaho where the Forest Service maintains a cache of emergency fire-fighting supplies, including land mobile radios used during emergencies wherever they are needed.

Recreation management requires radio communications to coordinate support for over 330 million visitor days per year involving 5,885 campgrounds, 328 swimming developments, 1,222 boating sites, 250 winter sports sites, 124,600 miles of rivers, and 369,000 miles of roads. Law enforcement communications support investigation and enforcement of wild land arson, archeological theft, timber theft, illegal drug activities, and access and control of wildfire areas. Incident support communications are used in disasters such as wildfires, earthquakes, hurricanes, volcanic eruptions, oil spills, and nuclear disasters.

Aviation communications coordinates aircraft operations for fire management and suppression. The aircraft operations include a dedicated fleet of forty-two fixed wing (air tankers, lead planes, air attack, smokejumper, and infrared scan), and one rotary-wing aircraft. The Forest Services also utilizes a contracted fleet of thirty-nine fixed wing aircraft (air tankers, air attack, and smokejumper) and 505 rotary wing aircraft. Most of these aircraft are used in support of wild land firefighting; however, some also transport personnel and equipment to support other incidents.

NATURAL RESOURCES CONSERVATION SERVICE

The Natural Resources Conservation Service (NRCS), originally the Soil Conservation Service, has operated since 1935 to provide leadership in a partnership effort to help America's private landowners and managers conserve their soil, water, and other natural resources. The NRCS carries out a variety of missions and programs requiring the use of the Federal Government radio spectrum. Some of these uses are snow survey and water supply forecasting, Farm Bill implementation, national resources inventory work, engineering, cultural resource identification, and personnel safety.

The NRCS radio system consists of operations in several frequency bands: 40.530 MHz and 41.530 MHz; 162-174 MHz; and 406.1-420 MHz. The Snow Survey and Water Supply Forecasting program utilizes 40.530 MHz and 41.530 MHz to operate the SNOTEL (SNOwpack TELemetry) system. These critical operations use meteor burst communication technology, and the SNOTEL system is a USDA mission critical system used to support the NWS flood-forecasting mission with hourly data, vital to developing projections of spring and summer stream flows and availability of water supplies.

The Soil Climate Analysis Network (SCAN) provides essential soil-climate information, which supports drought monitoring and mitigation, irrigation water management, fire-risk assessment, and disease and pest outbreak mitigation.

ANIMAL AND PLANT HEALTH INSPECTION SERVICE

The broad Animal and Plant Health Inspection Service (APHIS) mission is to protect the health and value of American agriculture and natural resources. The APHIS protects and promotes agricultural health by administering the Animal Welfare Act and carrying out wildlife damage management activities. APHIS communications support over 2,000 personnel across the country involved in wildlife disease monitoring, protecting citizens from wildlife related incidents such as mountain lion attacks, responding to citizen requests to control wildlife damage, overseeing field personnel, protecting personnel, and controlling or eradicating insect infestation.

APHIS uses land mobile radio for natural resources activities such as predator control, eradication, inspection, and administration. It uses telemetry for trapping, monitoring and eradication of feral ungulates. APHIS also uses satellite for voice, limited data and some additional telemetry for the monitoring of eagle projects. The use of land mobile radio communications provides reliable communications to support a multitude of operational mission functions. These systems are used throughout the continental U.S., U.S. properties and overseas. International operations are normally conducted through U.S. Embassies that help manage frequency use. The main radio users in APHIS are the Investigative and Enforcement Service (IES), Plant Protection and Quarantine (PPQ), Veterinary Services (VS), Wildlife Services (WS), and Marketing and Regulatory Program business services. The APHIS radio inventory includes 187 fixed repeaters, three transportable repeaters, 200 base stations, 2137 mobiles, and 1360 portables.

AGRICULTURAL RESEARCH SERVICE

The Agricultural Research Service (ARS) is USDA's principal in-house research agency leading the nation in agricultural research and providing agricultural information. The ARS mission is to conduct research to develop and disseminate solutions to agricultural problems of high national priority and provide information to:

1. ensure high-quality, safe food, and other agricultural products;
2. assess the nutritional needs of Americans;
3. sustain a competitive agricultural economy;
4. enhance the natural resource base and the environment; and
5. provide economic opportunities for rural citizens, communities, and society as a whole.

The ARS radio communications program consists predominantly of mobile and fixed radio equipment used at ARS research facilities throughout the country, which conduct farm and agricultural research and scientific exploration. ARS uses the 162-174 MHz and 406.1-420 MHz bands for voice communications, hydrologic systems on farms, well and piping systems, telemetry systems for research data collection, control and security, aerial applications, facility maintenance and operations, GPS telemetry, irrigation system control, data collection, weather systems, personnel safety and administration.

USDA Administration

The mission of the USDA Administration (DA) is to provide management and leadership to ensure that USDA administrative programs, policies, advice and counsel meet the needs of USDA program organizations, consistent with laws and mandates; and provide safe and efficient facilities and services to customers. USDA Administration provides central administrative management support to Department officials and coordinates administrative programs and services.

The DA uses nine frequencies for a campus-wide radio network to support maintenance and facilities operations such as campus guard communications and to support on-campus emergencies using a common command channel. The system is located solely in the National Capital Region and is supported by two to three repeaters. Agency administrators, emergency responders, and wardens can use the system in the event of a major incident or disaster.

Farm Services Agency

The Farm Services Agency (FSA) is a customer-driven agency dedicated to achieving an economically and environmentally sound future for American agriculture. FSA aids farmers and ranchers through its efforts to conserve resources, and provide credit and relief from disaster effects.

The FSA uses fixed radio telemetry systems to control of spray irrigation and water treatment facilities from remote locations. The system also transmits climatic data to the spray systems, which are operable under specific weather parameters.

Food Safety and Inspection Service (FSIS)

The Food Safety and Inspection Service (FSIS) is the public health agency in the USDA responsible for ensuring that the nation's commercial supply of meat, poultry, and egg products is safe, wholesome, and correctly labeled and packaged. It operates a small transportable land mobile radio system in the 162-174 MHz and the 406.1-420 MHz bands to support nationwide surveillance and investigation communications. This system uses fourteen portables, four mobiles, and two mobile repeaters that are transported to investigation and surveillance sites. The system is predominantly a simplex, mobile-to-mobile operation with limited repeaters.

Grain Inspection, Packers And Stockyards Administration

The mission of the Grain Inspection, Packers, and Stockyard Administration (GIPSA) is to facilitate the marketing of livestock, poultry, meat, cereals, oilseeds, and related agricultural products, and promotes fair and competitive trading practices for the overall benefit of consumers and American agriculture. It operates a land mobile communications system used for communication and safety for employees whose daily activities include working in grain elevators or on associated waterways.

OFFICE OF THE INSPECTOR GENERAL SPECTRUM USE AND REQUIREMENTS

The mission of the Office of the Inspector General (OIG) is to conduct audits and investigations; provide leadership and coordination to promote economy, efficiency, and effectiveness; and to prevent fraud, waste, and abuse in USDA's programs and operations. The OIG uses off-the-shelf land mobile radios for a nationwide radio system to support its operations.

SUMMARY OF USDA CURRENT SPECTRUM REQUIREMENTS

USDA operational requirements for Federal radio spectrum have remained fairly stable over the past ten years. These radio requirements primarily involve conventional land mobile radio systems and are concentrated in the: 162-174 MHz, 406.1-420 MHz, and 1710-1850 MHz (recognizing that the 1710-1755 MHz band will not be available for Federal use after January, 2009). There is also a small but growing requirement in the 30-50 MHz band.

The two largest users of spectrum at USDA are the Forest Service and the APHIS, which account for ninety-two percent of the frequencies assigned. Their programs have traditionally dominated radio and spectrum requirements within the USDA. However, other agencies and staff offices have demonstrated a critical need for the use of radio spectrum to conduct business associated with critical infrastructure applications. The Forest Service is currently upgrading its existing analog narrowband system to a much broader standards-based digital radio system to be shared by other state, local and Federal agencies, thereby improving interoperability.

USDA FUTURE SPECTRUM REQUIREMENTS

The following additional spectrum requirements have been identified:

1. Spectrum in the 162-174 MHz and 406.1-420 MHz band to accommodate system design changes when the department converts to digital narrowband technology. The current system networks do not account for all of the repeaters required for use of digital systems in low signal strength areas.
2. Additional spectrum may be required to support microwave systems displaced out of the 1710-1755 MHz band being transferred to the FCC for auction for commercial advanced wireless services.
3. Firefighting and aviation missions may require additional dedicated nationwide wideband spectrum to support aircraft downlinks to map fires using real-time infrared technologies and video.
4. Additional incident command frequencies may be needed to support large-scale incidents.
5. Growing requirements for commercial spectrum to support NRCS satellite imagery and existing wireless applications as programs areas expand their geographic footprints. In particular, the SCAN will need additional frequency assignments on 40.530 and 41.530 MHz throughout the United States and its possessions when it becomes a fully funded program.

USDA USE OF NEW TECHNOLOGIES

In the future OIG will likely join the DHS/DOJ/Treasury nationwide IWN system, in addition to phasing over to narrowbanded land mobile systems supporting the Project 25 encryption standard.

USDA USE OF SPECTRUM FOR FEDERAL COG, INTEROPERABILITY AND PUBLIC SAFETY

The USDA Forest Service regularly performs joint operations with state and local public safety agencies under its firefighting and emergency response missions, and maintains cooperative agreements for mutual aid. Under the National Response Plan (NRP), the Forest Service is the primary agency for Emergency Support Function #4 - Firefighting. Under this function, the Forest Service manages and coordinates firefighting activities, including the detection and suppression of fires on Federal lands, and provides personnel, equipment, and supplies in support of state, local, and tribal agencies involved in rural and urban fire fighting operations. In many cases, through co-operative agreements, the Forest Service also shares its communications assets with state and local agencies for activities such as search and rescue or providing emergency medical aid when that agency has no communications in the area.

USDA's Continuity of Operations Division is located within the DA's Office of Procurement and Property Management. All COOP sites have one or two non-encrypted satellite phones. The USDA Crisis Planning Division within DA supports COOP activities with a Crisis Action Team (CAT) and National Emergency Management Team. Up to eighty Wireless Priority Service (WPS) cellular telephones have been assigned to team members.

Furthermore, the COOP program participates as a Federal partner in the HF SHARES Program operated by the National Communications System. USDA also collaborates with FEMA to use the FEMA National Radio Network on a limited basis for emergency communications with other Federal agencies.

DEPARTMENT OF COMMERCE

AGENCY MISSION

The historic mission of the DOC is to foster, promote, and develop the foreign and domestic commerce of the United States. This has evolved, as a result of legislative and administrative actions, to encompass broadly the responsibility to foster, serve, and promote the nation's economic development and technological advancement.

The DOC has a number of offices, bureaus, and units, each with its own unique mission within the broad DOC mission. The missions of these entities are described below.

DOC SPECTRUM REQUIREMENTS

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

The mission of the National Oceanic and Atmospheric Administration (NOAA) is to understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet the nation's economic, social and environmental needs. NOAA is DOC's largest spectrum user. It utilizes the radiofrequency spectrum to support its operation of: meteorological aids; meteorological satellites; ocean-going ships; observation and hurricane reconnaissance aircraft; fish telemetry systems; and other systems to fulfill its mission.

NOAA has line offices that conduct its mission: 1) NWS; 2) NESDIS); 3) Oceanic and Atmospheric Research (OAR); 4) National Ocean Service (NOS); and 5) the National Marine Fisheries Service (NMFS). NOAA also operates the emergency-locating SARSAT system.

NOAA requires radio spectrum to observe and monitor the Earth and investigate and interpret how natural systems work together. There are no suitable replacements for radars and satellite-borne sensors. The raw data collected by the observing systems could not be transmitted to the modeling, analysis, and archiving centers without the necessary radio telemetry and satellite communications links. Furthermore, NOAA's products could not be provided to customers and the general public without the use of radio-based dissemination systems such as NOAA Weather Radio and the GOES downlinks that are used by radio and television stations to inform the public about weather conditions.

NOAA operates two types of meteorological satellites: 1) the GOES system, with four operational satellites and 2) six POES. The GOES and POES are critical to U.S. weather forecasting. The two main frequency bands used to uplink weather and hydrological information from data collection platforms are 137-138 MHz and 401-403 MHz. The 468.75-468.95 MHz band is used for satellite interrogation of the data collection platforms. For current and future data transmissions from space-to-Earth, the bands 1670-1710 MHz, 2200-2290 MHz, 7750-7850 MHz, 8025-8400 MHz, 18.1-18.3 GHz and 25.5-27.0 GHz are or will be used. The 2025-2110 MHz band is used for spacecraft command uplinks.

The NOAA SARSAT system is onboard the NOAA meteorological satellites, and it uses signals from EPIRBs to locate the position of people or ships in distress. The EPIRBs transmit to the SARSAT in the 121.45-121.55 MHz, 242.95-243.05 MHz, and 406.0-406.1 MHz bands.

NOAA operates a variety of ground-based and airborne meteorological radars with the WSR-88D NEXRAD being the main system at 127 locations in the continental United States. NOAA also operates meteorological research radars on the frequencies near 5650 MHz and 9.4 GHz. The 9.4 GHz band is being considered as a gap-filler to supplement the NEXRAD radars. NOAA operates wind profiler radars, whose operating frequency is being moved to 449 MHz; and it is considering new wind profiler radars operating in the 902-928 MHz band.

NOAA operates radiosondes and dropsondes, sensor packages that are lifted through the atmosphere via a balloon, or for dropsondes, dropped from aircraft. The systems operate in the 400.15-406.0 MHz band and the1668.4-1700 MHz band, with most operations in the 1675-1683 MHz band. NOAA operates 313 systems of the ASOS to provide weather information to airport control towers and pilots. The ASOS operates on frequencies in the 406.1-420 MHz band, with NOAA authorized to operate the link between the sensor link and the platform. The FAA is authorized to rebroadcast the weather information gathered by these systems to pilots in the 117.975-137 MHz aeronautical mobile band.

NOAA operates extensive hydrological networks called the Automated Local Evaluation in Real Time (ALERT). NTIA and the FCC have made special provisions with local communities to collect hydrologic data for flood and flash flood warnings, and share their information with NOAA. NOAA uses meteor burst technology to collect data from remote locations in Alaska. Two 16 kHz wide channels are used in the 40-42 MHz band for this function.

NOAA operates extensive wildlife and fish tracking systems, including tracking of marine mammals, salmon, and other fish. These tracking systems use 40 transmitters in the 164-165 MHz band for marine mammals; 57 transmitters at 401.650 MHz for marine mammal tracking; 100 transmitters at 30.05-30.25 MHz for fish tracking; 20 listening sites on 458.54 MHz for tracking salmon; and 20 systems operating on 134.2 MHz for salmon tracking. More operations will be conducted on these frequencies in the future.

In addition to supporting the NOAA mission, the spectrum requirements of NOAA are important for the continued development of the U.S. Integrated Earth Observation System (IEOS)[256] and the Global Earth Observation System of Systems (GEOSS). On February 16, 2005, the United States and 54 other countries endorsed a ten-year plan to develop and implement GEOSS. Development of IEOS, the U.S. contribution to GEOSS, which is being coordinated by the National Science and Technology Council's Committee on Environment and Natural Resources subcommittee on Earth Observations, will meet the Nation's need for high-quality, global, sustained information on the state of the Earth as a basis for policy and decision-making.

