FINAL REPORT

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SPECTRUM STUDY OF THE 2500-2690 MHz BAND

The Potential for Accommodating Third Generation Mobile Systems

Federal Communications Commission
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Office of Engineering and Technology
Mass Media Bureau
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International Bureau

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EXECUTIVE SUMMARY

This Final Report describes the current uses of the 2500–2690 MHz band and analyzes the potential for using that band for third generation (3G) wireless systems. This band is one of several frequency bands identified at the 2000 World Radiocommunication Conference (WRC-2000) for possible 3G use. Third generation wireless systems will provide mobile, high-speed access to the Internet and other broadband services. In the United States, the 2500-2690 MHz band is currently used by the Instructional Television Fixed Service (ITFS), Multipoint Distribution Service (MDS), and Multichannel Multipoint Distribution Service (MMDS). The study of the 2500-2690 MHz band has been conducted in two stages. In the Interim Report, we examined the nature and technical characteristics of planned 3G services, the current and planned use of the 2500-2690 MHz band by incumbent services, potential opportunities for sharing spectrum between 3G and incumbent services, and the potential impact on incumbent services of segmenting this band to provide separate spectrum for 3G and incumbent services. In this Final Report, we review and evaluate the earlier analyses and evaluate additional topics, including the possible relocation of incumbent services and the costs associated with such relocation.

This band study is one part of the FCC's effort to identify additional spectrum for advanced wireless systems, including 3G as well as future generations of wireless systems. The FCC issued the *Advanced Wireless Services Notice of Proposed Rulemaking* (NPRM) on January 5, 2001, to examine and propose spectrum for such use. This proceeding explores the possibility of introducing new advanced mobile and fixed services in frequency bands currently used for cellular, broadband Personal Communications Service ("PCS"), and Specialized Mobile Radio ("SMR") services, as well as in five other frequency bands: 1710-1755 MHz, 1755-1850 MHz, 2110-2150 MHz, 2160-2165 MHz and 2500-2690 MHz.

This Final Report represents the results of analyses by FCC staff in the Office of Engineering and Technology, Mass Media Bureau, Wireless Telecommunications Bureau, and International Bureau. It does not necessarily represent the views of the FCC or its Commissioners.

SUMMARY OF FINDINGS

The key findings of our study of the 2500-2690 MHz band are as follows:

- The International Telecommunication Union (ITU) has done considerable work to develop the key technical characteristics of 3G systems and to identify several frequency bands that could be used for 3G systems. The ITU is conducting further studies of how IMT-2000 may be implemented in the frequency bands that were identified at the 1992 World Administrative Radio Conference (WARC-92) and WRC-2000, taking into account the impact on incumbent systems, opportunities for worldwide roaming, equipment design considerations, and backward compatibility with first and second generation (1G and 2G) systems. There currently is no single global approach as to how the frequency bands identified at WARC-92 and

WRC-2000 will be used to implement 3G systems, and no consensus that common global bands for use by 3G systems are achievable.

- The 2500–2690 MHz band is in a state of rapid evolution by incumbent ITFS and MDS licensees. The MDS industry has invested several billion dollars to develop broadband fixed wireless data systems in this band, including high-speed access to the Internet. These systems offer a significant opportunity for further competition with cable and digital subscriber line (DSL) services in the provision of broadband services in urban and rural areas. The band is used to provide video services for education and training in schools, health care centers and a wide variety of other institutions, as well as for the provision of a commercial video distribution service known as wireless cable. This spectrum is heavily licensed throughout the country, with several licensees already providing high-speed Internet services to customers; other licensees are ramping up for full operational use in the very near term.

- Incumbent ITFS and MDS use of the 2500–2690 MHz band varies from one geographic area to another. This lack of uniformity presents serious challenges to developing band sharing or segmentation options that could be used across the country without severely disrupting ITFS and MDS use. For example, ITFS and MDS licensees provide a variety of analog and digital one-way and two-way services; ITFS and MDS are licensed with different authorized service or interference protection areas; extensive leasing arrangements exist between the two services; ITFS and MDS licensees have exchanged channels in various markets as permitted by current service rules; and flexible channel band plans for combined ITFS/MDS two-way systems will coexist with some incumbent one-way systems operating under the traditional channel band plan.

- This technical analysis shows that if currently contemplated 3G systems were to share the same spectrum or channels in any given geographic area large co-channel separation distances would be needed between 3G systems and incumbent ITFS and MDS systems. Without adequate separation distances, 3G systems and ITFS and MDS would cause extensive interference to each other. This is because the 2500-2690 MHz band is licensed to ITFS and MDS systems in most populated areas of the country and 3G licensees would likely want to operate in these same areas. There are, however, a few geographic areas where some spectrum is not used by incumbent systems. In areas where spectrum is not yet at full operational capacity, voluntary partitioning between incumbent users and 3G operators may offer some promise of sharing, although it is unlikely that these areas would be sufficient to deploy a viable 3G service in the band.

- Segmenting the 2500–2690 MHz band to enable third generation mobile wireless systems access to a portion of this spectrum would raise significant technical and economic difficulties for incumbents, especially if all ITFS/MDS operations were to be relocated within the band. While there may be long term options to segment the 2500-2690 MHz band, segmentation could affect the economics of current and planned ITFS and MDS systems and lessen their ability to provide service to rural areas or smaller markets. With reduced spectrum, ITFS/MDS providers may need to reduce their service areas and services to customers in outlying areas or add more transmitter sites to maintain services. In addition, any segmentation option would have to account for the flexible service configurations and offerings that incumbent licensees are currently implementing.

- There is no readily identifiable alternate frequency band that could accommodate a substantial relocation of the incumbent operations in the 2500-2690 MHz band. Furthermore, relocation of ITFS/MDS operations to a band above 3 GHz would affect deployment of these systems to account for changes in signal propagation in higher bands. Relocation to higher bands could affect significantly the economics of current and planned ITFS and MDS systems and lessen their ability to provide service to rural areas or smaller markets. In addition, incumbent users in those alternate bands would have to be relocated, causing serious disruption to other established services; and relocation of some incumbent users (*e.g.,* satellite systems) could significantly delay ITFS/MDS access to these alternate bands.

- Implementation of either the segmentation or relocation options would significantly affect deployment of and impose considerable costs on ITFS/MDS. One study suggests, for example, that the cost to ITFS/MDS operations over a ten-year period could be up to $19 billion. Either option would require considerable time to implement and significant costs to re-engineer and deploy systems; and delivery of fixed wireless broadband services to the public and educational users would be delayed or, in rural areas or smaller markets, may never be realized. The relocation option also would require other services to relocate, and the time and costs to move those additional services would be significant, ranging from approximately $10.2-30.4 billion. These costs would need to be balanced with the broad-based benefits to prospective users and the national economy of deploying both 3G and fixed wireless broadband systems.

The details of the analyses that lead to these findings are provided in the following Sections and Appendices.

SECTION 1
INTRODUCTION

This Final Report addresses the current spectrum uses and the potential for sharing or segmenting the 2500-2690 MHz band for possible third generation wireless systems, as well as the potential for relocating incumbent users of the band in order to make spectrum available for possible 3G wireless systems. This band study, which is in response to the October 13, 2000 Presidential Memorandum, follows the processes described in the Study Plan released by the Department of Commerce on October 20, 2000. This study relies on certain technical assumptions that are based largely on work conducted by the ITU and on information provided by industry.

This Final Report represents the results of analyses by the Federal Communications Commission (FCC) staff in the Office of Engineering and Technology, Mass Media Bureau, Wireless Telecommunications Bureau, and International Bureau. It does not necessarily represent the views of the FCC or the Commissioners.

THE PRESIDENTIAL MEMORANDUM AND THE STUDY PLAN

The October 13, 2000 Presidential Memorandum establishes guiding principles for the Executive Agencies to use in selecting spectrum for 3G wireless systems, and strongly encourages independent federal agencies, such as the FCC, to follow the same principles in any actions taken related to the development of 3G systems. These principles are: (1) the federal government must cooperate with industry to identify spectrum that can be used for 3G systems, whether by reallocation, sharing or evolution of existing systems; (2) incumbent users of spectrum identified for reallocation or sharing must be treated equitably, taking national security and public safety into account; (3) the federal government must be technology-neutral in spectrum allocation and licensing decisions; (4) the federal government must support policies that encourage competition in services and provide flexibility in spectrum allocations to encourage competition; and (5) the federal government must support industry efforts as far as practicable and based on market demand and national considerations to harmonize spectrum allocations regionally and internationally.

The Study Plan released by NTIA on October 20, 2000 adheres to the principles in the Presidential Memorandum. The Study Plan notes that a variety of frequency bands have been identified for possible 3G system use by two International Telecommunication Union (ITU) radio conferences, WARC-92 and WRC-2000. Further, the Study Plan indicates that the United States will give full consideration to all identified frequency bands in identifying spectrum for possible 3G system use. In order to have a full understanding of all options available, NTIA and FCC were tasked with studying two frequency bands identified by WRC-2000 for possible 3G use. NTIA is studying the 1755-1850 MHz band, and the FCC is studying the 2500-2690 MHz band. The Study Plan states that the purpose of the studies is to determine whether, and under what conditions, these bands could be made available for 3G systems and the cost and operating impacts to incumbent users.

The Study Plan notes that the same analysis will be applied to both bands under study. The basic requirements for the overall studies cover three areas: a description of 3G system requirements; a description of incumbent systems in the study bands; and identification of potential alternate bands for incumbent users of the study bands. Using this information, the studies are to include a technical evaluation of the following sharing/relocation options: (1) system sharing between current and planned systems in the bands and 3G systems; and (2) band/channel segmentation, including alternate band combinations to relocate incumbent users of the study bands. Finally, the studies are to consider costs for the spectrum sharing/relocation options identified for the study bands and benefits of using the spectrum in the study bands for 3G systems.

As noted by the Study Plan, the studies have been conducted in two phases. Interim Reports on each band were released November 15, 2000,[1] and each Report includes a description of 3G systems, a description of incumbent systems, and an evaluation of system sharing and band segmentation options. Final Reports on each band, to be released by March 30, 2001, build on the Interim Reports and include the remainder of the study requirements, including information on other bands, a description of alternate bands and relocation studies, and cost/benefit analyses of system sharing, segmentation and relocation options identified.

Outreach to industry is an important component of the overall process to identify spectrum for 3G systems. As instructed by the Presidential Memorandum, NTIA, on behalf of the Secretary of Commerce, initiated the Department's outreach program to industry. The outreach program, in which FCC staff participated, consisted of a series of regular public meetings, which were supplemented by a series of industry sponsored meetings. Most prominent in this regard was the formation of the 3G Industry Association Group.[2] This group held a series of meetings to develop technical and operational proposals for sharing between 3G and incumbent systems or for relocation of incumbent systems.[3]

FCC's ROLE IN IDENTIFYING SPECTRUM FOR 3G SYSTEMS

The FCC has several key roles in the overall process to identify spectrum for 3G systems. In addition to studying the 2500-2690 MHz band, the FCC issued a *Notice of Proposed Rulemaking* (*Advanced Wireless Services NPRM*) on January 5, 2001, to examine and propose

[1] FCC Staff Releases Its Interim Report on Spectrum Study of the 2500-2690 MHz Band (ET Docket No. 00-232), Public Notice, DA 00-2583 (rel. Nov. 15, 2000); *See Federal Operations in the 1755-1850 MHz Band: The Potential for Accommodating Third Generation Mobile Systems, Interim Report*, NTIA Special Publication 01-41 (rel. Nov. 15, 2000). The NTIA report is available on the internet at http://www.ntia.doc.gov/osmhome/reports/imt2000/.

[2] The Cellular Telecommunications & Internet Association, Personal Telecommunications Industry Association, and Telecommunications Industry Association, which represent a majority of the United States wireless industry established the Industry Association Group. *See* Industry Association Group Comments at ii.

[3] *Id.*

spectrum for allocation to fixed and mobile services that would be capable of being used to provide 3G wireless service.[4] The FCC has solicited industry input through this *NPRM* and other procedures to develop recommendations and plans for identifying spectrum for 3G wireless systems.

The *Advanced Wireless Services NPRM* recognizes that a number of frequency bands, including those identified by WARC-92 and WRC-2000, are capable of supporting third generation as well as future generations of mobile wireless systems. This proceeding explores the types of advanced mobile and fixed communication services that will likely be provided in the future, including the technical characteristics of such systems, and the spectrum requirements needed to support the introduction of such services, including the amount of spectrum needed and frequency bands that could be used by such systems.

