U.S. Department of Agriculture

Department of the Air Force

Department of the Army

U.S. Coast Guard

Department of Commerce

Department of Energy

Federal Aviation Administration

Federal Emergency Management Administration

Department of Health and Human Services

Department of the Interior

Department of Justice

National Aeronautics and Space Administration

National Science Foundation

Department of the Navy

Department of Treasury

U.S. Postal Service

FEDERAL OPERATIONS IN THE 1755–1850 MHZ BAND:

The Potential for Accommodating Third Generation Mobile Systems

Interim Report

November 15, 2000

U.S. DEPARTMENT OF COMMERCE

National Telecommunications and Information Administration

NTIA Special Publication 01–41

FEDERAL OPERATIONS IN THE 1755–1850 MHZ BAND:

The Potential for Accommodating Third Generation Mobile Systems

Interim Report

November 15, 2000

U.S. DEPARTMENT OF COMMERCE
Norman Y. Mineta, Secretary

Gregory L. Rohde, Assistant Secretary
for Communications and Information, and
Administrator, National Telecommunications
and Information Administration

PROJECT MANAGEMENT

William T. Hatch
Associate Administrator
Office of Spectrum Management

Fredrick R. Wentland
Director, Spectrum Plans and Policies

TEAM LEADER

W. Russell Slye
Manager, Strategic Spectrum Planning Program

TEAM MEMBERS

Spectrum Engineering and Analysis Division
Gerald F. Hurt
William T. Druhan, Jr.

Spectrum Plans
Darlene Drazenovich
James T. Vorhies

Spectrum Policies
Joseph P. Camacho

Public Safety
Gary M. Patrick
Robert C. Wilson

Office of Policy Analysis and Development
Joseph L. Gattuso

Table of Contents

Acronyms and Abbreviations

3G	Third Generation
ACMI	Air Combat Maneuvering Instrumentation
ACTS	Air Combat Training Systems
AFSCN	Air Force Satellite Control Network
CDMA	Code Division Multiple Access
dB	Decibel
dBi	dB Referred to Isotropic
dBm	dB Referred to 1 milliWatt
dBw	dB Referred to 1 Watt
DMSP	Defense Meteorological Satellite Program
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOJ	Department of Justice
DSP	Defense Support Program
DWTS	Digital Wideband Transmission System
EMC	Electromagnetic Compatibility
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FLTSATCOM	Fleet Satellite Communications
FSK	Frequency Shift Keying
GEO	Geosynchronous
GHz	Gigahertz (10^9 Hertz)
GMF	Government Master File
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GSO	Geosynchronous Orbit
HEO	High Earth Orbit
IMT–2000	International Mobile Telecommunications-2000
I/N	Interference-to-Noise Ratio
I+N	Interference plus Noise
ITU	International Telecommunication Union
ITU-R	ITU Radiocommunication Sector
ITU-T	ITU Telecommunication Standardization Sector
JTCTS	Joint Tactical Combat Training System
kbs	Kilobits per Second
kHz	Kilohertz (10^3 Hertz)
km	Kilometer
LEO	Low Earth Orbit
m	Meter
mbs	Megabits per Second
MHz	Megahertz (10^6 Hertz)

MILSTAR	Military Strategic and Tactical Relay
MSE	Mobile Subscriber Equipment
NATO	North Atlantic Treaty Organization
NDAA	National Defense Authorization Act
non-GEO	Non-Geosynchronous
NGSO	Non-Geosynchronous Orbit
NTIA	National Telecommunications and Information Administration
OBRA–93	Omnibus Budget Reconciliation Act of 1993
PCS	Personal Communications Services
PDT	Proliferation Detection Technology
RTS	Remote Tracking Station
RTT	Radio Transmission Technology
SATOPS	Satellite Operations
SBIRS	Space Based Infrared System
SCN	Satellite Control Network
SGLS	Space Ground Link Subsystem
SOCC	Satellite Operations Control Center
STS	Space Transportation System (Space Shuttle)
TACTS	Tactical Air Combat Training System
TDMA	Time Division Multiple Access
TT&C	Tracking, Telemetry, and Command
TVA	Tennessee Valley Authority
UFO	UHF Follow-On
UK	United Kingdom
USBS	Unified S-Band System
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
US&P	United States and Possessions
W-CDMA	Wideband Code Division Multiple Access
WARC–92	1992 World Administrative Radio Conference
WRC–97	1997 World Radiocommunication Conference
WRC–2000	2000 World Radiocommunication Conference

Executive Summary

The National Telecommunications and Information Administration (NTIA) is the Executive Branch agency principally responsible for developing and articulating domestic and international telecommunications policy. Accordingly, NTIA conducts studies and makes recommendations regarding telecommunications policies and presents Executive Branch views on telecommunications matters to the Congress, the Federal Communications Commission (FCC), and the public. NTIA also serves as manager of the Federal Government's use of the radio frequency spectrum.

President Clinton signed an executive memorandum dated October 13, 2000, that stated the need and urgency for the United States to select radio frequency spectrum to satisfy the future needs of the citizens and businesses for mobile voice, high speed data, and Internet-accessible wireless capability; the guiding principles to be used for the development of third generation (3G) wireless systems; and the direction to the Federal agencies to carry out the selection of spectrum. The President directed the Secretary of Commerce, in cooperation with the FCC, to issue interim reports by November 15, 2000 describing the current spectrum uses and the potential for reallocating or sharing the bands identified at the International Telecommunication Union (ITU) 2000 World Radiocommunication Conference (WRC–2000) for 3G wireless systems. The FCC, in conjunction with NTIA, is expected to identify spectrum by July 2001, and auction licenses to competing applicants by September 30, 2002.

In response to the President's memorandum, this interim report provides an examination of Federal operations in the1755–1850 MHz band, and a discussion of the potential for accommodating 3G, advanced mobile telecommunications systems in the band.

The 1710–1885 MHz and 2500–2690 MHz bands were two bands, among others, identified by the WRC–2000 as additional bands for 3G mobile systems, also called International Mobile Telecommunications–2000 (IMT–2000). The United States is planning for the introduction of IMT–2000 services by commercial providers, but unused spectrum to accommodate such services is currently not available. Both NTIA and the FCC are examining these candidate frequency bands (1755–1850 MHz and 2500–2690 MHz, respectively) identified by the conference that are under their respective jurisdictions, with a view towards accommodating IMT–2000 systems. NTIA and the FCC are issuing separate interim reports addressing the accommodation issues in the bands identified, and will issue final reports at a later date. Since the WRC–2000 identified these candidate bands for IMT–2000 operations, promoting worldwide harmonization of spectrum is a desired long-term goal.

In addition to the above two bands identified by the conference, other bands that could be considered in the United States are: 698–746 MHz, 747–762 MHz, 777–792 MHz, 806–960 MHz, 1850–1990 MHz, and 2110–2150 MHz.

The 1710–1755 MHz band will be transferred to the FCC in 2004 on a mixed use basis pursuant to the requirement of the Omnibus Budget Reconciliation Act of 1993, but Federal operations can remain in 17 protected areas. The 1850–1885 MHz band is under FCC regulatory jurisdiction and is currently used for personal communications services (PCS). The remaining 1755–1850 MHz band, which is the focus of this study, is under the jurisdiction of NTIA. Within the United States, the 1755–1850 MHz band is allocated on an exclusive basis to the Federal Government for fixed and mobile services. Footnote G42 to the National Table of Frequency Allocations provides for the co-equal accommodation of Federal space command, control, and range and range-rate systems for earth station transmission in the 1761–1842 MHz band. The Department of Defense (DOD) is the predominant user of the 1755–1850 MHz band. However, other Federal agencies operate extensive fixed and mobile systems in this band throughout the United States.

The Federal use of the 1755–1850 MHz band can be categorized into several broad classes of systems, 1) tracking, telemetry, and control for Federal space systems, 2) medium-capacity, conventional fixed microwave communications systems, 3) military tactical radio relay radios, 4) air combat training systems, 5) precision guided munitions, 6) high resolution airborne video data links, and various other aeronautical mobile applications, and 7) land mobile video functions such as robotics, surveillance, etc. This interim report specifically addresses the first four classes, but potential accommodation of IMT–2000 systems in the 1755–1850 MHz band must address all classes of systems, each of which involves unique sharing, relocation, reimbursement, and time line issues.

To aid in NTIA's evaluation of accommodating IMT–2000 services in the 1755–1850 MHz band, the DOD provided NTIA an initial report that detailed the electromagnetic compatibility (EMC) between major Federal systems in the 1755–1850 MHz band and IMT–2000 systems.

The EMC analyses showed the most serious challenges in accommodating IMT–2000 systems are related to sharing with the Federal Government uplink satellite control systems, the military radio relay systems, and the air combat training systems. These analyses have shown that the uplink satellite signal margins would be severely degraded by the aggregate IMT–2000 transmissions. Therefore, with regard to possible near- term use of the band for IMT–2000 systems, sharing considerations with the satellite control systems presents a fundamental go/no-go decision, since near-term replacement or changing frequencies in orbiting satellites is not possible. All DOD satellites use receivers that are set to specific channels and cannot be re-tuned after launch. The lifetimes of these satellites can exceed 10 years. Uplink sharing is further complicated by the fact that remote tracking stations must support global coverage of Federal satellite assets in all orbits, and deployable satellite control Earth stations are operated at deployed locations when necessary to accomplish the satellite control mission.

Conventional fixed systems are also a cause for concern because of their widespread use, but NTIA is developing rules for private sector reimbursement for relocating these systems currently operating in the 1710–1755 MHz band to other frequency bands, similar in some respects to the procedures used in clearing the commercial PCS band. These same procedures could also be used as a basis for reimbursement for the relocation of Federal systems, where necessary, from parts of the 1755–1850 MHz band.

The EMC analyses further indicated that the extensive use of the 1755–1850 MHz band by Federal entities, coupled with the projected build out of IMT–2000 systems, would make uncoordinated sharing with IMT–2000 systems infeasible. However, if restrictions on IMT–2000 operations in space or time prove feasible and under the conditions that (1) IMT–2000 operators reimburse Federal operators to relocate or retune convention fixed and various other systems prior to IMT–2000 operations commencing in the vicinity of the affected Federal operations, and (2) major Federal functions are not impacted, sharing might be possible. One such sharing approach would be to segment the 1710–1850 MHz band into three segments, 1710–1755 MHz, 1755–1805 MHz, and 1805–1850 MHz. This segmentation might make up to two, 45 MHz segments available for IMT–2000 services, under certain conditions. In this approach, mobile (handset) IMT–2000 units would share and transmit in the 1710–1755 MHz segment, the Federal Government would retain exclusive use of the 1755–1805 MHz segment, and the IMT–2000 base stations would share and transmit in the 1805–1850 MHz segment. IMT–2000 operators would coordinate their operations within *protection areas*, defined by separation distances from major Federal systems required to reduce mutual interference to an acceptable level. However, since both mobile and base stations transmit (and receive) in the 1710–1850 MHz band, simultaneous coordination of two frequencies may be necessary. These factors, plus sharing satellite control uplinks with IMT–2000 base stations, may preclude sharing under these conditions.

A second segmentation option would provide for IMT–2000 mobiles to share and transmit in the 1710–1790 MHz range, in phases, with the base stations transmitting in frequency bands above 2110 MHz. The Federal Government would retain exclusive use of the 1790–1850 MHz segment. This segmentation option would have three phases, the first phase allowing IMT–2000 mobile operations to share in the 1710–1755 MHz band, then adding shared use in the 1755–1780 MHz band, and finally in the 1780–1790 MHz band, if required. As described above, IMT–2000 operators would coordinate their operations within *protection areas*, defined by separation distances from major Federal systems that would reduce mutual interference to an acceptable level. IMT–2000 operators would also reimburse Federal operators to relocate, modify, or retune conventional fixed and various other systems, and DOD essential military capabilities must be maintained. This segmentation option presents greater flexibility than the in-band segmentation option, from an interference standpoint, because only half of the IMT–2000 system needs to be coordinated, and IMT–2000 base stations would not operate co-channel with satellite control uplinks. If further analysis determines that co-channel sharing with mobiles is feasible, satellite control uplinks would share with IMT–2000 mobiles in the 1761–1790 MHz band. This option could, in the long-term, make up to 80 MHz available for mobiles in the 1710–1790 MHz band to be paired with equivalent spectrum in a higher frequency band.

The alternatives to sharing would be for IMT–2000 services to be implemented in other frequency bands, or, Federal systems in the band segments required for IMT–2000 to be relocated to comparable spectrum. To evaluate options associated with possible relocation of Federal systems to alternate frequency bands, an examination of relocation costs, operational impact, and time schedules for moving must also be considered. This information will be available at a later date and will be included in subsequent reports. In implementing any of the options involving band segmentation, many Federal systems in the 1755–1850 MHz band may need to be either relocated to different frequency bands or modified to operate in the remaining portions of the band, and would be compensated in accordance with the compensation provisions of the National Telecommunications and Information Administration Organization Act (47 U.S.C. 923(g)(1) as amended by the National Defense Authorization Act (NDAA) for FY 1999, requiring compensation to affected Federal entities. Further, for the relocation of DOD systems, the NDAA for FY 2000 requires the NTIA and FCC to identify alternate frequency bands, subject to acceptance by the Secretary of Defense and the Chairman of the Joint Chiefs of Staff, for those affected DOD systems and that such alternative band or bands provide comparable technical characteristics to restore essential military capability that will be lost as a result of relocation. Compensation also applies for modification of all affected Federal systems. Specific compensation procedures are under development and will be released by NTIA at a later date.

I. Introduction

Background

The National Telecommunications and Information Administration (NTIA) is the Executive Branch agency principally responsible for developing and articulating domestic and international telecommunications policy. Accordingly, NTIA conducts studies and makes recommendations regarding telecommunications policies and presents Executive Branch views on telecommunications matters to the Congress, the Federal Communications Commission (FCC), and the public.

NTIA is also responsible for managing the Federal Government's use of the radio frequency spectrum. The FCC is responsible for managing spectrum used by the private sector, including state and local governments.

In support of these responsibilities, the NTIA has undertaken numerous spectrum-related studies. The objectives of these studies were to assess spectrum utilization, feasibility of reallocating government spectrum or relocating government systems, identify existing or potential compatibility problems between systems, provide recommendations for resolving any compatibility conflicts, and recommend changes to promote efficient and effective use of the radio spectrum and to improve spectrum management procedures.

Over the past decade, there has been enormous worldwide growth in the use of cellular-type personal mobile communications systems. Many countries initially introduced analog systems and are now transitioning to digital systems. Studies in the International Telecommunication Union (ITU) and elsewhere indicate that this growth in personal communications is likely to continue.

Third generation (3G) wireless systems will provide terrestrial and satellite-based broadband and multi-media capabilities, and represent a path for the evolution of existing cellular and personal communications services (PCS). Discussions relative to spectrum for third generation advanced mobile telecommunications systems are vital for administrations to plan their spectrum use and for industry to plan how it will meet the marketplace requirements of the future.

The International Mobile Telecommunications-2000 (IMT–2000) is an advanced mobile communications standard, and is considered to be a third generation wireless system. Key features of the IMT–2000 include a high degree of design commonality worldwide, compatibility of services within IMT–2000 and other fixed networks, and high-quality worldwide use and roaming capability for multi-media applications (e.g. video-teleconferencing and high-speed internet access). The ITU established an agenda item for the 2000 World Radiocommunication Conference (WRC–2000) which considered the “review of spectrum and regulatory issues for advanced mobile applications in the context of IMT–2000, noting that there is an urgent need to provide more spectrum for the terrestrial component of such applications and that priority should be given to terrestrial mobile needs, and adjustments to the Table of Frequency Allocations as necessary."[1]

The 1755–1850 MHz and 2500–2690 MHz bands were two of the candidate bands that WRC–2000 considered for IMT–2000 terrestrial systems. The United States position for this conference was negotiated by U.S. industry and government representatives, resulting in a proposal that the United States believed could be the basis for a compromise at the conference, given the conflicting positions of many of the other administrations. The United States suggested three possible bands for IMT–2000, including the 1710–1885 MHz band (favored by the Americas), the 2500–2690 MHz band (favored by Europe), and the 698–960 MHz band. At the conference, the United States stated that it would study these bands domestically. Since the WRC–2000 identified these candidate bands for IMT–2000 operations, promoting worldwide harmonization is a desired long-term goal.

In addition to the 1885–2025 MHz and 2110–2200 MHz bands already identified internationally for IMT–2000, the United States proposed and the WRC–2000 adopted regulatory flexibility, giving each administration the right to determine which bands or part of the three bands it may want to identify for IMT–2000. Also, the United States proposed to keep bands identified for IMT–2000 open to any technology rather than specifying a technology or standard for use in the spectrum.

Such national and international activities emphasize the need to investigate the accommodation of IMT–2000 wireless systems in several candidate frequency bands to include all or parts of the 698–746 MHz, 747–762 MHz, 777–792 MHz, 806–960 MHz, 1710–1850 MHz, 1850–1990 MHz, 2110–2150 MHz, and 2500–2690 MHz bands.