---

[256] The Strategic Plan for the United States Integrated Earth Observation System (IEOS) can be obtained at http://usgeo.gov/draftstrategicplan/IEOS_draft_strategic_plan_111004.pdf.

NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

In performing spectrum research, policy development, and regulating government spectrum use, the National Telecommunications and Information (NTIA) requires access to radio spectrum to perform its mission of evaluating and promoting telecommunications technology. Within NTIA, the Institute for Telecommunication Sciences (ITS) is a Federal laboratory providing telecommunications and information technology (IT) research and applied engineering in support of NTIA policy-making. The ITS conducts equipment testing and experiments, and the frequencies used depend on the equipment and activity and are usually not used over the long term. NTIA also utilizes spectrum in the 162-174 MHz band for a shared trunked land mobile systems, FedSMR, operated by a private contractor.

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

Many of the spectrum requirements for the National Institute of Standards and Technology (NIST) are limited to laboratory environments where intentionally radiated signals do not occur, and are not covered in this plan. NIST conducts research into electromagnetics such as fundamental microwave quantities; high-speed microelectronics; electromagnetic compatibility; antennas; electromagnetic properties of materials; and advanced measurement methods and standards for the magnetic data storage and superconductor power industries. While spectrum requirements are small for NIST, access to spectrum to transfer measurement standards is critical for NIST's operations.

NIST also operates transmitters that broadcast standard time and frequency signals, geophysical alerts, marine storm warnings, and GPS status reports at stations WWV and WWVB at Fort Collins, Colorado; and WWVH on the island of Kauai, Hawaii. WWV operates in the HF portion of the radio spectrum, transmitting 10,000 watts on 5, 10, and 15 MHz; and 2500 watts on 2.5 and 20 MHz. WWVH transmits 10,000 watts on 5, 10, and 15 MHz, and 5,000 watts on 2.5 MHz. Each frequency is broadcast from a separate transmitter. Although each frequency carries the same information, multiple frequencies are used because the quality of HF reception depends on many factors.

NIST radio station WWVB is located on the same site as WWV near Fort Collins, Colorado. The WWVB broadcasts on 60 kHz are used by millions of people throughout North America to synchronize consumer electronic products such as wall clocks, clock radios, and wristwatches. In addition, WWVB is used for high level applications such as network time synchronization and frequency calibrations.

DOC USES OF THE 162-174 MHZ AND 406.1-420 MHZ BANDS

The largest numbers of the DOC frequency assignments are in the 162-174 MHz and 406.1-420 MHz land mobile communications bands. These assignments are used for NOAA public all-hazards warnings; NOAA meteorological and hydrological observations; NOAA fish tracking telemetry; NOAA tide levels measurement; all DOC units for research support communications; and all DOC units for law enforcement. Furthermore, of these assignments, NOAA estimates that 2,000 sensing transmitters operate in the 162-174 MHz band; and 200 in the 406.1-420 MHz band.

The 406.1-420 MHz band is used for digital trunked land mobile communications operations by the Federal Radio Service Corporation (FedSMR) under contract to NTIA. The frequencies are assigned for operation in five urban areas in the east coast. The purpose of FedSMR is to provide spectrum-efficient trunked radio communications to a number of Federal users that can benefit from multiple talk groups and other features. The number of subscribers is growing, with the number doubling from 2002 to 2004. In Washington, DC, the main users are the Smithsonian Institution, the National Archives, the National Zoo and the United States Holocaust Memorial.

The DOC anticipates FedSMR growth will be 20 percent per year for at least the next five years, requiring about three additional channels per year. The FedSMR contractor is working with an equipment manufacturer to develop a digital system operating on 6.25 kHz channels.

DOC FUTURE SPECTRUM REQUIREMENTS

Future requirements include additional spectrum for meteorological satellite data transmission, satellite passive sensing, meteorological radars, telemetry links for control and programming of autonomous vehicles, and wildlife, marine life and fish tracking.

The most significant of the other future requirements are presented below.

NEXT GENERATION METEOROLOGICAL SATELLITES

NOAA is developing the next generation GOES satellites called the GOES-R that will include improved spacecraft and instrument technologies. This will result in more timely and accurate weather forecasts and improve detection and observations of meteorological phenomena that directly affect public safety, protection of property, and ultimately, economic health and development. The advanced technologies currently planned for GOES-R will also provide new coastal and lightning mapping capabilities. The first launch of a GOES-R series satellite is scheduled for 2012.

The GOES-R series will have significantly higher data rates than the current GOES satellites to transmit data from its atmospheric imager and sounder sensors. The current GOES imager and sounder data rates are 2.6 Mbps for the raw downlink and 2.1 Mbps for the global processed data. These data rates are comfortably handled by the existing allocation. However, for the GOES-R, NOAA/NESDIS will seek to support the significantly higher GOES-R data rates in the existing frequency assignments using higher order modulations and other technologies.

NOAA also is planning a next generation of polar satellites, called the NPOESS. Future polar satellites will require additional spectrum at 460-470 MHz; 7750-7850 MHz; 8025-8400 MHz; and 25.5-27.0 GHz.

MAJOR NEW SPECTRUM REQUIREMENTS IN THE 162-174 MHZ BAND

The NERON is a new program to install automated climate and weather observing stations every 400 square miles across the nation. Each station records air temperature and precipitation accumulation every five minutes and reports that information every 15 to 60 minutes via the 162-174 MHz band. This program is the only national climate networks in the world producing observations every five minutes and making them available in real time.

ANIMAL AND WILDLIFE TRACKING IN THE 162-174 MHZ AND 406.1-420 MHZ BANDS

A substantial increase in the use of the land mobile 162-174 MHz and the satellite 406.1-420 MHz bands for animal and fish tracking is forecasted.

ALL HAZARDS RADIO WARNINGS VIA COMMERCIAL SATELLITES

NOAA has a major future requirement for the use of commercial satellites in the 3700-4200 MHz and 5925-6425 MHz bands to send all-hazards warning messages to their NWS sites which broadcasts the messages to the public. This may require the deployment of up to 800 Earth stations.

NOAA USE OF NEW TECHNOLOGIES AND FUTURE SPECTRUM NEEDS

In coordination with the agencies supporting the IEOS Strategic Plan, NOAA will continue to identify new passive sensing bands above 275 GHz. This will allow the International Table of Frequency Allocations to be updated with new passive sensing allocations at frequencies above 275 GHz.

NOAA will continue its investigation of spectrum-efficient techniques for use in transmission of MetSat data. More efficient modulation schemes will allow NOAA to transit more data within limited spectrum. In conjunction with use of more efficient modulation techniques, NOAA supports the WRC-07 Agenda Item 1.2 for identifying additional meteorological satellite spectrum near 18 GHz.

NOAA also supports WRC-07 Agenda Item 1.3, seeking the upgrade of the radiolocation service to primary status in the International Table of Frequency Allocations. The radiolocation allocation upgrade will allow future operational meteorological gap filler radars to be operated on an equal status with other radars in the 9300-9500 MHz band.

NOAA will develop a better understanding of the technology and associated spectrum requirements for wildlife and fish tracking, and telemetry to autonomous vehicles in the future. New frequency allocations and assignments may be needed to address these operations.

NOAA will continue work to identify bands in the 18 to 24 GHz range and 27 to 40 GHz range for operation of meteorological radars in support of atmospheric research.

SPECTRUM EFFICIENCY IMPROVEMENTS

DOC strives to implement spectrum efficiency where it is cost effective and consistent with the DOC mission requirements. Some measures implemented by DOC include the use of commercial services, sharing spectrum with commercial services and other Federal agencies, and the use of more efficient modulation techniques and technologies.

COMMERCIAL SERVICES

DOC uses commercial telecommunication services in cases where the services fully support mission requirements and provide a cost-effective telecommunications solution. Commercial cell phone service and associated data services are used within DOC, reducing the government's reliance on Federal land mobile spectrum. However, the commercial services cannot be used for requirements where operations during disasters or emergencies must be assured, or simultaneous transmission to multiple users is needed.

DOC uses commercial FSS services to provide data connectivity between facilities and to end-users because such service offers a more cost effective solution for data circuits than can be achieved by dedicated Federal Government satellite systems. DOC also has future requirements to transmit data via commercial satellites to support the broadcast of all-hazards warning messages. And, NOAA supports NTIA's efforts to obtain interference protection rights for earth stations operated by Federal agencies in conjunction with commercial satellites.

SPECTRUM SHARING

DOC increases spectrum efficiency through sharing with other Federal agencies. Many of the atmospheric-observing systems operated by NOAA use highly sensitive receivers that are particularly sensitive to interference. However, NOAA has participated in study efforts where sharing has been found to be feasible.

Sharing of land mobile spectrum is accomplished through FedSMR, and other land mobile trunked radio systems which includes participation by other Federal agencies. DOC may also utilize IWN, and the DOD Pacific Mobile Emergency Radio System.

DOC has participated in many studies on the sharing of spectrum between government operations and commercial operations. Successful sharing scenarios are occasionally identified through cooperative studies between the Federal Government and the commercial sector.

USE OF MORE EFFICIENT TECHNOLOGIES AND MODULATION TECHNIQUES

The use of more advanced technologies and modulation techniques can, in some cases, greatly increase spectrum efficiency. NOAA is planning the next generation of GOES meteorological satellites. Increased spectrum efficiency is needed to accommodate the higher resolution sensors. Spectrum is not available to provide the necessary bandwidth if current technology is used, and an extensive engineering effort is underway to study the advantages and disadvantages of more spectrum-efficient modulation schemes, allowing transmission of more data per given bandwidth.

DOC has responded to the NTIA mandate to narrowband radio systems operated in 162-174 MHz by January 1, 2005, and in the band 406.1-420 MHz by January 1, 2008.

NOAA has also begun deployment of the RRS for the U.S. synoptic radiosonde network. Through deployment of Radiosonde Replacement System (RRS), the U.S. synoptic radiosonde spectrum requirements were cut by 50 percent or more, albeit at a per-radiosonde cost increase.

DOC USE OF SPECTRUM FOR FEDERAL COG, INTEROPERABILITY AND PUBLIC SAFETY

A number of frequency bands that are required for COG, COOP, and interoperability have been identified. DOC uses frequencies for COG as follows: NIST for time and frequency standard transmissions; NOAA maritime operations and marine weather warnings; NTIA SHARES operations in the HF and VHF bands; NOAA meteorological and hydrologic operations; NOAA public all-hazards radio warnings in the 162-174 MHz and 406.1-420 MHz bands; NOAA hurricane reconnaissance aircraft operations in the 225-400 MHz band; NOAA meteorological and hydrologic operations in the 406.1-420 MHz ban; NOAA meteorological radars operating in the 2700-3000 MHz band; and NOAA satellite passive sensing operations in many frequency bands.

DOC uses frequencies for COOP as follows: Office of the Secretary for emergency communications operations in the HF bands; NTIA SHARES operations in the HF and VHF bands; and NOAA EMWIN network operations in the 162-174 MHz band.

For interoperability, DOC uses frequencies as follows: HF communications by NOAA; HF and VHF supporting NTIA SHARES operations; aeronautical mobile communications in the 118.0-136.975 MHz band; and land mobile radio communications in the 406.1-420 MHz band.

DEPARTMENT OF DEFENSE

AGENCY MISSION

The DOD's mission is to provide the military forces necessary to deter war and to protect the security of the United States.

OVERALL DOD SPECTRUM REQUIREMENTS AND SPECTRUM MANAGEMENT STRATEGY

The DOD uses more spectrum than any other Federal agency. The combined joint forces need to operate with shared situational awareness, including a detailed shared view of the battlefield. This requires wideband communications systems providing both real and near real-time visibility of the tactical situation to any element based upon inputs selected from sensors and elements in the area of operation. The DOD has a near term and long term vision for this joint fighting force and its spectrum requirements.

The DOD's spectrum strategy is based on a network-centric architectural approach utilizing concepts such as rule-based spectrum management programmed into cognitive software defined radio systems with the operating rules for the specific areas and countries of operation.

The long-term objective of fighting terrorism could find the U.S. forces as part of a multilateral fighting force operating within a country where there is a host government. Unlike previous deployments of troops, the future picture of fighting terrorism is a worldwide effort, working within and under the jurisdiction of an established national entity. The use of electromagnetic spectrum by deployed U.S. and joint forces is likely to be subject to either established or newly-negotiated host country agreements on the use of spectrum. Spectrum use by the U.S. and coalition forces will have to fit within the rules and regulations of the host country and of the ITU region where the country is located.

The Future Combat System (FCS) is a part of the Army's contribution to the joint force. FCS is a networked system comprised of multiple sub-systems connected by a mobile network architecture that will enable levels of joint connectivity, situational awareness and synchronized operations never before realized. The FCS backbone is comprised of the JTRS, an SDR system using both the wideband network waveform and the soldier radio waveform. JTRS uses the network data link and the Warfighter Information Network. This system relies on SDR technologies to achieve the *ad hoc* wideband connectivity, alternate routing and enhanced spectrum management to react flexibly real-time in a fluid theater of operations. To avoid radio frequency interference and other spectrum management challenges with other components of a joint force and/or host-nation systems, FCS must be adaptable to operations in the United States and in all ITU regions and nations. This adaptability will require programming SDRs with the allocation tables and other significant rules for all three ITU regions and specific host nations as required.

OVERALL DOD SPECTRUM REQUIREMENTS

1. DOD's expects to have significant spectrum requirements in the bands below 3 GHz because of the ability of the bands to support many of the emerging net-centric capabilities and the implementation of software defined radios such as the JTRS-based communications architectures such as the FCS.
2. DOD anticipates additional spectrum requirements in the bands above 3 GHz, where the DOD currently has critical operations that are expected to expand in the future.
3. DOD recognizes that future spectrum requirements growth may not be fully supportable without advances in spectrum-utilization technologies and changes in spectrum management concepts and approaches.
4. The DOD strategy is a "Network Centric Architecture Vision" consisting of autonomous, self-healing, *ad-hoc* networks, producing a shared information environment, where the spectrum management is performed by the system in accordance with a base set of rules.
5. The objective of Network Centric systems of systems is wideband communications conduits, which allow better shared situational awareness of the battlefield. This establishes a spectrum management common picture across the battlefield to allow for immediate capitalization of available spectrum and bandwidth.
6. SDRs programmed with rules will dominate the future battlefield.
7. The GIG is the globally interconnected end-to-end set of information capabilities that manage and provide information on demand to warfighters, defense policy makers and support personnel. Spectrum use is a principal component of the DOD GIG foundation layer, particularly when extending the GIG down to the lowest echelons. The Global Electromagnetic Spectrum Information System (GEMSIS) is both a near and long term initiative to unify and improve DOD spectrum operations in anticipation of network-centric operations and associated spectrum requirements.
8. The use of DOD and commercial satellite communications spectrum and systems will increase substantially, possibly straining available satellite communications resources.
9. There will be increases in DOD radar spectrum requirements, with wider bandwidths and increased anti-jam capabilities.
10. Information System Technologies (IST) and Sensors, Electronics and Electronic Warfare (SEEW) will require greater amounts of new spectrum.
11. UAS, or UAVs, and the ground counterpart, the UGS, require large amounts of spectrum, especially for video and data links. The UAS and UGS deployments are expected to increase substantially in the future, with correspondingly large amounts of spectrum required.