This proceeding also will explore the possibility of introducing new advanced mobile and fixed services in frequency bands currently used for cellular, broadband Personal Communications Service ("PCS"), and Specialized Mobile Radio ("SMR") services, as well as in five other frequency bands: 1710-1755 MHz, 1755-1850 MHz, 2110-2150 MHz, 2160-2165 MHz and 2500-2690 MHz. Concerning the possible use of these additional bands for advanced wireless systems, the *Advanced Wireless Services NPRM* does the following:

- proposes to allocate for mobile and fixed services the 1710-1755 MHz band that was designated for reallocation from Federal Government to non-Federal Government use under two statutory directives, the 1993 Omnibus Budget Reconciliation Act ("OBRA-93") and the 1997 Balanced Budget Act ("BBA-97");
- seeks comment on providing mobile and fixed service allocations for the 1755-1850 MHz band, if spectrum in the band is made available for non-Federal Government use;
- proposes to designate advanced mobile and fixed service use of the 2110-2150 MHz and 2160-2165 MHz bands that are currently used for a variety of fixed and mobile services and that were identified for reallocation under the Commission's 1992 Emerging Technologies proceeding (ET Docket No. 92-9);
- seeks comment on various approaches for the 2500-2690 MHz band, which is currently used for Multichannel Multipoint Distribution and Instructional Television Fixed Services (MMDS and ITFS).

The Interim Report and Final Report on the 2500-2690 MHz band will become part of the official record for the rulemaking proceeding, and comments on the Reports will be considered in the context of that proceeding. Commenters to the rulemaking proceeding also may address the NTIA Interim Report and Final Report for the 1755-1850 MHz band.

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[4] *Amendment of Part 2 of the Commission's Rules to Allocate Spectrum Below 3 GHz for Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services, including Third Generation Wireless Systems* (ET Docket No. 00-258), Notice of Proposed Rulemaking, FCC 00-455 (rel. January 5, 2001) (hereinafter *Advanced Wireless Services NPRM*).

SCOPE OF FINAL REPORT ON 2500-2690 MHz BAND

For purposes of studying the 2500–2690 MHz bands, certain fundamental assumptions were made concerning the overall spectrum requirements and technical characteristics of future 3G systems. As we noted in the *Advanced Wireless Services NPRM*, we recognize that there are many ways in which various frequency bands may be partitioned or paired to implement 3G services. We expect further information in this regard to become available through dialogue with industry, additional international studies on 3G, and the FCC rulemaking proceeding. The assumptions made for purposes of this study are intended to facilitate analyses and are not intended to prejudge or foreclose other options.

The study of the 2500-2690 MHz band has been conducted in two phases. In the Interim Report, we examined the nature and technical characteristics of planned 3G services, the current and planned use of the 2500-2690 MHz band by incumbent services, potential opportunities for sharing spectrum between 3G and incumbent services, and the potential impact on incumbent services of segmenting this band to provide separate spectrum for 3G and incumbent services. We invited comment on the Interim Report in the *Advanced Wireless Services NPRM*.

The Final Report reviews the initial analyses in the Interim Report; identifies potential alternate bands for relocating incumbent users of the 2500-2690 MHz band; analyzes the relocation potential of incumbent users to alternate bands; and evaluates the cost and migration schedules for three time periods (2003, 2006, 2010) for the sharing, band segmentation and relocation options presented. To the extent possible, we have taken into consideration comments filed on the Interim Report in response to the *Advanced Wireless Services NPRM*, as well as information provided by industry during NTIA's outreach program.

The Final Report is organized in the following manner.

Section 2 summarizes the 3G system requirements identified in the Interim Report and discusses suggested changes to this study information basic requirement made in the rulemaking or outreach program.

Section 3 summarizes the information in the Interim Report on incumbent ITFS and MDS systems in the 2500-2690 MHz band, as well as suggested changes to this study information basic requirement made in the rulemaking or outreach program.

Section 4 evaluates the spectrum sharing options between ITFS/MDS and potential 3G systems presented in the Interim Report, including the co-channel and adjacent channel protection requirements of ITFS/MDS systems and the technical feasibility of co-channel sharing between ITFS/MDS and 3G systems.

Section 5 evaluates the possible options for segmenting the 2500-2690 MHz band to provide spectrum for 3G systems presented in the Interim Report. Using the Interim Report's assumption that the introduction of 3G systems in the band would require 90 megahertz of spectrum, this section addresses the impacts on incumbent systems if no additional spectrum were made available to them to compensate for the reduction of spectrum in this band.

Section 6 describes assumptions made in identifying appropriate spectrum for relocating incumbent ITFS/MDS systems to alternate frequency bands and identifies potential alternate frequency bands for these systems. This section also analyzes the potential for relocating ITFS/MDS systems to the identified potential alternate frequency bands. For each potential alternate band, this section addresses existing rules and regulations for the band; whether allocation or regulation changes would be needed to accommodate ITFS/MDS; whether the existing users of the potential alternate band would have to be relocated; and whether operational constraints would exist for ITFS/MDS and existing users of the potential alternate band.

Section 7 identifies cost estimates and potential benefits for implementing the sharing, band segmentation and relocation options discussed in the study. This section also describes the assumptions made in identifying the cost estimates and potential benefits.

SECTION 2
3G SYSTEM DESCRIPTION

As noted in the Interim Report, the Study Plan calls for the FCC to provide a description of 3G system requirements, which include: (1) nature of proposed use; (2) system technical characteristic description (as a minimum, the necessary information to perform sharing studies with candidate band systems); (3) spectrum required including channeling bandwidths and overall spectrum plans (includes segmentation of candidate bands) to cover regions or nationwide; (4) timing requirements for identification of spectrum; (5) planned geographical deployments; (6) interference thresholds (ITU based if available); (7) potential relationship with other countries' deployment of 3G and global roaming; (8) potential alternate spectrum band plans including any band segmentation; and, (9) any operational considerations that will have a bearing on the evaluation of the sharing/relocation options.

In the Interim Report, we simplified the presentation of the material called for in the Study Plan and combined the discussion of related items. For example, the discussion on 3G technical characteristics also addressed interference thresholds. The discussion on 3G spectrum requirements addressed other administrations' current spectrum usage for wireless mobile services as well as their planned spectrum usage for 3G systems. In addition, some of the information listed above was discussed in our analyses of spectrum sharing and band segmentation.

In this section, we provide a summary of the basic 3G system characteristics that were presented in the Interim Report and that provide the basis for the study of the 2500-2690 MHz band. As we noted in the Interim Report, the ITU has been fostering the development of 3G systems for a number of years, under the name IMT-2000 and, earlier, FPLMTS (future public land mobile telecommunication systems).[5] Therefore, for the purposes of this study, we relied largely on the international definitions and technical characteristics of IMT-2000 and 3G systems developed by the ITU. We also have incorporated other sources of information to the extent practicable. The information presented is intended to facilitate our analyses of the 2500-2690 MHz band and is not intended to prejudge or foreclose any future decisions that may be made regarding the implementation of 3G systems.

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[5] Other international organizations that have worked with and through the ITU have proved instrumental in beginning to establish characteristics of 3G systems. These organizations include the Telecommunications Industry Association (TIA), the Third Generation Partnership Project (3GPP), the Third Generation Project 2 Partnership (3GPP2), the Internet Engineering Task Force (IETF), the Universal Wireless Consortium (UWC), the CDMA Development Group (CDG), the European Telecommunications Standards Institute (ETSI) and others.

PROPOSED USES

According to the ITU, third generation or IMT-2000 wireless systems[6] will provide mobile, high-speed access to a wide range of telecommunication services supported by fixed telecommunication networks (*e.g.*, PSTN/ISDN), and to other services that are specific to mobile users. A range of mobile terminal types is encompassed, linking to terrestrial or satellite-based networks, and the terminals may be designed for mobile or fixed use. Key features of 3G or IMT-2000 systems are:

- high degree of commonality of design worldwide;
- compatibility of services within IMT-2000 and with fixed networks;
- high quality;
- use of small pocket-terminal with worldwide roaming capability;
- capability for multimedia applications, and a wide range of services (paging, voice telephony, digital data, audio and visual communications) and terminals.[7]

Table 2.1 describes some of the key service attributes and capabilities expected of IMT-2000 or 3G systems:

[6] We note that IMT-2000 is intended to encompass both terrestrial and satellite services. For purposes of this study we are only considering terrestrial services. Also, we have taken the liberty to use the terms IMT-2000 and 3G synonymously, although we recognize that 3G terrestrial wireless systems include those terrestrial wireless systems identified by the ITU as IMT-2000 systems.

[7] *See, e.g., Vocabulary of Terms for International Mobile Telecommunications-2000 (IMT-2000)*, Recommendation ITU-R M.1224 (1977), International Telecommunications Union, and *Key Characteristics for the IMT-2000 Radio Interfaces*, Recommendation ITU-R M.1455(2000), International Telecommunications Union.

Table 2.1: IMT-2000 Systems/Capabilities

Capabilities to support circuit and packet data at high bit rates: - 144 kb/s or higher in high mobility (vehicular) traffic - 384 kb/s or higher for pedestrian traffic - 2 Mb/s 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 Mb/s

A key objective of IMT-2000 is to enable users of personal terminals to go anywhere in the world and, in a variety of situations (*e.g.*, indoor/outdoor and in a range of geographic environments), to have access to a minimum set of services (*e.g.*, voice telephony and a selection of data services). Services will cover a wide range of offerings, and many new applications will be developed for IMT-2000 systems, of a nature that cannot readily be forecast today. IMT-2000 users will not, in most circumstances, notice that a radio link is used to connect their terminal to the world's telecommunication networks.

TECHNICAL CHARACTERISTICS

The ITU has developed a series of technical recommendations, or standards, that define the key characteristics of IMT-2000 radio systems. The standards are intended to minimize the number of different radio interfaces, maximize their commonality, and provide a transition path to 3G from first generation (1G) and second generation (2G) technologies. There are five recommended radio interfaces for the terrestrial component of IMT-2000:[8]

(1) *CDMA Direct Spread* - This interface is called the Universal Terrestrial Radio Access (UTRA) Frequency Division Duplex (FDD) or Wideband CDMA. FDD operations require paired uplink and downlink spectrum segments. The radio access scheme is direct-sequence CDMA with information spread over a bandwidth of about 5 megahertz with a chip rate of 3.84 Mcps. Modulation is dual-channel QPSK.

[8] *See Detailed Specifications of the Radio Interfaces of IMT-2000*, Recommendation ITU-R M.1457 (2000), International Telecommunication Union. A more comprehensive list of the technical characteristics for each of these interfaces is included in Appendix 2.1, which repoduces the 3G Industry Association Group's Report on 3G Characteristics.

(2) *CDMA Multi-Carrier* - This radio interface also is called cdma2000 and operates in FDD. The radio interface is a wideband spread spectrum system that uses code division multiple access (CDMA) technology and provides a 3G evolution for systems using the current TIA/EIA-95-B family of standards. RF channel bandwidths of 1.25 megahertz and 3.75 megahertz are supported at this time but the specification can be extended to bandwidths up to 15 megahertz.

(3) *CDMA TDD* - This radio interface employs a direct-sequence CDMA radio access scheme. There are two versions: UTRA Time Division Duplex (TDD) that uses a 5 megahertz bandwidth and a chip rate of 3.84 Mcps, and TD-SCDMA that uses 1.6 megahertz bandwidth with a chip rate of 1.28 Mcps. TDD systems can operate within unpaired spectrum segments. The UTRA TDD specifications were developed to provide commonality with UTRA FDD. In addition, the specifications were developed based on an evolved GSM-MAP but include capabilities for operation with an evolved ANSI-41 based network.

(4) *TDMA Single-Carrier* - This radio interface also is called Universal Wireless Communication-136 (UWC-136) and is an FDD system. It was developed with the objective of maximum commonality between TIA/EIA-136 and GSM General Packet Radio Service. The radio interface is intended for evolving TIA/EIA-136 technology to 3G. This is done by enhancing the voice and data capabilities of the 30 kHz channels, adding a 200 kHz carrier for high speed data (384 kbits/s) for high mobility applications and adding a 1.6 megahertz carrier for very high speed data (2 Mbits/s) for low mobility applications.

(5) *FDMA/TDMA* – This radio interface also is called Digital Enhanced Cordless Telecommunications (DECT) and is defined by a set of European Technical Standards Institute (ETSI) standards.

These five radio interfaces support various channel bandwidths and have significantly different technical characteristics. The FCC has generally declined to mandate specific air interface standards for commercial mobile radio services. We anticipate that this policy will likely apply in any spectrum that may be made available for IMT-2000 systems. Therefore, United States providers of these services may choose to employ the IMT-2000 standards for 3G systems, or they could deviate from these standards provided they do not cause interference to other users of the spectrum.

SPECTRUM CONSIDERATIONS

As indicated in the Interim Report, the ITU has identified a number of frequency bands for possible use by terrestrial 3G operations. WARC-92 identified the 1885-2025 MHz and 2110-2200 MHz bands for future public land mobile telecommunications systems, including those that later became known IMT-2000. Over the past decade, the United States participated in the ITU's efforts to determine how much additional spectrum next-generation wireless systems would require and sought to identify additional frequency bands outside of the 1885-2025 MHz and 2110-2200 MHz bands that could be used for IMT-2000 systems. ITU Task Group 8/1 eventually determined that by 2010 up to 160 megahertz of *additional* spectrum might be needed for terrestrial IMT-2000 systems– *i.e.*, spectrum beyond that already allocated for first- and second-generation wireless systems and previously identified at WARC-92.[9]

WRC-2000 identified additional spectrum for possible use by terrestrial IMT-2000 systems, including the 806-960, 1710-1885 and 2500-2690 MHz bands. The WRC-2000 results allow countries flexibility in deciding how to implement IMT-2000 systems.[10] The conference recognized that in many countries the frequency bands identified for 3G use are likely to be heavily encumbered by equally vital services that for either strategic or economic reasons cannot be readily displaced or relocated. Furthermore, not all countries in the world require equal amounts of spectrum to support future wireless services. The availability of spectrum to be used for future wireless services depends upon current spectrum usage, ease of deployment of future radio-based systems, and possible transition of incumbents to different frequency bands.