Subsequent to the WRC–2000, the Assistant Secretary of Commerce for Communications and Information, the Chairman of the FCC, and representatives of the State Department and the Department of Defense (DOD) met with White House staff to define the process by which spectrum would be identified for advanced mobile telecommunications systems, such as IMT–2000, in the United States. It was decided that studies would be performed by NTIA (on the 1755–1850 MHz band) and the FCC (on the 2500–2690 MHz band) to determine if either or both of these bands would be viable candidates for accommodation of future 3G mobile systems.

President Clinton signed an executive memorandum dated October 13, 2000, that stated the need and urgency for the United States to select radio frequency spectrum to satisfy the future needs of the citizens and businesses for mobile voice, high speed data, and Internet-accessible wireless capability; the guiding principles to be used for the development of advanced wireless systems; and the direction to the Federal agencies to carry out studies to identify spectrum that

[1] Resolution 721 (WRC–97) Agenda for the 1999 World Radiocommunication Conference, International Telecommunication Union Radio Regulations, Volume 3, (Geneva: ITU 1998) at 319.

could be used by 3G wireless systems.[2] In summary, the President directed that the Secretary of Commerce, in cooperation with the FCC to:

- develop a plan by October 20, 2000, for the identification and analysis of possible spectrum bands for 3G services that would enable the FCC to select specific frequencies by July 2001 for 3G and complete the auction for licensing advanced wireless providers by September 30, 2002.

- issue interim reports by November 15, 2000, on the current spectrum uses and the potential for reallocation or sharing the bands identified at the WRC–2000 that could be used for advanced wireless systems, in order that the FCC can identify, in coordination with NTIA, spectrum by July 2001, and auction licenses to competing applicants by September 30, 2002.

- develop an outreach program to work with government and industry representatives through a series of public meetings to develop recommendations and plans for identifying spectrum for advanced wireless systems.

All of the above work is expected to lead to the issuance of a final report to be released in the first half of 2001 that describes the potential use of all identified bands for advanced wireless applications, and the costs incurred for any potential relocation for the time frames of 2003, 2006, and 2010. Because of the need for interaction with the commercial sector, and the time required to evaluate costs and mission impacts, NTIA and the FCC will issue separate interim reports, followed by final reports that included mission impact, cost data, and time lines. This NTIA interim report primarily addresses the Federal use of the 1755–1850 MHz band, but data on Federal use of the 1710–1755 MHz band is also included.

The DOD released to NTIA on October 30, 2000, an initial report detailing the electromagnetic compatibility (EMC) interactions between major DOD radiocommunications systems operating in the 1755–1850 MHz band and IMT–2000 systems. This report, entitled *Department of Defense IMT–2000 Technical Working Group - Initial Report - Investigation of the Feasibility of Accommodating the International Mobile Telecommunications (IMT) 2000 Within the 1755–1850 MHz Band,*[3] was used herein for evaluation of the potential for sharing the 1710–1850 MHz band with IMT–2000 systems.[4]

The entire 1710–1885 MHz frequency range is very heavily used by government and non-government users. In the 1755–1850 MHz portion alone 4,869 Federal Government assignments

---

[2] Presidential Memorandum, Subject: Advanced Mobile Communications/Third Generation Wireless Systems, The White House, October 13, 2000.

[3] Initial Report - Investigation of the Feasibility of Accommodating the International Mobile Telecommunications (IMT) 2000 Within the 1755–1850 MHz Band, IMT–2000 Technical Working Group, Department of Defense, October 27, 2000 [hereinafter DOD Initial Report].

[4] This study may be accessed on the NTIA web page at the following URL address: http://www.ntia.doc.gov/osmhome/reports/dodreport.

are registered in the Government Master File (GMF), as of September 2000. Internationally, the 1755–1850 MHz band falls in the 1710–1930 MHz band allocated on a primary basis to the fixed and mobile services for all three regions. The 1755–1850 MHz band is allocated for exclusive Federal Government use in the United States. Space command, control, range and range rate systems for earth stations transmission only (including installation on certain Navy ships) may be accommodated on a co-equal basis with the fixed and mobile services in the 1761–1842 MHz band. This band is a primary band for Federal spacecraft tracking, telemetry, and command (TT&C).

Objectives

The objectives of this interim study are to document Federal Government use of the 1755–1850 MHz band, and to address issues relevant for possible use of the 1710–1850 MHz band to accommodate advanced mobile telecommunications systems, such as IMT–2000, in the United States relative to:

(1) the current and emerging Federal uses, and

(2) the potential for sharing between Federal systems and IMT–2000 systems.

This Interim Report does not address costs, as detailed information was not available in the time frame required for the release of this report. The costs to relocate the various Federal systems are, among other things, determined by a number of factors, including the frequency band to which the system is to be relocated, and the time frame for the relocation. The cost data, time lines, and operational impacts will be included in a subsequent report, to be released in the first half of 2001.

II. Third Generation System Description[5]

Introduction

Third generation or IMT–2000 services are the names commonly used to refer to the next generation mobile wireless telecommunications services. The 3G family of services, and the systems that will provide them, are intended to reflect a high degree of commonality and are to be compatible with each other. These services will support mobile and fixed users employing a wide range of devices including small pocket terminals, handheld telephones, laptop computers, and fixed-receiver equipment. Third generation services are envisioned to be ubiquitous throughout the globe, as available in a remote part of a developing country as they are in an urban area in a highly developed country. Seamless roaming is a key attribute. Access to services is expected to be uniform. Furthermore, the user will be able to roam from an urban to a suburban and into a rural setting without loss of basic services.

The ITU has been fostering the development of the underlying radio and network standards for what is now defined as IMT–2000 services for over 15 years. The radio transmission technologies (RTTs) providing for standardized 3G air-interfaces adopted in November 1998 were the culmination of many years of arduous effort under the auspices of the ITU's Radiocommunication Sector (ITU-R) Task Group 8/1. These RTTs form the basis for connecting the user's mobile or portable device to the physical infrastructure supporting IMT–2000 services. ITU-R Task Group 8/1 also developed methods that can be used to assess the amount of additional spectrum needed to accommodate the expected future growth in demand for 3G mobile services.[6] The ITU's Telecommunication Standardization Sector (ITU-T) is actively working to develop 3G signaling and communication protocols, network requirements needed to support expected 3G services, and service definitions for IMT–2000 applications. Table 1 below, derived from ITU-T Draft Recommendation Q.1701,[7] describes selected essential capabilities of IMT–2000 systems.

Consumer demand for services available at any place, coupled with the expectation of high quality and increased transmission speed, are key drivers in the effort to establish commonality and compatibility of 3G terrestrial telecommunication systems. It is estimated that by the year 2010 there will be one billion wireless subscribers worldwide on 3G networks.[8] At the present time, the worldwide penetration of wireless service is approximately 7½ percent and it is expected to exceed 30 percent by the end of the first decade of the new millennium.[9] There are over 1,300 cellular and second-generation terrestrial mobile service networks currently operating worldwide, each with a limited geographic coverage. It becomes more important to harmonize

---

5 This section was furnished by the Federal Communications Commission.

6 ITU-R Recommendation M. [IMT.SPEC], ITU-R Radiocommunication Assembly, Istanbul, Turkey, May 2000.

7 ITU-T Draft Recommendation Q.1701, Geneva.

8 United States Talking Points for WRC–2000 on IMT–2000 spectrum requirements.

9 *Id.*

spectrum allocations for 3G services if companies are to provide uniform services and seamless roaming on a regional or global scale.

Table 1
IMT–2000 Services/Capabilities

Capabilities to support circuit and packet data at high bit rates: - 144 kbs or higher in high mobility (vehicular) traffic - 384 kbs or higher for pedestrian traffic - 2 mbs or higher for indoor traffic
Interoperability and roaming among IMT–2000 family of systems
Common billing/user profiles: - Sharing of usage/rate information between service providers - Standardized call detail recording - Standardized user profiles
Capability to determine geographic position of mobiles and report it to both the network and the mobile terminal
Support of multimedia services/capabilities: - Fixed and variable rate bit traffic - Bandwidth on demand - Asymmetric data rates in the forward and reverse links - Multimedia mail store and forward - Broadband access up to 2 mbs

Spectrum Identified for IMT–2000

The ITU concluded that IMT–2000, or 3G, systems will require use of spectrum that extends beyond that already encumbered by first and second generation mobile systems. A major issue in the global debate regarding 3G system design, standards, and services that must be resolved is the amount of common or “harmonized” spectrum that will be available on a global and regional basis to support 3G systems. For ease in roaming, to help stimulate commonality in services and economies of scale, proponents of 3G services believe it is important to identify as much contiguous, harmonized spectrum to support worldwide 3G operations as is practical. This will stimulate the development of global and regional coverage of 3G systems by reducing the cost and complexity for system development, thus providing users with more cost-effective services.

Referring back to the data rates given in the first row in Table 1 above, and assuming state-of-the-art data compression capabilities, signal processing gains, and signal processor chip rates, the amount of channel bandwidth needed to provide wireless services at 2 mbs could be as much as 15–20 MHz (one-way); at 384 kbs it could be a high as 5 MHz (one-way). Current second-generation mobile systems easily support 9.6–14.4 kbs data rates using channel band-widths of 30–200 kHz, with 64 kbs being possible when employing sophisticated channelization and coding schemes. The 25 to over 500-fold increase in channel bandwidth needed to provide higher-end data rates dramatically illustrates the reason for the demand for additional spectrum to support 3G wireless services.

WARC–92. At the 1992 World Administrative Radio Conference (WARC–92), 230 MHz of spectrum at 1885–2025 MHz and 2110–2200 MHz was identified for use by countries wishing to implement 3G systems. Shortly after WARC–92, the FCC conducted auctions for licenses in the paired 1850–1910/1930–1990 MHz band which lead to the rapid deployment of advanced mobile wireless communications services throughout the United States. The success of the PCS rollout has done much to increase competition in the provision of mobile telecommunications services in the United States and at the same time has stimulated the demand for even more advanced wireless services. Recently, countries around the world have started to license 3G systems within paired frequency bands identified at WARC–92: 1920–1980/2110-2170 MHz. The United Kingdom (UK) and Germany have, for example, conducted auctions for IMT–2000 spectrum within the past four months. The United States and the European experience indicates that the demand for advanced mobile services is projected to continue to grow at a rapid rate for some time to come.

WRC–2000. At the WRC–2000, additional spectrum to support IMT–2000 services was identified.[10] Three frequency bands, consistent with those proposed by the United States to the conference, were identified for use by administrations wishing to implement IMT–2000 services in addition to those adopted at WARC–92.

IMT–2000 System Characteristics. During preparations for WRC–2000, the United States committed to studying the feasibility of using the 1755–1850 MHz and 2500–2690 MHz bands (or parts thereof) for IMT–2000 operations. Such a study would involve determining the impact of the operation of IMT–2000 systems on the systems already licensed to operate in these bands. The 1755–1850 MHz band is used in the United States to support Government services, mostly military space operations, air-to-air training missions, and tactical communications operations. The 1755–1850 MHz band is also used by Federal law enforcement agencies to conduct covert video surveillance across the United States and Possessions (US&P) during criminal investigations and protective/security operations. The 1710–1755 MHz portion of the 1700/1800 MHz band identified at WRC–2000 is currently in the process of becoming available for commercial use. The 1850–1885 MHz portion of the same IMT–2000 band is already used to support PCS operations in the United States. The 2500–2690 MHz band is used to provide instructional television fixed services and multi-point distribution services throughout the United States.

Because of the physical processes governing the propagation of radio waves in the frequency range below 3 GHz, these frequencies can be efficiently transmitted and received by small, compact, relatively lightweight user terminals. This feature, coupled with the ability to support high data rates, makes them ideally suited for uses requiring mobility and portability of telecommunications services. Any 3G service that is targeted to mobile users is most effectively

---

[10] Provisional Finals Acts of WRC 2000, 8 May-2 June 2000, Istanbul, Turkey, International Telecommunication Union.

provided by taking advantage of the properties of radio waves operating below 3 GHz. Those 3G applications where the data rates are so high that fixed terminals are needed, or terminals that require antennas so large that they can only be employed in a stationary configuration, are better provided using frequencies above 3 GHz that can more effectively support higher data rate systems. It is the problem of identifying the spectrum bands that *can and cannot* be used to support 3G services that forms the crux of the effort to assess the degree to which IMT–2000 services can be included in bands already encumbered by services operating at 1755–1850 and 2500–2690 MHz.

In order to determine the impact of operating IMT–2000 systems in bands that are encumbered, it is necessary to assess to what degree the proposed and incumbent systems can co-exist in the same band. Stated in simple radio engineering terms, it is necessary to determine whether or not harmful interference is generated into one of the systems (incumbent or proposed) by the operation of the other(s). Furthermore, if it is determined that harmful interference is likely to occur, it is desirable to isolate the conditions under which it occurs and whether or not there exists means to mitigate its effects and costs associated with implementing such mitigation techniques.

The interference assessment mentioned above requires values of the technical characteristics for the systems being studied and the ability to quantify the systems' performance. For the case of the incumbent systems in the bands 1755–1850 MHz and 2500–2690 MHz, it is reasonable to assume that the pertinent parameters required for interference analysis studies are readily available to the individuals tasked with performing the studies. This is not the case however for all the parameters that are required to characterize IMT–2000 systems. These systems, many of which are in the planning or development stage, do not have well-defined or universally accepted values associated with every system parameter. Thus, we assume values for certain IMT–2000 system parameters that are to be used in the conduct of the interference studies. When assumptions had to be made concerning values to be used in characterizing IMT–2000 systems, an attempt was made to adopt values that are consistent with values documented in readily available material such as the reports and recommendations of the ITU-R, reports and findings of industry-led working groups addressing IMT–2000 issues, and absent any other readily available information, FCC rules for second-generation (PCS) mobile systems that were used as guides for 3G systems. In addition to values for the technical parameters themselves, it is also necessary to assume certain characteristics of the rollout of proposed IMT–2000 services, such as when they are likely to occur, whether there will be a time-phasing of the rollout, what regions of the globe are likely to support rollout earlier than others, and within a region, whether there will be a geographical preference i.e., urban versus suburban versus rural, for the rollout. These assumptions also were based on as readily available material and information as possible.

Tables 2 through 5 provide information on the various IMT–2000 system parameters and rollout characteristics that are to be used in undertaking the studies being addressed here.