DOD SPECTRUM NEEDS FOR AERONAUTICAL TELEMETRY

The ITU has recognized the need for additional spectrum for aeronautical telecommand and telemetry via Agenda Item 1.5 of the 2007 WRC, which charges WRC-07 ". . . to consider additional spectrum requirements and possible additional spectrum allocations for aeronautical telecommand and high bit-rate aeronautical telemetry, in accordance with Resolution 230 (WRC-

03)."[257] The Resolution 230 adopted at the WRC-03 calls for: "[C]onsideration of mobile allocations for use by wideband aeronautical telemetry and associated telecommand."[258]

The United States' preparations for WRC-07 include several aeronautical telemetry-related documents submitted to ITU-R Working Party (WP) 8B. United States' input document, Document 8B/139-E, addresses potential candidate bands for wideband aeronautical telemetry, concluding that, "[O]f the bands considered, the potential for success in meeting the short to near term spectrum requirements seems greatest in the 4400-4940 MHz and 5925-6700 MHz bands."[259] For long-term requirements, where technology advances are necessary, the preferred bands are 22.5-23.6 GHz, 24.75-25.5 GHz, and 27.0-27.5 GHz.[260] However, the document acknowledges that the five preferred bands have incumbent users with potential spectrum sharing challenges and proposes that further study of the feasibility of sharing between AMT and the incumbent services.[261]

The United States also submitted Document 8B/143-E to address the future spectrum requirements for airborne telemetry. Using queuing analysis and various scenarios, the document concludes that "…even if the most advanced spectrally–efficient modulation techniques were used for telemetering, by the end of 2017, a single aerial vehicle would not have sufficient spectrum to send its data, even assuming all others in the area ceased operation." The study also showed that, given current trends, "no less than 650 MHz would be required for a single test vehicle by the year 2024."[262] The 650 MHz would be used for safety-related and time-critical information, networked downlink telemetry, video downlinks, and uplink traffic.[263]

DOD SPECTRUM NEEDS FOR MOBILE-SATELLITE SERVICE

The DOD has requirements for additional MSS spectrum below 3 GHz because atmospheric and foliage penetration losses are relatively low, components are inexpensive, and small, efficient antennas can be used for handheld operations. Tactical and strategic military communications are essential to linking current and growing requirements of the military command, control, communications and intelligence. Operation by commercial MSS systems in the 1525-1559 MHz and 1626.5-1660.5 MHz bands preclude their availability for dedicated Federal systems. Currently, Federal earth stations are allocated on a primary basis for operations with commercial satellites in the 1610- 1626.5 MHz, and 2483.5-2500 MHz bands. NTIA recommended that the FCC make appropriate changes to the Table of Frequency Allocations to extend the Federal MSS earth station only allocation to an allocation that would permit a federal MSS system in the 1615.5-1621.35 MHz, 2483.5-2492 MHz, and 2498-2500 MHz bands in order to satisfy existing and growing Federal MSS spectrum requirements and to enhance

---

257 *Supra* note 29.
258 *Id.*, Resolution 230 (WRC-03) (Geneva, 2003).
259 *Potential Candidate Bands for Wideband Aeronautical Mobile Telemetry (AMT)*, U.S. Input Document 8B/139-E submitted to ITU-R Working Party 8B at 3 (March 30, 2005).
260 *Id.* at 3.
261 *Id*. at 7.
262 *Spectrum Requirement for Aeronautical Mobile Telemetry*, United States Input Doc. 8B/143-E, at 5 (March 31, 2005).
263 *Supra* note 262 at 8.

communications for national defense, law enforcement, and emergency relief.[264] The Commission did not support this request to change the allocation table but noted its intent to continue to work with NTIA and others in the Federal Government to address spectrum sharing issues in general.[265]

DOD SPECTRUM CHALLENGES

DOD is likely to experience delays in funding, procurement and development of DOD-dedicated advanced systems. Thus, it will continue to rely on commercial communications systems, including mobile, fixed and satellite services. The Transformational Satellite constellations may not be available in the near future due to programmatic and funding constraints. Unlicensed devices, networks, and systems are currently being used to fill immediate operational and tactical needs. While these devices and systems may meet certain requirements, most do not have the level of security required by most DOD systems and may be susceptible to interference.

Other issues relating to implementation of IP-based systems such as IPv6, may cause delays in development of spectrum-dependent systems which must interface with such systems. While DOD has substantial existing systems, they do not provide sufficient wideband communications capacity and other components sufficient to fully support the DOD net-centric objectives.

Because of DOD's need to operate globally, it will continue to face challenges in obtaining host-nation agreements and ensuring that operations outside the U.S. do not conflict with non-DOD systems. Implementation of systems which can operate on a wide range of frequencies, utilizing various waveforms and other technical operating parameters, and which can adapt to their environment, is critical to achieving DOD's long-term vision.

---

[264] NTIA Comments, *supra* note 101.

[265] *Review of the Spectrum Sharing Plan Among Non-Geostationary Satellite Orbit Mobile Satellite Service Systems in the 1.6/2.4 GHz Bands*, IB Docket No. 02-364, Report and Order, Fourth Report and Order and Further Notice of Proposed Rulemaking, 19 F.C.C.R. 13356, 13390-91 at ¶¶ 78-79 (2004). *See also, MSS Order*, 18 F.C.C.R. 1962 at ¶¶ 174, 235-36 (2003).

DEPARTMENT OF ENERGY

AGENCY MISSION

The mission of the DOE is to advance the national, economic, and energy security of the United States; to promote scientific and technological innovation in support of that mission; and to ensure the environmental cleanup of the national nuclear weapons complex. DOE has four strategic goals toward achieving its mission: 1) defense strategic goal; 2) energy strategic goal; 3) science strategic goal; and 4) environment strategic goal. To achieve these goals, DOE conducts and sponsors research, develops energy technology, markets Federal electrical power and promotes energy conservation. DOE also oversees energy regulatory programs and aspects of the nation's nuclear programs, including assuring safety in missile and weapons testing, and the security and disposal of nuclear materials.

DOE SPECTRUM REQUIREMENTS

DOE operates many wireless communications systems to carry out its mission. These systems include emergency HF systems, point-to-point microwave systems that convey data transmissions across large distances, and land mobile radio communications networks that provide voice communications for DOE's mobile workforce.

The DOE administrations and bureaus with the largest spectrum use are: 1) the National Nuclear Security Administration (NNSA); 2) WAPA; and 3) BPA. Table B-9 presents the three agencies, the most used frequency bands and radiocommunication services.

Table B-9. Major DOE Spectrum Uses

Freq. Band (MHz)	Administration	Function
162.01–173.4 MHz	WAPA, BPA	Land Mobile
406–410 MHz	NNSA Service Center, Nev. Ops. Off.	Land Mobile
410–420 MHz	NNSA Service Center, Nev. Ops. Off.	Land Mobile
932–944 MHz	BPA, WAPA	Microwave Pt-to-Pt
1710–1755 MHz	WAPA, BPA	Microwave Pt-to-Pt
1755–1850 MHz	WAPA, BPA	Microwave Pt-to-Pt
2200–2290 MHz	NNSA Service Center	Microwave Pt-to-Pt
7.3–7.45 GHz	WAPA, BPA	Microwave Pt-to-Pt
7.55–7.75 GHz	BPA, WAPA	Microwave Pt-to-Pt
7.75–7.9 GHz	BPA, WAPA	Microwave Pt-to-Pt
8.025–8.175 GHz	BPA, WAPA	Microwave Pt-to-Pt
8.215–8.4 GHz	BPA, WAPA	Microwave Pt-to-Pt

DOE SPECTRUM REQUIREMENTS BELOW 3 MHZ

The DOE has frequency assignments below 3 MHz that are used primarily for the DOE Emergency Radio System (ERS) and for aircraft (aerial) tracking. The ERS is located at DOE headquarters and program operations offices throughout the country. The aircraft tracking frequencies are used for the operational safety and control of aircraft involved in: (1) aerial tracking and measurement of nuclear radiation; (2) searching for lost nuclear devices and assisting in their recovery; and (3) scientific research in nuclear and related fields. The aerial tracking applications are used nationwide.

DOE Spectrum Requirements in the HF Bands

DOE has assignments in the HF bands that are used for COOP and COG functions. Examples include the DOE ERS, Emergency Action Coordination Team (EACT) communications, coordination between the Emergency Relocation Center and the EACT, and coordination between the EACT and aircraft involved in the tracking and measurement of nuclear materials. Furthermore, some HF frequencies supplement VHF land mobile coverage when dictated by terrain.

DOE Spectrum Requirements in the 162-174 MHz and 406.1-420 MHz Bands

DOE has frequency assignments in the 162-174 MHz band used mainly for supporting the DOE electrical power administrations. The bands are used for land mobile communications systems for operations, maintenance, and security of the power grid and facilities.

DOE has a large number of its frequency assignments in the 406.1-420 MHz band. The NNSA sites and facilities primarily use the band for land mobile radio communications for site operations and security. The power administrations also heavily use the band for land mobile radio communications as well as for fixed stations for SCADA applications. The number of assignments in this band has increased over the past ten years.

The NNSA field offices have transitioned from conventional radio systems in the 162-174 MHz band to trunked systems in the 406.1-420 MHz band, accounting for much of the growth. This trend is not expected to continue. Instead, DOE expects a slow decline in the number of assignments as the power administrations move their SCADA applications to other bands. The SCADA applications have data rate requirements that are not able to operate on narrowband channels in the 406.1-420 MHz band.

DOE Spectrum Requirements in the 2200–2290 MHz Band

DOE primarily uses the 2200–2290 MHz band for NNSA telemetry support for various research programs. These programs include missile and weapons testing. The use of this band has been fairly consistent over the past few years.

BPA SPECTRUM REQUIREMENTS

The BPA has assignments in the 4400–4940 MHz and 7125–8500 MHz bands for microwave radio-relay networks. The microwave networks are arranged in backbone and spur systems for monitoring, operations, and maintenance of the electrical power grid. The microwave links are also used to close fiber rings when the geographical and topological conditions prevent the use of fiber. BPA also operates SCADA systems in these bands to control the power grid, schedule the system, and monitor customer usage.

BPA's spectrum use in the 7125–8500 MHz has remained steady over the last ten years, but BPA is anticipating additional future requirements in this band resulting from an increase in the amount of data transmitted as more remote control and system monitoring applications are implemented. There also continues to be an increased demand for video monitoring for security purposes. BPA is also strongly considering moving some of its SCADA applications to this band from the 406.1-420 MHz band. The narrowbanding of the 406.1-420 MHz to 12.5 kHz channels does support the data rate required for SCADA applications.

WAPA SPECTRUM REQUIREMENTS

WAPA operates microwave communications networks in the 941–944, 1710–1850, and 7125–8500 MHz bands. These applications are used for control and operation of the power transmission grid.

DOE FUTURE SPECTRUM REQUIREMENTS

DOE FUTURE SPECTRUM REQUIREMENTS IN THE BAND BELOW 3 MHZ

There has been an increase in the number of assignments in the bands below 3 MHz as DOE has expanded its ERS. Additionally, the NNSA has seen an increase in the number of temporary assignments used to support new post-nuclear testing activities via aircraft. In particular, the Nevada Test Site has seen a large number of these assignments.

DOE FUTURE SPECTRUM REQUIREMENTS IN THE HF BANDS

DOE anticipates a slight increase in need for frequencies in the HF fixed bands as the COOP and COG plans are completed.

DOE FUTURE SPECTRUM REQUIREMENTS IN THE 162-174 MHZ BAND

The DOE anticipates a slight increase in the need for spectrum in the 162-174 MHz band. As the power distribution grid grows to accommodate the demand for electricity, the power administrations will be required to expand their operations and maintenance networks. DOE also has had difficulty in obtaining assignments in the Canadian border area. Additional assignments are needed to address this problem.

DOE OTHER FUTURE SPECTRUM REQUIREMENTS

BPA's spectrum use in the 4400–4940 MHz band has remained steady over the last five to ten years; however, it is planning to move many operations now in the 1710–1755 MHz band into the 4400-4940 MHz band. The other BPA requirements currently met in the 1710-1755 MHz band will be transitioned to other systems. BPA also plans to use the 4400-4940 MHz band as an alternative when spectrum is not available in the 7125–8500 MHz band.

Additional spectrum will be required by WAPA in the 7125–8500 MHz band to support new electrical power distribution facilities in addition to increasing demand for data from existing facilities. These demands include increased equipment and status monitoring as well as video monitoring for security purposes.

DOE also has requirements for (UWB) systems that will operate in the 1-5 GHz band.

DOE USE OF SPECTRUM FOR FEDERAL COG, INTEROPERABILITY AND PUBLIC SAFETY

The DOE COG minimum essential responsibilities include the protection of our nation's power generation and distribution capabilities and nuclear assets. Spectrum is a vital component of COG planning, ensuring that in the event of a catastrophic emergency, when traditional methods of communication cannot be relied upon, backup systems and communications methods are in place. These backup systems primarily include wireless systems that will be critical in maintaining communications. Local land mobile communications systems, longer-distance HF communications, microwave links, and satellite communications may all be required at some point during the COG process to ensure that DOE can fulfill its minimum essential responsibilities.

The DOE plans to evaluate and revise its COG plans and the resulting spectrum requirements as a continuing part of implementing its strategic goals.

DEPARTMENT OF HOMELAND SECURITY

AGENCY MISSION

The mission of the DHS is to: 1) prevent terrorist threats; 2) reduce America's vulnerability to terrorism; 3) minimize the damage and recover from attacks that occur; and 4) respond to and recover from disasters.

DHS SPECTRUM REQUIREMENTS

In addition to the extensive spectrum use by the USCG, the DHS components using the most spectrum are 1) Customs and Border Protection (CPB); 2) ICE; 3) United States Secret Service; 4) the Transportation Security Administration (TSA); and 5) FEMA. The large majority of the assignments of the spectrum use by these top five agencies are for land mobile communications. The DHS units have about 85 percent of its LMR assignments in the 162-174 MHz band; and about 15 percent of its LMR assignments in the 406.1-420 MHz band. Furthermore, DHS uses LMR communications and IWN in conjunction with the DOJ and Treasury for law enforcement. The DHS did not exist when the IWN was designed and developed, and thus DHS did not review the spectrum requirements and planned spectrum use for IWN. Thus, there may be additional DHS spectrum needs for IWN in the future, especially in urban areas and along U.S. borders.

These DHS units have numerous assignments above 3 GHz, most of which are used for the fixed service microwave radio relay systems. These DHS units also have a large number of assignments in the HF bands, split equally between CPB and FEMA.

DHS FUTURE SPECTRUM REQUIREMENTS

DHS, to meet public safety requirements, including interoperability and implementation of broadband capabilities, supports the statutory allocation of 24 megahertz of spectrum in the upper 700 MHz band for public safety use, as well as the FCC's adoption of an upper 700 MHz D Block to be used as part of a 700 MHz Public/Private Partnership to provide wireless broadband services to public safety.

DHS' use of HF spectrum is expected to increase, despite the reduction in HF allocations. DHS believes that further loss of critical HF spectrum resources should be opposed, and if possible additional HF spectrum allocations made to support operational requirements.