In the United States, the 698-746, 746-794, 806-960 (includes present cellular band), 1710-1850, 1850-1990 (present PCS bands), 2110-2150, 2160-2165 and 2500-2690 MHz bands could be considered for use by future 3G systems. The FCC has initiated the *Advanced Wireless Services* proceeding to identify spectrum that could be made available for use by 3G systems.

WRC-2000 also adopted a plan for the ITU-R to study the additional frequency bands identified for IMT-2000 systems in order to determine their applicability for providing IMT-2000 systems. Included in this plan (Resolution 223[11] and Annex 1 thereto) are studies that address the sharing implications of IMT-2000 with other services in the newly identified bands above 1 GHz, harmonized frequency arrangements for the implementation of IMT-2000 systems taking into account the frequency arrangements of second generation systems in the bands, and means to facilitate global roaming in light of different regional band usage. The ITU-R studies recognize the fact reflected in the US proposal to WRC-2000 that not all the spectrum required for IMT-2000 systems can, and must be, obtained from the same frequency bands. ITU Working Party 8F has been tasked to perform these studies over the next three years. In performing this work, Working Party 8F is expected to examine various ways in which the spectrum identified both at the WARC-92 and WRC-2000 might be divided into blocks and potentially paired to facilitate backward compatibility with 2G systems. At this time Study Group 8F is in the early stages of identifying a variety of options for further consideration and study.

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[9] *See* Report ITU-R M.2023, *Spectrum Requirements for International Mobile Telecommunications-2000 (IMT-2000)*.

[10] The WRC adopted two key resolutions concerning the terrestrial component of IMT-2000: Resolution 223 (WRC-2000), "Additional frequency bands Identified for IMT-2000," which addresses frequency bands above 1 GHz; and Resolution 224 (WRC-2000), "Frequency bands for the terrestrial component of IMT-200 below 1 GHz," which addresses frequency bands below 1 GHz. *See* Resolutions 223 and 224, Final Acts of WRC-2000, 2nd ed., Istanbul, Turkey, June 2000.

[11] *See* Resolution 223, Final Acts of WRC-2000, Istanbul, Turkey, June 2000.

There currently is no global consensus as to how the frequency bands identified at the WARC-92 and WRC-2000 will be used to implement 3G. The Interim Report described the current and intended used of these bands by various countries. The chart in Appendix 2.2, which includes excerpts from ITU-R Report M.2024, summarizes some of the current uses of the 1710-1885 MHz and 2500-2690 MHz bands around the world. Since the release of the Interim Report there have not been any major changes involving these bands.

OTHER CONSIDERATIONS

For any frequency band identified for possible use by 3G systems, the time period in which spectrum may need to be made available for 3G systems will greatly affect the impact on incumbent services in those bands. Also, various operational considerations often will enable different systems to share spectrum. For example, fixed satellite and terrestrial fixed operations often are able to share spectrum due to the ability to coordinate operations to avoid mutual interference. 3G systems are expected to be ubiquitous and may operate at any time. These timing and operational considerations are considered in the sharing, segmentation and relocation aspects of this study.

SECTION 3
INCUMBENT SYSTEMS IN
THE 2500-2690 MHz BAND

The Interim Report noted that a basic requirement of the Study Plan is to describe incumbent systems in the candidate band. Specifically, the studies are to describe incumbent systems in the candidate bands, including: (1) nature of use, (2) system technical characteristics (at a minimum, the necessary information to perform sharing studies with 3G systems), (3) spectrum currently used, including channeling bandwidths and overall spectrum to cover regions or nationwide, (4) current geographical deployments, (5) planned geographical deployments, (6) system life expectancy, (7) planned replacement systems, (8) interference thresholds (ITU based, if available), (9) unique operational features (*e.g.*, specific location, area or elevation required, or relationship with other frequency bands such as separation between uplinks and downlinks), and (10) any operational considerations including national security and public safety that will have a bearing on the evaluation of the sharing or relocation options.

The Interim Report provided information on the incumbent uses of the 2500-2690 MHz band. In this section, we provide a summary of the information presented in the Interim Report as well as some additional information on incumbents' planned uses of the band.

The predominant use of the 2500-2690 MHz band is by the Fixed Service for Multipoint Distribution Service (MDS), Multichannel Multipoint Distribution Service (MMDS), and Instructional Television Fixed Service (ITFS).[12] ITFS licensees make extensive use of the spectrum to provide formal classroom instruction, distance learning, and videoconference capability to a wide variety of educational users throughout the nation. Often supported by leasing arrangements to access excess capacity from ITFS licensed spectrum, MDS licensees provide a commercial video programming service in this frequency band. The frequency band is in a state of rapid evolution and development by both ITFS and MDS licensees so that they can provide high-speed, two-way access to the Internet. The MDS industry has invested several billion dollars to develop the band for broadband fixed wireless data systems. These systems will provide a significant opportunity for further competition with cable and digital subscriber line (DSL) services in the provision of broadband services in urban areas and deliver broadband services to rural areas. These systems also will enable ITFS operators to bring a wide variety of broadband services to educational users, often in cooperation with MDS operators in the band.

[12] Due to the fact that the terms "MDS" and "MMDS" are often used interchangeably, some clarification is necessary with respect to use of those terms in this Report. In fifty markets in the country, Multipoint Distribution Service or "MDS" utilizes two 6 megahertz channels (Channel Nos.1 and 2) in the 2150-2162 MHz band (in the rest of the country, the 6 megahertz No. 2 channel is replaced by a 4 megahertz No. 2-A channel (2156-2160 MHz)). The shared spectrum between 2500 and 2690 MHz is referred to as the Multichannel Multipoint Distribution Service or "MMDS." For purposes of this Report, the term "MDS" will not only refer to the Nos. 1, 2, and 2-A channels located in the 2150-2162 MHz spectrum, but also the channels located in 2500-2690 MHz spectrum. When the terms "MDS systems" or "ITFS/MDS systems" are referenced throughout this paper, licensees may be using the MDS channels in the 2150-2160 MHz spectrum.

NATURE OF USE

The predominant use of the 2500-2690 MHz band is by ITFS, which is licensed under Part 74 of the Commission's Rules, and MDS, which is licensed under Part 21 of the Commission's Rules.[13] ITFS and MDS share 190 megahertz of spectrum in the 2500-2690 MHz band. ITFS licensees are allotted 120 megahertz of spectrum, and MDS licensees are allotted 66 megahertz of spectrum. In addition, the 4 megahertz of spectrum in the 2686-2690 MHz band is allotted for ITFS response channels and is shared between ITFS licensees and private operations.

ITFS has approximately 1,275 entities holding over 2,175 ITFS licenses in urban and rural locations throughout the United States.[14] Over 70,000 locations serve as registered ITFS receive sites, although the number of actual locations at which ITFS programming is viewed is likely much higher since receive sites are typically located within a 56.3-kilometer (35-mile) protected service area around an ITFS base station. ITFS stations traditionally have been utilized for a wide variety of services, including the provision of formal telecourses (on the K-12, secondary, and post-secondary levels) to schools, hospitals, workplaces and other places of learning; transmission of other educationally valuable programming (including news, public affairs and similar material) into schools; provision of professional and worker training (such as for teachers, health professionals and public safety officers); and transmission of teleconferences for educational, training and administrative purposes. ITFS licensees are permitted to lease excess channel capacity to MDS licensees, with the income from those leases typically helping to underwrite the cost of providing ITFS.

Traditionally, MDS spectrum has been primarily used to deliver multichannel video programming, similar to cable television service, to residential customers. MDS currently has 2,570 station licensees and conditional licensees (*i.e.*, authorizations to construct or modify facilities). ITFS and MDS share the spectrum through complex licensing and leasing arrangements that have evolved over time and that are not uniform in all geographic areas.

Although the ITFS/MDS spectrum traditionally was used for one-way analog video transmission, the Commission rules permit the spectrum to be used for very high speed, fixed wireless broadband services. The Commission's July 1996, *Digital Declaratory Ruling*

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[13] In addition to ITFS and MDS use, thirty-eight fixed stations are licensed to two entities in this band under the Fixed Microwave Service rules in Part 101. Although the band also is allocated to Fixed Satellite and Broadcasting Satellite Services, there are no users of this band in those services. Finally, the Radio Astronomy service is allocated on a secondary basis and there are a few stations in use around the country.

[14] An ITFS licensee is required to be an educational institution or governmental body engaged in the formal education of enrolled students. In addition, nonprofit organizations formed to provide instructional material to enrolled students and entities eligible to be licensees of noncommercial educational broadcast television stations are eligible to become ITFS licensees.

permitted licensees to digitize their MDS and ITFS spectrum.[15] With this Commission ruling and the advances in digital technology, ITFS/MDS video providers can now deliver as many as 200 channels of programming. In October 1996, the Commission allowed wireless cable and ITFS operators to use their spectrum for high-speed digital data applications, including Internet access.[16]

In 1998 the FCC approved the use of two-way transmissions on MDS and ITFS frequencies, effectively enabling the provision of voice, video, and data services.[17] The introduction of two-way service will allow many educational users to develop broadband access to support education throughout the nation and MDS entities to develop a commercial wireless broadband alternative, especially to residential and small office/home office ("SOHO") customers.

Given the complex interference environment in the 2500-2690 MHz band, the Commission adopted a specific authorization process for this band. The initial filing window for two-way service occurred from August 14, 2000 until August 18, 2000, and approximately 2, 267 applications were received. On November 29, 2000, we issued a Public Notice listing the applications tendered for filing.[18] At the conclusion of a 60-day amendment period, we issued a Public Notice on February 1, 2001, listing the applications that had been accepted for filing; all tendered applications were accepted for filing.[19] Absent petitions to deny, these applications will be granted after an additional 60-day period, which ends in early April, 2001. Subsequent to this initial licensing process, two-way applications will be processed under a rolling one-day filing window.[20]

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[15] *See In the Matter of the Request for Declaratory Ruling on the Use of Digital Modulation by Multipoint Distribution Service and Instructional Television Fixed Service Stations,* 11 FCC Rcd 18839 (1996).

[16] *See The Mass Media Bureau Implements Policy for Provision of Internet Service on MDS and Leased ITFS Frequencies*, 11 FCC Rcd 22419 (1996).

[17] *See Two-Way Order,*13 FCC Rcd 19112 (1998), *recon.*, 14 FCC Rcd 12764 (1999), *further recon.*, FCC 00-244 (released July 21, 2000). In the *Two-Way Order*, the Commission decided to: (1) permit both MDS and ITFS licensees to provide two-way services on a regular basis; (2) permit increased flexibility on permissible modulation types; (3) permit increased flexibility in spectrum use and channelization, including combining multiple 6 megahertz channels to accommodate wider bandwidths, dividing 6 megahertz channels into smaller bandwidths, and swapping licensed MDS and ITFS channels; (4) adopt a number of technical parameters to mitigate the potential for interference among service providers and to ensure interference protection to existing MDS and ITFS services; (5) simplify and streamline the licensing process for stations used in cellularized systems; and (6) modify the ITFS programming requirements in a digital environment.

[18] *See Public Notice*, Report No. 148 (MMB November 29, 2000).

[19] *See Public Notice*, Report No. 164 (MMB February 1, 2001).

[20] *See Public Notice*, DA 01-751 (MMB March 26, 2001).

MDS entities have been able to provide two-way service on MDS channels located at 2150-2160/2162 MHz since 1998, and MDS providers such as Sprint, WorldCom and Nucentrix have continued to roll-out high-speed Internet access in new markets across the country.

- Sprint has acquired interests in more than 90 markets covering about 30 million households. It holds licenses for 642 MDS/commercial ITFS channels; leases to use the capacity of 349 MDS/commercial ITFS channels; and leases to use the capacity of 1394 ITFS channels. Sprint indicates that it holds a total of 532 leases, two-thirds of which are with ITFS licensees.[21] Sprint Broadband Direct service is now available in Phoenix, AZ, Tucson, AZ, Detroit, MI, Colorado Springs, CO (business only), Houston, TX, San Jose, TX, Oakland, CA, Denver, CO, Salt Lake City, UT, Wichita, KS, Melbourne, FL, Oklahoma City, OK and Fresno, CA. Applications for 15 additional markets were granted in December 2000. Sprint was providing advanced fixed wireless services to more than 20,000 residential and small business customers as of December 31, 2000 and is adding over 2,000 new customers every week.[22] In addition, Sprint and its partners filed almost 400 applications in 45 markets prior to the end of the Commission's two-way filing window. Sprint's residential Broadband Direct service provides downstream speeds of 1 Mbps,[23] upstream speeds of 512 kbps, and burst rates of up to 5 Mbps.