Table 2
Characteristics of IMT–2000 Mobile Stations

Parameter	CDMA-2000	CDMA-2000	UWC-136 (TDMA)	UWC-136 (TDMA) GPRS/EDGE	W-CDMA
Carrier Spacing	1.25 MHz	3.75 MHz	30 kHz	200 kHz	5 MHz
Transmitter Power	100 mW	100 mW	100 mW	100 mW	100mW
Antenna Gain	0 dBi	0 dBi	0 dBi	0 dBi	0 dBi
Antenna Height	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m
Body Loss	0 dB	0 dB	0 dB	0 dB	0 dBi
Access Techniques	CDMA	CDMA	TDMA	TDMA	CDMA
Data Rates Supported	144 kbps	384 kbps	44 kbps	384 kbps	384 kbps
Modulation Type	QPSK/BPSK	QPSK/BPSK	4-DQPSK 8-PSK	GMSK 8-PSK	QPSK
-3 dB	1.1 MHz	3.3 MHz[f]	0.03 MHz	0.18 MHz	3 GPP
-20 dB	1.4 MHz	4.2 MHz	0.03 MHz	0.22 MHz	TS25.101
-60 dB	1.5 MHz	4.5 MHz	0.04 MHz	0.24 MHz	
Receiver Noise Figure	9 dB	9 dB	9 dB	9 dB	9 dB
Receiver Thermal Noise Level	-113 dBm[a] -105 dBm[b]	-109 dBm[a] -100 dBm[b]	-121 dBm[a]	-113 dBm[a]	-109 dBm in 384 kbps
Receiver Bandwidth					
-3 dB	1.10 MHz	3.30 MHz	0.03 MHz	0.18 MHz	
-20 dB	1.6 MHz	4.7 MHz	0.04 MHz	0.25 MHz	
-60 dB	3.7 MHz	11 MHz	0.09 MHz	0.58 MHz	
E_b/N_o for $P_e = 10^{-3}$	6.6 dB	6.6 dB	7.8 dB	8.4 dB	3.1 dB*
Receiver Sensitivity[c]	-107 dBm	-103 dBm	-101 dBm	-94 dBm	-106 dBm
Interference Threshold 1[d]	-119 dBm	-115 dBm	-127 dBm	-119 dBm	N/A
Interference Threshold 2[e]	-104 dBm	-100 dBm	-111 dBm	-103dBm	N/A

[a] In bandwidth equal to data rate
[b] In receiver bandwidth
[c] For a 10^{-3} raw bit error rate, theoretical E_b/N_o
[d] Desired signal at sensitivity, I/N = -6 dB for a 10 percent loss in range
[e] Desired signal 10 dB above sensitivity, S/(I+N) for a 10^{-3} BER
[f] Shaded values were estimated.
* Assumes E_b/N_o for P_e = 10E-6 without diversity

Table 3
Characteristics of IMT–2000 Base Stations

Parameter	CDMA-2000	CDMA-2000	UWC-136 (TDMA)	UWC-136 (TDMA) (GSM) GPRS/EDGE	W-CDMA
Operating Bandwidth	1.25 MHz	3.75 MHz	30 kHz	200 kHz	5 MHz
Transmitter Power	10 W	10 W	10 W	10 W	10 W
Antenna Gain	17 dBi per 120 deg. sector	17 dBi per 120 deg. sector	17 dBi per 120 deg. sector	17 dBi per 120 deg. sector	17 dBi per 120 deg. sector
Antenna Height	40 m	40 m	40 m	40 m	40 m
Tilt of Antenna	2.5 degs down	2.5 degs down	2.5 degs down	2.5 degs down	2.5 degs down
Access Techniques	CDMA	CDMA	TDMA	TDMA	CDMA
Data Rates Supported	144 kbps	384 kbps	30 kbps 44 kbps	384 kbps	384 kbps
Modulation Type	QPSK/BPSK	QPSK/BPSK	4-DQPSK 8-PSK	GMSK 8-PSK	QPSK
Emission Bandwidth					
-3 dB	1.1 MHz	3.3 MHz[f]	0.03 MHz	0.18 MHz	3 GPP
-20 dB	1.4 MHz	4.2 MHz	0.03 MHz	0.22 MHz	TS25.104
-60 dB	1.5 MHz	4.5 MHz	0.04 MHz	0.24 MHz	
Receiver Noise Figure	5 dB	5 dB	5 dB	5 dB	5 dB
Receiver Thermal Noise Level	-117 dBm[a] -109 dBm[b]	-113 dBm[a] -104 dBm[b]	-125 dBm[a]	-117 dBm[a]	-113 dBm in 384 kbps
Receiver Bandwidth					
-3 dB	1.10 MHz	3.3 MHz	0.03 MHz	0.18 MHz	
-20 dB	1.6 MHz	4.7 MHz	0.04 MHz	0.25 MHz	
-60 dB	3.7 MHz	11 MHz	0.09 MHz	0.58 MHz	
E_b/N_o for $P_e = 10^{-3}$	6.6 dB	6.6 dB	7.8 dB	8.4 dB	3.4 dB*
Receiver Sensitivity[c]	-111 dBm	-107 dBm	-101 dBm	-94 dBm	-110 dBm
Interference Threshold 1[d]	-123 dBm	-119 dBm	-131 dBm	-123 dBm	N/A
Interference Threshold 2[e]	-108 dBm	-104 dBm	-115 dBm	-107 dBm	N/A

[a] In bandwidth equal to data rate
[b] In receiver bandwidth
[c] For a 10^{-3} raw bit error rate, theoretical E_b/N_o
[d] Desired signal at sensitivity, I/N = -6 dB for a 10 percent loss in range
[e] Desired signal 10 dB above sensitivity, S/(I+N) for a 10^{-3} BER
[f] Shaded values were estimated.
* Assumes E_b/N_o for P_e = 10E-6 without diversity

Table 4
IMT–2000 Traffic Model Characteristics[a]

<table>
<tr><th>Parameter</th><th colspan="2">Value</th></tr>
<tr><td>Traffic Environments</td><td colspan="2">Rural
Vehicular
Pedestrian
In-building (central business district)</td></tr>
<tr><td>Maximum Data Rates</td><td colspan="2">Rural - 9.6 kbps
Vehicular - 144 kbps
Pedestrian - 384 kbps
In-building - 2 Mbps</td></tr>
<tr><td>Cell Size</td><td colspan="2">Rural - 10 km radius
Vehicular - 1000 m radius
Pedestrian - 315 m radius
In-building - 40 m radius</td></tr>
<tr><td>Users per cell during busy hour</td><td colspan="2">Rural - not significant
Vehicular - 4700
Pedestrian - 42300
In-building - 1275</td></tr>
<tr><td>Percent of total uplink traffic
>64 kbps during busy hour</td><td colspan="2">Rural - not significant
Vehicular - 34%
Pedestrian - 30%
In-building - 28%</td></tr>
<tr><td>Percent of total downlink traffic
>64 kbps during busy hour</td><td colspan="2">Rural - not significant
Vehicular - 78%
Pedestrian - 74%
In-building - 73%</td></tr>
<tr><td rowspan="4">Average number of users per cell per MHz during busy hour assuming frequency duplex operation</td><td>Rural</td><td>Not significant</td></tr>
<tr><td>Vehicular</td><td>< 64 kbps - 16
> 64 kbps - 4</td></tr>
<tr><td>Pedestrian</td><td>< 64 kbps - 150
> 64 kbps - 64</td></tr>
<tr><td>In-building</td><td>< 64 kbps - 4
> 64 kbps - 2</td></tr>
</table>

[a] Values in the table are for a mature network.

Table 5
Rate of IMT–2000 Network Development[a]

Local Environment	Calendar Year		
	2003	**2006**	**2010**
Urban	10%	50%	90%
Suburban	5%	30%	60%
Rural	0%	5%	10%

[a] For some interactions the potential for interference will be influenced by the degree to which IMT–2000 networks are built out. Tables 4 and 5 identify assumptions that will be used in the assessments with respect to the degree to which US IMT–2000 networks are developed following the granting of licenses. The levels of aggregate emissions for a fully mature IMT–2000 environment will be taken from ITU-R 687.2 or other reference material as appropriate.

This page left intentionally blank.

III. Federal Use of the 1755–1850 MHz Band

Overview

Nationally, the 1755–1850 MHz band is allocated on a exclusive basis to the Federal Government for fixed and mobile. Footnote G42 to the National Table of Frequency Allocations provides for the co-equal accommodation of Federal space command, control, and range and range-rate systems for earth station transmission in the 1761–1842 MHz band. The band supports several Federal functions; (1) tracking and control for DOD space systems, (2) medium-capacity, conventional fixed microwave communications systems, (3) military tactical radio relay radios, (4) air combat training systems, (5) precision guided munitions, (6) high resolution video data links, and various other aeronautical mobile applications, and 7) land mobile video functions such as robotics, surveillance, etc. The radio systems supporting these functions are located across the United States. Figure 1 is a pictorial representation of the functions of major Federal systems supported in the 1710–1850 MHz band.

The Air Force is responsible for controlling DOD, classified, Allied, and certain other Federal satellites. These satellites are used for many purposes including navigation, missile warning, surveillance, weather, communications, and civil functions, all of which contribute significantly to the defense and well- being of the American civilian population. Although the Air Force owns and operates the Air Force Satellite Control Network (AFSCN), it is a national

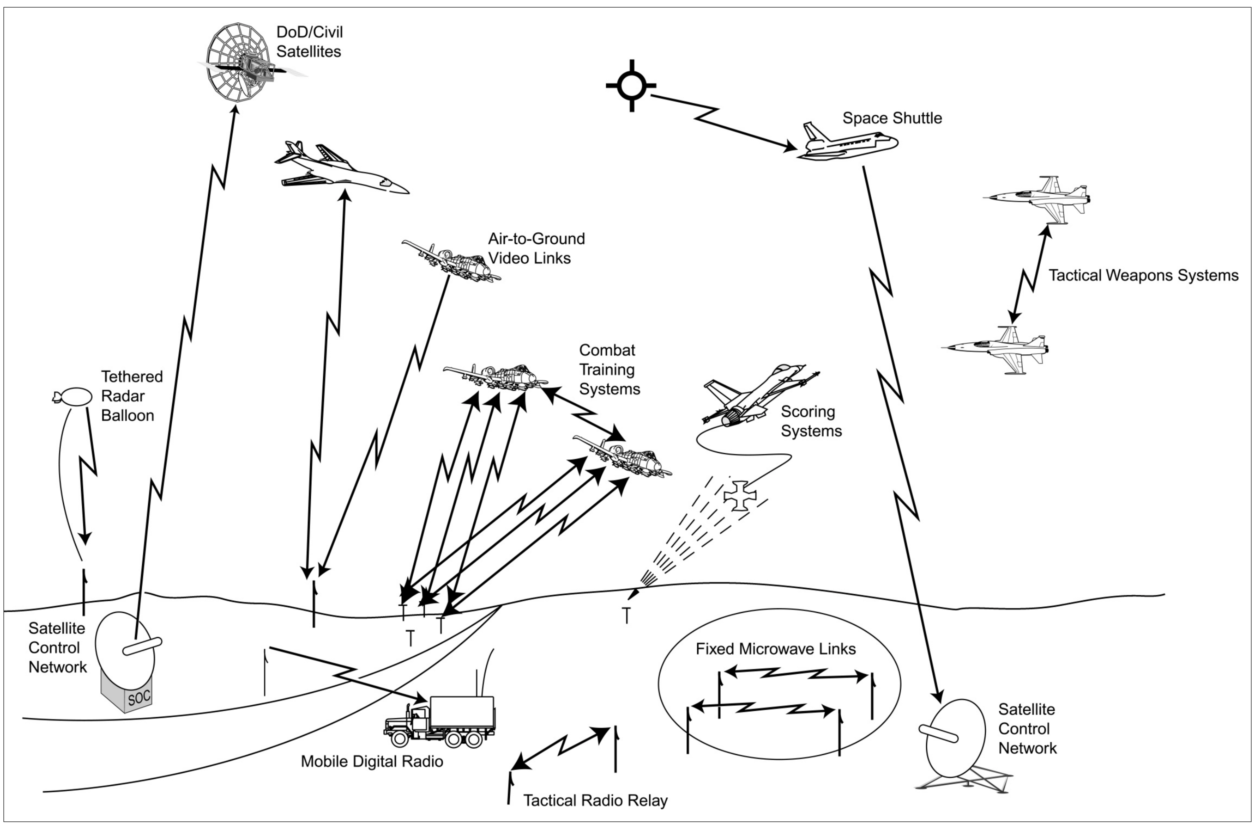

Figure 1. Pictorial Representation of Major Systems in the 1710–1850 MHz Band.

asset that serves many organizations in addition to the military. The satellite control stations transmit to the satellites in the 1761–1842 MHz band from several stations in the United States, and stations in host nations.

Fixed microwave networks in the 1755–1850 MHz band support backbone communications systems for many of the Federal agencies. Fixed links are operated by Federal agencies for voice, data, and/or video communications where commercial service is unavailable, excessively expensive, or unable to meet required reliability. Applications include law enforcement, emergency preparedness, support for the national air space system, military command and control networks, and control links for various power, land, water, and electric-power management systems. Other fixed links include data relay, timing distribution signals, video relay, video surveillance systems, and robot video systems for hazardous material response in support of explosive and forensic investigations.

As an example of fixed systems, the U.S. Army Corps of Engineers uses this band extensively for its fixed microwave radio systems serving backbone communications for the engineering districts in the continental United States. The Corps also uses this frequency band for various purposes such as operating remotely-controlled hydro-electric generating stations; providing communications support for emergency civilian relief, flood control and sensor telemetry; temporary communications in each district; and maintenance and traffic control of approximately 48,000 kilometers of inland waterways, traffic movement, harbors, locks, and dams.

Transportable radio relay systems are used by the military for nodal communications stations that support tactical communications for a wide area. The most common system is called the Mobile Subscriber Equipment (MSE). This system is used extensively in the United States by warfighters to establish tactical communications supporting command and control for wide-area networks. Several thousand tactical radio relay systems are in the military inventory and used at many military establishments throughout the country. The propagation characteristics of the band permit excellent tactical nodal connectivity. Radio relay systems link various subordinate, lateral and strategic headquarters, functional and component nodes, into an integrated area-wide network. Congestion and use of the band are heavy in proximity to military bases and training areas. Naval task forces use a variant of this system known as the Digital Wideband Transmission System (DWTS) which is a surface-based, point-to-point communications, and mobile system that is used at several Naval facilities. This system has approximately 600 units in the field.

One of the most difficult training missions is the training of air combat crews. Current air combat training involves actual air-to-air encounters, with a network of ground stations monitoring the training activity. Information regarding the aircraft's flight parameters are relayed to ground stations, and other information is sent to the aircraft from the ground stations. Several systems are in use by the military services, and are variations of the Air Combat Training Systems (ACTS). These systems currently operate in the 1755–1850 MHz band, and new systems will be coming on line soon.

Additionally, the Federal law enforcement agencies use this band to employ undercover low-power video surveillance devices during criminal investigations. These devices may be authorized throughout the US&P for both protective operations and criminal investigations. The video footage obtained during these investigations is critical for providing rapid response support to undercover officers and agents, and is used as evidence during criminal trials and procedures.

There are 4,869 assignments for Federal stations in the 1755–1850 MHz band listed in the GMF as of September, 2000. The GMF is the Federal Government's master list of frequency assignments authorized by NTIA, but does not represent the number of equipments associated with each assignment. There may be many pieces of radio equipment operating under a single frequency assignment. Further, some assignments may be for nation-wide use. The average growth of new assignments in the 1755–1850 MHz band is about 300 assignments per year. The majority of these assignments are in the fixed service (80 percent), followed by mobile, space, land mobile, and aeronautical-mobile services. The five categories of radio services (plus experimental stations) support the four main functions that are carried out in this band. Presently, 25 Federal entities are authorized to operate in the 1755–1850 MHz band. The major users are: Army, Air Force, Navy, U.S. Department of Agriculture (USDA), the Department of Energy (DOE), the Department of Justice (DOJ), the Federal Aviation Administration (FAA), and the Department of the Interior (DOI). Table 6 shows the GMF summary count of station classes per agency and service in the subject band as of September 2000. A plot of the location of these assignments is shown in Figure 2.

Table 6
Number of Frequency Assignments in the 1755–1850 MHz Band

Agency	Total Number	Fixed Service[2]	Mobile Service	Aeronautical Mobile Service	Land Mobile Service	Space Services	Experimental
Army	1106	1054	17	3	10	0	22
Air Force	979	418	209	18	24	224	81
Navy	709	353	276	17	23	40	0
USDA	671	671	0	0	0	0	0
DOE	507	484	0	2	19	0	2
DOJ	262	256	0	0	6	0	0
FAA	222	221	0	0	1	0	0
DOI	135	135	0	0	0	0	0
CG	98	98	0	0	0	0	0
TVA	64	64	0	0	0	0	0
Treasury	34	31	0	3	0	0	0
NASA	20	3	8	7	1	1	0
Other Agencies	62[1]	48	0	0	3	1	0
Totals	4869	3836	510	50	87	266	105

Notes:
1. Ten assignments fall into radio services not shown in the table. For example, telemetry for special projects.
2. The fixed service category includes a number of assignments that are employed by the military services for transportable equipment.

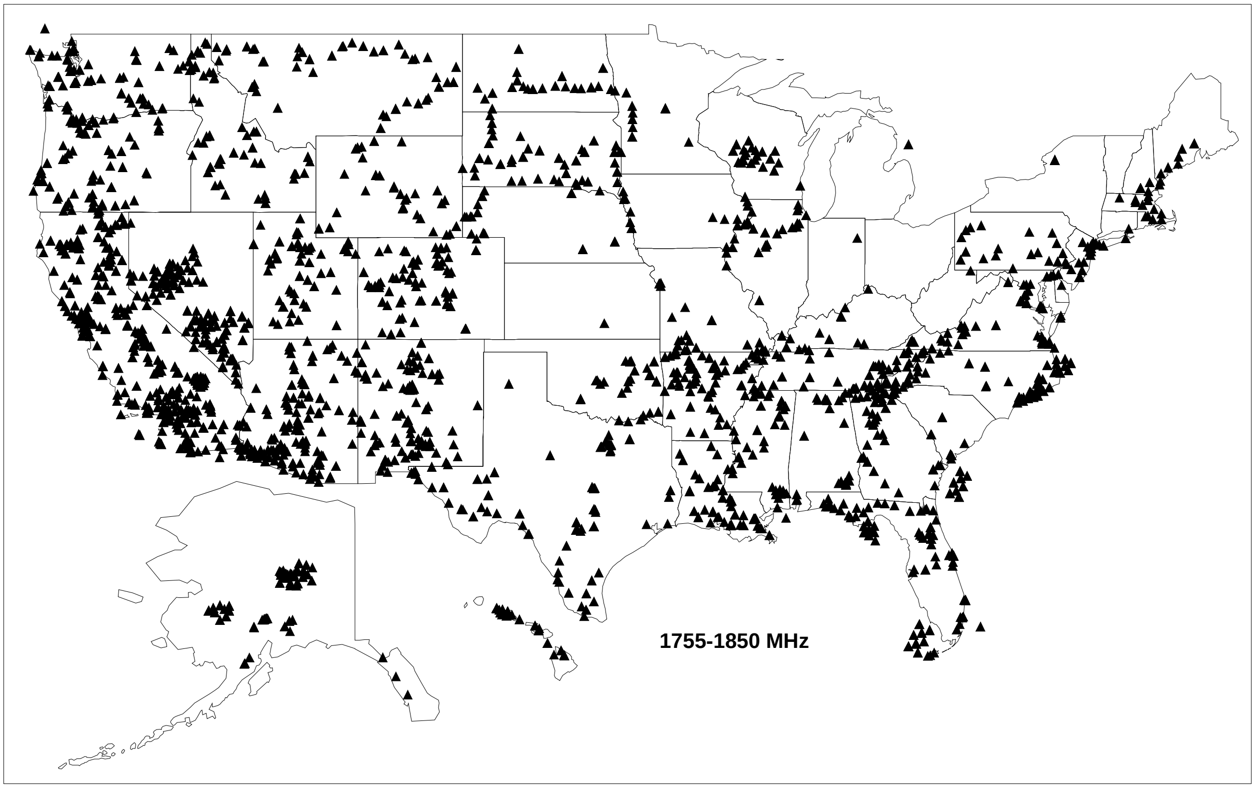

Figure 2. Plot of Frequency Assignments in the 1755–1850 MHz Band.
Note: The symbols may indicate multiple assignments at a geographic location, assignments may cover multiple emitters, and assignments authorized on a US&P basis are not reflected.