DHS SPECTRUM FOR FEDERAL COG, INTEROPERABILITY AND PUBLIC SAFETY

Enhanced methods for interoperability could result from better policy coordination by the NTIA and the FCC with DHS. The spectrum-related barriers to interoperability include:

1. The lack of adequate spectrum policy at NTIA and FCC to deal with the requirements for interoperability among and between public safety agencies at the Federal, state, local, and tribal levels.

2. The need to make policy and rules more flexible to provide for less complicated and more timely use of spectrum to resolve immediate and long-term needs.
3. The requirement for improved methods of coordination and consistency, to the extent possible, of policy, rules, and plans between NTIA and the FCC.
4. The need for commonly adopted technical interoperability standards between NTIA and the FCC.

A primary barrier to improved interoperability among public safety agencies is the lack of flexible frequency or channel plans that allow all public safety agencies to use Federal and non-Federal emergency frequencies without lengthy approval processes. DHS is working with SAFECOM, FPIC, IRAC, NTIA, and the FCC to create a channeling plan including all public safety bands for seamless nationwide incident response.

DEPARTMENT OF INTERIOR

AGENCY MISSION

The mission of the DOI is to protect and provide access to the nation's natural and cultural heritage and honor the trust responsibilities of Indian Tribes and the commitments to island communities. The DOI relies on spectrum-dependent telecommunications technologies and resources in accomplishing its mission.

DOI SPECTRUM REQUIREMENTS

NATIONAL PARK SERVICE (NPS)

The NPS operates all of the nation's national parks which have extensive communications requirements, resulting in the NPS being the largest DOI user of the radio frequency spectrum. The majority of the NPS land mobile communications systems and associated radio frequency assignments are critical to public safety. DOI supports the planning, acquisition and use of radio frequency dependent telecommunications, various electronics equipment and new fixed and mobile "wireless" technologies. These devices are commonly used for public safety and administrative related missions, including support to national programs requiring interoperability of communications for law enforcement, emergency medical services, fires on wild land and on NPS structures, search and rescue, hazardous materials incidents, as well as facility administration and maintenance.

The NPS uses its numerous radio frequency assignments for over 300 VHF and UHF land mobile communications networks and traveler information systems operating in the AM broadcasting band. It is highly dependent upon microwave backbone systems, video surveillance systems, wildlife tracking systems, and many other communications and electronic systems. To communicate with state and local public safety units, the NPS park security enforcement units also require access to spectrum allocated to non-Federal users.

The NPS is facing ongoing challenges of greater use of both licensed and non-licensed wireless technologies to support various voice, data and video requirements in the parks and to support the DHS/CPB and DHS/ICE missions.

UNITED STATES GEOLOGICAL SURVEY (USGS)

The USGS is the nation's principal earth-science agency, and its basic mission is to provide geologic, topographic, and hydrologic information that contributes to the wise management of the Nation's natural resources and promotes public health, safety, and well being. At the major USGS sites, voice, data, and video may traverse integrated high-speed transport facilities. The USGS uses radio frequency assignments in the VHF/UHF and HF bands to support these scientific missions. The spectrum is used for seismic telemetry for scientific research. Other stations include fixed repeaters, transportable stations for communications by field research parties and to support geological surveys. USGS stations are located throughout the United States.

BUREAU OF LAND MANAGEMENT

Bureau of Land Management (BLM) uses its radio frequency assignments in the VHF/UHF and HF bands to support its mission of sustaining the health, diversity and productivity of the public lands. The BLM also communicates with state government units, using non-Federal spectrum. BLM plans to continue the reengineering and consolidation of land mobile radio systems with its partners to reduce spectrum demand and system support, and to improve interoperability with those partners. These new designs will be based on clearly defined business needs for voice and data communications, with priority given to the health and safety of employees. The new capabilities provided by digital technology will also be included to enhance the value of the spectrum BLM and its partners use.

BUREAU OF INDIAN AFFAIRS

The Bureau of Indian Affairs (BIA) operates and maintains a national land mobile radio network to service various programmatic functions in support of tribal constituencies including law enforcement services, forest fire management, education, irrigation, and transportation. The services include from emergency response and mutual aid to general administrative requirements. The BIA uses its radio frequency assignments in the VHF/UHF and HF bands to support these missions.

BUREAU OF RECLAMATION

The mission of the Bureau of Reclamation (BOR) is to manage, develop, and protect water and related resources in an environmentally and economically sound manner. The BOR uses its radio frequency assignments in the 162-174 MHz VHF, 406.1-420 MHz UHF and 1.7 GHz bands to support its missions.

US FISH AND WILDLIFE SERVICE

USFWS uses its numerous radio frequency assignments to provide the primary communications for resource management, law enforcement and fire management in the National Wildlife Refuges. The USFWS has the responsibility to provide reliable 2-way radio systems for all fire activities, law enforcement, recreation, and other activities.

The USFWS manages the wildlife telemetry program for the DOI and for other Federal agencies, using interstitial channels between 164 MHz and 174 MHz for dedicated wildlife telemetry use. The USFWS uses 3500-4000 assignments in the 162-174 MHz band, on interstitial channels within the 12.5 KHz channel plan. These are used for tracking migratory birds, four legged mammals, fish, manatees and snakes. Information is used to support environmental and species-related research.

MINERALS MANAGEMENT SERVICE

Minerals and Management Service (MMS) strategic planning initiatives are geared toward providing a unified communications network and management strategy to fit into an evolving distributed computing environment. The MMS uses VHF radio frequencies to support its mission.

OFFICE OF THE SECRETARY (OS)

The Office of the Secretary (OS) technical wireless management, consulting, and operations are provided for all tenants in the DOI main facilities in Washington, DC, and 53 field offices. OS operations will complete an inventory of all wireless local area networks within the Department's main facilities and develop configuration blueprints for troubleshooting and planning future installations and expansions.

DOI FUTURE SPECTRUM REQUIREMENTS

The goals of DOI's Spectrum Management Program are to provide radio frequency resources supporting DOI staff in performance of their assigned duties in the most effective manner. In response to increased use of Federal oversight of Federal IT and spectrum management, DOI will implement the following goals for DOI wireless strategy for years 2005 through 2010:

1. Maximize radio spectrum efficiency in radio systems throughout the DOI;
2. Develop forward looking policies enabling new uses and efficiencies for the user community; and
3. Prepare for the worst and deliver the best interoperable radio communications systems and services in support of the DOI public safety mission.

The DOI has projected future agency requirements for their systems and services. These include the following:

- BIA is expecting 16 percent growth over the next three years in mobile and portable usage in addition to an increased use of satellite services. A similar increase in non-Federal VHF spectrum use also is anticipated, and this is likely to be satisfied through greater use of state frequency band allocations.

- BLM requirements for 162-174 MHz VHF land mobile and for the 406.1-420 MHz UHF fixed service communications will increase. As BLM transitions to P25 standard systems over the next five to seven years, the VHF spectrum needs will increase by 20 percent. The increased backhaul requirements will result in UHF and higher spectrum needs increasing by 30 percent over the same period.

- The USFWS foresees an increase in the number of state-generated spectrum requirements for animal tracking over the next few years. The dependence on spectrum allocated for Federal use has resulted from unavailability of spectrum allocated for non-Federal use.

Most of the increases will be in the VHF spectrum, except for fish monitoring which requires utilization of 30-300 kHz (LF) spectrum.

- NPS foresees an increase in licensed and unlicensed wireless technology use in the near future to support various DHS operations.
- The demand for data networking and higher bandwidth transmission services will grow while costs for these services continue to fall.
- There will be increased examination of using state land mobile radio systems on a shared basis which might reduce future demand on spectrum allocated to the Federal Government, especially in Rocky Mountain States.
- Elsewhere, more spectrum-efficient technologies will become increasingly important in radio network design. Most current 162-174 MHz fixed and mobile radio 25 kHz wideband equipment will be phased out between the years 2005-2010, to be replaced by narrowband equipment using 12.5 kHz channel spacing. The 406.1-420 MHz fixed and mobile radio 25 kHz wideband systems will be phased out over the years 2000-2010, to be replaced by equipment also utilizing 12.5 kHz channel spacing.
- Mobile radio networks as well as fixed point-to-point networks will be moved into the highest frequency bands feasible to support the mission requirements. Use of fixed links is expected to be examined in an effort to identify spectrum for new technologies and to assure compliance with policies requiring use of commercial carriers when possible.

DOI USE OF NEW TECHNOLOGIES

Fiber optics will play an important role in meeting DOI missions currently supported primarily by wireless mobile and fixed links. Fiber also will be used to interconnect with DOI wireless systems, leveraging the use of both wired and wireless technologies. Network design will take into account new technologies, including more spectrum efficient technologies.
To the extent feasible, the number of fixed point-to-point radio networks will be reduced to facilitate freeing the spectrum to support new technologies.

DOI USE OF SPECTRUM FOR FEDERAL COOP AND COG

DOI uses frequencies and systems already employed for a variety of its missions for COOP and COG functions and is identifying whether additional systems are required to support COOP and COG.

DEPARTMENT OF JUSTICE

AGENCY MISSION

DOJ's mission is to enforce the law and defend the interests of the United States according to the law; to ensure public safety against threats foreign and domestic; to provide Federal leadership in preventing and controlling crime; to seek just punishment for those guilty of unlawful behavior; and to ensure fair and impartial administration of justice for all Americans.

There are several primary bureaus and administrations within the DOJ that have their own spectrum dependent requirements. These organization units have their own complementary, yet independent mission statements, and are engaged in unique activities that drive their own requirements for spectrum use.

DOJ SPECTRUM REQUIREMENTS

The DOJ organizations with the greatest spectrum use are the Federal Bureau of Investigation (FBI); the Drug Enforcement Administration (DEA); the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF); the United States Marshals Service (USMS); and the Bureau of Prisons (BOP). Spectrum use within the DOJ is as diverse as the activities that the organization conducts in support of global law enforcement operations. From HF band assignments, to assignments in the Super High Frequency (SHF) band, the DOJ's access and use of the spectrum is based in many cases on the type and amount of spectrum that is capable of satisfying select mission requirements.

The most significant requirement for spectrum assignments within the DOJ is in direct support of tactical communications. This requirement is predominantly satisfied within the two Federal land mobile frequency bands of 162-174 MHz and 406.1-420 MHz. There is also a critical requirement for interoperability with non-Federal public safety users, which is achieved by frequency and channel sharing, and has necessitated cooperative use of the 150.8-162 MHz and 420-870 MHz bands.

Table B-10 provides frequency bands and associated major uses of the larger DOJ agencies.

Table B-10. DOJ Frequency Band Use

Frequency Band	MAIN FUNCTIONS
2-30 MHz	Long haul backup and contingency communications
30-88 MHz	Cooperative support with non-Federal law enforcement agencies
150.8-162 MHz	Cooperative support with non-Federal law enforcement agencies
162-174 MHz	Primary Land Mobile Radio (LMR) band for day-to-day communications
406.1-420 MHz	Voice, data, radio controlled alarms, paging, robot control, camera control, point-to-point links, beacons, vehicle tracking, regular and cross-band repeater operations, and training
420-512 MHz	Cooperative support with non-Federal law enforcement agencies
512-806 MHz	Cooperative support with non-Federal law enforcement agencies
806-870 MHz	Cooperative support with non-Federal law enforcement agencies
1000-2000 MHz	Point to point video links for field offices and special units; Satellite Communications; Cellular Phones
2100-2500 MHz	Point to point video links for video links, search cameras
4300-5000 MHz	Video surveillance operations, airborne surveillance, and concealment operations
7100-7900 MHz	Audio and Video Microwave in field offices
8100-8500 MHz	Point to Point video links
13.750-14.5 MHz	Satellite Communications

DOJ FUTURE SPECTRUM REQUIREMENTS

The DOJ does not foresee any change in mission, technology, or the environment that would allow it to relinquish any of its frequency assignments, allotments, spectrum access or rights to currently authorized spectrum use.

Specific future spectrum needs of DOJ include:

- An increase in assignments in the 162-174 MHz and 406.1-420 MHz bands to accommodate significant anticipated growth in tactical communications and surveillance requirements. This increase may be satisfied with technologies that more effectively use the existing spectrum.

- Expanded use of the 150-162 MHz, 450-470 MHz, and 800 MHz non-Federal bands to support interoperability and sharing operations between Federal law enforcement and state and local law enforcement officials.

- Expanded and improved use of commercial services, particularly in long haul, tracking, wide area, and high capacity transmission service areas. Primary examples include: SARSAT operating at 406 MHz; the Argos Satellite at 401.65 MHz; INMARSAT, Iridium and Globalstar Satellites; Verizon CDMA cellular services at 800 and 1900 MHz; T-Mobile's cellular GSM services at 900 and 1800 MHz; Mobitex cellular at 400, 800, and 900 MHz; the SMART System at 902 MHz to support DF tracking; GPS (1575 MHz, L1 Frequency); satellite uplinks at 5.9-6.425 GHz and 4.2 GHz for downlink; satellite uplinks from 14 to 14.5 GHz and downlinks between 11.7 and 12.7 GHz bands; and the ISM 2.4 GHz and 5.8 GHz bands in which 802.11/802.16 wireless standards apply.

DOJ's future spectrum requirements will be based upon the following various factors in order to support the agency's missions:

- Robust Wireless Communications
- Data Access and Sharing
- Interoperability
- Rapid Response
- Counter Adversary Role
- Operational Environment

DOJ USE OF NEW TECHNOLOGIES

DOJ's implementation of the new IWN is exploiting modern system and trunking technologies to allow spectrum sharing and reuse between all DOJ component organizations, as well as DHS and Treasury. Based on its IWN implementation in the Seattle, Washington area, the DOJ alone will achieve a 50 percent reduction in the use of spectrum resources, and a 65 percent reduction in 162-174 MHz VHF frequency assignments. The use of IWN also will enable DOJ to achieve narrowbanding.

Future emphasis on technical improvements will predominantly be directed towards increasing operational efficiencies and capacities without the necessity for additional spectrum. Technology advancements have allowed use of spectrum bands above the UHF range, previously unsuitable for mobile and fixed applications. Exploiting higher spectrum bands to support critical law enforcement needs requires continued spectrum analysis, research, and development efforts by industry to ensure availability of suitable technology, equipment and systems. In addition, “smart” technologies will be pursued that demonstrate the potential for adaptively exploiting available spectrum resources. When intelligent systems are fully mature and suitable to meet DOJ’s missions, spectrum can be dynamically accessed to support real time operational requirements.

DOJ USE OF SPECTRUM FOR FEDERAL COG, INTEROPERABILITY AND PUBLIC SAFETY

Since there is no specific spectrum allocation dedicated to COG/COOP activities *per se*, all communications capabilities, regardless of frequency band, that are currently designated, shared, or used by the DOJ are leveraged as necessary in support of the COG/COOP. In addition, since the instantaneous nature of COG/COOP does not allow for detailed system development or spectrum coordination, all existing DOJ system assets are candidates for use. In general, the DOJ will continue to assess communications capabilities to ensure that there are redundancies in wireless system capabilities, across all bands that support existing operations, so that they can be used as necessary to support COG/COOP.

DEPARTMENT OF STATE

AGENCY MISSION

DOS mission is to ensure a more secure, democratic, and prosperous world for the benefit of the American people and the international community.