- WorldCom holds MDS licenses covering over 31 million households in 78 markets.[24] WorldCom is offering fixed wireless high-speed Internet access to residential and SOHO customers. Currently, the company is providing commercial fixed wireless broadband services in Jackson, MS; Baton Rouge, LA; and Memphis, TN and plans to provide service in 30 markets by the end of 2001.[25] WorldCom plans to roll out fixed wireless service to 30 metropolitan areas by the end of 2001.[26] In August, the company filed over 380 applications to offer two-way service in more than 60

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[21] *See* Sprint Comments at 3. Throughout this Final Report, references to comments refer to those received in response to the *Advanced Wireless Services NPRM*, unless otherwise noted.

[22] *Id.* at 8.

[23] *Sprint Rolls Out Wireless DSL in Phoenix,* COMMUNICATIONS DAILY, May 9, 2000.

[24] *See* Worldcom Comments at 6. *See also, Annual Report and Analysis of Competitive Market Conditions With Respect to Commercial Mobile Services, Fifth Report,* FCC 00-289, rel. Aug. 18, 2000 at E-5 (*Fifth Report*).

[25] *See* Worldcom Comments at 6.

[26] *See* Worldcom Comments at 6. *See also*, Greg Keizer, *E-Goals for '01*, Small Business Advisor from ZDWire, Dec. 28, 2000, available in 2000 WL 31553911.

markets.[27] WorldCom offers its residential customers two-way speeds of 310 kbps and businesses speeds of 128 kbps to 8 Mbps.[28]

- Nucentrix Broadband Services, Inc. ("Nucentrix") currently offers two-way high-speed Internet access service in Austin and Sherman-Denison, TX,[29] and is conducting a trial of the service in Amarillo, TX. In February 2001, Nucentrix announced it would extend its trial in Amarillo, where it is testing Cisco's Vector Orthogonal Frequency Division Multiplexing (VOFDM) technology[30] with over 125 customers, until April 2001.[31] Nucentrix holds licenses that cover 90 small and medium markets across Texas and the Midwest.[32] In August 2000, Nucentrix filed applications to offer two-way service in 70 markets.[33]

At least 24 other companies offer fixed wireless services in approximately 33 different counties. These companies are small, independent MDS licensees offering Internet access at up to 11 Mbps downstream to a limited number of residential and small business customers in one to five markets apiece (generally smaller towns and cities). For example, LMA Systems offers two-way Internet access at 1.54 Mbps downstream and 768 kbps upstream in Wilkes-Barre and Sunbury, PA. and has plans to enter additional markets.[34] Oxford Telecom offers two-way MDS-based Internet access in Portland, ME.[35] Some MDS carriers - including QuadraVision in Carson City and Reno, NV and American Rural TV in La Junta, CO – offer fixed wireless Internet access on a one-way basis and use a telephone line for the return path.[36]

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[27] *Id. See also*, Matt Moore, *WorldCom Seeking Licenses for Fixed-Wireless Services*, Associated Press Newswires, Aug. 15, 2000.

[28] Paul Kagan Associates, Inc., WIRELESS/PRIVATE CABLE INVESTOR, Mar. 9, 2000, at 1. WorldCom has stated that its capital expenditures for rolling out MMDS services are approximately $2000 per square mile. *Telephony*, COMMUNICATIONS DAILY, Mar. 8, 2000.

[29] *Nucentrix Broadband Networks Announces Effectiveness of Shelf*, BUSINESS WIRE, Dec. 17, 1999.

[30] Vector Orthogonal Frequency Division Multiplexing supports non-line of sight operation, which can significantly improve signal coverage in a market.

[31] *Nucentix and Cisco Extend Broadband Wireless Trial in Amarillo*, News Release, Nucentrix Broadband Networks, Feb. 2, 2001.

[32] *Nucentix and Cisco Extend Broadband Wireless Trial in Amarillo*, News Release, Nucentrix Broadband Networks, Feb. 2, 2001.

[33] *Nucentrix Broadband Networks Announces FCC Notice of Fixed Wireless Applications*, News Release, Nucentrix Broadband Networks, Inc., Nov. 30, 2000.

[34] *See* LMA web page at http://www.lmasys.com/homepage.htm.

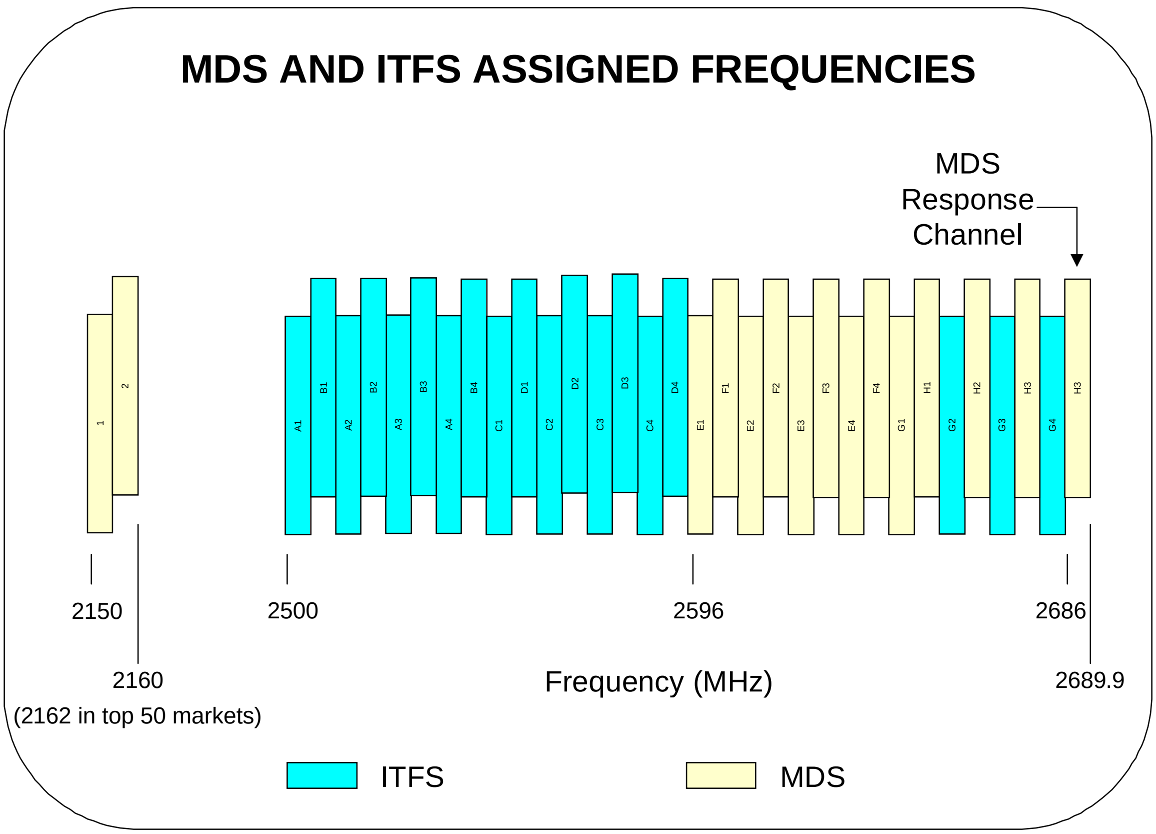
[35] *See* http://www.microtimes.com/newsfeeds/julyfeeds%2000/july10.html.

[36] *See* http://www.cabledatacomnews.com/wireless/cmic12.html for a listing of wireless broadband trials and deployments.

SPECTRUM USE

Except for two channels at 2150 MHz, the majority of ITFS and MDS operations are located in the 190 megahertz in the 2500-2690 MHz band. In this band, ITFS licensees are allotted five groups of 6 megahertz channels (120 megahertz of spectrum), and MDS licensees are allotted three groups of 6 megahertz channels (66 megahertz of spectrum). Each 6 megahertz channel has associated with it a 125 kHz response channel (4 megahertz of spectrum). In the largest fifty metropolitan areas in the country, MDS utilizes two 6 megahertz channels in the 2150-2162 MHz band.[37] In the rest of the country, the 6 megahertz MDS 2 channel is replaced by a 4 megahertz MDS 2-A channel (2150 to 2160 MHz). The channel plan is shown in Figure 3.1.

Figure 3.1: ITFS/MDS Channel Plan



Over the years, the MDS and ITFS operators typically operated in a symbiotic relationship with MDS operators providing funding used by ITFS licensees for their educational mission in exchange for the extra channel capacity needed to make MDS systems viable. Today, most ITFS licensees lease excess capacity to MDS operators, subject to certain technical

[37] *See* 47 C.F.R. § 21.901. *See also* footnote 12, *supra.*

limitations and programming requirements. Although the Commission's licensing processes can identify in a given geographic area how many channels MDS licensees own through either area-wide and site specific licensing, this information does not reveal how much additional spectrum is being leased from ITFS licensees or the extent to which MDS spectrum is being leased to other companies.

In its 1998 *Two-Way Order*, the Commission established a regulatory framework under which MDS has become a fully flexible service in which licensees can provide either one-way or two-way service to fixed or portable locations in response to local marketplace demands. MDS and ITFS licensees were given the flexibility to reconfigure their licensed spectrum not only to change the direction of transmissions but also to change the bandwidth used in any direction. In these two-way systems, operators are able to deploy a cellular configuration to take advantage of frequency reuse techniques and to employ modulation schemes that would permit the use of variable bandwidth while assuring appropriate levels of interference protection to other licensed users of the spectrum. The most common characteristics of the two-way systems now being deployed are described below. *See* Appendix 3.3 for a pictorial representation of ITFS/MDS band plans.

- Either the highest or lowest frequencies in the 2500-2690 MHz band are used for "upstream" service from the user to the system's receiver; downstream voice and/or data channels occupy the remaining spectrum. This arrangement provides approximately 30 megahertz separation between upstream and downstream transmissions to provide sufficient isolation of upstream and downstream signals in the duplex switch.

- Bandwidth is assigned as needed to meet the asynchronous bandwidth needs of their customers, including offering adjustable bandwidth "on demand." Licensees can subchannelize and superchannelize[38] the 6 megahertz main channels and the I-channels (125 kHz response channels)[39] to permit the maximum possible operating flexibility. For example, the downstream Internet speeds reported by MDS operators range from 750 kbps to 11 Mbps, and MDS Internet systems can be designed in point-to-point or point-to-multipoint configurations to meet these requirements. Upstream data channels typically are either 200 or 400 kHz, and they are most often delivered by subchanneling 6 megahertz main channels. Licensees can choose the bandwidth plan for each licensed station, taking into account channel availability (both licensed and leased channel availability) and interference protection to other authorized users of the band. Thus, the bandwidth plans for two-way systems will likely vary from one geographic area to another.

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[38] Subchannelization is the division of a standard channel of fixed bandwidth into multiple, although not necessarily equal, channels of lesser bandwidth. Superchannelization is the aggregation of multiple contiguous channels of standard bandwidth into channels of larger bandwidth.

[39] *See* 47 C.F.R. § 74.939 (providing that the 2686-2690 MHz is divided into 31 narrowband (125 kHz) response station channels).

- ITFS and MDS licensees can exchange channels, subject to Commission approval. Also, under certain circumstances, MDS entities could apply for licenses for up to eight ITFS channels per community, and ITFS entities have a subsequent right of access to those channels.[40]

GEOGRAPHIC DEPLOYMENT

ITFS and MDS are licensed with different service areas and thus have different geographic areas entitled to interference protection. ITFS is authorized on a site-specific and channel-specific basis. Although an ITFS licensee may be authorized to use multiple channels, not all available ITFS channels may be licensed at any given site or in any given geographic area. Originally, ITFS transmit and receive sites were licensed on a point-to-point basis. Eventually the Commission adopted a protected service area (PSA) concept and, with the adoption of the *Two-Way Order*, receive sites located within a 56.3 kilometers (35 miles) radius of a licensed ITFS transmitter are entitled to interference protection. The Commission continues to provide interference protection to numerous previously registered receive sites that are beyond the 56.3 kilometer (35 mile) PSA boundary. Today, interference protection for ITFS transmit and receive sites is an amalgam of different channels and geographic boundaries that vary from location to location.

MDS originally was licensed on a site-specific and channel-specific basis as well. Because MDS is a point-to-multipoint service, the Commission subsequently provided interference protection to receivers located within a PSA of 56.3 kilometers (35 miles), surrounding licensed transmit sites. In 1996, the Commission allotted, through a simultaneous multiple round bidding process, one MDS authorization for each of the 487 Basic Trading Areas (BTAs) and six additional similar geographic areas.[41] The BTA licensees are authorized to construct facilities to provide service over any usable MDS channel within the BTA and have

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[40] *See* 47 C.F.R. §§ 74.990, 74.991, 79.992; *Amendment of Parts 21, 43, 74, 78, and 94 of the Commission's Rules Governing Use of the Frequencies in the 2.1 and 2.5 GHz Bands*, 6 FCC Rcd 6792, 6801-06 (1991). The rules provide that an MDS operator may be licensed on ITFS frequencies in areas where at least eight other ITFS channels remain available in the community for future ITFS use. In addition, no more than eight ITFS channels per community may be licensed to MDS operators. To be licensed on ITFS channels, an MDS applicant must hold a conditional license, license or a lease; must have filed an unopposed application for at least four MDS channels to be used in conjunction with the facilities proposed on the ITFS frequencies; and must show that there are no MDS channels available for application, purchase or lease. Finally, ITFS entities have the right to demand access to ITFS channels licensed to MDS operators.