Satellite Control Systems

Introduction. Satellites orbit the Earth in either geosynchronous orbits (GSO) or non-geosynchronous orbits (NGSO). Satellites operated by the DOD include both GSO and NGSO, and are used for such functions as communications, navigation, surveillance, missile early warning and attack characterization, weather monitoring, and research and development. The criticality of the Satellite Control Network (SCN) functions is such that DOD satellites can neither be launched or operated without the SCN. These satellites must be supported by the SCN to achieve proper orbit, be initialized for operations, maintain orbit and configuration, perform emergency recovery operations following on-orbit failures, and for disposal operations at end-of-life. Generally, satellites can be controlled to maintain proper orbit, and must be commanded to perform certain functions. This is the control function. The satellite controller must know the location of the satellite to determine the present orbit. This is called a tracking function. The operators also need to know the "health" of the satellites, so a telemetry link sends back to the ground station information relating to the status of the electrical systems onboard the satellite. This is the telemetry function. The combination of these functions for satellite control is termed TT&C. The uplink TT&C function is performed in the 1755–1850 MHz band for military satellites. The associated downlink for these satellites is in the 2200–2290 MHz band.

Tracking, Telemetry, and Command. The 1761–1842 MHz band segment supports the TT&C for the DOD satellites, in addition to the North Atlantic Treaty Organization (NATO) and British military satellites, and various space and ballistic missile test programs. TT&C supports automatic space vehicle acquisition and tracking, ranging, reception and recording of vehicle telemetry data, and transmissions of commands to the space vehicle.

The TT&C subsystem monitors and controls all of the other systems on the spacecraft, transmits the status of those systems to the control segment on the ground, and receives and processes instructions from the control segment. Telemetry components include sensors throughout the satellite to determine the status of various components, transmitters and antennas to provide the data to the control segment, and even the data itself.[11] The SCN is critical to launch and early orbit functions for virtually all U.S. satellites and emergency recovery for most U.S. government satellites.

Telemetry also includes data on the operation and status of the satellite's payload. For example, on a communications satellite, telemetry would include data on power output of transponders, pointing direction of antennas, and antenna and transponder switch configurations. Tracking involves determining a satellite's position, altitude and other orbital parameters. Many satellites carry a beacon which transmits a signal to help ground tracking receivers locate the satellite. On-board sensors, such as star trackers, horizon scanners and inertial navigation sensors provide other tracking data. Tracking information is essential to determine a satellite's orbital parameters so that accurate predictions can be made of where the satellite will be in the future. In this way, the satellite's orbit can be adjusted so that it will be where it is supposed to be when it is supposed to be there.

Commanding is the act of controlling a satellite. Commanding a satellite is accomplished by sending signals to it which initiate an action or change the configuration in some way. Commands may be executed by the satellite immediately upon receipt, or stored for later execution. Some commands are part of onboard software that allows the satellite to execute certain functions autonomously when a predefined condition exists. Commands may direct the thrusters to fire to change the orbit, or may reconfigure the payload to meet the needs of users.

The major system operating in this band segment that supports the TT&C functions is the Air Force Space Ground Link Subsystem (SGLS). The band plan for SGLS comprises 20 discrete frequencies within the 1761–1842 MHz band segment beginning at 1763.721 MHz and ending with 1839.795 MHz. Each channel is 4.004 MHz wide. Although most TT&C operations are provided by fixed sites, the Air Force also uses transportable SGLS-compatible earth stations to provide additional coverage during launches, early orbit operations, anomaly resolution, and critical orbit insertion maneuvers. These transportable stations are moved as necessary to accomplish the mission. The NTIA, in its Final Reallocation Report, noted that Air Force maintained that it is not possible to change the frequencies for satellites which have

[11] U.S. Department of the Army, Army Training and Doctrine Command, Army Space Reference Text, *Chapter 7, Space Systems*, (visited September 13, 2000) <www.tradoc.army.mil/dcscd/spaceweb/chap07a.htm>, at Section 7-1: Control Segments (Telemetry, Tracking and Commanding).

already been launched, and while it may be possible to change the frequency of satellites which have yet to be launched, in the near term this would be extremely expensive.[12]

In addition to supporting TT&C for military satellites, the 1761–1842 MHz band segment supports TT&C for the cooperative DOE/DOD Proliferation Detection Technology (PDT) Program. The PDT Program will demonstrate advanced system technologies for remotely monitoring nuclear facilities and for identifying and characterizing undeclared and clandestine nuclear facilities. Although this program is directed at nuclear proliferation monitoring, the technology could potentially serve a variety of other national security and civilian needs.[13]

The operation of U.S. satellite control facilities internationally, is authorized by specific host nation agreements in those countries in which the SGLS-compatible stations are deployed. The lack of spectrum support for continued satellite control operations in the 1755–1850 MHz band would have implications for U.S. allies as well, since both NATO and the UK depend on satellite control stations operating in the 1755–1850 MHz band to provide military spacecraft TT&C support for the NATO SATCOM IV and the UK SKYNET satellites, respectively.

Air Force Satellite Control Network. The Air Force is the designated service responsible for platform control of most DOD satellites. The organizations and facilities involved are organized into the AFSCN. The principal organization in the AFSCN is the 50th Space Wing of the Air Force Space Command, with headquarters at Schriever Air Force Base, Colorado.

The AFSCN provides support for the operation, control and maintenance of a variety of DOD and some non-DOD satellites. This involves continual execution of the tasks involved in TT&C. In addition, the AFSCN provides prelaunch simulation, launch support and early orbit support while satellites are in initial or transfer orbits and require maneuvering to their final orbit. The AFSCN provides tracking data to help maintain the catalog of space objects and distributes various data such as satellite ephemeris, almanacs, and other information.

The AFSCN consists of satellite control centers, tracking stations and test facilities located around the world. Satellite Operations Centers are located at Schriever Air Force Base near Colorado Springs, Colorado and Onizuka Air Force Base, Sunnyvale, California. These centers are manned around the clock and are responsible for the command and control of their assigned satellite systems. The control centers are linked to remote tracking stations (RTS's) around the world. The RTS's provide the link between the satellite being controlled and the control center. A similar relationship exists for dedicated networks. RTS's around the world are needed to maintain frequent communications with the satellite. Without RTS's, the control centers would only be able to contact a satellite when it came into the control center's view. Some satellites, especially those in geostationary orbit, never come within view of their control

---

12 *See* National Telecommunications and Information Administration, U.S. Department of Commerce, NTIA Special Publication 95–32, Spectrum Reallocation Final Report (1995), at 4–13 [hereinafter NTIA Final Reallocation Report].

13 *Id*.

center (most control centers do not have antenna capabilities to communicate directly with satellites in this band). Space vehicle checkout facilities are used to test launch vehicles and satellite platforms to ensure that the onboard systems operate within specifications.

Remote Tracking Stations. Each RTS performs essential mission operations on a 24 hours/day, 7 days/week basis (normally approximately 400 satellite contacts/day). The operations are driven by the requirements to support U.S. national security space operations, as well as by NATO, UK, and NASA. Each RTS has one to three antennas transmitting in the 1755–1850 MHz band. On the occasion of major maintenance or antenna replacement, transportable assets are deployed to the RTS sites to continue operations. The antennas used are typically 60, 44, and 33 feet in diameter. They are supported by transmitters operating between 250 and 7000 watts, depending on the required mission operation. Filters are employed to limit out-of-band radiation. The antennas may be pointed low on the horizon to communicate with low-altitude satellites which have very short visibility times. Low-angle radiation will also occur at Vandenberg AFB, California and Cape Canaveral AFS, Florida to conduct open loop check-out of satellites on launch pads and to verify communications links prior to launch. For other satellite contacts, the antennas are typically pointed at higher elevation angles. The infrastructure at each RTS has evolved over the last 34–40 years and is extensive and sophisticated with regard to facility power, emergency power and connectivity to commercial terrestrial communications. For the most part, the RTS's are located on U.S. military or host nation military/government facilities. RTS's are located as follows:

1. Vandenberg Tracking Station, Vandenberg AFB, California.
    - Three antennas
    - Missions: satellite operations, space launch, and ballistic missile test launch

2. New Hampshire Tracking Station, New Boston Air Station, New Hampshire.
    - Three antennas
    - Missions: satellite operations and space launch.

3. Thule Tracking Station, Thule Air Base, Greenland.
    - Four antennas
    - Mission: satellite operations

4. Guam Tracking Station, Andersen AFB, Guam.
    - Two antennas
    - Mission: satellite operations

5. Hawaii Tracking Station, Kaena Point, Oahu, Hawaii.
    - Two antennas
    - Missions: satellite operations and ballistic missile test launch

6. Colorado Tracking Station, Schriever AFB, Colorado.
    - One antenna
    - Mission: satellite operations

7. Oakhanger Telemetry and Command Station, Borden, Hampshire, England.
    - Two antennas
    - Mission: satellite operations

8. Diego Garcia Tracking Station, British Indian Ocean Territory, Diego Garcia.
    - One antenna
    - Mission: satellite operations

9. Camp Parks Communications Annex, Pleasanton, California
    - One antenna
    - Mission: satellite operations

10. Eastern Vehicle Checkout Facility, Cape Canaveral AFS, Florida.
    - One antenna
    - Mission: pre-launch spacecraft compatibility testing

11. Onizuka AFS, California
    - One antenna
    - Mission: satellite operations

The AFSCN sites at Vandenberg, Thule, New Hampshire, Camp Parks, and at Onizuka AFS include a data link terminal antenna which provides communications functions using SGLS.

Other Transmitting Sites. Other than the AFSCN stations, certain satellites are controlled through dedicated sites to support specific programs. The Defense Meteorological Satellite Program has a dedicated network operated by the Suitland Satellite Operations Control Center (SOCC) in Suitland, Maryland. The SOCC performs all primary TT&C functions for the Defense Meteorological Satellite Program (DMSP) through the use of AFSCN assets. The SOCC has a back-up facility at Offutt AFB, Nebraska. The Global Positioning System (GPS) has a Mission Control Center at Schriever Air Force Base operated by the Air Force Space Command, 50th Space Wing, 2nd Satellite Operations Squadron. There are also dedicated GPS monitoring stations at Ascension Island, Diego Garcia, Kwajalein, Cape Canaveral, and Hawaii Tracking Stations.[14]

[14] Some of the satellite systems are for the Defense Support Program (missile warning), global positioning system (navigation), Nuclear Detonation Detection System, Defense Meteorological Satellite Program (weather and environmental monitoring), Defense Satellite Communications System (communications), MILSTAR (communications), Fleet SATCOM (communications), and the UHF Follow-on (communications).

In addition to the AFSCN, the GMF lists the following facilities that are authorized to transmit on SGLS frequencies:

1. Blossom Point, Maryland
2. Buckley Air National Guard Base, Colorado
3. Cape Canaveral Air Force Station, Florida
4. Fairbanks, Alaska
5. Laurel, Maryland
6. Kelly Air Force Base, Texas
7. Kirtland Air Force Base, New Mexico
8. Quantico, Virginia

Further, the Air Force also has transportable tracking facilities that can be relocated worldwide to satisfy immediate requirements for TT&C, such as anomaly resolution, that cannot be accomplished at the fixed facilities. Under those conditions, the transportable terminals usually operate on Federal land (e.g., military bases and installations). The Navy operates additional sites at Prospect Harbor, Maine; Laguna Peak, California; and Finegayan, Guam. Figure 3 shows the locations of SGLS-compatible uplink stations in the United States.

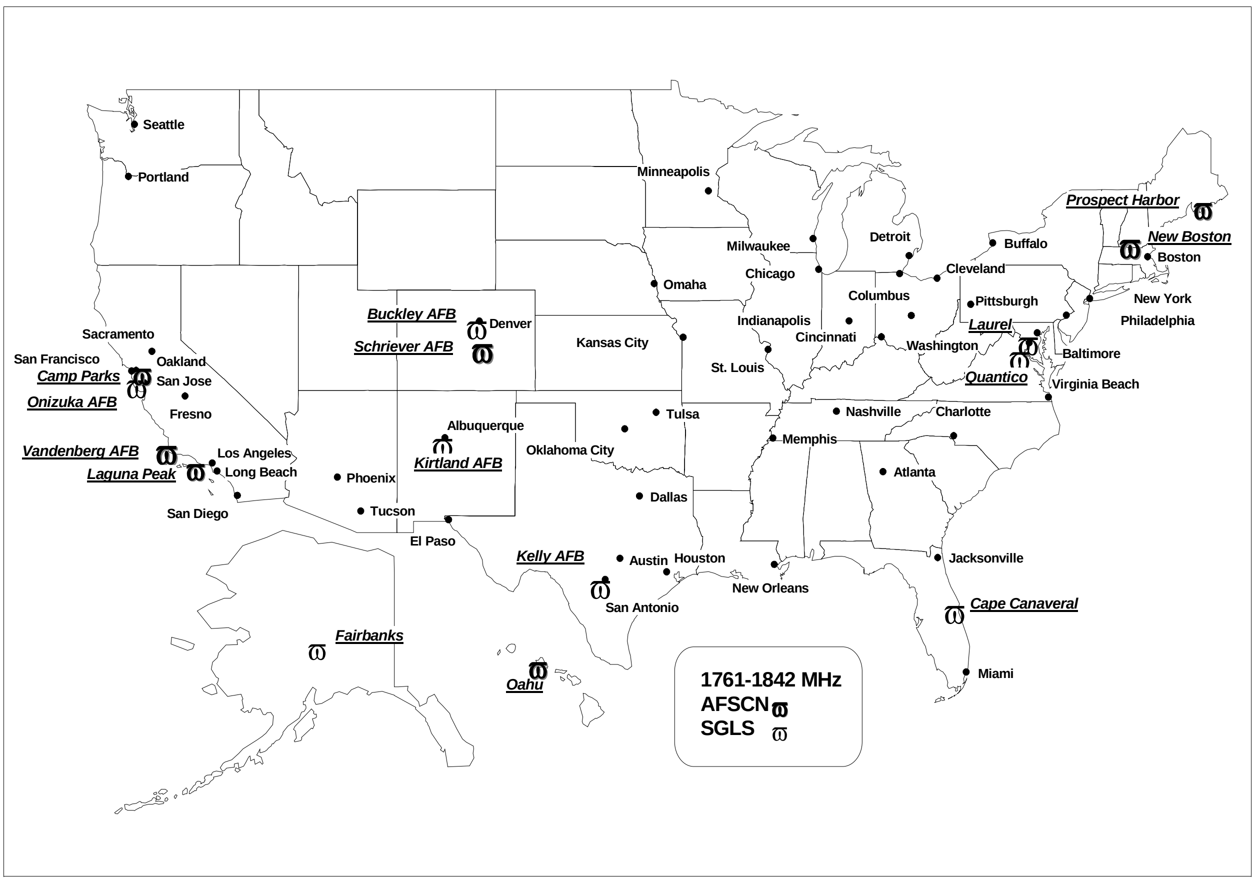

Figure 3. Satellite Control Network Sites.

Satellites Supported. The following is a summary of unclassified satellite systems supported by DOD.