DOS also has spectrum management responsibility regarding authorizing foreign governments to operate radio communications systems in the United States such as at embassies in Washington, DC. This responsibility stems from the Communications Act of 1934, as amended, which is reflected in the NTIA Manual as follows:

> the Assistant Secretary of Commerce is hereby delegated the authority vested in the Secretary of Commerce under subsection 305(d) of the Communications Act of 1934, as amended, to authorize a foreign government to construct and operate a radio station pursuant to this subsection and the assignment of a frequency for its use shall be made only upon recommendation of the Secretary of State and after consultation with the Attorney General and the Chairperson of the Federal Communications Commission.[266]

DOS SPECTRUM REQUIREMENTS

DOS uses spectrum mainly for land mobile communications for security forces at its facilities in the Washington, DC area, New York City, and at other locations. The DOS has assignments in the 162-174 MHz band and in the 406.1-420 MHz band.

EMBASSY SPECTRUM USE

The DOS has frequency assignments that are used by foreign embassies located in Washington, DC. There is a common pool of HF frequencies that are used for embassy communications, ranging from about 5.6 MHz to about 26.7 MHz.

DOS FUTURE SPECTRUM REQUIREMENTS

Over the next ten years, DOS anticipates an annual growth rate of three percent in the number of permanent assignments, except for the 406.1-420 MHz band where 100 new assignments are expected.

DOS is transitioning its Internet protocol version 4 (IPv4) to IPv6, and DOS believes that the impact of the transition relative to spectrum management requires further analysis by NTIA and the FCC.

---

[266] NTIA Manual, *supra* note 39 at 1-2.

DEPARTMENT OF TRANSPORTATION

AGENCY MISSION

The mission of the DOT is to serve the U.S. by ensuring a fast, safe, efficient, accessible, and convenient transportation system that meets the vital national interests and enhances the quality of life of the people, today and in the future. The DOT has thirteen operating administrations and bureaus, each with its own management and organizational structure. The major spectrum users and DOT spectrum-interested units are: FAA; the Federal Highway Administration (FHWA); the Federal Railroad Administration (FRA); the Maritime Administration (MARAD); the FAA Office of Commercial Space Transportation; and the St. Lawrence Seaway Development Corp (SLSDC). Of these, the FAA is by far the largest DOT spectrum user.

The FAA mission is to provide the safest, most efficient aerospace system in the world and the FAA vision is to improve the safety and efficiency of aviation, while being responsive to its customers and accountable to the public.

FAA SPECTRUM REQUIREMENTS AND USAGE

The FAA is responsible for providing the national airspace infrastructure by operating the NAS to support the nation's air operations within the United States and certain oceanic areas. This responsibility extends from air traffic control, system security, and safety to international coordination. The FAA is charged with the responsibility of serving the flying public, twenty-four hours a day, and 365 days a year. The FAA also provides a service supporting national security by providing air traffic control and vital information to DOD and law enforcement aircraft.

A key resource for providing these critical safety services to the aviation community is the continuing availability of sufficient radio spectrum to support the air traffic control system. Spectrum integrity and aviation safety are inextricably linked. International spectrum harmonization is necessary to ensure worldwide seamless safe air travel. Thus, the FAA spectrum utilization is harmonized through the ICAO, a United Nations organization. The FAA, sometimes in conjunction with NASA, conducts extensive research into modernizing the systems used in the NAS.

The FAA utilizes spectrum to operate the NAS, which is divided into three main functions:

DOT FAA Pilot-to-Controller Communications Spectrum Requirements

The 2-23 MHz HF band is used for aeronautical mobile communications in oceanic and Alaskan airspaces and the 118-137 MHz VHF band is used to provide pilot-to-controller communications nationwide. The currently used communications system in this VHF band is planned to be replaced by a future mixed system of voice and data. The 225-400 MHz band is used to provide voice communications support to military aircraft.

The FAA also uses satellite-based systems, and has plans for expanding such communications in the future. The 960-1215 MHz band is used for a satellite-based integrated communications and surveillance system. The 1545-1559 MHz, 1610-1626.5 MHz, and the 1646.5-1660.5 MHz bands are used for commercial satellite links for integrated voice and data communications system. The 2483.5-2500 MHz band also is allocated for non-Federal satellite use that is available on a leased basis.

DOT FAA Aeronautical Radionavigation Spectrum Requirements

The FAA operates numerous aeronautical radionavigation systems in twelve frequency bands. The ILS system uses the 74.8-75.2 MHz, 328.6-335.4 MHz, and 108.0-117.975 MHz bands. The non-directional beacon system operates in the 190-435 kHz and 510-535 kHz bands. The VOR system uses the 108.0-117.975 MHz band and the DME/TACAN systems operate in the 960-1215 MHz band.

Many of the FAA planned future systems will be GPS-based, using the 1215-1260 MHz and the 1559-1610 MHz bands for the GPS. The 5150-5250 MHz band is needed for future terminal weather surveillance. Some currently operational MLS operations also use the band. The 9.2-10 GHz and 34.7-35.2 GHz bands are being considered for airborne enhanced vision systems for precision landing systems in low-visibility conditions.

DOT FAA Aeronautical Surveillance Spectrum Requirements

The FAA uses radars for its aeronautical surveillance functions. The band 1215-1390 MHz is used for long-range enroute radars, most of which are joint DOD/FAA radars, and the band 2700-3000 MHz for terminal surveillance and weather radars. The frequencies 1030 MHz and 1090 MHz are used for the ATCRBS aircraft identification system.

The band 5600-5650 MHz is used for terminal Doppler weather radars. The band 5150 – 5250 MHz is the expansion band for the terminal Doppler weather radars. The 9300-9500 MHz and 13.25-13.4 MHz bands are used for airborne weather navigation radars.

The new ASDE-X operates in the 9000-9200 MHz band. The legacy ASDE systems operate in the bands 15.7-16.2 GHz and 24.45-24.65 GHz.

FAA OFFICE OF COMMERCIAL SPACE TRANSPORTATION

The mission of the FAA Office of Commercial Space Transportation (AST) is to ensure protection of the public, property, and the national security and foreign policy interests of the United States, during commercial launch and reentry activity, and to encourage, facilitate, and promote United States commercial space transportation. The availability of radio spectrum is critical to the commercial space industry for many telecommunications services, ranging from air and space traffic control, communications and telemetry to radionavigation.

The commercial space industry uses the existing rocket launch facilities operated by the United States military agencies. The systems used for range safety, telemetry, and tracking radars operate on frequencies assigned to the military agencies.

ST. LAWRENCE SEAWAY DEVELOPMENT CORP.

SLSDC and the St. Lawrence Seaway Management Corp. (SLSMC) operate and maintain one of the world's most comprehensive inland navigation systems. Management of the seaway is shared by and coordinated between the United States and Canada, through the SLSDC for the United States, and the SLSMC for Canada. The SLSDC is responsible for the operations and maintenance of the United States portion of the Seaway between Montreal and Lake Erie.

SLSDC and SLSMC employ radar and communications as key parts of the VTS system to monitor the progress of commercial maritime traffic, ensuring thousands of safe and expeditious passages through the Seaway annually.

In the mid-1990s, consistent with IMO requirements and ITU regulations, the SLSDC and SLSMC began to sponsor the development of a GPS-based VTS system using the Seaway AIS at its core. AIS is a shipboard broadcast transponder system operating on 161.025 MHz and 162.025 MHz in the maritime band that is capable of sending and receiving ship information, such as identification, position, heading, speed, ship length, beam, type, draft, and hazardous cargo information, to other ships and to shore.

The SLSDC uses radio frequencies for many other operations and maintenance activities. Frequencies are used by the Office of Lock Operations and Marine Services for maintaining voice communications with vessels transiting the Seaway, for transmitting weather and visibility information from stations along the river, for aids to navigation (*i.e.*, RACONS), and for hydrographic surveying operations. The Office of Maintenance utilizes various frequencies to maintain voice communications between work crews.

FEDERAL HIGHWAY ADMINISTRATION

The FHWA use of spectrum is dominated by efforts related to the Intelligent Transportation System (ITS) where it conducts and sponsors extensive research. For example, the FHWA sponsored the research and development of automobile collision avoidance radars for private sector use; however, the FHWA does not operate any of the systems. FHWA also has a Dedicated Short Range Communications (DSRC) program conducting research and development.

The FHWA is currently testing the use of the 220 MHz band for several ITS applications. It also is testing the 902-928 MHz, 5850-5925 MHz, the 6.9 GHz band and the 11, 23, and 31 GHz bands for point-to-point microwave systems. FHWA is testing bands in the 47-77 GHz range for various DSRC applications.

FEDERAL RAILROAD ADMINISTRATION

Spectrum use by the FRA is dominated by efforts related to the development of the Intelligent Railroad System. The spectrum uses are necessary for the implementation of the High-Speed Ground Transportation Act of 1965. The FRA conducts and sponsors research and development, but does not operate the systems. Following development and product availability, the systems will be operated by the private railroad systems.

The FRA research and development efforts include modernization covered under the Positive Train Control Initiative. This initiative combines digital communications, advanced sensor technology and use of the NDGPS operating in the 415-495 kHz band for control and safety enhancements to the nation's rail infrastructure and operations, including Rail Defect Location and Automated Track Surveying.

MARITIME ADMINISTRATION

The U.S. maritime transportation system utilizes spectrum-dependent systems to support the maritime industry. The DOT/MARAD works with the Coast Guard, and ten other Federal agencies to improve the maritime portion of the national transportation system. President Bush issued the United States Ocean Action Plan on December 17, 2004 to improve the maritime transportation system.

MARAD recognizes the importance of the GMDSS and VHF radio communications as integral components of the worldwide maritime radio communications system.

DOT FUTURE SPECTRUM REQUIREMENTS

FAA

Aeronautical Radionavigation Service

The FAA plans on implementing a satellite-based navigation system, based on use of the GPS. The FAA systems are comprised of the WAAS and the LAAS. The WAAS is a major step towards modernizing critical navigation systems to a satellite-based system. The WAAS is designed to provide horizontal and vertical navigation for enroute navigation precision, airport departures, and airport landing approaches in all weather conditions. The key part of the WAAS is the augmentation of the GPS signal from its normal 20 meter accuracy to 1.5-2 meters in both horizontal and vertical directions. Although the WAAS was developed for aviation, it is being used in non-aviation applications such as agriculture, surveying, recreation, and automotive and maritime surface transportation.[267]

The WAAS uses a network of precisely located ground reference stations that collect and process the GPS signals and send the processed signals to WAAS master stations. The WAAS

[267] Fact Sheet, "Wide Area Augmentation System," Satellite Navigation Product Teams, FAA, 2005.

master stations develop a WAAS correction signal that is then transmitted to a geostationary satellite and made available to all users who receive it on the satellite's downlink.

The WAAS uses dedicated payloads onboard the Canadian Telesat Anik F1R and the United States Intelsat Galaxy 15 satellites. The RPS is operated by Lockheed Martin under a government contract and FCC licenses. The system operates at L5 on 1166.20-1186.70 MHz, and at L1 at 1565.17-1585.67 MHz.

The WAAS signal has been available since August 2004 and numerous manufacturers have developed WAAS-enabled GPS receivers for the consumer market. There already are millions of non-aviation WAAS-enabled GPS receivers in use.[268]

The FAA's LAAS is expected to provide pilots with safe vertical instrument guidance to heights ranging from less than 200 feet to down to the runway surface. While LAAS is independent of WAAS, it will complement WAAS. The LAAS is expected to augment the GPS with an ultimate configuration that will pinpoint an aircraft's position to one meter or less. The LAAS is also expected to be used by controllers for surface-area navigation to determine the accurate position of all approaching and taxiing aircraft and airport surface vehicles.[269]

The LAAS system consists of three segments: 1) the LAAS Ground Facility or LGF, which provides differential corrections, integrity parameters, and precision approach path point data transmitted to aircraft over a VHF frequency; 2) the space segment, which provides the LGF with the GPS signals; and 3) the airborne subsystem, which applies corrections to the GPS signals.

Table B-11 presents the spectrum required for the LAAS, and the spectrum that will no longer be needed. With respect to GPS modernization the FAA plans to use the new L5 navigation signal at 1176.45 MHz for both the WAAS and LAAS. The LAAS will broadcast GPS corrections and integrity data pertinent to both L1 and L5, and in the event of interference on either L1 or L5, the system will be able to automatically select the unaffected frequency.[270]

The GPS signal as corrected by the LAAS will be transmitted to aircraft on frequencies in the 108-117.975 VHF frequency band.

---

[268] *Wide Area Augmentation System*, *supra* note 155.

[269] *Local Area Augmentation System* (LAAS), Satellite Navigation Product Teams, U.S. Dep't. of Transportation, FAA (2004). *See also*, *supra* note 159.

[270] *GPS Modernization*, *supra* note 160. *See also*, *Minimum Operational Performance Standards for GPS/Local Area Augmentation System Airborne Equipment*," Washington, D.C., RTCA SC-159, WG-4A, DO-253A (Nov. 28, 2001).

Table B-11. LAAS Spectrum Needs for Aeronautical Radionavigation

Frequency Band	Applications	DOT Remarks
74.8-75.2 MHz	ILS marker beacons, until LAAS provides full modernized precision landing guidance capability.	No other aeronautical uses are envisioned for this band after ILS phase out, which is expected no later than 2010.
108.0-117.975 MHz	ILS localizers (until LAAS provides full modernized capability); and LAAS and/or SCAT-1 precision landing guidance capability.	This band is also potentially useful for new satellite communications applications (*e.g.*, WAAS). ILS phase-out is expected no earlier than 2010.
328.6-335.4 MHz	ILS glide slope (until LAAS provides full modernized capability.) LAAS may use this band. LAAS may use this band.	The beginning of ILS phase-out is expected no earlier than 2010.
1559-1610 MHz	LAAS pseudo-satellites.	This band is the sole radio spectrum allocated for satellite radionavigation systems.
5000-5250 MHz	LAAS may use this band.	Band also used by other services.

Aeronautical Mobile Radiocommunications

In 1995, the ICAO adopted the NEXCOM concept with its all-digital 25 kHz TDMA system (four independent voice or data link circuits on each RF channel). NEXCOM is based on VHF data link mode 3 (VDL-3) which uses TDMA technology to provide four independent communications circuits in one each 25 kHz channel. The four circuits can be any mix of voice or data link circuits. It was previously estimated that the NEXCOM would be implemented and operational in the 2010 time period. However, the FAA NEXCOM program has been deferred and it is estimated that a new system will not begin to be implemented until 2012.

To solve the critical shortage of aeronautical mobile radiocommunication channels in Europe, EUROCONTROL adopted an ICAO-approved interim solution of dividing the 25 kHz channels by three to an 8.33 kHz channel system. This decision required carriers to buy new radios. (By dividing by three, the new European channel plan essentially doubled the available number of channels.) However, it is believed that the 8.33 kHz interim solution will run out of available channels beginning in 2012 or 2013.[271]

The FAA is continuing work on the development of a roadmap for aeronautical mobile communications as part of a joint EUROCONTROL/FAA Future Communications Study that will recommend a future system. Adopting a new all-digital system would require replacement of all FAA and aircraft radios, voice switching equipment, communications lines, and modems. The transition would be a major undertaking, and would require huge amounts of resources. Moving to an all digital technology would require a transition period where both the current DSB-AM and the digital systems would operate in adjacent channels.