[41] Basic Trading Areas (BTAs) are based on the *Rand McNally 1992 Commercial Atlas & Marketing Guide*, 123rd Edition, at pages 38-39, with the following additions: American Samoa (492), Guam (490), Northern Mariana Islands (493), San Juan, Puerto Rico (488), Mayagüez/ Aguadilla-Ponce, Puerto Rico (489), and the United States Virgin Islands (491). For extensions and revisions by the Federal Communications Commission, *see* 59 FR 46195 (September 7, 1994); *see also*, http://www.fcc.gov/oet/info/maps/areas/.

preferred rights to the available ITFS channels.[42] Today, some incumbent site-specific MDS licensees continue to provide service within PSAs that either overlap with or lie within licensed BTAs.

As discussed above, the *Two-Way Order* allows both ITFS and MDS licensees to modify the historic band plan and to operate with subchannels or superchannels. In effect, the traditional channel boundaries across the band are erased, but the geographic protection areas licensed to a particular band segment remain for interference protection purposes. This has practical consequences for combined systems that utilize interleaved channels from both MDS and ITFS channel groups. For example, channel B1 is immediately adjacent to channel A1. Protection of the BTA boundary would only apply to the band segment licensed under the MDS channel group, whereas a 56.3 kilometer (35 mile) PSA boundary would apply to the band segment licensed under the ITFS channel group or MDS stations authorized prior to the BTA auction. Consequently, the actual overlay of BTA and PSA boundaries would be a relevant consideration in determining the actual service area boundary of a superchannel that crosses historic band channel boundaries.

SYSTEM CHARACTERISTICS

The architectures and technical characteristics of ITFS/MDS systems in the 2500-2690 MHz band vary and depend on the type of service being offered, the population of the market being served, and terrain characteristics of the area being served. Today there are four basic service offerings by ITFS/MDS operators: downstream analog video, downstream digital video, downstream digital data and downstream/upstream digital data. An ITFS or MDS system may be providing any one of these services or a combination of services.

The typical system characteristics of traditional one-way ITFS and MDS systems as well as proposed two-way ITFS and MDS systems is considered below. In Appendix 3.2, the specific technical characteristics for stations in traditional one-way ITFS and MDS systems are provided in Tables 3-A (base stations) and 3-B (response stations). These are primarily specifications for analog systems, and they also apply to any digital system authorized prior to the adoption of the *Two-Way Order* in 1998. In Appendix 3.2, the specific technical characteristics for stations in two-way ITFS and MDS systems are provided in Tables 3-C (base stations) and 3-D (response stations). These are primarily specifications for two-way digital systems that have been authorized since 1998.

Traditional One-Way ITFS Systems

Traditional one-way ITFS systems provide one-way video transmission service to their users. In such a system, a main station transmitter broadcasts (usually omnidirectionally) to multiple receive sites located within the system service area, typically a radius of 56.3 kilometers

[42] Since the auctions concluded in 1996, there have been bankruptcy defaults for 4 of the auctioned BTAs. In 1997, the Commission adopted default orders for two of the BTAs, Hickory, NC and Hagerstown, MD. Commission action for two additional BTAs, York, PA and Reading, PA, is pending.

(35 miles). Such receive sites are typically at schools or similar facilities where a reception antenna can be located on a tower or roof in order to provide a line-of-sight path back to the main station location. A 125 kHz response station transmitter may be located at any or all of the receive sites to enable students (and/or faculty) at the receive site to communicate with faculty (and/or students) at the main station site. One or more booster stations may be used to retransmit the main station signal to locations where the signal cannot be received directly, *e.g.*, where there is terrain blockage. Most systems make use of standard 6 megahertz composite NTSC video/audio modulation for the downstream signal and wideband FM for response transmissions.

Traditional One-Way MDS Systems

Traditional one-way MDS systems provide one-way multichannel video programming to subscribers, a service known as "wireless cable." Wireless cable systems operate similar to ITFS systems, with a main station transmitter broadcasting (usually omnidirectionally) multiple channels of fee-for-service entertainment television programming to customer premises located within the MDS service area. Each customer typically has a tower-mounted or rooftop-mounted reception antenna and is connected, via a block downconverter, to one or more television sets. As in ITFS systems, an MDS system makes use of booster stations to achieve coverage in portions of the service area where direct coverage from the main station is impossible. Also in common with ITFS systems, most MDS systems make use of standard 6 megahertz composite NTSC video/audio modulation, although a few systems have implemented digital modulation in recent years.

Two-Way ITFS/MDS Systems

The *Two-Way Order* introduced a wholly new method of configuring MDS and ITFS systems. In discussing the technical aspects of ITFS/MDS systems, it is important to be familiar with the following terms:

> *Main Station*: The primary station authorized by the Commission to the MDS or ITFS licensee for providing coverage within a given service area. A maximum station power of 33 dBW (2000 watts) (per 6 megahertz bandwidth) effective isotropic radiated power (EIRP) is permitted.
>
> *Booster Station (high power):* A station used by an ITFS or MDS licensee to provide service within a given service area to locations not served by the main station. Any number of such stations may be located within a given service area and they may both repeat main station transmissions and originate transmissions. These stations operate at a power level greater than -9 dBW (125 milliwatts) up to a maximum of 33 dBW (2000 watts) (per 6 megahertz bandwidth) EIRP.
>
> *Booster Station (low power):* Same as above except limited to a maximum power of –9 dBW (125 milliwatts) (per 6 megahertz bandwidth) EIRP. These stations may be activated without prior Commission approval and operate so long as they do not cause harmful interference.

Receive Site: A location at which a receiver is located and used in conjunction with an ITFS system. A site may be 'registered' (with the Commission) and thus protected from harmful interference or 'unregistered' and not protected from interference in certain circumstances.[43]

Response Station (traditional): A transmitting station used within a traditional, one-way ITFS system for transmitting an audio signal from a receive site back to the main station using 125 kHz 'response channels' located in the 2686-2690 MHz range.

Response Station (two-way system): A customer-premises transceiver used for the reception of downstream and transmission of upstream signals as part of a large system of such stations licensed under the authority of a single license. A maximum EIRP of 33 dBW (2000 watts) (per 6 megahertz) is permitted.

Hub Station: A receive-only station licensed as part of a system of response stations in a two-way system and used for the purpose of receiving the upstream transmissions of those response stations.

Sectorization (at main or booster stations): The use of multiple directional transmitting antennas for the purpose of achieving simultaneous frequency *re*use at a single site.

Sectorization (at hub stations): The use of multiple directional receiving antennas for the purpose of receiving transmissions on the same frequencies from multiple directions simultaneously.

In a two-way MDS or ITFS system, a main station transmitter is used to send data using digital modulation to numerous users. Each user has at least one response station transceiver with its receive antenna oriented towards the main station and its transmit antenna oriented towards its associated hub station. Typically, a large number of response stations will be served by a single main station and by a single hub station linked to that main station, and in most cases these stations will be co-located. Additionally, typical systems will utilize numerous booster stations, each of which serves its own system of response stations and is associated with its own hub station. Similar to other cellular networks, two-way systems employ frequency reuse techniques such as using sectored antennas within a cell or splitting one cell into several cells. Two-way systems using digital modulation may also 'subchannelize' and 'superchannelize' their authorized spectrum on a real-time dynamic basis to meet needs within the system. There is no limit on the number or locations of response stations so long as the aggregate interference generated by the stations within the system falls at or below the level required for protection of

[43] As explained above, all receive sites within 56.3 kilometers (35 miles) of the main station transmitter are protected from interference whether they are 'registered' or 'unregistered.' Receive sites that are further than 56.3 kilometers from the main transmitter site are only protected from interference if they are 'registered.'

neighboring systems. Bandwidths and associated data rates may be symmetrical or asymmetrical for upstream and downstream paths, dependant on system architecture and the nature of the service(s) provided. 'Hybrid' systems are also permissible, consisting of both 'traditional one-way' and 'two-way' operations within the same service area.**[44]**

In the wake of the *Two-Way Order*, MDS equipment manufacturers have begun developing new ways to use the available MDS spectrum more efficiently, such as sectored antennas and advanced modulation techniques.[45] For example, Wireless Online utilizes an antenna technology that enhances the coverage, quality, and capacity of MDS networks.[46] NextNet, Inc. has developed a sectorized base station that uses 6 megahertz channels, with each of the six 60-degree sectors of the base station occupying one channel. The system minimizes multi-path signal propagation and reportedly delivers maximum user capacity per megahertz allocated.[47] Hybrid Network, Inc.'s equipment allows licensees to split one 6-megahertz channel into three 2-megahertz channels and thereby offer different levels of service using the different 2 megahertz channels.[48] Also, in December 1999, Cisco Systems released a cellularization technology for MDS and unlicensed spectrum called VOFDM.[49] VOFDM captures signals as they bounce off buildings and other objects and redirects them to end-user transceivers, therefore eliminating the need for a fixed line-of-sight between a transmitter and a receiver.[50] Nucentrix recently completed a field trial of Cisco's VOFDM equipment in Austin, TX and plans to deploy the technology in at least 20 markets by the end of 2001.[51] WorldCom is also testing VOFDM in its Dallas trial.[52] All of these innovations permit MDS licensees to make ever more effective use of their spectrum.

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[44] Cable Datacom News® presents an overview of wireless broadband technology and serices and wireless broadband network diagrams on their web site at http://www.cabledatacomnews.com/wireless/.

[45] Sue O Keefe, MMDS: From Back Burner to Center Stage, Telecommunications, Sept. 1, 1999.

[46] *Wireless OnLine Adds Vice President of Product Management*, PR NEWSWIRE, Jan. 5, 2000.

[47] NextNet, Inc., *Products* (visited Jan. 20, 2000) http://www.netwnetworks.com/products_prod_botton.html.

[48] Regional Wireless Operators Select Hybrid Networks' 2-Way Today Solution to Launch Multiple Markets, PR Newswire, Jan. 10, 2000.

[49] Cliff Edwards, *Cisco Hopes Advances New Wireless Technology for Internet*, AP NEWSWIRES, Dec. 2, 1999.

[50] *Id*.

[51] *Nucentrix Files for FCC Approval to Launch Broadband Fixed-Wireless Services*, News Release, Nucentrix Broadband Networks, Inc., Aug. 21, 2000; *Nucentrix Successfully Completes Initial Field Trial of Cisco Broadband Fixed-Wireless Solution*, News Release, Nucentrix Broadband Networks, Inc., Aug. 15, 2000.

[52] *MCI WorldCom Adds Dallas to 'Fixed Wireless' Service Trials*, News Release, WorldCom, Inc., Apr. 5, 2000.

INTERFERENCE PROTECTION STANDARDS

The calculation of permissible interference levels on an inter-system basis is extremely complex. The requirements for MDS system protection are set out in sections 21.902, 21.909, 21.913, 21.933, 21.937 and 21.938 of the Commission's rules.[53] The requirements for ITFS system protection are set out in sections 74.903, 74.939, 74.949 and 74.985 of the Commission's rules.[54] Additional requirements and procedures for interference protection for stations in both services are found in Appendix D (titled "Methodology") to *Report and Order on Further Reconsideration and Further Notice of Proposed Rulemaking* in MM Docket 97-217.[55] Interference is calculated using desired/undesired (D/U) signal ratios and field strength values that are always referenced to the bandwidths of the two signals involved in the calculation. The D/U values specified in the MDS and ITFS rules are normalized to 6 megahertz and all calculations are based on these normalized values. Interference is also calculated using a reference field strength value specified in dBW per square meter, and this value is also always referenced and normalized to 6 megahertz bandwidth.

The geographical areas for MDS systems that must be protected fall into 3 basic categories. First, there are protected service areas (PSA), typically with a 56.3 kilometer (35-mile) radius, for "incumbent" MDS licensees who received their authorizations prior to March 1996 when the MDS channels were auctioned nationwide. The second geographic classification is a Basic Trading Area (BTA), including portions of BTAs that are created when a BTA is partitioned. Finally, ITFS registered receive sites within an area swept by a 56.3 kilometer (35-mile) radius surrounding the main station transmitter are entitled to protection.

Interference is calculated using 'aggregated' values for the power flux density on any given channel, subchannel or superchannel, *i.e.*, interference potential is based on the summation of all of the individual potential interference contributions of all of the transmitters within a system, which might be received in a neighboring system. Aggregation must be used for calculation of both D/U signal ratios and field strength values.

Interference protection is calculated with reference to specific, known locations in an ITFS system, and to general geographic areas. The calculation is done using a grid of points laid

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[53] *See* 47 C.F.R. §§ 21.902, 21.909, 21.913, 21.933, 21.937 and 21.938.

[54] *See* 47 C.F.R. §§ 74.903, 74.939, 74.949 and 74.985.