Short Name	Number of Satellites*	Orbit**
USGCSS PH 2/3/3B	5 (O) 4 (S)	GEO
FLTSATCOM	5 (O)	GEO
MILSTAR	6 (O)	Inclined GEO
UFO	8 (O) 1 (S)	GEO
Skynet (UK)	1 (O)	GEO
NATO III/IV	1 (O) 1 (S)	GEO
DSP	3 (O) 2 (S)	
SBIRS (Planned)	4	GEO
USBUD	4	GEO
USDKA	3	GEO
USGAE	22	GEO
USGBS	5	GEO
USGCSS PH5	12	GEO
USOBO	11	GEO

Notes: * Operational (O), Standby (S)
** Geosynchronous (GEO)

Short Name	Number of Satellites	Orbit***
DMSP	2	Non-GEO
GPS	26	Non-GEO
STS (Shuttle)	5	Non-GEO
GFO	1	Non-GEO
P-Series	7	Non-GEO
USAPEX	1	Non-GEO
OTF	1	Non-GEO
Various R&D	10	Non-GEO (LEO, HEO)

Notes: ***Low Earth Orbit (LEO), High Earth Orbit (HEO)

Conventional Fixed Systems[15]

The military services are extensive users of conventional fixed microwave relay systems in the 1755–1850 MHz band. As mentioned earlier in this report, the U.S. Army Corps of Engineers operates fixed microwave systems throughout the country. All of the Services employ fixed microwave systems on military installations and test and training ranges to support a variety of functions. These functions include general purpose communications to remote areas, relaying radar data from remote range areas back to control centers, relaying video data from remote bombing and gunnery ranges, sending command and control data to tethered aerostat radars and relaying radar data from tethered aerostats to ground control facilities.

The Forest Service of the USDA is one of the Federal Government's largest users of fixed microwave radio sites. These sites provide backbone communications support to land mobile

[15] Conventional fixed systems as used herein refers to point-to-point systems using commercial off-the-shelf, or equivalent equipment.

radios in national forests and lands managed by USDA for the public. The backbone links provide primary radio interconnection between mountaintop radio repeaters and the base stations, which further interconnects with either mobile or portable handheld radios. Some USDA microwave links are shared with other agencies such as the DOJ. These systems are essential for law enforcement, firefighting, and emergency preparedness disaster control (e.g., earthquake, volcanic eruption, and hurricane) communications.

The DOI manages its natural resources programs using fixed microwave links to accomplish Congressionally-mandated missions. These microwave operations support a variety of functions including: firefighting, law enforcement, disaster control within national forest and parks, communications services to Native American Tribal lands, and earthquake monitoring. Operations are spread throughout the United States in suburban, urban, and rural areas, some of which are remote and almost inaccessible so that commercial service is not available or reliable.

As a result of the Omnibus Budget Reconciliation Act of 1993 (OBRA–93) reallocation of the 1710–1755 MHz band, the FAA and U.S. Coast Guard (USCG) are in the process of procuring fixed microwave links in the 7/8 GHz band. The FAA uses fixed microwave links as part of a nationwide network to interconnect the nation’s air traffic control facilities. The USCG uses are for vessel traffic control and safety operations, communications support of the national distress system, and remote distress and safety communications.

The Department of Justice uses a nation-wide network of fixed point-to-point links to connect its land mobile users. Bureaus within the DOJ have also begun the transition to higher frequency bands (e.g., 7/8 GHz band). These Federal law enforcement systems require secure communications to prevent monitoring, which could disrupt investigations and/or cause life-threatening situations for law enforcement personnel.

DOE has fixed microwave operations in support of the National Defense and Petroleum Reserve Programs with a variety of functions such as remote keying of high frequency transmitters, backbone and security, and remote control of robots, cranes and alarms.

Specific agency applications of the fixed microwave wide-area network systems include the following: the FAA remote data transmission in support of aviation safety systems; the USDA and the DOI backbone links for control of land mobile radio systems necessary in firefighting, law enforcement and disaster control within national forests, and for provision of voice data connections between sites where commercial service is not available; and the Department of Treasury and DOJ microwave links related to law enforcement. This band is also used by the USCG for vessel traffic safety systems, for communications support of the VHF national distress system, and remote distress and safety communications and control networks.

One example of a wide-area network is the DOE and Tennessee Valley Authority (TVA) use of this band for supervision, control, and protection of electrical power transmission. The channels are used for high speed data relaying, supervisory control, load control, telemetering, data acquisition, land mobile radio dispatching, operations and maintenance. The present system connects, via wireline and radio, all Federal Government power marketing control facilities in the western half of the United States and TVA region. Common equipment exists with the non-Federal sector allowing interconnectivity for critical communications dealing with all aspects of generating and distributing power.

The U.S. Customs Service currently operates and maintains an analog microwave system in Hawaii, commonly referred to as the Rainbow Microwave System, that provides a common backbone system servicing Federal, state, and local agencies. Rainbow was included in the list of Federal stations that will remain in the 1710–1755 MHz band due to the high priority, public safety missions it supports, and currently employs frequencies throughout the entire 1710–1850 MHz band. Although Rainbow is protected from interference under the mixed use criteria established by Title VI of the Budget Reconciliation Act of 1993, there is no digital equipment available to replace the aging analog microwave system, due to the reallocation of this band. Therefore, the digital microwave system must operate in higher frequency bands at a higher cost to the users. There is currently a study underway to evaluate this system upgrade and the cost to continue the support of the public safety community in Hawaii.

Tactical Radio Relay Equipment

The DOD uses tactical radio relay for command and control of forces. The majority of tactical radio relay in the band is supported by the MSE. Primary areas of operations for MSE in the United States are shown in Figure 4.

The MSE is a multi-band, tactical line-of-sight radio system, more accurately described as a “system-of-systems,” because it is composed of several components, each of which are fully operational systems. The individual components that make up the MSE are dependent upon several portions of the radio frequency spectrum (e.g., 30–88 MHz, 225–400 MHz, 1350–1850 MHz, and 14.5–15.35 GHz). The inability of any of these components to operate successfully would result in the failure of the overall system. One critical component of the MSE, the AN/GRC–226(V)2 radio, is dependent on the 1755–1850 MHz band. It is used to connect radio access units to the node center switch of the network. Operational use plans call for 465 units per Army Corps, giving a total of 2,325 units for five Corps. The AN/GRC-226(V)2 is a digital radio that can tune to any of 4000 available channels, spaced at 125 kHz, between 1350–1850 MHz; however, due to the allocation of most of this band to other services, users rarely have access to spectrum outside of 1350–1390 MHz and 1710–1850 MHz bands. The follow-on radio now in production, the AN/GRC-245, will have extended tuning of 1350–2690 MHz.

The DWTS used by the Navy is a surface-based, frequency modulated, point-to-point and mobile communications system that carries 9, 18, or 36 voice channels or digital data, and can be carried on a high mobility multipurpose wheeled vehicle. The DWTS is used at Camp LeJeune, North Carolina; Twentynine Palms, California; Oahu, Hawaii; and at other military installations and proving grounds where training exercises are conducted. This system is fully deployed with

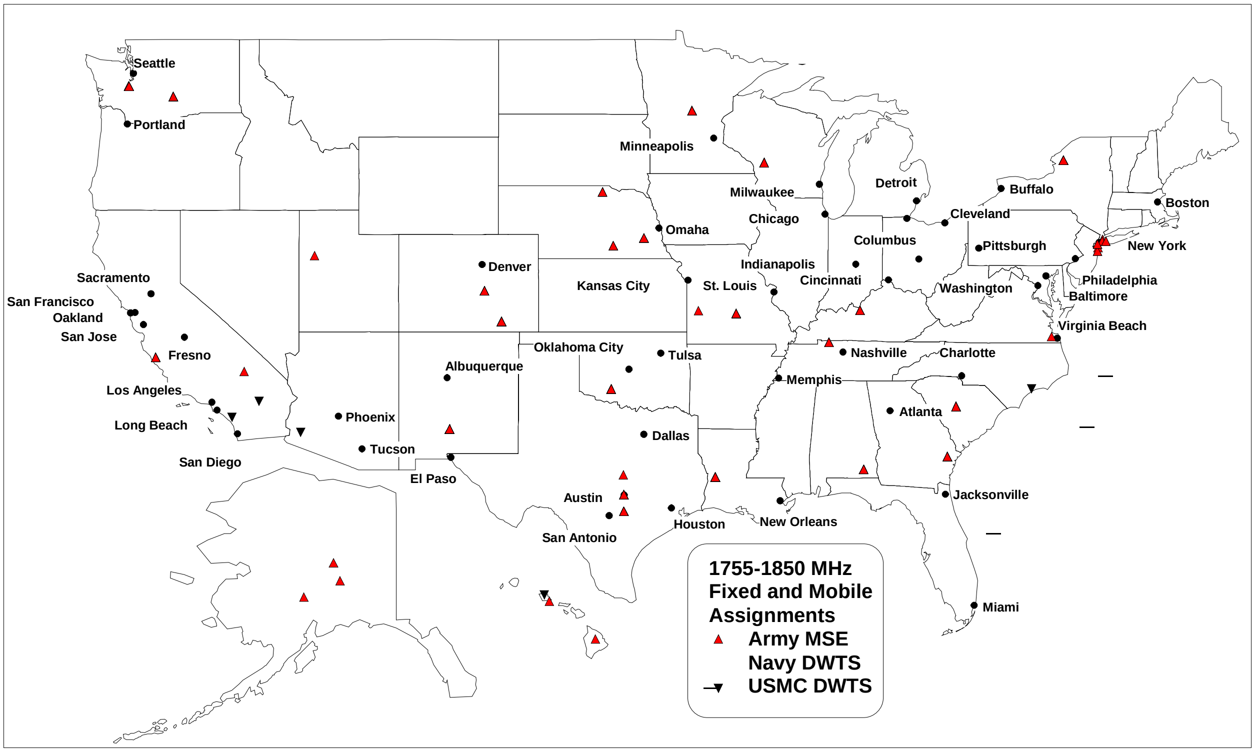

Figure 4. Concentrations of Fixed and Mobile Sites in the 1755–1850 MHz Band.

approximately 600 units in the field. The DWTS consists of two systems: the AN/MRC-142 operating in the fixed service at land-based facilities and the AN/SRC-57 operating in the mobile service for ship-to-ship and ship-to-shore communications (land-based AN/MRC-142 units).

Air Combat Training Systems

The ACTS are used extensively in the 1755–1850 MHz band. ACTS are complex by the nature of their operations, because both fixed and aeronautical mobile equipment are used.

ACTS that operate in this band segment include the Air Force's Air Combat Maneuvering Instrumentation (ACMI), and the Navy's Air Combat Maneuvering Range and Tactical Air Combat Training System (TACTS). Two types of these systems are described in the DOD Initial Report: the current ACMI and TACTS (both called ACTS, herein) and the Joint Tactical Combat Training System (JTCTS) which is intended to replace the existing ACTS.[16] These systems provide critical training for and evaluation of aircrews in air combat tactics and performance. These systems are in operation at all test and training ranges as well as other bases including Reserve and Air National Guard locations that may include civilian airports.

[16] *See* DOD Initial Report, *supra* note 3 at E-1.

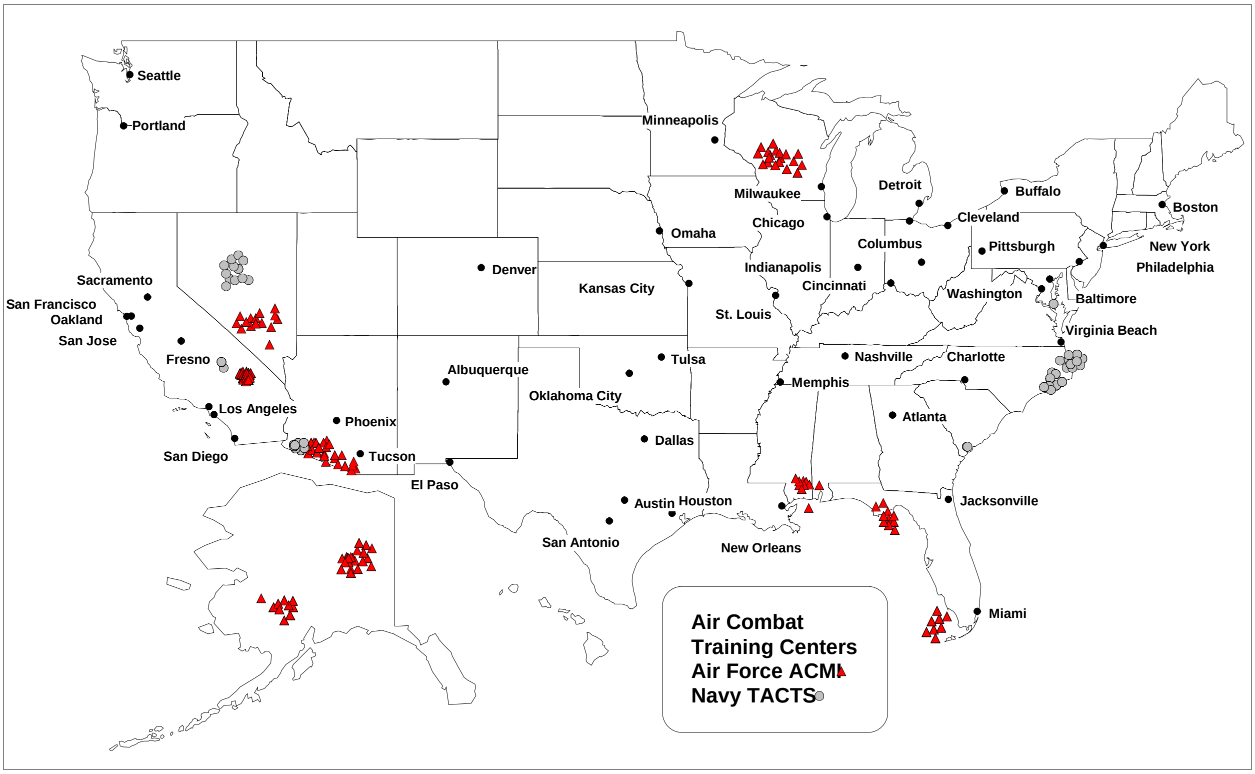

Figure 5. Air Combat Training Center Sites.

Figure 5 represents permanent Air Force and Navy Training sites in the United States. Air Force and Navy ACT S employ factory preset frequencies throughout the 1761–1842 MHz band segment that are used to transmit information to and from aircraft. The DOD has stressed that training support systems such as these are key elements in the military's effort to provide realistic simulation and combat preparedness for pilot training in a peacetime environment.

The U.S. Air Force ACMI/ACTS, the U.S. Navy TACTS, and its several variants provide training associated with aircraft missions ranging from squadron level up to and including joint force missions. The Navy and Air Force use these systems as the final readiness training prior to deployment to combat areas around the world. ACTS provides real-time monitoring of aircraft combat operations and maneuvering, such as gun-scoring, no-drop bombing training, and evasion and intercept tactics and electronic warfare during exercises and training. It also records and plays back aircraft maneuvers for mission analysis and debriefing. The system is composed of the ground-based tactical instrumentation subsystem (ground-to-air) and the aircraft instrumentation subsystem (air-to-ground) mounted internally or via a pod on the aircraft. The two-way data link between these two subsystems is the only means by which they interact and allow the overall system to function.

On the ground, there are remote stations that receive the aircraft downlink signal and transmit commands to the aircraft, and relay the received aircraft data to a master station. Six frequencies are used in the 1755–1850 MHz band for remote stations, and one frequency for the master station to transmit to the remote stations. There are two ground-to-air frequencies, and two air-to-ground frequencies.

During a mission, active Aircraft Instrumentation Subsystem pods are sequentially interrogated on a periodic basis using the same frequency, and each responds when addressed by its unique digital address code. The Aircraft Instrumentation Subsystem transmits both ranging signals and stored digital data over a single channel. Each training range uses 10 frequencies within the 1755–1850 MHz band.

ACTS is employed at ranges in United States, Canada, Taiwan, Thailand, Egypt, Okinawa, Korea, and Italy. Canadian F–18 fighter aircraft are fitted with an internal ACTS box (and dedicated 1710–1850 MHz antenna) for use on the ranges similar to the U.S. Navy F–18's. The Royal Netherlands Air Force uses ACTS with the Arizona Air National Guard at Goldwater Air Field, Arizona. This system is fully deployed and includes approximately 120 tracking instrumentation systems and 1,400 aircraft instrumentation systems.

The JTCTS will operate in the same band, at the same locations, and perform the same function/mission as the ACTS. However, the JTCTS will differ from the current ACTS equipment in several important respects. From the spectrum management aspect, the most significant of these are the dual-bandwidth operation capability, and the spread spectrum nature of the signal. The JTCTS is designed to tune throughout the 1710–1850 MHz band in 5 MHz increments for a total of 27 possible channels. The second major difference is that the JTCTS does not require a dedicated range with numerous ground stations. This mode of operation, called “rangeless”, operates in a air-to-air configuration, and therefore, can be used anywhere over the United States or the world in airspace set aside for military operations.

The JTCTS has host nation coordination and permanent frequency assignments for Japan. The United States has also requested host nation coordination for several other countries.

Both the Tactical Instrumentation Subsystem and the Aircraft Instrumentation Subsystem have planned replacements. The Aircraft Instrumentation Subsystem began upgrading to the AN/ASQ-T31 in June of 1996. Plans are to acquire 155 units. This equipment is portable and includes provisions for data encryption. The Tactical Instrumentation Subsystem will be replaced by the JTCTS, which is being developed by the Navy, and is becoming operational. Most of the combat training ranges will be upgraded to JTCTS within a 10–year period.