[271] Meeting Minutes, RTCA, Inc., ATMAC Requirements and Planning Work Group, Future Communications Sub-Group Meeting, April 20, 2005.

DOT FHWA FUTURE SPECTRUM REQUIREMENTS

There is a need for 5850–5925 MHz for future FHWA applications such as intersection collision avoidance, vehicle safety inspections, rollover warnings, and warnings of approaching emergency vehicles. The FHWA may not operate the deployed systems, and most will be operated by state and local governments.

DOT USE OF NEW TECHNOLOGIES

As discussed previously, the FAA is planning on new satellite-based radionavigation services and new technology for aeronautical mobile communications. The FAA is also participating in the research and international discussions of using new modulation techniques for air-to-ground communications in the Future Communications Study program.

DOT IDENTIFICATION OF SPECTRUM NO LONGER NEEDED

Seven frequency bands are identified by DOT as no longer needed to support its mission requirements: 9-14 kHz; 90-110 kHz; 4400-4500 MHz; 16.2-17.7 GHz; 24.250-24.650 MHz; 25-250-27.5 GHz; and 36-38.6 GHz. The bands 190-435 kHz and 510 – 535 kHz are planned to be used for NDBs in Alaska even after all NDBs in the lower 48 states are decommissioned. And, the band 3500–3650 MHz should be reserved as an expansion band for terminal radars.

DOT USE OF SPECTRUM FOR FEDERAL COG, INTEROPERABILITY AND PUBLIC SAFETY

DOT uses the 3-30 MHz band in support of COG operations.

DEPARTMENT OF TREASURY

AGENCY MISSION

The Treasury has the overall mission of promoting the conditions for prosperity and stability in the United States and encouraging prosperity and stability in the rest of the world. It serves as the nation's chief financial agent, collecting taxes, and manufacturing currency and coins; and it is the manager of the national debt. It has five major administrative departments with missions that are supported by spectrum dependent systems as described below.

TREASURY SPECTRUM REQUIREMENTS

Treasury's main spectrum usage is for land mobile radio communications systems for tactical missions. Voice communication is the main communications mode used by agents to carry out law enforcement, investigative, facilities security and protection, and homeland security related missions. In addition to law enforcement and protection-related missions, land mobile systems are used to provide communications for facility maintenance.

Prior to the formation of the DHS in 2003, Treasury used numerous frequency assignments across all of its bureaus that supported tactical missions. As a result of the creation of DHS, the majority of Treasury's spectrum-user base, including the Secret Service, Border Patrol, and Customs agencies moved to DHS, leaving Treasury with approximately 25 percent of its original frequency assignments. Treasury still maintains government-owned radio communications services to support its tactical missions.

INTERNAL REVENUE SERVICE

The Internal Revenue Service's Criminal Investigation (IRS-CI) is the IRS law enforcement branch that investigates financial misconduct related to taxes, money laundering, and Bank Secrecy Act violations. The IRS-CI is Treasury's largest communications and spectrum user.

The IRS-CI operates 162-174 MHz narrowband digital communications systems with 250 repeater sites nationwide to support its mission-related activities. The IRS-CI also participates with other Federal and state agencies in money laundering and narcotics investigations to provide state and Federal agencies with financial investigative expertise.

Treasury's IRS operates UHF land mobile communications systems at IRS facilities nationwide to conduct mission-related activities including building security and law enforcement operations.

TREASURY INSPECTOR GENERAL FOR TAX ADMINISTRATION

The Treasury Inspector General for Tax Administration (TIGTA) mission is to provide audit and investigative services that promote integrity in the administration of the internal revenue laws. The TIGTA goals are to detect and deter fraud and abuse in the IRS programs and operations, and to protect IRS against external attempts to corrupt or threaten its employees.

TIGTA operates a nationwide 162-174 MHz narrowband digital communications system at forty-six repeater sites to support its investigative and enforcement functions through the United States. For its surveillance activities, TIGTA operates eleven stand-alone video surveillance systems that are deployable as needed.

BUREAU OF ENGRAVING AND PRINTING

The Bureau of Engraving and Printing (BEP) mission is to design and manufacture high-quality security documents that meet customer's requirements for quantity, quality, and performance and deter counterfeiting.

To realize its goal of securing its personnel, facilities, and products, BEP uses government-owned UHF land mobile radio communications systems for its campus communications systems located in Fort Worth, Texas, and Washington, DC. The communications systems support administrative, investigative, enforcement, and facilities maintenance activities at each BEP facility.

BUREAU OF THE PUBLIC DEBT

The Bureau of Public Debt's (BPD) mission is to borrow the money needed to operate the Federal Government and to account for the resulting debt.

The BPD operates land mobile communications systems at its Parkersburg, West Virginia facility to support its physical campus security, to direct and dispatch its maintenance personnel, and to direct emergency personnel or first responders.

UNITED STATES MINT

The United States Mint's mission is to apply world-class business practices in making, selling, and protecting the nation's coinage and assets.

The United States Mint operates six conventional radio communications systems at its campus systems, three VHF and three UHF, to support enforcement operations at its facilities in San Francisco, California; Denver, Colorado; Washington, DC; Fort Knox, Kentucky; Philadelphia, Pennsylvania; and West Point, New York.

TREASURY USE OF NEW TECHNOLOGIES

To date, three Treasury Bureaus – TIGTA, IRS-CI, and OIG have complied with the NTIA narrowbanding mandate. However, other Bureaus, including BEP and United States Mint, are still actively in the process of complying with the mandate and plan to meet the deadlines set by NTIA for implementation.

Use of any other new technologies is not planned.

SUMMARY OF CURRENT TREASURY SPECTRUM REQUIREMENTS

The vast majority of the radio assignments belong to two Bureaus - IRS-CI and the TIGTA, comprising approximately 80 percent of all Treasury frequency assignments. Furthermore, approximately 82 percent of Treasury's assignments are located in the 162-174 MHz band, with almost all of the other assignments in the 406.1-420 MHz band.

TREASURY FUTURE SPECTRUM REQUIREMENTS

The IWN, a partnership between DOJ, DHS, and Treasury, is planned to be a nationwide, fully interoperable digital trunking land mobile communications system. The IWN will use the Project 25 standard, operating on narrowband channels in the 162-174 MHz band. The IWN will be scalable to accommodate emerging technologies. As part of its commitment to the IWN, Treasury has developed a business justification through an OMB Exhibit 300 to purchase all equipment required by the Bureaus to operate and interface with the IWN infrastructure. As part of its commitment to the IWN, Treasury has budgeted $60 million over the next ten years to purchase all equipment required by the Bureaus to operate and interface with the IWN infrastructure.

TIGTA and IRS-CI have participated in IWN activities, including the efforts in Seattle/Blaine, the Southeast, and the Southwest. TIGTA and IRS-CI plan to fully migrate to the IWN in the future.

In conjunction with the IWN, Treasury plans to improve campus communications infrastructure communications for BEP, United States Mint, and IRS–Facilities, by transitioning from 162-174 MHz spot locations to an exclusively 406.1-420 MHz land mobile infrastructure. Treasury anticipates that this will decrease Treasury's 162-174 MHz spectrum requirements because all three Bureaus will use only 406.1-420 MHz campus communications systems. For these Bureaus to interface with the IWN, Treasury plans to provide a gateway to the IWN for incidents that involve multi-agency communications (*e.g.*, emergencies, law enforcement activities). BEP and United States Mint do not plan to transition to the IWN because they require their current existing systems to provide specific capabilities, including in-building coverage that may be lost if they move to the IWN.

TREASURY USE OF SPECTRUM FOR FEDERAL COG, INTEROPERABILITY AND PUBLIC SAFETY

HF NETWORK

In addition to the transitioning many Treasury spectrum and wireless requirements to IWN, Treasury is in the process of implementing a Treasury HF network at Treasury Bureau COOP sites for emergency communications, which resulted in the need for additional HF assignments. Treasury has purchased HF radios and obtained sufficient spectrum for current requirements. However, as the system is tested and operational, additional spectrum may be required to ensure adequate capacity for COOP requirements.

FEDERAL (TREASURY) COMMON INTEROPERABLE CHANNEL

In addition to use of the IWN for interoperability, Treasury maintains and promotes an interoperability frequency assignment called the Treasury Common, which is being renamed Federal Common. The Federal Common channel can be shared among all Federal agencies for law enforcement operations as well as for coordination with state and local police in emergency operations.

DEPARTMENT OF VETERANS AFFAIRS

AGENCY MISSION

The mission of the VA is to develop and operate programs that benefit military veterans and their families. These programs include the operation of medical centers, clinics, and nursing homes. The VA provides assistance to veterans in the form of pensions, education, rehabilitation, disability payments, home loan guarantees, and it manages the National Cemetery System.

VA SPECTRUM REQUIREMENTS

The VA groups that use spectrum to support their missions are:

1. Medical centers, nursing homes, and clinics;
2. Public safety/emergency planning teams;
3. Senior executives and middle managers; and
4. Education/information awareness specialists.

The VA's specific uses of spectrum to support the various missions include:

1. Coronary care units use medical telemetry to monitor patient vital signs;
2. VA medical centers use unlicensed WiFi systems to administer and track dispensing of drugs using the Bar Code Medication Administration (BCMA) Software package;
3. Microwave communications systems link VA centers to satisfy National Fire Protection Code requirements and provide links to local medical colleges; and
4. Commercial satellite systems are used to deliver education, information and entertainment content to VA centers. Mobile satellite systems are used for emergency communications means for VA medical centers, regional benefits offices, and senior executives at the VA central office.

The VA has numerous frequency assignments, with 57 percent in the 162-174 MHz and 406.1-420 MHz bands that are used for land mobile communications and paging systems. Another 35 percent of the assignments are under the generic mobile allocation, and are used for communications related to medical services such as telemetering a patient's vital signs from an ambulance or medical helicopter.

The VA also has many fixed assignments in various bands for its Emergency Medical Services (EMS) system. These are used to interconnect VA medical centers via point-to-point microwave systems. The VA uses the 1800-1900 MHz, 7125-7250 MHz, 8025-8815 MHz and 14.2-14.4 GHz bands for the microwave links. The VA also uses systems in the 22.55-23.6 GHz band for microwave links for security purposes.

The VA uses the 909-924 MHz band for emergency room telemetry and patient monitors. The 460-470 MHz band is used for coronary patient care telemetry, but these operations will be moved to the 608-614 MHz band.

VA USE OF SPECTRUM ALLOCATED FOR NON-FEDERAL USES AND USE OF COMMERCIAL SERVICES

The VA medical centers interconnect with other hospitals, ambulances, and medical facilities operated by private entities, local governments, or non-profit entities. The VA needs to interoperate with these entities to provide for patient care, especially in emergency medical situations. VA operates on non-Federal frequencies in the 138-144 MHz; 157.0375-157.1875 MHz; 152.855-157.0375 MHz; 157.1875-161.575 MHz; 450-460 MHz; and 956.4125 MHz bands for these functions.

The VA also uses commercial cell phones and the Iridium satellite system.

VA FUTURE SPECTRUM REQUIREMENTS

The VA plans to expand the use of presently allocated spectrum but does not foresee any major increases in spectrum requirements. VA plans to complete a HF emergency Long-Haul HF system called the Trans America Radio Program (TARP) which will link all VA facilities.

VA USE OF FUTURE TECHNOLOGIES

The VA will use the following new technologies in the near future:

1. RFID device use is expected to rise significantly, as the VA utilizes new applications, in addition to the BCMA.

2. Ground Penetrating Radar and GPS will be used for locating and mapping cemetery underground irrigation systems and for locating pre-placed crypts.

3. Very Small Aperture Terminal (VSAT) commercial satellite services will be used as backup for long-haul radio systems when the latter are damaged by natural occurrences.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AGENCY MISSION

The mission of NASA is to research the challenges of flight within and outside the Earth's atmosphere, and to ensure that the United States conducts activities in space devoted to peaceful purposes for the benefit of humankind.

NASA SPECTRUM REQUIREMENTS

NASA has developed and implemented a continually evolving infrastructure of communication systems and networks to support the exploration of space throughout the solar system and beyond, the exploration of our home planetary system including the Earth and its moon, and the environmental and ecological monitoring and sensing of the Earth. NASA communication systems provide the means to control spacecraft and the acquisition and delivery of scientific data obtained by the spacecraft instruments.

The NASA Long Range Electromagnetic Spectrum Forecast (NASA Forecast) presents detailed information on current spectrum requirements, divided into communication system use, sensor system use, and by mission and frequency pairing. These frequency allocation requirements are worldwide in nature, since communication between orbiting objects requires worldwide ground coverage. NASA leads the international efforts to secure operating spectrum for these systems with the ITU, to allow for worldwide participation in United States and space ventures led by other nations.

NASA's main operations are in the space science services, defined by the ITU as: 1) space operations; 2) space research; 3) Earth exploration-satellite; 4) meteorological-satellite; and 5) intersatellite service. NASA also conducts research on radio astronomy, radar astronomy, and radionavigation satellites. Furthermore, NASA space systems require spectrum for transmitting data from the scientific space sensors to Earth. NASA also operates the Wallops Flight Facility for launches of rockets, weather balloons, etc., at Wallops Island, Virginia, where various systems such as radars and telemetry are used to track, telemeter, and safeguard the launches.

NASA has other Federal agency partners to support its activities. For example, NASA maintains a number of standing communications agreements with DOD regarding Space Shuttle operations, including memoranda of agreement with the Air Force and the U.S. Space Command for launch range services in Florida and Vandenberg AFB, California. NASA also partners with the NSF, FAA, DOD, and NOAA for conducting aeronautical and space research and with international and private sector partners.

NASA's scientific spacecraft must be tracked and controlled, and the health, condition, and safety of the spacecraft must be monitored, and the scientific data must be transmitted and received. NASA operates a communications infrastructure that includes the TDRSS, Ground Network (GN), and Deep Space Network (SN). The TDRSS uses communications satellites in the geostationary orbit to relay data from scientific spacecraft to a fixed ground location. The GN operates a number of ground-based tracking facilities to provide direct support to the aircraft without the need for a relay. The DSN is used to support scientific spacecraft whose missions are beyond 2-million kilometers from Earth such as missions to other planets.

NASA operates active and passive space sensors in 42 frequency bands in the spectrum between 5250 MHz and 2.4 THz. The allocations in 38 of the 42 bands are to the EESS, or to the SRS. NASA operates sensors in four bands where there are no allocations to the EESS or SRS. The bands utilized for services not identified with their formal allocations are 33.4-34.2 GHz used on the JASON-1 mission; 64-65 GHz used on the UARS mission; and the 240 GHz, 640 GHz, and 2.4 THz bands used on the AURA mission.

Table B-12 presents the NASA communications spectrum used to obtain data from the scientific space sensors, communicating with astronauts, and sending uplink information and telecommand signals. The spectrum is used for deep space missions, near-Earth satellites and missions, and for satellite networks. NASA reuses many of the same frequency bands such as 2025-2110 MHz for many space missions.