[55] *See* Appendix D, Report and Order on Reconsideration In the Matter of Amendment of Parts 1, 21 and 74 to Enable Multipoint Distribution Service and Instructional Television Fixed Service Licensees to Engage in Fixed Two-Way Transmissions, MM Docket 97-217, 14 FCC Rcd 12764 (2000) (hereinafter "Methodology") for details. The Methodology is periodically refined to accommodate real-world technical concerns. *See, e.g., Public Notice, Commission Amends Methodology Used for Calculation of Interference Protection and Data Submission for MDS and ITFS Station Applications for Two-Way Systems*, DA 00-938, released April 27, 2000. A copy of the most recent version of the Methodology can be found at http://www.fcc.gov/mmb/vsd/files/methodology.doc.

out checkerboard fashion using a reference antenna pattern and a reference standard antenna height above ground level (AGL).

The most interference-sensitive portion of a two-way system is the hub station receiver. This receiver must be protected down to its ‘noise floor’ by all neighboring systems, using a calculation that takes into account its noise figure, feedline loss, antenna gain and other pertinent factors. All ITFS/MDS interference calculations must utilize the Epstein-Peterson propagation formulations found in the Methodology. Because the locations of response stations in two-way systems are not known prior to licensing of the system, a totally theoretical construct was devised for estimating interference from response stations into neighboring systems.[56]

[56] *Id.*

SECTION 4
EVALUATION OF SPECTRUM SHARING

In the Interim Report, we presented a technical evaluation of options for sharing between 3G and incumbent ITFS and MDS operations in the 2500-2690 MHz band. In this section, we review and assess that technical evaluation. The technical feasibility of co-channel and adjacent channel sharing between licensed ITFS/MDS stations and 3G base and mobile stations was examined by calculating minimum distance separation requirements using the interference protection criteria established in the Commission's rules for ITFS and MDS.[57] ITFS/MDS licenses within the spectrum band were examined to assess where, in light of the minimum separation distances, 3G systems could operate without causing harmful interference to ITFS/MDS systems. In this Final Report, we also assess the predicted levels of co-channel interference from an ITFS/MDS transmitter into 3G base and mobile stations.

INTERFERENCE PROTECTION REQUIREMENTS

In the Interim Report we calculated the predicted levels of co-channel and first adjacent channel interference from 3G base and mobile stations into an ITFS/MDS licensees' receivers at hub and response sites and determined the minimum distance separation required to avoid harmful interference.[58] As discussed below, we determined that large co-channel separation distances are needed between 3G systems and ITFS/MDS systems to avoid causing harmful interference to ITFS/MDS systems, and that adjacent channel separation requirements do not appear to be as limiting.

In order to perform technical analyses of the ability of 3G systems to share spectrum with incumbent systems, we made certain assumptions about 3G systems and incumbent ITFS/MDS systems:

- For the likely technical characteristics of 3G systems, such as the power levels likely to be used by base stations and mobile units and the bandwidths of 3G signals, we used, where appropriate, the ITU technical standards for IMT-2000 systems. These technical characteristics have been updated since the release of the Interim Report by the Industry Association Group.[59]

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[57] *See* 47 C.F.R. §§ 21.902, 21.909, 21.913, 74.903, 74.939, and 74.985. *See* also, Section 3 *supra* regarding ITFS/MDS Interference Protection Standards.

[58] ITFS/MDS receivers, for purposes of this interference analysis include not only response station receivers located at commercial customer premises and registered ITFS receive sites, but also the main station receivers associated with the main station transmitters. Main station receivers receive signals on 125 kilohertz response channels associated with each 6 megahertz channel.

[59] The Industry Association Group 3G Technical Characteristic Report is included as Appendix 2.1. There are only minor differences between the characteristics listed in the ITU documents and those presented in the Industry Association Group Report.

- Interference from a 3G system into the ITFS/MDS stations receivers' could come from either the 3G base station or the 3G mobile unit. Because base stations are fixed, it was fairly straightforward to predict the interference from a 3G base station into ITFS/MDS receivers. We also analyzed the effect that a single typical 3G mobile unit would have on ITFS/MDS receivers.[60]

- ITFS/MDS systems can be implemented using a main transmitter configuration or architecture.[61] These systems typically have a single high power base station transmitter located at high elevation with an omnidirectional or wide cardioid antenna pattern. FCC rules set the maximum permitted EIRP for ITFS/MDS base stations at 2000 watts (33 dBW).[62] Typical EIRP for analog systems are in the 100-1000 watt (20-30 dBW) range and are slightly higher for digital or cardioid antennas. Both horizontal and vertical polarization are used and are often precisely calibrated to avoid co-channel interference to neighboring systems. Booster stations are also used in some system designs to overcome signal loss within a protected service area.

- Cellular architectures are also being developed and deployed for two-way ITFS/MDS data transmission systems in densely populated areas. Because transceivers are located close together, power levels are scaled back for both downstream and upstream transmissions to between 1 and 100 watts (0-20 dBW) EIRP, using the minimum power necessary to achieve path reliability. Interference is controlled within the protected service area by careful frequency planning and by using polarization, sector geometry and receive antenna isolation. For example, antennas located at customer premises have downstream gains of 12 to 27 dBi, similar to that for a single cell one-way system, and have upstream gains of 10 to 24 dBi.

- To determine co-channel and first adjacent channel protection requirements, technical characteristics specified in the FCC rules for a typical ITFS/MDS station were used. Current FCC rules require co-channel ITFS/MDS licensees to maintain a D/U signal level of 45 dB at all unobstructed areas within the 56.3 kilometer (35 mile) radius protected service area of an incumbent station.[63] This is particularly important in

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[60] Because mobile units could potentially operate at any location at any time, a complete analysis of the effect of multiple 3G mobile stations would require assumptions regarding their level of deployment within an area. Such assumptions are beyond the scope of this Final Report. For example, such assumptions may include statistics regarding how many mobile units may be operating in any given area at any one time and the calling patterns of users.

[61] ITFS/MDS services in the 2500-2690 MHz band tend to fall within one of four distinct architectures: 1) downstream analog video; 2) downstream digital video; 3) downstream digital data; and 4) downstream/upstream digital data. Although variations exist, a substantial number of technical characteristics are consistent across the four different architectures.

[62] 47 C.F.R. §§ 21.904 and 74.935.

[63] *See* 47 C.F.R. §§ 21.902, 21.909, 21.913, 74.903, 74.939, and 74.985.

analog single station architectures, where a high D/U ratio is required to maintain a high quality video signal. For digital single station architectures, the D/U ratio can be less than 45 dB as a practical matter because digital systems can tolerate more interference. However, FCC rules do not specify different D/U ratio values based upon whether the incumbent licensee is operating an analog or digital system. Therefore, for purposes of this study the required 45 dB D/U ratio was used for the co-channel analysis. For the adjacent channel analysis, FCC rules specify that a D/U ratio of 0 dB be maintained. Tables 4-A and 4-B in Appendix 4.1 summarize the pertinent provisions of the FCC rules for ITFS/MDS response stations and ITFS/MDS main stations.

The analysis assumed two operating scenarios for 3G base stations based on the five IMT-2000 radio interface standards, one operating with high power – 500 watts EIRP (27 dBW), and one operating with low power – 10 watts EIRP (10 dBW). The analysis of the interference potential from an IMT-2000 mobile station into an ITFS/MDS receiver assumed the 3G mobile station was operating with 100 milliwatts (-10 dBW) EIRP.

Table 4.1 shows the minimum spacing required to prevent interference between co-channel 3G base and mobile stations and ITFS/MDS hub and response station receivers based on our assumptions and the planning factors set forth in Tables 4-A and 4-B in Appendix 4.1.[64] The required separation is first tabulated assuming free space conditions, as prescribed in the FCC's rules for radio propagation predictions for ITFS/MDS service.[65] However, as a practical matter, interference does not extend beyond the radio horizon. FCC rules recognize this concept by setting 161 kilometers (100 miles) as a limiting distance for purposes of establishing minimum distance separations.[66] Accordingly, if the calculated free space distance separation exceeds this limit, the practical limit of 161 kilometers (100 miles) is shown in the table.

[64] The minimum distance separation is rounded to the nearest kilometer. Additional data is available in Tables 4-C – 4-E of Appendix 4.1.

[65] *See* 47 C.F.R. §§ 21.902 and 74.903.

[66] *Id.*

Table 4.1: Calculation of Co-channel Separation Distances of 3G Stations to ITFS/MDS Stations

ITFS/MDS System Parameters		3G System Parameters		3G Base Station (500 Watts)		3G Base Station (10 Watts)		3G Mobile Station (100 milliwatts)	
Protected Receiver Type	Bandwidth (kHz)	Modulation Type	Bandwidth (kHz)	EIRP (dBW)	Minimum Separation (km)	EIRP (dBW)	Minimum Separation (km)	EIRP (dBW)	Minimum Separation (km)
Hub	125	CDMA	1250	27	161	10	161	-10	161
	125	CDMA	3750	27	161	10	161	-10	148
	125	W-CDMA	5000	27	161	10	161	-10	127
	125	TDMA	30	27	161	10	161	-10	161
	125	TDMA	200	27	161	10	161	-10	161
Response Station	6000	CDMA	1250	27	161	10	161	-10	161
	6000	CDMA	3750	27	161	10	161	-10	114
	6000	W-CDMA	5000	27	161	10	161	-10	100
	6000	TDMA	30	27	161	10	161	-10	161
	6000	TDMA	200	27	161	10	161	-10	161

Similar to the analysis above, Table 4.2 tabulates the minimum spacing required to prevent interference between 3G base and mobile stations and first adjacent ITFS/MDS main and response station receivers.[67]

Table 4.2: Calculation of Adjacent Channel Separation Distances of 3G Stations to ITFS/MDS Stations

ITFS/MDS System Parameters		3G System Parameters		3G Base Station (500 Watts)		3G Base Station (10 Watts)		3G Mobile Station (100 milliwatts)	
Protected Receiver Type	Bandwidth (kHz)	Modulation Type	Bandwidth (kHz)	EIRP (dBW)	Minimum Separation (km)	EIRP (dBW)	Minimum Separation (km)	EIRP (dBW)	Minimum Separation (km)
Hub	125	CDMA	1250	27	101	10	14	-10	1
	125	CDMA	3750	27	58	10	8	-10	1
	125	W-CDMA	5000	27	51	10	7	-10	1
	125	TDMA	30	27	161	10	93	-10	9
	125	TDMA	200	27	161	10	36	-10	4
Response Station	6000	CDMA	1250	27	161	10	99	-10	10
	6000	CDMA	3750	27	161	10	57	-10	6
	6000	W-CDMA	5000	27	161	10	50	-10	5
	6000	TDMA	30	27	161	10	161	-10	64
	6000	TDMA	200	27	161	10	161	-10	25

These tables show, generally, that large co-channel separation distances are needed between 3G systems and ITFS/MDS systems to avoid causing harmful interference to ITFS/MDS systems. For example, a 3G base station, whether a high-powered 500 watt base

[67] The minimum distance separation is rounded to the nearest kilometer. Additional data is available in Tables 4-F-4-H of Appendix 4.1.

station or a low-powered 10 watt base station, would need to be beyond the radio horizon of the ITFS/MDS station or 161 kilometers (100 miles) to avoid causing interference to co-channel ITFS/MDS receivers at either hub or response stations. Very low-powered 3G mobile stations must maintain distances between 100 kilometers (62 miles) and 161 kilometers (100 miles) to avoid causing harmful interference to co-channel ITFS/MDS hub and response stations. The results of this analysis of predicted level of interference and associated minimum separation distances are consistent with a similar study conducted by MSI.[68]

The analyses in the Interim Report relied on appropriate ITU standards for the 3G system technical characteristics.[69] As noted above, these technical characteristics have been superseded by the Industry Association Group 3G Technical Characteristics Report. A review of the updated 3G technical characteristics reveals that much of the data we relied on for calculating co-channel and adjacent channel separation distances only has minor changes or is unchanged.[70] Taking these changes into account, we believe that the conclusions of our initial analysis remain valid. In addition, we note that commenters from both the ITFS/MDS and wireless industries also concluded that sharing in the 2500-2690 MHz band was not feasible.[71]

In addition to the interference from a 3G system into an ITFS/MDS system, we considered the interference that a 3G system would receive from a co-channel ITFS/MDS system for this Final Report. In its comments to our *Advanced Wireless Services NPRM*, the WCA included such an analysis performed by MSI.[72] MSI concludes that very large separation distances are needed to protect co-channel 3G systems from receiving interference from ITFS/MDS systems. In general, MSI's analysis shows that ITFS/MDS and 3G systems must be separated by distances exceeding the radio horizon (161 km or 100 mi) to ensure that ITFS/MDS transmitters will not cause harmful interference to 3G receivers. We agree with the conclusions contained in this analysis and do not believe that further analysis is necessary at this time.

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[68] George W. Harter, MSI, "Feasibility Study on Spectrum Sharing between Fixed Terrestrial Wireless Services and proposed Third Generation Mobile Services in the 2500-2690 MHz Bands" October 2000. *See* Appendix 4.2.