Other National Defense Systems

Other critical DOD systems, such as precision munitions and high resolution video links, operate in this band and are vital to national defense. Precision munitions include a number of weapons systems that employ communications in this band between a launched weapon and a controlling platform allowing for precision delivery of the weapon’s payload. These advanced systems are normally employed against high value and hardened enemy targets. DOD precision guided munitions (e.g., AGM-130 and GBU-15) were designed for employment against fixed, high-value targets. These weapons, in the 2000-pound class, are launched from tactical aircraft from either low or high altitude at ranges from 5 to in excess of 30 nautical miles. Equipped with television or infrared sensors, and aided by GPS, these weapons provide operators the ability to attack targets in all weather conditions, day or night. These weapons can be controlled from either the launch aircraft or a standoff aircraft at a range of more than 100 nautical miles. Operators require access to a video and a command link frequency at any time during the mission, including ground operations, post take-off pre-launch operations, and post-launch weapon flight operations. Access to frequencies is critical during all training operations—these operations require use of the frequencies for two hours at a time.

The weapon control data link systems provide operators with the ability to control the precision guided weapons. Video from the weapon seeker is transmitted to a weapon systems officer who identifies the target and manually controls the bomb to the designated impact point. The AGM-130 provides a longer range, compared to the GBU-15, because its flight is assisted by use of a rocket motor. Both data link systems associated with these munitions, the AXQ-14 and ZSW-1, use multiple frequencies within the 1710-1855 MHz band for both video and command links. The AXQ-14 and ZSW-1 weapon control pods carried on the centerline station on the aircraft, receive the weapon video for display, and transmit weapon guidance signals through the command link.

In addition to precision munitions and high resolution video links, the 1755–1850 MHz band also supports deployable emergency communications systems, combat identification systems, mobile tactical voice and data systems, robotic control functions, and target scoring systems.

IV. Approaches for IMT–2000 Accommodation

We have divided the analysis of how to accommodate IMT–2000 into two parts: 1) co-channel sharing; and 2) segmentation of the band, which was in turn assessed using two different models. Although it was not possible in the time available to analyze definitively the full operational or cost implications, the following discussion raises significant issues about the feasibility of co-channel sharing and begins to address the challenges of band segmentation.

Sharing Potential Employing Protection Areas

The most straight-forward solution for accommodation of IMT–2000 would be for these systems to share Federal and commercial frequency bands that are currently occupied. Co-channel sharing is generally accomplished either by geographical separation, time separation, or by transmitting waveforms that are designed specifically to reduce interference to other systems in shared bands. The discussion in this section will focus on the potential for geographical and time separation as the main mechanisms to reduce interference. The discussion in this section references the DOD Initial Report, based on considerations of only the 1.25 MHz and 3.75 MHz IMT–2000 bandwidths with minimal interference thresholds, as listed in Tables 2 and 3. The 1.25 MHz and 3.75 MHz bandwidths were selected to represent the typical technical characteristics for evaluating the EMC between IMT–2000 systems and selected DOD systems. The viability of such sharing must be studied further. In addition to the technical concerns, there would be concerns with long-term Federal access due to possible restrictive protection of IMT–2000 systems for emergency 911 calls.

1. Ground Based Satellite Control (SGLS) Systems

In the 1994 Preliminary Spectrum Reallocation Report, NTIA noted the extensive studies conducted on the possible interference to space research and space operations from terrestrial systems.[17] Various studies of interference to satellite uplinks generally concluded that "... the introduction of ... land mobile systems in the frequency bands used by the space service would cause unacceptable interference to the space services."[18] Although those studies were focused on the 2025–2110 MHz (uplink) and 2200–2290 MHz (downlink) bands, the results would seem to apply equally for the 1761–1842 MHz band segment.

Satellite support requires that the SGLS stations transmit to the space vehicle during the time of its visibility. Some LEO satellites have only a short (approximately 10 minutes) window of visibility. The station will want to acquire the satellite as soon as possible, and may start the acquisition process with the antenna pointed at the horizon point where the satellite will appear. The SGLS antenna will track the satellite through its arc of visibility, which could be up to 180

[17] National Telecommunications and Information Administration, U.S. Department of Commerce, NTIA Special Publication 94-27, Preliminary Spectrum Reallocation Report (1994).

[18] International Telecommunication Union, Use by the Mobile Service of the Frequency Bands 2025-2100 MHz and 2200-2290 MHz, Resolution 211, WARC–92 (Malaga-Torremolinos, 1992).

degrees. However, the main beam of the antenna will be pointed in any given direction for a relatively short time.

The DOD Initial Report contains a preliminary analysis of the potential for interference between these operations and IMT–2000 systems.[19] The potential for interference is analyzed as a result of (1) interference to orbiting satellites caused by the aggregate transmissions from IMT–2000 transmitters, and (2) the potential interference to IMT–2000 receivers from SGLS transmitters.

A finding in the DOD Initial Report summarizes the problem of SGLS sharing with IMT–2000: "Interference from IMT–2000 base stations is much more severe than from the mobile stations, but both represent significant interference to SATOPS (satellite operations). The higher the orbit and the lower the elevation angle the more degradation in the link margin, given a constant transmit power. The negative net margins predicted for the GPS and geostationary orbits indicate that co-channel sharing with IMT–2000 base stations may not be feasible even in the initial stages of IMT–2000 implementation. With a fully built out IMT–2000 system, interference to spacecraft in lower orbits is predicted to be significant. Sharing with mobile stations will be less of a problem. Even so, negative net margins are predicted at the geostationary orbit in 2003 and at the GPS orbit by 2010. Increasing AFSCN transmitter power will minimize the interference on the uplink, but will increase interference to IMT–2000 receivers. Note that these predictions are based on traffic loading at the busy hour. Interference levels at other times will be less, but may not be low enough to be negligible."[20]

Interference to the satellites may be the limiting factor in sharing, since the frequencies on the satellites cannot be changed to avoid interference, and the satellites continually "see" a large portion of the Earth. IMT–2000 transmissions will be received by the satellites and can potentially interfere with uplink signals sent by the SGLS sites. The analysis indicates that the link margin (the amount of signal in excess of that minimally required) would be increasingly degraded as the build-out of IMT–2000 systems progresses. The study finds that mobile IMT–2000 units would degrade the link margin by 10 dB in 2003, by 17 dB in 2006, by 19.5 dB in 2010, and by 20 dB when full build-out is accomplished. For transmitting IMT–2000 base stations, the degradation in link margin would be 27 dB in 2003, 34 dB in 2006, 36 dB in 2010, and 37 dB for full build-out.[21] Under this scenario, sharing would not be feasible. However, if further analysis shows that the link margin will not be so severely degraded in an environment of IMT–2000 transmitters, then there might be some possibility of sharing, using a combination of geographical and time separation.

To protect IMT–2000 systems on co-channel operations, *protection areas* around SGLS sites could be determined based on the distance from an SGLS transmitter such that interference

[19] See DOD Initial Report, *supra* note 3 at Appendix B (Interference to Satellite Operations) and Appendix C (Interference to IMT–2000 receivers).

[20] *Id.* at B-3.

[21] *Id.* at B-5 through B-12.

would not be caused to an IMT–2000 receiver. Within the *protection areas*, some method of coordination is necessary to achieve sharing. Using smooth-Earth propagation analyses, Tables 7 and 8 list the radii of *protection areas* around SGLS sites that would be necessary to reduce SGLS signals to the interference threshold of IMT–2000 mobile and base stations. The DOD Initial Report also includes sample plots of received signal levels as a function of SGLS transmitter power and antenna elevation angles.[22] The propagation prediction used was based on actual terrain surrounding sample SGLS stations. The distances using terrain data are generally less than distances derived from smooth-Earth data for the same signal level. As can be seen from Tables 7 and 8 using smooth-Earth data, the combination of low SGLS power and mobile IMT–2000 systems receiving produces the smallest *protection areas*. However, SGLS cannot always use the low power setting, as some satellites, because of their orbits, require higher power. Further, as the number of IMT–2000 transmitters increase, SGLS may need to increase power to maintain the required carrier-to-noise ratio at the satellites.

If sharing is implemented to reach an accommodation between IMT–2000 and the essential military capability identified in the National Defense Authorization Act 2000, attention will need to focus on a transition schedule which will preserve the essential military capability based on satellite lifetimes, satellite replenishment time lines and launch constraints, time to renegotiate contracts, time to perform satellite modifications, time to relocate ground facilities, and the resources to fund the relocation.

Table 7
Protection Distance in Kilometers at -119 dBm (Mobile)/-123 dBm (Base)
for CDMA Carrier Spacing of 1.25 MHz Received Power for Smooth Earth Propagation

IMT–2000 Station Type	SGLS Antenna Elevation	SGLS Transmitter Power		
		250 Watts	2000 Watts	7000 Watts
Mobile	3 degrees	59 km	110 km	151 km
Mobile	5 degrees	48 km	76 km	110 km
Mobile	10 degrees	42 km	50 km	66 km
Base	3 degrees	301 km	389 km	448 km
Base	5 degrees	232 km	334 km	389 km
Base	10 degrees	174 km	253 km	315 km

22 *Id.* at C-11 through C-14.

Table 8
Protection Distance in Kilometers for -115 dBm (Mobile)/-119 dBm (Base) for CDMA Carrier Spacing of 3.75 MHz Received Power for Smooth Earth Propagation

IMT–2000 Station Type	SGLS Antenna Elevation	SGLS Transmitter Power		
		250 Watts	2000 Watts	7000 Watts
Mobile	3 degrees	50 km	83 km	121 km
Mobile	5 degrees	45 km	57 km	83 km
Mobile	10 degrees	31 km	46 km	51 km
Base	3 degrees	253 km	349 km	406 km
Base	5 degrees	201 km	293 km	349 km
Base	10 degrees	148 km	213 km	270 km

Table 9
AFSCN Transmit Parameters

AFSCN Transmitter Power	250 W, 2000 W, 7000 W
AFSCN Antenna Gain Towards Horizon (49 dBi main beam gain)	23.4 dBi (3^o elevation angle) 17.7 dBi (5^o elevation angle) 10.3 dBi (10^o elevation angle)
AFSCN Antenna Height	15 meters

2. Conventional Fixed Systems

As a result of the OBRA–93, some systems that were in the 1710–1755 MHz band were retuned to the remaining 1755–1850 MHz portion of the band. For example, the Forest Service of the USDA, determined the feasibility of this option based on the scarcely populated and remote geographical areas of its operations.

Recommendation ITU-R F.1334 concludes “in order to cover all possible sharing scenarios–separation distances on the order of 70–120 kilometers are needed for co-channel sharing between the fixed service in the 1–3 GHz and IMT–2000 stations.”[23] Because of the number and distribution of Federal fixed service stations in the United States, co-channel sharing with IMT–2000 systems does not seem to be feasible.

[23] International Telecommunication Union, Geneva, Switzerland, ITU–R Recommendation F.1334 [hereinafter ITU-R F.1334].

3. Tactical Radio Relay

The tactical radio relay system in use is generally the MSE. The MSE is a multi-band, multi-channel , tactical line-of-sight trunk radio system composed of several components. The part of the MSE that operates in the 1755–1850 MHz band (and in the 1710–1755 MHz band) is the AN/GRC-226 (V)2 radio. This radio is capable of tuning from 1350 to 1850 MHz, transmitting from 0.5 to 5.0 Watts, and using a 20 dBi gain antenna. The system is capable of 16 kbps per channel with 16, 32, or 64 channels per trunk, at 256, 512, and 1024 kbps total capacity. A 50 MHz separation is required between transmit and receive frequencies.

As a result of OBRA–93, operation of MSE in the 1710–1755 MHz band is restricted to the protected sites listed in Appendix F of the NTIA Final Reallocation Report[24] shown in Figure 6. Operations at other training areas are limited to the 1350–1390 MHz and 1755–1850 MHz bands.

The analysis in the Initial DOD Report addresses the potential for interference between IMT–2000 systems and the Army's AN/GRC–226, and also the AN/MRC–142 and AN/SRC–57 as part of the Navy's DWTS. The use of military radio relay, employing relatively broad beamwidth antennas, is unique to military operations, and hence is chosen for specific analysis in the DOD Initial Report. Recommendation ITU–R F.1334 addresses the sharing situation

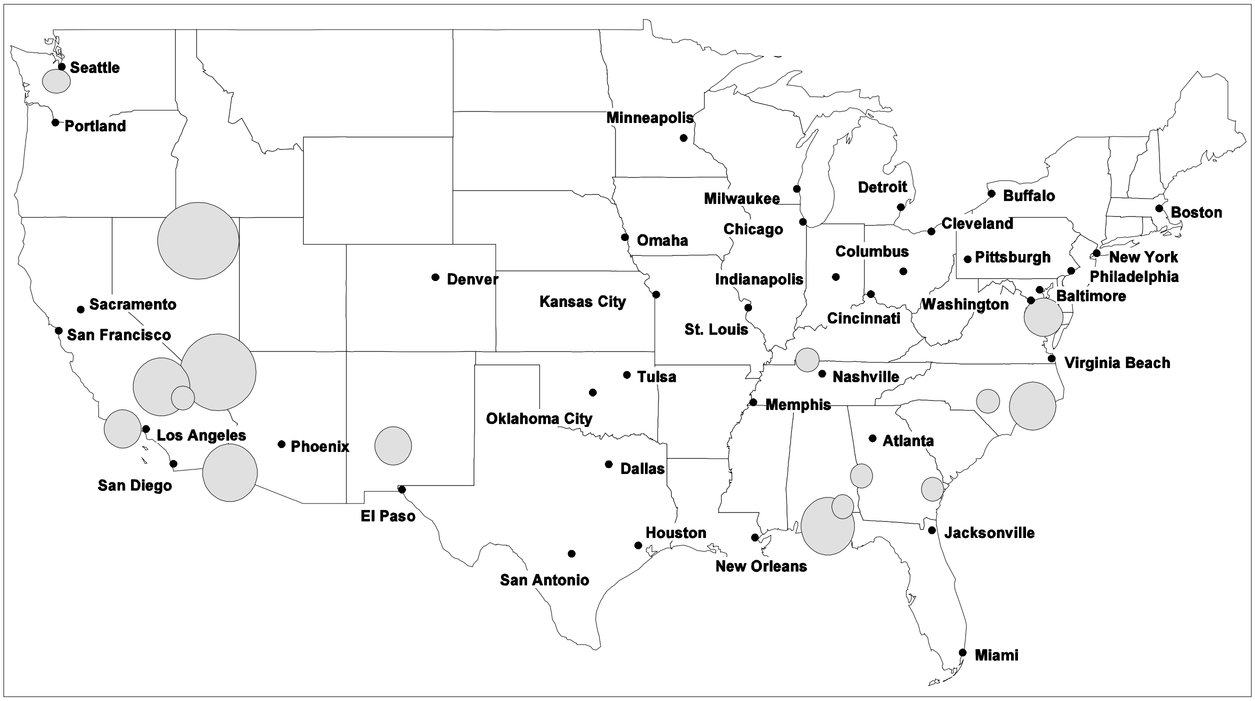

Figure 6. Federal Sites Operating Fixed Microwave, Tactical Radio Relay, and Aeronautical Mobile Stations in the 1710–1755 MHz Band Will Be Retained Indefinitely per OBRA–93.

---

24 *See* NTIA Final Reallocation Report, *supra* note 12 at F-4.

between fixed point-to-point microwave links using high gain, directive antennas.[25] The potential for interference is analyzed as a result of (1) interference to fixed service systems, such as MSE, caused by the aggregate transmissions from IMT–2000 transmitters, and (2) the potential interference to IMT–2000 receivers from MSE transmitters.

Recommendation ITU-R F. 1334 finds that separation distances on the order of 70–120 kilometers are needed for co-channel sharing between the fixed service in 1–3 GHz and IMT–2000 stations.[26]

Co-channel sharing of tactical radio relay and IMT–2000 systems would require significant distance separations. To ensure compatible operations between MSE and IMT–2000 systems on co-channels, *protection areas* around MSE sites could be determined, for example, based on the distances shown in the DOD Initial Report.[27] An example is shown in Figure 7. These *protection areas* are shown, as an example, with radii of 75 kilometers.