Table B-12.   NASA Communications Spectrum Usage

137.825-138.0 MHz	Space-to-Earth
450 MHz	Earth-to-Space
2025-2110 MHz	Earth-to-Space
2110-2120 MHz	Earth-to-Space
2200-2290 MHz	Space-to-Earth
7145-7190 MHz	Earth-to-Space
7190-7235 MHz	Earth-to-Space
8025-8400 MHz	Space-to-Earth
8400-8450 MHz	Space-to-Earth
8450-8500 MHz	Space-to-Earth
13.4-14.050 MHz*	Space-to-Earth
14.6-15.25 GHz*	Earth-to-Space
25.5-27.0 GHz	Space-to-Space
25.5-27.0 GHz	Space-to-Earth
31.8-32.3 GHz	Space-to-Earth
34.2-34.7 GHz	Earth-to-Space

* TDRSS communications satellites.

NASA FUTURE SPECTRUM REQUIREMENTS

In addition to its current spectrum requirements, NASA has identified additional spectrum requirements to support its overall mission. President Bush has made space travel to the moon and Mars a priority for NASA. To meet this challenge, the NASA forecasts detailed future spectrum requirements necessary to fulfill mission requirements. The NASA spectrum requirements are for operations worldwide in all ITU regions to operate and make available these systems to all countries.

In the SRS and to augment the allocations provided at the WRC-03 allocation in the 25.5-27.0 GHz band which provided for transmissions from space-to-Earth, NASA needs 500 MHz additional of nearby spectrum in the Earth-to-space direction to support mission data communications and command and control links. This estimate might increase with manned missions. NASA believes that this allocation change for additional space-research spectrum may need to be on a future WRC agenda.

In support of NASA's deep space mission space-to-Earth communications, an additional 2.5 GHz is required in bands between 27.5-40 GHz, which NASA believes may need to be on a future WRC agenda. The need for this large projected increase in spectrum requirements to support the missions of the next ten to thirty years, results from:

1. Future United States deep space missions are predicted to require a much higher data rate capability in the range of hundreds of megabits-per-second to support the large amount of on-board generated data. Downlink data rate predictions are:

Year	***Data Rate***
2010	125 Mbps
2020	150 Mbps
2030	1500 Mbps

2. The number of missions is predicted to increase as more space agencies send missions to explore the solar system and beyond.

NASA expects that the bandwidth needed to support future deep space missions will far exceed the capacity of all existing allocations even after accounting for use of bandwidth efficient techniques.

Access to an additional 1 MHz of spectrum is required in the 100-150 MHz range to support the SAR part of the Microwave Observatory of Subsurface and Subcanopy (MOSS). NASA believes that this requirement for a new primary allocation for this 1 MHz spectrum may also need to be on a future WRC agenda.

NATIONAL SCIENCE FOUNDATION

AGENCY MISSION

The mission of the NSF is to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes. The NSF, a Federal agency created by Congress through the National Science Foundation Act of 1950, is responsible for advancing science and engineering in the United States across a broad and expanding frontier. NSF develops state-of-the-art science and engineering facilities, tools, and other infrastructure that enable discovery, learning, and innovation. Many of these facilities, for example radio telescopes and atmospheric radars, require access to portions of the radio spectrum.

United States scientists also need to access the radio spectrum for data relay or logistical purposes, *e.g.*, when carrying out NSF's Antarctic mission, oceanographic research, or wildlife tracking and telemetry. Communications with NSF's Antarctic facilities are inconceivable without appropriate access to certain bands of the radio spectrum. Radio astronomers and other scientists primarily use spectrum in a passive (receive only) mode. Some science applications, such as ionospheric research, may require the use of both passive and active radio techniques.

NSF SPECTRUM REQUIREMENTS

NSF funds the operation of radio astronomy facilities within the United States and abroad, based on scientific objectives. NSF supports radio astronomy facilities, including the telescopes operated by the NRAO and by NAIC, and contributes to the support of university owned and operated radio astronomy observatories. U.S. radio astronomy facilities, recognized to be among the best and most versatile worldwide, cover practically the entire allocated spectrum. The spectrum coverage extends far beyond the upper limit of currently allocated spectrum (275 GHz), well into the terahertz region. Responding to science requirements, United States radio observatories cover not only the bands allocated to radio astronomy, but also most of the spectrum that is not specifically allocated to radio astronomy. Observations in bands not allocated to radio astronomy are made on an unprotected basis, and at reduced efficiency.

Scientific research often requires access to specific, well-defined parts of the spectrum. For example, radio astronomers cannot always choose the frequencies of their observation, as many of the cosmic signals they study take the form of spectral lines covering a limited frequency range. These lines are generated at characteristic frequencies associated with transitions between quantized energy states of atoms or molecules. In order to obtain the information that the astronomer seeks these spectral lines must be observed at specific frequencies. Radio astronomers also cannot limit their observations to a few bands. For example, establishing the chemical composition and dynamics of interstellar matter requires measurements of many spectral lines across the millimeter wave spectrum. Similar considerations apply to observations of other natural phenomena. In addition, international observing programs or campaigns may necessitate the use of common equipment, and dictate the choice of frequencies for a given experiment.

Researchers are interested not only in observations in the allocated part of the spectrum, but they are also interested in studies of emissions at frequencies below 9 kHz and above the current 275 GHz upper limit of the allocations. The radio astronomy systems utilized have an enormous range in terms of power. Radio astronomers routinely make observations of cosmic sources with power flux densities at the Earth of ~ 10-30 W m-2 Hz-1 (amounting to ~ 10-24 watts of detected power), and even less. Such observations are among the most sensitive ones made by humans. On the other hand, ionospheric researchers and radar astronomers routinely use some of the most powerful transmitters ever built, beaming effective radiated powers of the order of several terawatts toward distant objects.

Scientists continue to pioneer the use of ever-higher radio frequencies. Astronomical observations up to 1000 GHz and even higher are not unusual. Some of the highest frequency radio instruments have begun to blur the line between radio and infrared detection techniques.

Table B-13 presents the 24 frequency bands that are allocated in the United States solely to services such as radio astronomy that are passive (non-transmitting). No fundamental emissions from other spectrum users should be evident in these bands, at any location in the United States and possessions. However, unwanted spurious or out-of-band emissions and emissions from some weak unlicensed services can impact use of these bands for radio astronomy.

Table B-13. Frequency Bands Allocated Exclusively in the United States to Radio Astronomy and Other Passive Services

No.	Frequency Band
1.	13.36 - 13.41 MHz
2.	25.55 - 25.67 MHz
3.	73 - 74.6 MHz
4.	1400 - 1427 MHz
5.	1660.5 - 1668.4 MHz
6.	2690 - 2700 MHz
7.	4990 - 5000 MHz
10.	10.68 - 10.7 GHz
11.	15.35 - 15.4 GHz
12.	23.6 - 24 GHz
13.	31.3 - 31.8 GHz
14.	86 - 92 GHz
15.	100 - 102 GHz
16.	109.5 - 111.8 GHz
17.	114.25 - 116 GHz
18.	226 - 231.5 GHz
19.	250 - 252 GHz
20.	148.5 - 151.5
21.	164 - 167 GHz
23.	182 -186 GHz
24.	200 -209 GHz

Radio astronomy observations are made in 30 other frequency bands shared with other radio services on an equal primary basis in the range from 38 MHz to 275 GHz. Seven other bands in the spectrum range of 37.5 MHz to 250 GHz are used on a secondary basis. The radio astronomy service also operates in 23 other frequency bands in the spectrum range from 1350 MHz to 945 GHz, via a footnote in the Table of Frequency Allocations.

NSF FUTURE SPECTRUM REQUIREMENTS

RADIO ASTRONOMY

Radio astronomy requirements within the range of currently allocated spectrum are expected to be satisfied during the next decade through interagency coordination for interference mitigation. NSF does not anticipate a requirement for new radio astronomy allocations at frequencies up to 275 GHz. NSF, however, believes that new allocations in the 275 GHz to 1 THz region of the spectrum to radio astronomy and other science services may be needed within a decade. These requirements are due to the intense interest of the astronomy community in millimeter wave observations and the large international investment being made for facilities to observe this spectral region. Spectrum allocations above 1 THz may also become necessary beyond the next decade.

ATMOSPHERIC PHYSICS

Scientists also make extensive use of the radio spectrum for upper and lower atmospheric research. This requires the use of transmitters—mostly specialized radars—as well as passive systems. The facilities operated by the National Center for Atmospheric Research (NCAR) and by various universities cover the radiolocation service bands in the ~ 40 MHz to 100 GHz range. The requirements of the atmospheric community are expected to remain largely unchanged, and to remain limited to the radiolocation bands in the foreseeable future.

NSF USE OF NEW TECHNOLOGIES

New radio astronomy facilities and observation expansions will occur at several locations:

1. The Green Bank, West Virginia telescope will increase its instrumentation to cover entire 100 MHz-110 GHz design range of the antenna;
2. The Expanded Very Large Array (EVLA) will add elements and increase spectrum monitoring to cover between 1-50 GHz with a bandwidth of 8 GHz; and
3. ALMA will expand to operate in the 30 GHz to 1 THz frequency range.

TENNESSEE VALLEY AUTHORITY

AGENCY MISSION

The TVA mission is to provide affordable and reliable electrical power, to promote sustainable economic development, and to maintain environmental responsibility in the Tennessee Valley region. The TVA is a wholesaler working with its distributors to supply electricity for 8.3 million people and businesses in a seven-state 80,000-square mile service area. In environmental stewardship, TVA manages the Tennessee River System, balancing the benefits of navigation, flood control, power production, water supply, water quality, recreation, and land use. TVA promotes economic development by providing technical assistance, research data, and funding assistance to communities and businesses. The TVA generates electrical power via three nuclear plants, 11 coal-fired plants, 29 hydroelectric plants, six combustion turbine natural gas/oil power plants, and 16 solar energy sites, with over 17,000 miles of electrical transmissions lines. The TVA Strategic Plan indicates that the changing electrical power markets result in more open wholesale markets with larger and longer-distance power flows. The TVA operates 49 dams in the watershed, and manages 11,000 miles of public shoreline to maintain the integrity of the reservoir system. TVA also manages 293,000 acres of public land to support wildlife, recreation, and water quality.

TVA SPECTRUM REQUIREMENTS

TVA makes extensive use of radio communications systems and networks that use the spectrum to monitor and control the electrical power flow, maintain electrical grid security, monitor water levels and quality in rivers, reservoirs and dams, and to provide for the environmental stewardship, protection and security of public lands. TVA currently has numerous frequency assignments, with 67 percent in the 162-174 MHz and 406.1-420 MHz bands that are used for land mobile radio communications and for fixed service point-to-point links. The TVA uses a direct load control system with 45,000 receive-only terminals operating on a single frequency in the 162-174 MHz band. There are 22 transmitters operating on a single frequency, sending signals to control transmission system load by turning on and off water heaters and air conditioners in residences and businesses.

The key TVA land mobile radio communications system is its Regional Operations Radio System that provides communications for area operations personnel in their daily operation and maintenance activities for the transmission system throughout the TVA region. This system uses assignments in the 29-50 MHz band where propagation losses are lower to achieve reliable communications over a very large area. The regional system also uses the 162-174 MHz and 406.1-420 MHz bands to interconnect the repeaters and for repeater control links. Commercial communications services are not available in many of the remote areas, so the TVA must operate its own network. TVA uses in-plant LMR communications systems including some trunked systems to provide radio and telephone patching coverage inside and in close proximity to TVA's generating plants. TVA uses a combination of LMR repeaters and simplex portables to operate and maintain its power plants.

The TVA operates its own security police radio system to provide communications for TVA police personnel throughout the TVA service area. The TVA security police use this system to provide security and protection for TVA's plants, facilities and personnel. The network is a 162-174 MHz repeater system, using the 406.1-420 MHz band for vehicle repeater communications to portable units.

TVA uses various communications systems at its nuclear power plants, some of which support the Nuclear Emergency Operations Center. A VHF radio paging system is used to alert personnel to operate the center. TVA uses a nuclear power emergency preparedness mobile radio communications system operating in the VHF band for various radiological, hydrological, and meteorological purposes. The TVA uses an LMR band for a repeater system interconnecting siren emergency alerting systems at its nuclear power plans. The sirens provide nuclear radiological warnings to residents within ten miles of the nuclear plants.

In the environmental stewardship part of the TVA mission, the TVA operates a river system operation and environment radio system in the VHF band to provide communications coverage along river areas. The TVA sends rain gauge and stream gauge data via an uplink to the GOES satellite.

MICROWAVE RADIO RELAY COMMUNICATIONS SYSTEMS

Over the years, TVA has deployed various microwave systems as part of its communication network. The low 24 to 48 channel capacity analog systems are in the 932-955 MHz band and the higher capacity analog systems operate in the 1710-1850 MHz band. Most of the high capacity digital microwave systems are in the 7125-8400 MHz band, with a few assignments for digital systems in the 15 GHz and 22 GHz bands.

COMMERCIAL SERVICES AND UNLICENSED SPECTRUM USE

TVA is using a commercial cellular system to aid radio communication across its service area. In addition, TVA has partnered with this cellular operator to extend coverage inside all TVA fossil, nuclear, and major office facilities.

TVA has installed unlicensed spread spectrum microwave radio to reach "the last mile" to substations and other facilities. The various microwave systems serve as a backbone for voice, protective relaying, and network control using high-speed data.

TVA FUTURE SPECTRUM REQUIREMENTS

The TVA will continue to use currently used spectrum for at least the next 10 years. TVA is exploring new technologies for SCADA, including satellites, commercial cell phone networks, and new spread spectrum technologies. Some of the 932-955 MHz analog microwave systems may be upgraded to digital in either the same 900 MHz band, or to the 4400-4900 MHz or the 7125-8400 MHz bands. As part of vacating requirements in 1710-1755 MHz band, TVA is planning to migrate to either the 4400-4990 MHz or 7125-8400 MHz bands.

UNITED STATES COAST GUARD

AGENCY MISSION

The Coast Guard is a military, multi-mission, maritime service charged with reducing America's risk throughout the maritime domain while maximizing safety and accessibility to the economic and recreational benefits of the nation's waterways. As part of the DHS, the Coast Guard is the lead Federal agency for maritime homeland security. The Coast Guard's mission is to protect the public, the environment, and U.S. economic interests – in the nation's ports and waterways, along the coast, on international waters, or in any maritime region as required to support national security.

The Coast Guard participates in the IMO, a United Nations treaty organization concerned with maritime and maritime-related issues. Many of the Coast Guard activities are driven by the IMO treaty and associated regulations and standards. For example, the GMDSS is a set of rules and regulations established in the ITU and IMO that have treaty status, and must be followed in maritime distress and safety operations.

COAST GUARD SPECTRUM REQUIREMENTS

The Coast Guard requires all present spectrum allocations to continue in order to support its current missions indefinitely and may have additional spectrum requirements for the future.

MARITIME SAFETY

Maritime safety operations include search and rescue (SAR) operations and marine safety systems for the protection of lives and safety of those at sea. The Coast Guard SAR involves multi-mission stations, cutters, aircraft and boats all linked by essential terrestrial and satellite communications networks using multiple radio frequencies. The Coast Guard's current use of spectrum for the maritime safety mission includes:

1. 518 kHz to transmit navigation information to ships;
2. 2-30 MHz HF for communications, GMDSS and MF/HF DSC;
3. 121.5 MHz for EPIRBS;
4. 156-162 MHz for GMDSS, ship-to-shore communications; DSC, and NDRS;
5. 162-174 MHz for secure law enforcement (LE) sensitive communications;
6. 225-400 MHz for indicating radio beacon aircraft communications and navigation;
7. 401-406 MHz for EPIRBS;
8. 960-1215 MHz, 1030 MHz, and1090 MHz for aircraft navigation and identification; and
9. 2900-3100 MHz and 9200-9500 MHz for land based navigation radars.