[69] For example, ITU-R Recommendaiton 1457, Detailed Specifications of the Radio Interfaced of International Mobile Telecommuications-2000 (IMT-2000).

[70] For example, the value for receiver sensitivity for CDMA-2000 1x used in the Interim Report was –107 dBm and the Industry Association Group updated this value to -104 dBm total received power in a fully loaded system. The updated Report also shows that the value of this parameter is –119.6 dBm for a single 9600 bit per second (bps) traffic channel in additive white gaussian noise (AWGN) for 1% frame error rate (FER).

[71] *See e.g.,* Sprint Comments at 17-18; Verizon Comments at 19.

[72] George W. Harter, MSI, "Interference to 3G Systems from ITFS/MDS Systems Sharing the Same Frequencies." *See* Appendix 4.3.

ITFS/MDS CHANNEL LICENSING

In the Interim Report, we examined the 2500-2690 MHz band to determine if there are any vacant channels (*i.e.*, channels not currently licensed) that could be made available for 3G use. This study looked at channel availability in the 50 largest metropolitan areas in terms of population.[73] To determine whether there are any vacant channels, the FCC's database as of November 6, 2000 was used. The database contains information on licensees, their channel number and geographic coordinates of the main transmitter. Using this licensing data, the number of ITFS/MDS channels licensed within 161 kilometers (100 miles) of the city center coordinates was determined for each of the 50 cities. Appendix 5.4 of the Interim Report indicated the number of channels licensed per city. This analysis showed that in 49 of the 50 cities all 31 ITFS/MDS channels are licensed within 161 kilometers (100 miles) of the 50 cities considered.[74] We also analyzed the locations of hub and response stations and the protected service areas for each of the of 31 ITFS and MDS channels.[75]

We noted that the entire 66 megahertz of spectrum allocated to MDS is encumbered throughout the entire United States. This is because the rights to provide MDS in all areas of the country were acquired by winning auction bidders and are not subject to a site specific license and protected service area. Recognizing that not all of the BTAs have been completely built-out, we also examined the actual occupancy of a sample MDS channel to identify where licensed facilities exist. This analysis was done in order to be as complete as possible in describing the occupancy of this spectrum band for purposes of assessing the feasibility of sharing with 3G systems, *e.g.*, whether MDS licensees might be able to partition an area within their BTA to prospective 3G system operators.[76]

Our analysis showed that there are no significant differences in use and occupancy across each of the 11 MDS channels. MDS channels are generally fully deployed in each of the major metropolitan areas of the United States. As an example, figures 4.1 and 4.2 show only limited areas within some BTAs where MDS Channel E1 might be available for 3G systems use, given a 161 kilometer minimum separation between 3G and MDS systems.

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[73] The study used the center city coordinates and list of cities currently in the FCC rules for Part 90 licensees. *See* 47 C.F.R. § 90.741. We also confirmed that the list of 50 most populated cities had not changed significantly by comparing this list with 1999 data from the United States Bureau of the Census.

[74] The exception is Salt Lake City where 5 channels currently are not licensed, although applications have been tendered for 4 of the 5 channels.

[75] Our analysis reflected the 56.3 kilometer (35 mile) radius protected service area provided for in the FCC's rules, rather than a minimum distance separation zone as shown in tables 4.1 and 4.2. Maintaining the standard protected service areas set by our rules provides a very conservative estimate of the potential unencumbered geographic areas for the 2500-2690 MHz band and recognizes the potential for engineering solutions that might permit sitings closer than the separation distances calculated above.

[76] Partitioning is the assignment of a portion of a geographic service area to another entity. The partitionee becomes the licensee for the spectrum in the partitioned area.

Figure 4.1: Single MDS Channel E1

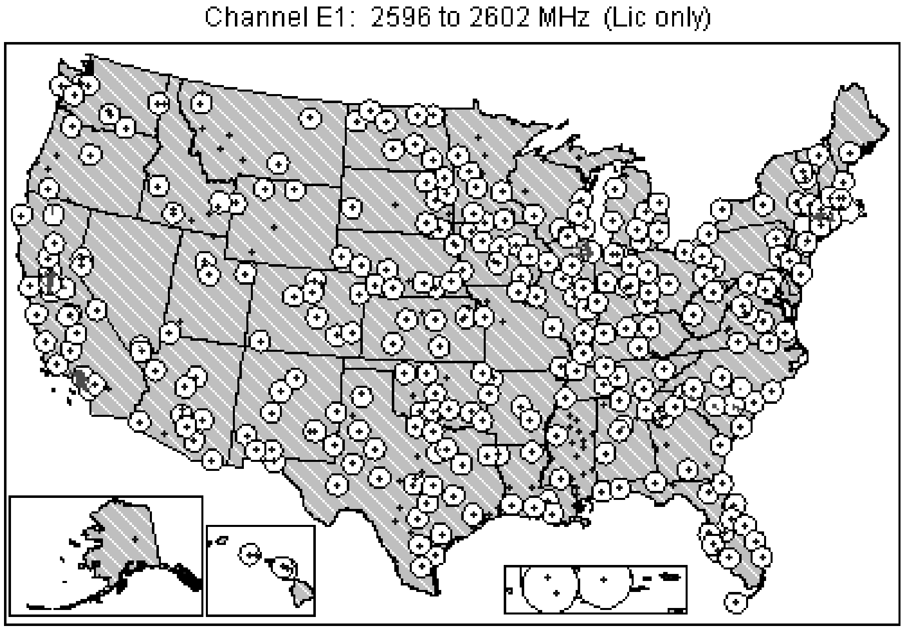
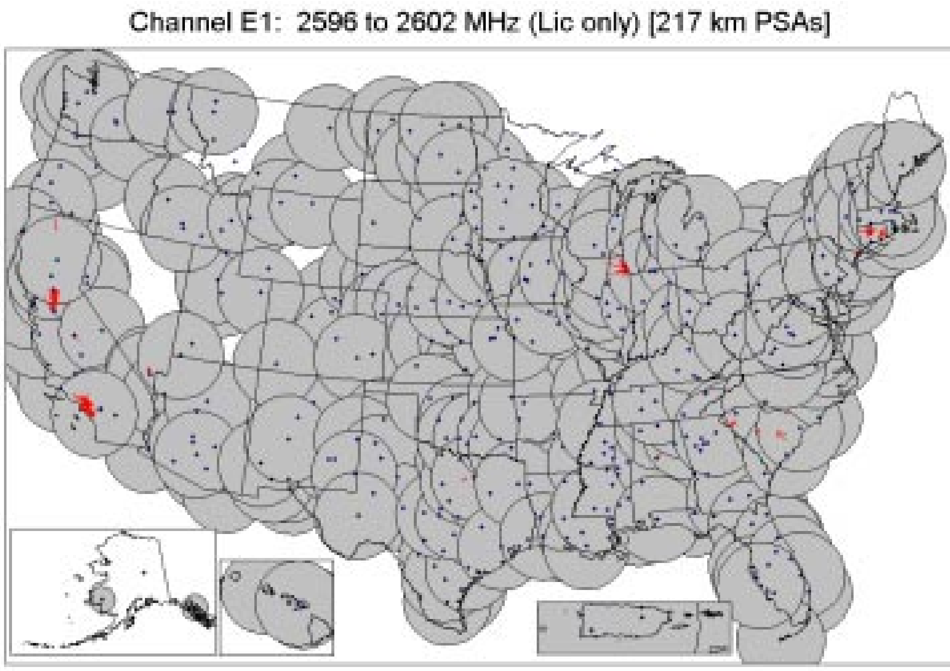


Figure 4.1 shows the 56.3 kilometer (35-mile) protected service areas of licensed MDS stations on MDS channel E1. Figure 4.2 shows the map of Channel E1 but substitutes 217 kilometer (135 mile) circles for the 56.3 kilometer (35 mile) protected service areas shown in Figure 4.1.[77] Only in the very limited white space of Figure 4.2 would it be possible to locate a 3G station on Channel E1 and maintain the 161 kilometer (100 mile) base station separation requirement.

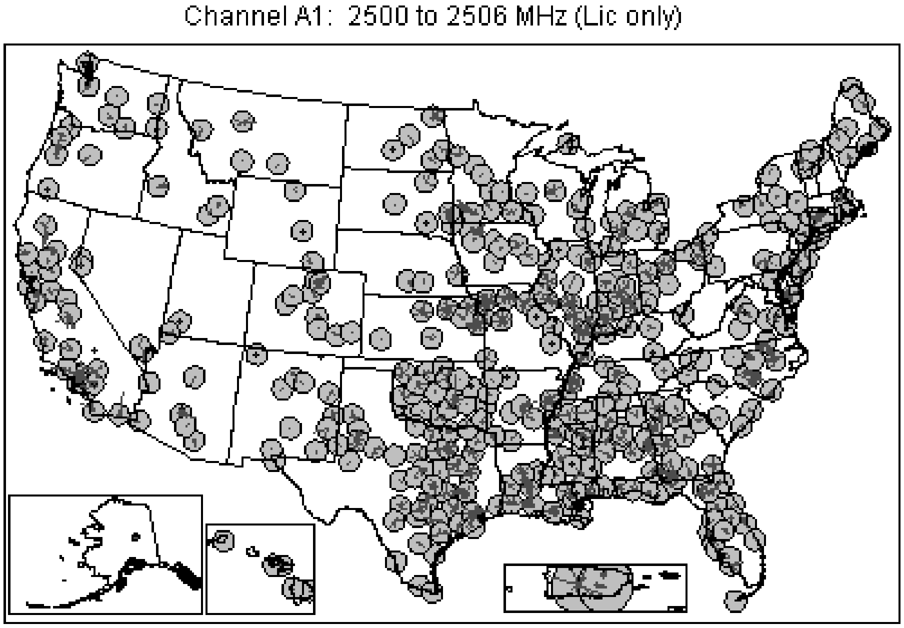
[77] The circles are drawn with radius 217 kilometers (135 miles) rather than 161 kilometers (100 miles) to ensure that receivers located at the edge of the 56.3 kilometer (35 mile) protected service area are protected.

Figure 4.2: Single MDS Channel E1 With 217 kilometer (135 mile) Protected Service Areas



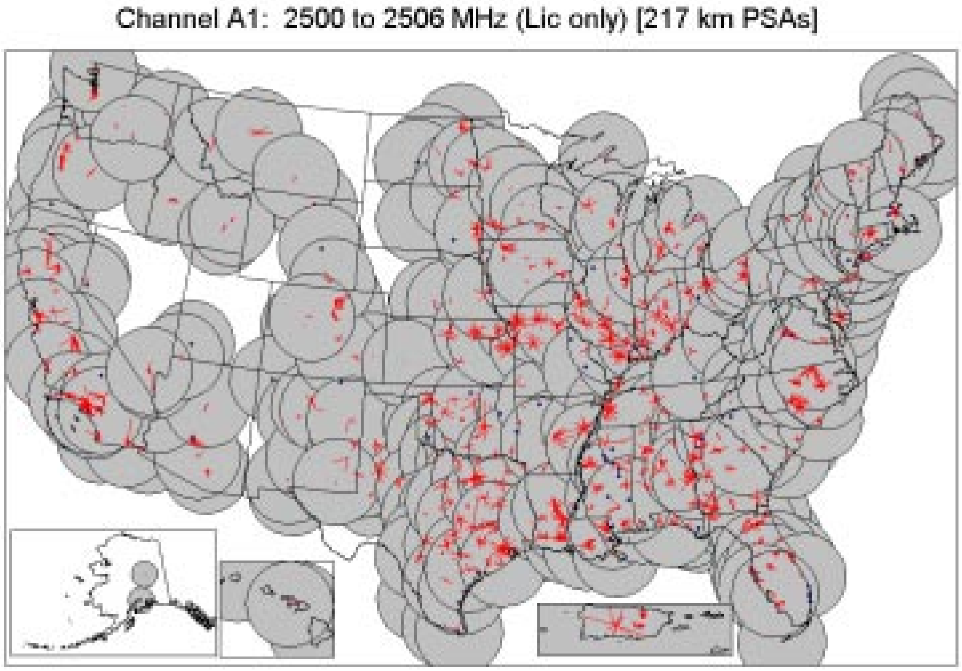
We also conducted a similar analysis of the 20 ITFS channels. Our analysis showed that at least one ITFS station operates in most areas of the United States, and that the use and occupancy of the 20 ITFS channels is not significantly different for any ITFS channel. As an example, to visualize the degree to which each ITFS channel is used, the occupancy of ITFS Channel A1 was examined. Our analysis showed that although co-channel operation of 3G systems might be possible in some areas, these areas would be significantly limited if a 161 kilometer minimum separation were to be achieved between 3G and ITFS systems. For Channel A1, this is illustrated by figures 4.3 and 4.4.

Figure 4.3: Single ITFS Channel A1



The white areas of this map reflect those areas of the country beyond the 56.3 kilometer (35 mile) protected service area of current ITFS stations. This reveals that only in the least populated areas of the country is ITFS spectrum not currently occupied. However, as noted above, co-channel sharing of 3G with ITFS/MDS may not occur within 161 kilometers (100 miles) of an ITFS/MDS receive site. Thus, the available area for locating a 3G system within the ITFS spectrum is significantly less than the white area depicted in Figure 4.3. To illustrate, this map is reproduced, but instead of depicting the 56.3 kilometer (35 mile) protected service areas, the circles are enlarged to 217 kilometers (135 miles) and show the areas of the country where a 3G system can be deployed without causing harmful interference. Only in the very limited white space of Figure 4.4 would it be possible to locate a 3G station and maintain the 161 kilometer (100 mile) base station separation requirement.