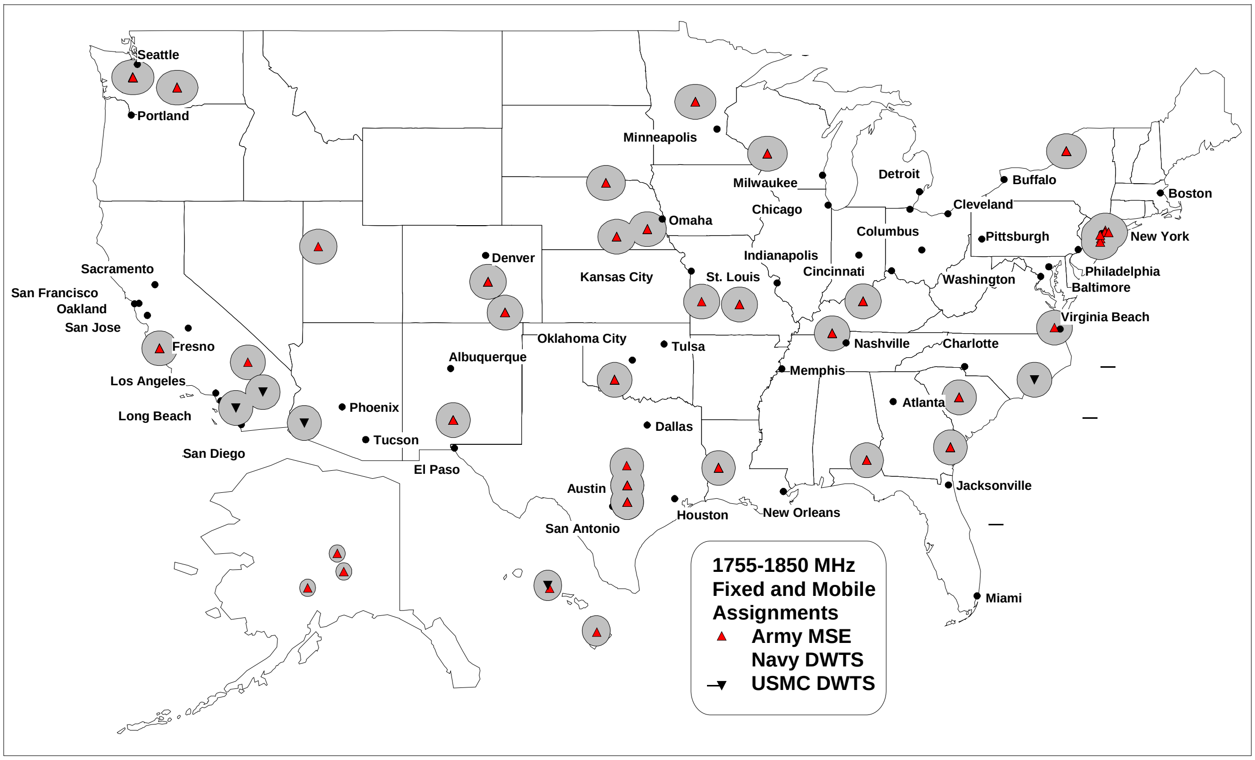

Figure 7. Protection Areas of 75 Kilometers Around MSE Sites.

---

25 *See* ITU-R F.1334, *supra* note 23.

26 *Id.*

27 *See* DOD Initial Report, *supra* note 3 at D-6 through D-10.

Table 10
AN/GRC-226 (MSE) Parameters

Transmitter Power	-3 dBw or 7 dBw
Antenna Gain	20 dBi main beam, 11 dBi (20°-90°), 2 dBi (90°-180°)
Antenna Height	30 meters
Receiver Bandwidth	0.85 MHz
Receiver Noise Figure	8 dB
Receiver Noise Power Level	-137 dBw
Allowed Interference Power	-143 dBw

4. Air Combat Training Systems

The existing ACTS ground stations transmit data to the aircraft on factory-preset frequencies of 1830 MHz or 1840 MHz, and receive data from the aircraft on 1778 MHz or 1788 MHz. Phase-modulated ranging tones and 62.5 kbps or 198.4 kbps data, using frequency shift keying (FSK), transmit altitude, location, velocity, angle of attack, missile firings and other data from up to 100 aircraft. The ACTS uses either omni-directional, or sector antennas with gains of 0 dBi and 12 dBi, respectively. The geographical area of coverage for ACTS systems is up to 65 nautical miles in diameter and operations may last up to 10 hours a day. Additionally, point-to-point links in this band are used to communicate the data from remote sites to a central location (master station).

It should be noted the JTCTS is scheduled to replace the existing ACMI/TACTS. The JTCTS has similar operational requirements as the ACMI/TACTS with the additional flexibility to tune across the 1710–1850 MHz band in 5 MHz increments. The JTCTS has the capability to operate without ground stations, in a "rangeless" air-to-air mode.

In the NTIA Final Reallocation Report, NTIA addressed the technical issues regarding the 1761 –1842 MHz band segment used for ACTS systems such as ACMI and TACTS.[28] The report addressed interference to ACTS airborne receivers from mobile service stations as well as interference to terrestrial stations from ACTS ground station transmitters. NTIA determined ACTS airborne receivers are most susceptible to interference in the FSK demodulation stage. NTIA concluded reallocation of the 1845–1850 MHz band segment for terrestrial mobile and personal stations with a 5 MHz guard band will degrade uplink ACTS transmissions.[29]

The DOD Initial Report contains preliminary analyses of the potential for interference between IMT–2000 base and mobile stations and ACTS and the JTCTS operating in the frequency band 1755–1850 MHz.[30] The analyses assess the 1) potential for interference between

---

[28] *See* NTIA Final Report *supra* note 12 at 4-11 and D-14 through D-18.

[29] *Id.*

[30] *See* DOD Initial Report, *supra* note 3 at E-1.

IMT–2000 and ACTS, 2) potential for interference from IMT–2000 systems into ACTS, and 3) interference into ACTS airborne receivers.

Interference to the ACTS airborne receiver may be the limiting factor in sharing, since the factory fixed frequencies on the ground transmitters and aircraft receivers cannot be changed to avoid interference. Depending on operational altitudes (16kft–30kft), IMT–2000 transmissions could potentially degrade the ACTS airborne receivers requiring large *protection areas* around training sites.

ACTS systems require large ground separation from IMT–2000 systems in order to operate co-channel. To ensure compatible ACTS operations and protect IMT–2000 systems on co-channel operations, *protection areas* around ACTS (ACMI/TACTS) sites could be determined, for example, based on the distances shown in the DOD Initial Report.[31] An example is shown in Figure 8. These *protection areas* are shown, as an example, with radii of 400 kilometers.

Table 11
ACTS Parameters

Aircraft Altitude	9000 meters
Ground Transmitter Power	7 dBw
Ground Antenna Height	30 meters
Ground Receiver Noise Figure	6 dB
Ground Antenna Gain	26 dBi main beam
System Losses	2 dB
Transmitted Data Rate	198.4 kbps
Aircraft Antenna Gain	0 dBi
Aircraft Receiver Noise Figure	7 dB
E_b/N_o for BER = 10^{-5}	13.35 dB

31 *Id.* at E-16.

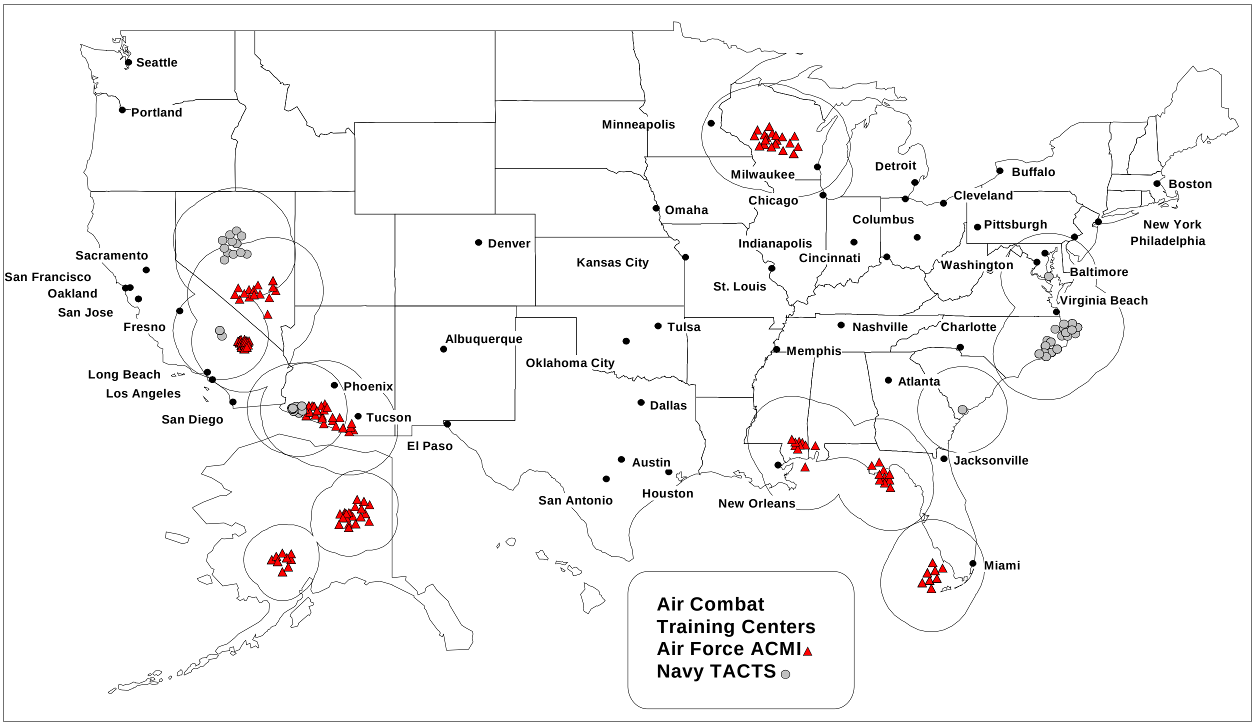

Figure 8. Protection Areas of 400 Kilometers Around ACTS Sites.

5. Others Systems

Other systems that operate in this band are critical to national defense and the missions of other Federal agencies. These systems include precision munitions, deployable range training systems, deployable emergency communications systems, combat identification systems, mobile tactical voice and data systems, high resolution video links, robotic control functions, and target scoring systems. These systems will be analyzed on a case-by-case basis as necessary.

Band Segmentation Options

This section examines two approaches to segmentation of the 1710–1850 MHz band. Other approaches to segmentation may be possible. Further analysis is required to determine the feasibility of segmentation, including the ability of Federal systems to be retuned where necessary on a one-time or phased basis. The first approach would be an in-band pairing with IMT–2000 mobiles operating in the 1710–1755 MHz band, and base stations in the 1805–1850 MHz band. The second arrangement would place mobiles in the lower end of the 1710–1850 MHz band and the base stations in band(s) above 2110 MHz. These options, along with options for the 2500–2690 MHz band, are being actively studied in the ITU-R Working Party 8F, from the perspective of international harmonization in the use of IMT–2000 spectrum.

Option 1: In-Band Pairing of the 1710–1850 MHz Band

1. *Discussion*

The 1710–1885 MHz band is available in Europe primarily for Global System for Mobile Communications (GSM) systems. GSM mobiles transmit in the 1710–1785 MHz band, and the base stations transmit in the 1805–1880 MHz band. This results in up to 2x75 MHz for GSM second generation usage. The 1850–1880 MHz portion might not be available in the United States since it is currently used for PCS. Dividing the 1710–1850 MHz band into segments of 1710–1755 MHz and 1805–1850 MHz would yield a maximum of 2x45 MHz (90 MHz) as a candidate for IMT–2000 deployment. ITU–R Working Party 8F has initially concluded that this could potentially facilitate the global harmonization of 2x45 MHz of spectrum, but also notes that this would perpetuate the existing incompatible use in part of this band (1850–1880 MHz) globally, and does not offer a full worldwide solution for IMT–2000.[32]

Sharing these band segments with IMT–2000 systems would be possible only if restrictions in space and/or time prove feasible. The conditions for sharing would include (1) IMT–2000 operations not impacting Federal military operations, and that (2) most, if not all, of the Federal conventional fixed systems would be relocated to alternative bands under a reimbursement plan.[33] IMT–2000 sharing with the present nation-wide set of Federal fixed systems would not be feasible. The satellite control function, and military radio relay would operate as normal, with the IMT–2000 systems sharing on the basis of geography and time. This sharing scenario must be further explored to determine its merit. Alternately, all Federal systems would need to be relocated, at a cost and time line to be determined, or IMT–2000 would not be deployed in this band.

Sharing in the 1710–1755 MHz Band Segment. The 1710–1755 MHz band was identified to be transferred to the FCC under OBRA–93 as a mixed-use band.[34] Certain military facilities, safety-of-life and power distribution fixed links were exempted from the reallocation. *Protection Areas* were established around the military facilities as shown in the NTIA Final Reallocation Report. In this segmentation option, IMT–2000 mobiles would transmit in this portion of the band. To allow IMT–2000 operation within the *protection areas*, IMT–2000 base stations would need their operation coordinated with military operations. One option would be for IMT–2000 base stations to be designed with a listen-before-transmit feature to avoid interference to and from military systems in the band. The base stations within the *protection areas* would listen on each of the IMT–2000 mobile channels, and would not assign a mobile to that channel if it detected a signal above a pre-determined threshold level.

---

[32] Report of the San Diego Meeting of ITU–R 8F, August 2000, ITU–R 8F/63 at 55.

[33] NTIA is drafting a Notice of Proposed Rulemaking to address reimbursement of costs incurred for relocating Federal radio systems as a result of Omnibus Budget Reconciliation Act of 1993 and the Balanced Budget Act of 1997.

[34] "Mixed Use" is a term defined in the Omnibus Budget Reconciliation Act of 1993 for frequency bands reallocated from Federal to private use in accordance with this Act, which are partially retained for continued use by Federal stations.

Federal stations operating in the 1710–1755 MHz band are eligible for compensation for relocation to another frequency band. Therefore, the currently-exempt fixed links could be moved at the expense of commercial IMT–2000 operators. This would clear the band of most Federal operations, with the exception of the 17 protected military operations areas, and various other Federal users.

Sharing in the 1805–1850 MHz Band Segment. The 1805–1850 MHz portion of the band is currently used as described earlier in this report. This part of the band includes one-half of the SGLS channels, i.e. channels 11 through 20. This band also includes 5 ACTS ground-to-ground frequencies, and two ground-to-air frequencies. The MSE also operates in this band with assignments generally spaced 500 kHz apart.

A large number (3,836) of Federal frequency assignments for stations in the fixed service are in this portion of the band. These conventional fixed stations are eligible for compensation for relocation by IMT–2000 operators. It is postulated that this band could be cleared of most conventional fixed systems by a reimbursement process.

There are also a variety of other Federal operations not detailed in this report. Many of these operations involve law enforcement, and operate nation-wide. These systems would also need to be relocated from the 1710–1755 MHz and 1805–1850 MHz segments by a reimbursement process.

2. *Potential Sharing Conflicts*

In this interim report we are postulating that it might be possible to share the 1710–1850 MHz band with IMT–2000 systems, under certain conditions. The first condition is that the 17 protected areas as shown in the NTIA Final Reallocation Report remain, and DOD operations within these areas are not impacted. Second, that it would be possible to determine *protection areas* around other Federal operations, such that IMT–2000 systems operate normally outside of these areas, but would need coordination with Federal operations within the areas. Third, that it would be necessary to relocate most conventional Federal fixed service systems to alternate bands by a method of reimbursement. Further, various other Federal operations would need to relocate to other bands or re-tune to the remaining 1755–1805 MHz segment. The size of the *protection areas* will vary from the preliminary values shown in this report, and would be determined by either a detailed analysis of each site, using terrain data, or by field measurements of signal strengths.

1710–1755 MHz Segment

Tactical Radio Relay. The MSE system is used to support the warfighters' data communications capabilities at all echelons of tactical operations. Because MSE systems are transportable and used to support total Army missions, they can be in operation at any time. Unlike conventional fixed systems, the antennas associated with MSE systems are pointed in different directions when activated at new locations. Using the data from the DOD Initial

Report, IMT–2000 mobile stations could cause interference to MSE receivers at distances from 9 to 20 km for 3.75 MHz IMT–2000 systems, and from 11 km to 23 km for 1.25 MHz systems, depending on the position of the mobile station relative to the main beam of the MSE antenna.[35]

The MSE transmitters could cause interference to IMT–2000 base receivers at ranges from 60 to 75 km for 3.75 MHz systems, and from 62 to 82 km for 1.25 MHz systems, depending on the location of the base station antenna relative to the main beam of the MSE antenna, and interference thresholds for different IMT–2000 systems.[36]

Since the required separation distance, as a factor of the antenna coupling of the IMT–2000 station to the MSE antenna, is shown to be less outside of +/- 20 degrees of the MSE antenna boresight, and minimum outside of +/- 90 degrees, there is about a 50 percent probability of a IMT–2000 station being in a minimum interference zone for any given MSE station. Within this minimum interference zone, the protection distances would be from 9 km to11 km for co-channel mobile transmitters (3.75 MHz and 1.25 MHz systems respectively),[37] and from 60 km to 62 km for IMT–2000 base receivers (3.75 MHz and 1.25 MHz systems respectively).[38] The AN/GRC-245 and other similar radios performing radio relay functions have nominally the same protection distances.