MARITIME SECURITY

The Maritime Security mission encompasses the Coast Guard's role as one of the five military services and the role lead Federal agency for Maritime Homeland Security. Additionally, the Coast Guard is the lead Federal agency for maritime drug interdiction and shares lead responsibility for air drug interdiction with DHS/CBP. As the primary maritime law enforcement agency, the Coast Guard is tasked with enforcing immigration law at sea, and with enforcing laws pertaining to U.S. Exclusive Economic Zones, which extend up to 200 miles from U.S. shores. Finally, as the lead agency for Maritime Homeland Security, the Coast Guard is responsible for preventing and protecting against maritime security threats. The Coast Guard's spectrum use for the maritime security mission includes:

1. 406.1-420 MHz for inter-ship and intra-ship communications and boarding parties;
2. 2900-3100 MHz and 9225-9500 MHz for coastal surveillance radars; and
3. 7125-8400 MHz for microwave radio relay to transmit harbor radar video surveillance data.

NATIONAL DEFENSE

The Coast Guard is one of the five military services that provide essential capabilities to support our national security and national military strategies. This mission is satisfied through the use of spectrum described for other missions.

MARITIME STEWARDSHIP

Maritime stewardship involves the use of radio Aids to Navigation (AtoN) and waterways management and protection of national resources. The AtoN assists government, commercial and recreational vessels with navigation and alerts them to obstructions and hazards. Maritime stewardship also includes ice operations, including ice breaking activities in the Great Lakes, the Northeast and Polar Regions. The Coast Guard actively protects the marine environment from oil and chemical spills and in clean-up activities in the aftermath of spills. While enforcing living marine resources laws, the Coast Guard protects U.S. economic interests from the coast line through the U.S. Exclusive Economic Zones. The Coast Guard's spectrum use for the maritime stewardship missions include:

1. 90-100 kHz for LORAN-C radionavigation;
2. 285-325 kHz for DGPS;
3. 3-10 MHz for HF command and control;
4. 156-174 MHz and 406-420 MHz for VHF/UHF command and control
5. 161.975 MHz and 162.025 MHz for AIS;
6. 2900-3100 MHz and 9300-9500 MHz for radar beacons in United States waterways and for ship borne radars; and
5. 5200-5900, 8750-8850, 9000-9250 and 9300-10000 MHz for airborne radar systems, used for surveillance and navigation.

FUTURE COAST GUARD SPECTRUM REQUIREMENTS

The future Coast Guard spectrum requirements are based upon the increased missions manifested in three emerging programs: IDS, RESCUE 21, and the MDA Program. The Coast Guard plans to make increased uses of UAVs and tethered radar systems to fulfill various missions. The future spectrum requirements resulting from all three programs, which constitute a major increase in numbers, types, and geographical coverage for Coast Guard missions, are summarized in Table B-14.

Table B-14. Summary of Future Additional Coast Guard Spectrum Requirements

Band	**Additional Bandwidth Required**	**Comments**
285-325 KHz	60 KHz	Differential GPS nationwide
3-30 MHz	1 MHz	Needed for maritime mobile communications
108-137 MHz	25 Ch. 8.33 kHz	Aeronautical mobile communications
156-162 MHz	10 % growth over current needs; other	Maritime mobile communications
156-162 MHz	25 kHz	AIS Satellite sensing – long range vessel tracking
156-162 MHz	Additional channel of 25 kHz	Additional AIS channel for vessel traffic
156-162 MHz	25 kHz	Data channel for force tracking
162-174 MHz	12.5 kHz	Data channel for force tracking
162-174 MHz	300 % growth over current needs	Land mobile communications
225-400 MHz	25 kHz channels	Aeronautical mobile communications
243.855-269.95 MHz	5 kHz channels	Mobile satellite downlink
292.85-317.325 MHz	5 kHz channels	Mobile satellite uplink
406.1-420 MHz	300 % growth	Land mobile communications
700-800 MHz	30 MHz	Multi-agency interoperability
1215-1380 MHz	TBD*	Tethered aerostat radar systems (TARS)
1525-1559 MHz	TBD*	Commercial mobile satellite uplink
1610-1660.5	TBD*	Commercial mobile satellite downlink
2900-3100 MHz	TBD*	TARS
7250-7750 MHz	TBD*	Federal fixed satellite downlink
7900-8400 MHz	TBD*	Federal fixed satellite uplink
8.5-10.55 GHz	TBD*	Synthetic Aperture Radar (SAR)
9-10 GHz	TBD*	TARS
13.4-14.2 GHz	TBD*	SAR
14-14.5 GHz	TBD*	Commercial mobile satellite
14.4-15.35 GHz	5 MHz	Mobile tactical common data link (TCDL)
15.4-17.7 GHz	TBD*	SAR
Various Bands	TBD*	Point-to-point microwave communications

*TBD-To be determined.

Military and commercial satellite communications will be required for high speed data connectivity. The Coast Guard will also use UAVs such as the RQ-4 model that uses many frequency bands including commercial 12/14 GHz satellite links for tactical data. The Coast Guard is also planning an HF radar system for which there are no current spectrum allocations.

UNITED STATES POSTAL SERVICE

AGENCY MISSION

The mission of the United States Postal Service (USPS) is to bind the country together through the personal, educational, literary, and business correspondence of the people by providing prompt, reliable, and efficient mail service to all communities. The USPS is a semi-independent Federal agency, mandated to be revenue-neutral, with a no-profit break-even objective. In a typical year, the USPS delivers mail to 134 million delivery addresses, including 20 million post office boxes. The USPS currently handles more than 200 billion pieces of mail a year, or five pieces per address per day. It operates out of more than 27,000 facilities. The USPS has over 220,000 vehicles and 300,000 field-type employees that will be considered for radio communications services of various types, including scanners, personal digital assistants (PDAs) and mesh networks. The USPS future plans include mobility communications between its employees and applications via the postal network. The USPS has 750,000 employees, so the effort to provide such communications will be significant.

USPS SPECTRUM REQUIREMENTS

As shown in Table B-15, the USPS utilizes radio spectrum to support various functions of the USPS operations including:

- Mail Division's use of land mobile radio systems for operations and maintenance;
- Mail processing organizations use of large numbers of unlicensed systems to support loading dock operations; and
- Inspection Service's use of spectrum to operate a wireless surveillance system.

Table B-15. Current and Future USPS spectrum usage including bandwidth and frequency allocations

Frequency Band	Total Bandwidth Used	Use
162.0-174.0 MHz	413 kHz	land mobile communications
406.1-420.0 MHz	588 kHz	land mobile communications
1429.0-1435.0 MHz	Future use	RFID tracking; asset management
1755.0-1850.0 MHz	30 MHz	video surveillance
5400-5800 MHz	24 MHz in future	mesh networks
14.4-15.35 GHz	180 MHz	commercial satellite for interoffice communications

There is extensive use of unlicensed systems as backup communications systems for internal operations at postal facilities. The USPS Spectrum Management office prohibits use of unlicensed family radio and citizen's band radios for critical backup communications.

USE OF COMMERCIAL SYSTEMS

More commercial systems could be used by USPS, depending on logistics and cost. Scanners and PDA use is planned for tracking the postal delivery functions in the field. The USPS already uses commercial satellite VSATs operating in the 14.4-15.35 GHz band for data communications between field offices and the postal network. VSAT use may grow to 7,000-14,000 terminals.

FUTURE SPECTRUM REQUIREMENTS

The future USPS requirements in terms of systems, services and spectrum, in addition to the presently utilized spectrum, are:

1. Use of RFID devices, which will track all USPS mobile assets internal and external to the agency facilities. The intention is to use approximately 20 kHz of the 1429-1435 MHz band for RFID tracking and asset management systems.

2. USPS intends to use approximately 24 MHz of the 5400-5800 MHz band for vehicle telematics, data transmissions and vehicle navigation via GPS. This would provide services to over 220,000 vehicles and 300,000 field personnel, augmenting commercial systems where they are cost effective.

3. Future use of VSATs could increase to between 7,000 and 14,000 to support postal network intercommunications voice and data needs.

The first objective of these data communications systems is to provide for mobile vehicular telemetry providing information on vehicle system integrity and GPS systems to maximize routing and fuel efficiency. The spectrum will be also be used to allow for the use of mesh networking devices on mobile platforms and within stationary building elements in large and medium sized cities. These same systems will be used for future wireless data access which would include scanners and PDAs for the delivery function in the field.

USPS USE OF NEW TECHNOLOGIES

The USPS plans on merging its Inspection Service department land mobile radio communications network into the IWN Network. The USPS will continue the use of narrowband technologies within the 162-174 MHz and 406.1-420 MHz bands. The USPS expects to institute a real time delivery confirmation and signature capture capability; however,– no specific spectrum has been identified for this capability. The USPS plans to expand its use of GPS in conjunction with other radio communications networks for asset tracking.

USPS USE OF SPECTRUM FOR FEDERAL COG, INTEROPERABILITY AND PUBLIC SAFETY

All of the present allocations would be utilized for COG purposes to ensure that the operations of the USPS system are maintained.

ANNEX TO APPENDIX B

LIST OF TABLES

TABLE B-1. NASA USES OF EESS (ACTIVE) SENSORS B-105
TABLE B-2 NASA USE OF EESS SPECTRUM FOR PASSIVE SENSORS....B-106
TABLE B-3. DOC USE OF EESS SPECTRUM FOR PASSIVE REMOTE SENSING B-107
TABLE B-4. CURRENT METSAT SPECTRUM USE AND FUTURE NOAA METSAT SPECTRUM REQUIREMENTS....B-111
TABLE B-5 FREQUENCY BANDS ALLOCATED TO THE METEOROLOGICAL AIDS SERVICE B-115
TABLE B-6 NOAA CURRENT AND FUTURE SPECTRUM REQUIREMENTS B-118
TABLE B-7. ADDITIONAL NASA AND NASA-RELATED SPACE-TO-SPACE OPERATIONS B-126
TABLE B-8. EXISTING NON-FEDERAL PUBLIC SAFETY FREQUENCY BANDS* B-136
TABLE B-9. MAJOR DOE SPECTRUM USES B-177
TABLE B-10. DOJ FREQUENCY BAND USE....B-188
TABLE B-11. LAAS SPECTRUM NEEDS FOR AERONAUTICAL RADIONAVIGATION B-197
TABLE B-12. NASA COMMUNICATIONS SPECTRUM USAGE....B-206
TABLE B-13. FREQUENCY BANDS ALLOCATED EXCLUSIVELY IN THE UNITED STATES TO RADIO ASTRONOMY AND OTHER PASSIVE SERVICES....B-209
TABLE B-14. SUMMARY OF FUTURE ADDITIONAL COAST GUARD SPECTRUM REQUIREMENTS....B-215
TABLE B-15. CURRENT AND FUTURE USPS SPECTRUM USAGE INCLUDING BANDWIDTH AND FREQUENCY ALLOCATIONS B-217

ACRONYMS AND ABBREVIATIONS

ALERT	Advanced Law Enforcement Response Technology
ALMA	Atacama Large Millimeter Array
APHIS	Animal and Plant Health Inspection Service
BBG	Broadcasting Board of Governors
BEP	Bureau of Engraving and Printing
BOP	Bureau of Prisons
C2	Command and Control
C2I	Command, Control, and Intelligence
C4	Command, Control, Communications and Computer
C4I	Command, Control, Communications, Computers, and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CAF	Combat Air Forces
CBP	Customs and Border Patrol
CNO	Chief of Naval Operations
CONUS	Continental United States
DCS	Defense Communications System
DEA	Drug Enforcement Administration
DHHS	Department of Health and Human Services
DISA	Defense Information Systems Agency
DOD	Department of Defense
DOE	Department of Energy
DON	Department of Navy
DOS	Department of State
DRU	Direct Reporting Unit
DS	Diplomatic Security
DSCS	Defense Satellite Communications System
DUITS	Digital, Ubiquitous, Interoperable, Transparent, and Secure
EA	Electronic Attack
EAF	Expeditionary Air Force
ECM	Electronic Countermeasures
EHF	Extra high frequency
EVA	Extra Vehicular Activity
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FLETC	Federal Law Enforcement Training Center

FS	Fixed Service
FSS	Fixed-Satellite Service
FWPC	Federal Wireless Policy Committee
GHz	Gigahertz
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
GSA	General Services Administration
HF	High Frequency
IRAC	Interdepartment Radio Advisory Committee
ITS	Intelligent Transportation System
ITU	International Telecommunication Union
kHz	Kilohertz
LE	Law enforcement
MAJCOM	Major Command
MHz	Megahertz
MSS	Mobile-Satellite Service
NAIC	National Atmosphere and Ionosphere Center
NAS	National Airspace System
NASA	National Aeronautics And Space Administration
NATO	North Atlantic Treaty Organization
NAVAIRSYSCOM	Naval Air Systems Command
NAVEMSCEN	Naval Electromagnetic Spectrum Center
NAVSEASYSCOM	Naval Sea Systems Command
NCAR	National Center for Atmospheric Research
NCW	Network Centric Warfare
NEMS	National Emergency Management System
NESDIS	National Environmental Satellite, Data, and Information Service
NIH	National Institute of Health
NIST	National Institute of Standards and Technology
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAO	National Optical Astronomy Observatories
NOS	National Ocean Service
NRAO	National Radio Astronomy Observatory
NRCS	Natural Resources Conservation Service
NSF	National Science Foundation
NTIA	National Telecommunications and Information Administration
NTIA-ITS	NTIA Institute for Telecommunications Science
NTS	Naval Telecommunications System
NWS	National Weather Service

(OR)	Off Route
OPNAV	Office of the Chief of Naval Operations
PCS	Personal Communications Service
PDD	Presidential Decision Directive
PHS	Public Health Service
RCS	Radio Conference Subcommittee
RF	Radio Frequency
RRS	Radiosonde Replacement System
SARSAT	Search And Rescue Satellite
SHF	Super High Frequency
SPAWARSYSCOM	Space and Naval Warfare Systems Command
TDRSS	Tracking and Data Relay Satellites
TIGTA	Treasury Inspector General for Tax Administration
TT&C	Telemetry, Tracking, and Command
UHF	Ultra High Frequency
USAF	U.S. Air Force
USCENTCOM	U.S. Central Command
COAST GUARD	U.S. Coast Guard
USCS	U.S. Customs Service
USDA	U.S. Department of Agriculture
USJFC	U.S. Joint Forces Command
USMS	U.S. Marshals Service
US&P	U.S. and its Possessions
USPS	U.S. Postal Service
USSOUTHCOM	U.S. Southern Command
USSS	U.S. Secret Service
USSTRATCOM	U.S. Strategic Command
VA	Department of Veterans Affairs
VHF	Very High Frequency
VLA	Very Large Array
VLBA	Very Long Baseline Array
VOA	Voice of America
WRC	World Radiocommunication Conference