Conventional Fixed. The Federal Government operates many fixed, point-to-point service links in the1710–1755 MHz band. This band will be transferred to the FCC in 2004 on a mixed-use basis. Fixed links in this band that are within the military *protection areas,* and those power distribution and public safety links shown in the NTIA Final Reallocation Report, will be protected. These *protection areas* vary in size from 50 to 120 km. However, Federal stations may be reimbursed for relocation to alternate frequency bands. ITU–R Recommendations have concluded that separation distances up to 120 km are necessary to prevent interference between mobile and fixed stations.[39] Due to the significant number of protected fixed systems, the establishment of *protection areas* surrounding each of these protected fixed service links is not practical.

1805–1850 MHz Segment

Government Satellites. Under this segmentation option, the IMT–2000 base stations would be transmitting (and mobile stations receiving) in the 1805–1850 MHz portion of the band. A large number of base stations transmitting simultaneously would cause interference to the satellite uplinks. The DOD Initial Report shows that IMT–2000 base station transmitters would cause a degradation to the link margin of DOD satellites from 27 to 37 dB, depending on

---

35 *See* DOD Initial Report, *supra* note 3 at D-6.

36 *Id.* at D-7.

37 *Id.* at D-6.

38 *Id.* at D-7.

39 *See* ITU-R F.1334, *supra* note 23.

degree of IMT–2000 build-out.[40] It is doubtful that sharing would be feasible under this scenario. If further analysis shows that the link margin will not so severely degraded in an environment of IMT–2000 base transmitters, then the 1805–1850 MHz band might be shared with IMT–2000 base stations, using a combination of geographical and time separation.

Satellite Control Stations. Data from Tables 7 and 8 show that when satellite control stations are transmitting, the IMT–2000 mobile receivers could receive interference at distances from 31 km to 121 km for 3.75 MHz mobile systems, and from 42 km to 151 km for 1.25 MHz mobile systems, depending on SGLS transmitter power and antenna elevation. Actual distances will be less than was calculated using a smooth-Earth model, because actual SGLS signals will be propagated over rough terrain. For comparison, several plots of interference contours surrounding SGLS sites, using actual terrain data, are included in the DOD Initial Report.[41]

Tactical Radio Relay. The MSE system is used to support the warfighters' data communications capabilities at all echelons of tactical operations. Because MSE systems are transportable and used to support total Army missions, they can be in operation at any time. Unlike conventional fixed systems, the antennas associated with MSE are pointed in different directions when activated at new locations. Using the data from the DOD Initial Report, IMT–2000 base stations could cause interference to MSE receivers at distances ranging from 61 km to 78 km for 3.75 MHz systems, and from 64 km to 87 km for 1.25 MHz systems, depending on the position of the mobile station relative to the main beam of the MSE antenna.[42] The MSE transmitters could cause interference to IMT–2000 mobile receivers at ranges from 18 km to 32 km for 3.75 MHz systems, and from 20 km to 34 km for 1.25 MHz systems, depending on the location of the mobile station relative to the main beam of the MSE antenna, and the interference threshold used.[43]

Since the required separation distance, as a factor of the antenna coupling of the IMT–2000 station to the MSE antenna, is indicated to be minimum outside of +/- 20 degrees of the MSE antenna boresight, and minimum outside of +/- 90 degrees, there is about a 50 percent probability of a IMT–2000 station being in a minimum interference zone for any given MSE station. Within this minimum interference zone, the protection distances would range from 61 km to 64 km for co-channel base transmitters (3.75 MHz systems and 1.25 MHz, respectively).[44] Protection distances would range from 18 km to 20 km for co-channel IMT–2000 mobile receivers (3.75 MHz systems and 1.25 MHz systems respectively).[45] The AN/GRC-245 and other similar radios performing radio relay functions have nominally the same protection distances.

---

[40] *See* DOD Initial Report, *supra* note 3 at B-9 and B-12.

[41] *Id.* at C-11 through C-14.

[42] *Id.* at D-6.

[43] *Id.* at D-7.

[44] *Id.* at D-6.

[45] *Id.* at D-7.

Air Combat Training Systems. Generally, the analysis in the DOD Initial Report shows that the airborne receiving component of the air combat systems would suffer degradation throughout much of the United States, with up to 29 dB reduction in link margin in fairly large areas due to IMT–2000 base stations transmitting (the only ACTS aircraft links in this band segment are ground-to-air links).[46] Five remote-to-master ground links would be affected, as well as the two ground-to-air links. Data from the DOD Initial Report, indicates that the ACTS ground stations would require separation distances ranging from 70 km to 146 km from transmitting IMT–2000 base stations,[47] but the mobile stations could operate at distances of from 12 to 48 km from transmitting ACTS ground stations.[48] Operation of the ACTS system without the use of ground stations, (rangeless operation) would not be feasible due to the widespread interference.

Unlike the ACMI/TACTS, the JTCTS will employ an air-to-air communication function as its primary link. The EMC between IMT–2000 systems and this JTCTS air-to-air link needs to be investigated to determine the feasibility of sharing.[49] The separation distances for the air-to-ground function of the JTCTS, which is similar to ACMI/TACTS, are nominally the same.[50] This function will be a secondary link for JTCTS. The ground-to-ground function of the JTCTS will be considered a tertiary data link and will not always be used.

Interference Mitigation. If the IMT–2000 base stations were to monitor the IMT–2000 mobile channels on a listen-before-transmitting protocol, interference would be mitigated at the expense of IMT–2000 system capacity. It should be noted, in a general sharing scenario, that there will be a greater potential for interference to and from IMT–2000 systems when both links (mobile and base) are within the 1710–1850 MHz band as opposed to only one link being in the band.

Option 2: Dual-Band pairing using the 1710–1790 MHz Band

1. *Discussion*

Under this arrangement (Option 2), IMT–2000 mobiles would transmit from 1710 MHz up to 1790 MHz in phases,[51] and base stations would transmit in frequency bands above 2110 MHz. This would, in the long-term, yield up to 2x80 MHz for IMT–2000 implementation. This pairing arrangement is included in the work being undertaken by ITU–R Working Party 8F, which had the preliminary comments: “[This pairing] could provide global arrangements in the longer term and hence economies of scale, but would require substantial re-planning of existing

[46] *Id.* at E-10.

[47] *Id.* at E-13.

[48] *Id.* at E-15.

[49] *Id.* at E-23.

[50] *Id.* at E-13, E-19.

[51] *Id*. at 1-3

allocations, might provide not enough forward-link capacity, and accommodation of TDD requirements needs to be considered."[52] Some countries in the Americas have endorsed this approach in order to promote long-term harmonization.[53]

The analysis of the DOD Initial Report shows that IMT–2000 mobile transmitters would cause from 10 to 20 dB degradation to the link margin of DOD satellites as a function of IMT–2000 build-out. If further analysis shows that the degradation of link margin is less, or will not severely impact DOD satellite operations, then the 1760–1790 MHz portion of the band could also be considered for sharing with IMT–2000 mobiles, using a combination of geographical and time separation. This sharing arrangement would consist of three phases. For this report, no estimate of the timing of Phases 2 or 3 is given. The three phases are as follow:

Phase 1. In Phase 1, IMT–2000 mobiles would transmit in the 1710–1755 MHz band, under conditions similar to the 1710–1755 MHz part of the in-band sharing Option 1 described above, except that the mobile stations are now paired with base stations transmitting above 2110 MHz. *Protection Areas* are protected areas around military facilities as shown in the NTIA Final Reallocation Report.[54] The 1710–1755 MHz band was identified for transfer to the FCC under OBRA–93 as a mixed-use band. Certain military facilities, safety-of-life and power distribution fixed links were exempted from the reallocation.

As an option to allow IMT–2000 operation within the *protection areas*, IMT–2000 base stations would need to be designed with a listen-before-transmit feature to avoid interference from military systems in the band. Within the *protection areas*, IMT–2000 base stations monitor the mobile station's transmit channel frequencies. If signals are detected on a transmit channel, mobiles are prohibited from transmitting on that channel. The base station will assign a transmit channel to a mobile only on a channel in which no other signal is detected.

Federal stations operating in the 1710–1755 MHz band are also eligible for compensation for relocation to another frequency band. Therefore, the currently-exempt fixed links could be moved at the expense of commercial IMT–2000 operators. This would clear the band of most Federal operations, with the exception of the 17 protected military operation areas.

Phase 2. In Phase 2, the 1755–1780 MHz band is added for sharing with mobiles, paired with base stations above 2110 MHz. The potential for interference to satellite control uplinks is also added, since this band segment contains SGLS channels 1–5. IMT–2000 mobile transmitters would cause from 10 to 20 dB degradation to the link margin of DOD satellites as a function of IMT–2000 build-out. If further analysis shows that the degradation of link margin is less, or will not severely impact DOD satellite operations, then the 1761–1780 MHz portion of the band could be considered for sharing with IMT–2000 mobiles. The 1780 MHz end point for Phase 2 was chosen to avoid IMT–2000 interference to the GPS uplink control channel (SGLS

---

[52] Report of the San Diego, CA meeting of ITU–R 8F, August 2000, ITU–R 8F/63 at 62 .

[53] *See* October 2000 contribution to ITU–R WR8F, ITU-R Doc 8F/148, Oct 20, 2000.

[54] *See* NTIA Final Reallocation Report, *supra* note 12 at F-4.

channel 6) at 1783.74 MHz (+/- 2.002 MHz). If further analysis shows possible interference to GPS, then the Phase 2 additional band would be reduced. New *protection areas* could be established around satellite control sites for a -123 dBm base station received signal with maximum transmit power of that control site (but not to exceed 7 kW) and antenna elevation of 3 degrees. Federal conventional fixed stations are assumed to be relocated from the 1755–1780 MHz band by a reimbursement process.

The ACTS would not be able to share co-channel with IMT-2000 systems. Therefore, the frequencies of 1768 MHz and 1778 MHz would need to be relocated by a reimbursement process (alternately, establish *protection areas* around Air Combat Training areas for the frequency 1778 MHz[55]). Within the *protection areas* for ACTS and satellite control sites, IMT–2000 base stations would monitor the mobile station's transmit channels. If signals are detected on the transmit channel, mobiles would be prohibited from transmitting on that channel. The base station will assign a transmit frequency to a mobile only on any frequency on which nothing is heard on the transmit frequencies. Within the *protection areas,* IMT–2000 channels in the 1710–1755 MHz band will be assigned first. If those channels are used within a given cell, only then will the channels in the 1755–1780 MHz band be assigned.[56]

1755–1780 MHz Segment. This band segment contains 1,225 frequency authorizations, distributed among the following categories as follows:

Fixed	MSE	SGLS	ACTS	Others
1,010	336	56	146	57

Phase 3. In Phase 3, the1780–1790 MHz band is added for mobiles to transmit, paired with base stations above 2110 MHz. SGLS channels 6, 7 and 8 are in this band. IMT–2000 mobile transmitters would cause from 10 to 20 dB degradation to the link margin of DOD satellites as a function of IMT–2000 build-out. If further analysis shows that the degradation of link margin is less, or will not severely impact DOD satellite operations, then the 1780-1790 MHz portion of the band could be considered for sharing with IMT–2000 mobiles. Federal conventional fixed stations could be relocated from the 1780–1790 MHz band by a process of reimbursement. Within the *protection areas,* IMT–2000 base stations monitor the mobile station's transmit channels as above. IMT–2000 channels in 1710–1780 MHz band would be used first. If all those channels are busy, then channels in the 1780–1790 MHz band will be assigned.

---

[55] This is the aircraft downlink frequency, and would be more difficult to move than the ground station frequency.

[56] This gives maximum protection to the satellite uplinks.

1780–1790 MHz Segment. This band segment contains 498 frequency authorizations, distributed among the following categories as follows:

Fixed	MSE	SGLS	ACTS	Others
385	85	25	39	113

2. *Potential Sharing Conflicts*

1710–1755 MHz Segment

The sharing potential would be the same as discussed under sharing Option 1. It is assumed that in the long-term, most conventional fixed links outside on the *protection areas* will be relocated to alternate frequency bands by a reimbursement process. Fixed links within the *protection areas* may remain indefinitely, or be relocated by reimbursement.

1755–1790 MHz Segment

The 1755–1790 MHz segment has in it the kinds of Federal systems seen in both the 1710–1755 MHz and the 1805–1850 MHz segments .

Government Satellites. An analysis of the potential for IMT–2000 mobile (handheld) stations to interfere with the SGLS uplink is contained in the DOD Initial Report. This analysis shows that the uplink signal margin would be degraded from 10 dB (in 2003) to 20 dB (full IMT–2000 build-out)[57].

A conclusion taken from the DOD Initial Report states "Interference from IMT–2000 base stations is much more severe than from the mobile stations, but both represent significant interference to SATOPS (satellite operations). The higher the orbit and the lower the elevation angle the more degradation in the link margin, given a constant transmit power. The negative net margins predicted for the GPS and geostationary orbits indicate that co-channel sharing with IMT–2000 base stations may not be feasible even in the initial stages of IMT–2000 implementation. With a fully built out IMT–2000 system, interference to spacecraft in lower orbits is predicted to be significant. Sharing with mobile stations will be less of a problem. Even so, negative net margins are predicted at the geostationary orbit in 2003 and at the GPS orbit by 2010. Increasing AFSCN transmitter power will minimize the interference on the uplink, but will increase interference to IMT–2000 receivers. Note that these predictions are based on traffic loading at the busy hour. Interference levels at other times will be less, but may not be low enough to be negligible.[58]

Satellite Control Stations. The IMT–2000 mobile stations would be transmitting (and base stations receiving) in the1755–1790 MHz portion of the band. This portion of the band contains SGLS channels 1–8, including the GPS uplink channel. The data from Tables 7 and 8

---

[57] *Id.* at B-5 and B-8.

[58] *Id.* at B-3.

show that the radius of the *protection areas* surrounding satellite control sites would vary from 148 km to 406 km for 3.75 MHz systems, and 174 km to 448 km for 1.25 MHz systems, based on a smooth-Earth propagation model, depending on the uplink transmitting power and the antenna elevation angle. Actual distances will be less due to propagation over rough terrain. For comparison, several plots of interference contours surrounding SGLS sites, using actual terrain data, are included in the DOD Initial Report.

Tactical Radio Relay. The assessment for tactical radio relay in the 1755–1790 MHz segment is the same as for the 1710–1755 MHz segment.

Air Combat Training Systems. Generally, the DOD Initial Report shows that the ACTS downlink at 1778 MHz and the ACTS master ground station transmitting at 1768 MHz would cause interference to IMT–2000 receiving base stations at distances ranging from 48 km to 405 km (slant range from aircraft)[59] and from 49 km to158 km from the ground stations,[60] respectively.

Unlike the ACMI/TACTS, the JTCTS will employ an air-to-air communication function as its primary link. The EMC between IMT–2000 systems and this JTCTS air-to-air link needs to be investigated to determine the feasibility of sharing.[61] The separation distances for the air-to-ground function of the JTCTS, which is similar to ACMI/TACTS, are nominally the same.[62] This function will be a secondary link for JTCTS. The ground-to-ground function of the JTCTS will be considered a tertiary data link and will not always be used.

Other Issues

1. International Issues

The possibility exists that other countries will implement IMT–2000 systems in the 1755–1850 MHz frequency band and the United States will not. A particular concern in this case is the potential impact to United States space borne and airborne receivers since these receivers will be especially subject to the emissions of IMT–2000 systems operating in other countries.

2. National Defense Authorization Act of 2000[63]

Sharing scenarios have been postulated in this report as a means of accommodating IMT–2000 systems. However, if sharing is determined not to be feasible, then either Federal systems in the band segments required for IMT–2000 operation would be relocated, and the band

[59] *See* DOD Initial Report, *supra* note 3 at E-16.

[60] *Id.* at E-15.

[61] *Id.* at E-23.

[62] *Id.* at E-13, E-19.

[63] *See* National Defense Authorization Act 1999, Pub. L. No. 106–65, 113, Stat. 512 (October 5, 1999).

reallocated, or IMT–2000 services will not be implemented in the band.   It must be noted that the NDAA-FY00 contains provisions that restrict certain frequency reallocation actions. Specifically, before DOD can surrender any bands of frequencies in which is a primary user, (1) NTIA, in consultation with the FCC, must identify and make available to the DOD an alternative band or bands of frequencies as a replacement; and (2) The Secretary of Commerce, the Secretary of Defense, and the Chairman of the Joint Chiefs of Staff have jointly certified to both the Committee on Armed Services and the Committee on Commerce, Science and Transportation of the Senate, and the Committee on Armed Services and the Committee on Commerce of the House of Representatives, that the replacement band or bands of frequencies as identified above provides comparable technical characteristics to restore essential military capability that will be lost as a result of this reallocation.

The DOD would be regarded as a primary user in the1755–1850 MHz band, thus requiring the approval actions noted above.

3. Sharing Issues

The sharing options presented in the sections above are preliminary, based on current EMC studies, assumptions of IMT–2000 parameters, and the assumed ability of base stations to "listen" before assigning transmit frequencies to the mobile stations. These and other technical factors will need to be studied further to determine the degree of merit these sharing options possess.

DEPARTMENT OF COMMERCE

UNITED STATES OF AMERICA