Figure 4.4: Single ITFS Channel A1 With 217 kilometer (135 mile) Protected Service Areas



Our analyses demonstrated that there is no significant difference between any of the ITFS or MDS channels and Channels A1 and E1. We determined that ITFS and MDS channels are used in the major metropolitan areas, and the areas available for possible 3G services within the 2500-2690 MHz band is significantly limited when the 161 kilometer (100 mile) minimum distance separation requirement is considered.

SUMMARY

Based on the assumptions used, we accordingly concluded in the Interim Report that sharing between 3G systems and ITFS/MDS operations is extremely problematic. We affirm this conclusion in this Final Report. Although voluntary partitioning between incumbent users and 3G operators could offer some promise of sharing as an interim measure, there does not appear to be enough spectrum in the 2500-2690 MHz band in populated areas to support a viable 3G service based on sharing of existing spectrum in this band.

SECTION 5
EVALUATION OF BAND SEGMENTATION

In the Interim Report, we described three possible band segmentation options for the 2500-2690 MHz band. We noted that band segmentation would require the relocation of ITFS/MDS systems from a portion of the band so that spectrum could be made available for 3G systems. In this Final Report, we review the analysis regarding the feasibility of dividing the 2500-2690 MHz band into segments to meet the radiocommunications requirements for 3G systems and ITFS/MDS systems. We also examine what impact the segmentation options would have on ITFS/MDS systems if we did not replace the spectrum that would be used by 3G systems, and instead require ITFS/MDS to operate only on the remaining spectrum in the 2500-2690 MHz band. In addition, because segmentation entails placing ITFS/MDS and 3G systems side-by-side at the edges of segmented spectrum, we estimate the size of the guard band that would be necessary to protect adjacent channel ITFS/MDS and 3G systems from interfering with each other.[78] In this Section, we focus our analysis primarily on the relationships between decreased spectrum availability, system deployment, and cell size; possible relocation of ITFS/MDS to alternate frequency bands is discussed in Section 6. Finally, our evaluation considered implementation of the three segmentation options in three possible time periods—2003, 2006 and 2010.

SPECTRUM REQUIREMENTS FOR 3G SYSTEMS

In the Interim Report, in order to perform an analysis of band segmentation options, we made certain assumptions about the overall amount of spectrum that may be made available for 3G systems in the 2500–2690 MHz band. We believe that these assumptions are still valid, and we review them below.

First, we assume that a substantial part of the 2500–2690 MHz band would continue to be required to support ITFS/MDS operations.

Second, a number of options are under consideration in the ITU for either developing IMT-2000 for independent operation in the 2500-2690 MHz band or to pair some portion of this spectrum with other bands. It is not clear at this time what, if any, spectrum from other bands will be suggested for pairing with the 2500-2690 MHz band for 3G systems. Therefore, for purposes of this study, we assume that 3G systems would operate independently in this band.

If 3G systems were implemented independently in the 2500–2690 MHz band, sufficient spectrum would need to be made available to support multiple licensees to promote competition. Also, the spectrum would need to be of sufficient size to enable development of systems that are economically viable and support the economies of scale necessary to warrant development of transmitters, antennas, consumer handsets, and other related equipment. For example, the

[78] A guard band ensures interference free operations between adjacent services by providing a buffer zone in which out-of-band emissions can attenuate to a point where their liklihood of producing adjacent channel interference is minimized.

Commission has allocated a total of 120 megahertz of spectrum for Personal Communications Service (PCS) in the 1.9 GHz band, which provided for three licenses of 30 megahertz and three licenses of 10 megahertz in each geographic area. Also, a number of European countries have recently made spectrum available for 3G services in excess of 100 megahertz.

Spectrum also must be made available in contiguous blocks of some minimal size, both to facilitate reasonable system design and to allow licensees to choose from all available technologies. For example, wideband CDMA technology requires a minimal spectrum block size of about 5 megahertz - paired, duplex operation would require two blocks of 5 megahertz.

In light of these factors, to assess the viability of various segmentation options in this study, we assume that 90 megahertz of spectrum in the 2500-2690 MHz band would be made available for 3G systems. This would continue to leave more than half of the current spectrum available for ITFS/MDS. It would also provide sufficient spectrum for multiple 3G licenses. For example, an allocation of 90 megahertz could provide for three 3G licenses of 30 megahertz each, or three 3G licenses of 20 megahertz each and three 3G licenses of 10 megahertz each.

In comments filed in response to the *Advanced Wireless Services NPRM*, Verizon argues that only six megahertz of spectrum is needed to support an ITFS station's instructional purposes and that both 3G systems and ITFS can be accommodated through segmentation of the band.[79] Verizon states that 30 megahertz appears to be sufficient to ensure the economic viability of one 3G system, and that at least two operators should be licensed to facilitate the economies of scale necessary to warrant the development of 3G equipment. Accordingly, Verizon recommends that at least 60 megahertz of spectrum be made available for 3G systems in the 2500-2690 MHz band.[80] VoiceStream, on the other hand, supports making at least 120 megahertz of spectrum available in the band for 3G systems, using two 60 megahertz blocks, in order to ensure that adequate spectrum is available for 3G systems over the next 5-10 years.[81]

For purposes of this study, we continue to assume that 90 megahertz of spectrum may be needed in this band to support the introduction of 3G systems. With respect to the comments of Verizon and VoiceStream, we do not believe that there would be a significant difference in the analysis of band segmentation options if 60 or 120 megahertz was made available for 3G systems. We note however, that the assumption of 90 megahertz has been chosen solely to illustrate possible band segmentation scenarios. It should not in any way be considered indicative of any position that the Commission may ultimately take on how much spectrum or which frequency band(s) should be used for the provision of 3G services.

Other factors are also relevant in analyzing various segmentation options. For example, the choice of frequency division duplex (FDD) or time division duplex (TDD) radio interfaces affects the segmentation options studied. Similarly, the architecture of planned new two-way

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[79] *See* Verizon Comments at 23.

[80] *Id.* at 25.

[81] *See* VoiceStream Reply Comments at 4.

ITFS/MDS systems must be taken into account. As described in Section 3, most planned implementations use FDD technology and require a separation of at least 30 megahertz between upstream (customer to base) and downstream (base to customer) transmissions. For FDD operation, this separation is necessary to provide sufficient isolation of upstream and downstream signals in the duplexer.[82] TDD systems also must be accommodated. These systems, which tend to be less robust than FDD systems, generally require a guard band between their band of operation and adjacent bands to minimize the potential of harmful interference.[83]

Finally, a variety of other technical factors may also be relevant to determining spectrum requirements for future 3G systems. These include constraints on the separation between paired frequency blocks for frequency duplex technologies, compatibility with existing channeling plans for incumbent systems, adjacent channel interference, and backward compatibility with existing 1G and 2G systems. The traffic loading requirements for 3G data services, where downstream traffic is much greater than upstream traffic, may lead to asymmetric pairing of spectrum bands. These factors were not considered in the Interim Report, nor are they considered in this Final Report because no new information has become available.

TWO-WAY ITFS/MDS SYSTEMS: BAND PLANS

As discussed in Section 3, ITFS and MDS licensees are now beginning to deploy two-way systems in the 2500-2690 MHz band. System configuration in any given geographic area is subject to certain limitations arising from current spectrum use in that area. As noted, geographic MDS licenses have been awarded through the competitive bidding process. These licensees, in implementing their systems, must protect incumbent MDS systems licensed on a site-specific basis for 56.3 kilometers (35 miles) around each transmitter. With respect to ITFS channels, not all are licensed in all areas. However, where they are licensed, the MDS licensee may lease excess capacity on the ITFS channels, and MDS and ITFS licensees can broker channel swaps with each other. Additionally, geographic MDS licensees have limited ability to gain access to ITFS channels that are not licensed at this time. Because of the regulatory flexibility that the Commission has allowed in this band and the licensing differences between each geographic area, conclusions cannot be made regarding the configuration of a typical ITFS/MDS system.

To accommodate this flexibility, the MDS industry has initiated a number of band plans to accommodate new service offerings, such as two-way service, as well as to accommodate existing ITFS and MDS users. The figure in Appendix 3.1 shows a pictorial representation of the various band plans that MDS licensees are contemplating. The sample plans presented in this figure are for study purposes only and do not reflect other options that could be deployed by ITFS/MDS licensees in the future. As seen in this figure, WorldCom has indicated that it is implementing three types of two-way deployment. WorldCom-1 depicts a scheme where two-way ITFS/MDS is overlaid in a market that has heavy ITFS video use. WorldCom-2 depicts

[82] A duplexer is a device that permits simultaneous transmission and reception with a common antenna.

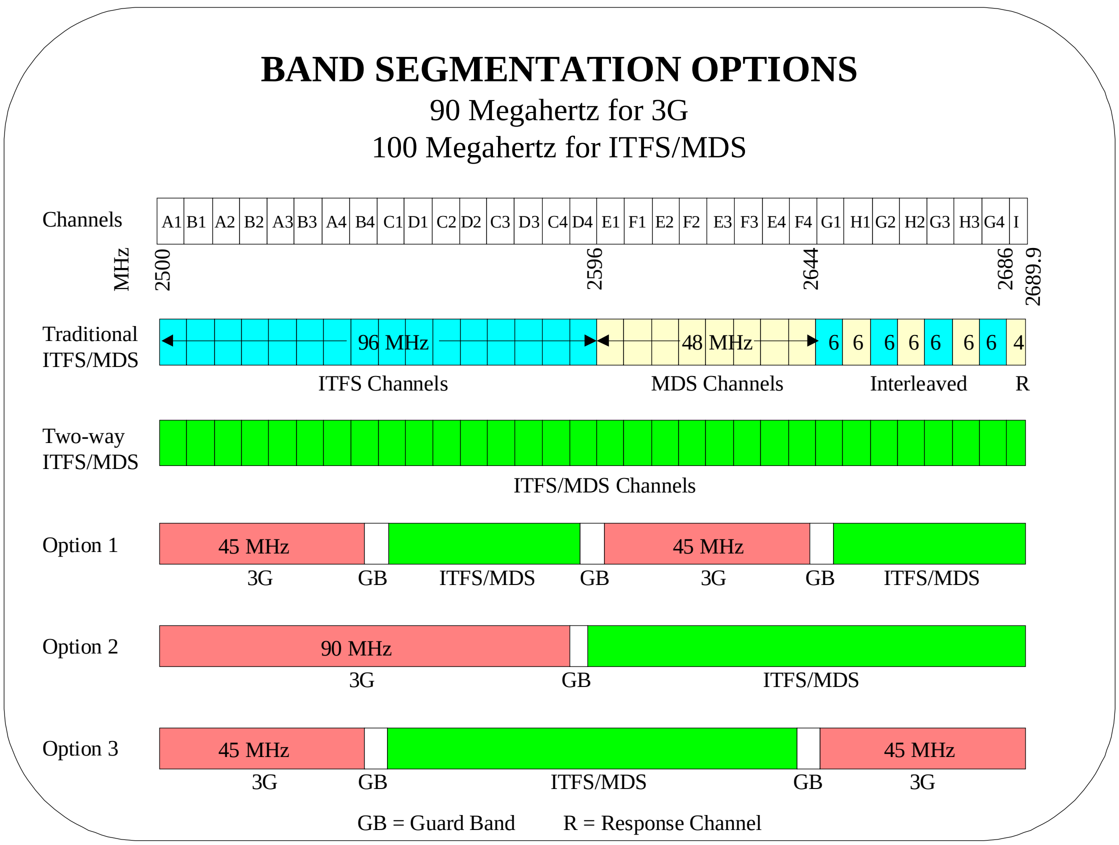
[83] An estimate of the amount of spectrum needed for a guard band is presented later in this Section.

a band plan that provides a single main transmitter and cellular configurations where video would be accommodated either on the two-way system or a limited number of ITFS channels.[84] WorldCom-3 depicts a deployment that has to accommodate various individual licenses. Sprint and Nucentrix both indicate two generic plans each that depict asymmetric systems by grouping the upstream transmissions on either the upper or the lower channels. And as noted above, all plans depict a 30 megahertz separation between the upstream and downstream data transmissions.

BAND SEGMENTATION OPTIONS

The Interim Report presented three band segmentation options. These are depicted in Figure 5.1 below. The Interim Report's analysis of the impact that these options would have on ITFS/MDS and 3G systems, which is summarized below, considered the functional and operational factors described in the previous sections.

Figure 5.1: Band Segmentation Options



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[84] An architecture which uses a single main transmitter, sometimes referred to as a super-cell, uses a single base station to provide service over the entire service area. It is usually characterized by a tall tower and relatively high power. A cellular configuration, sometimes referred to as a mini-cell system, uses many cells to serve a geographic area. They will often use low towers and low power.

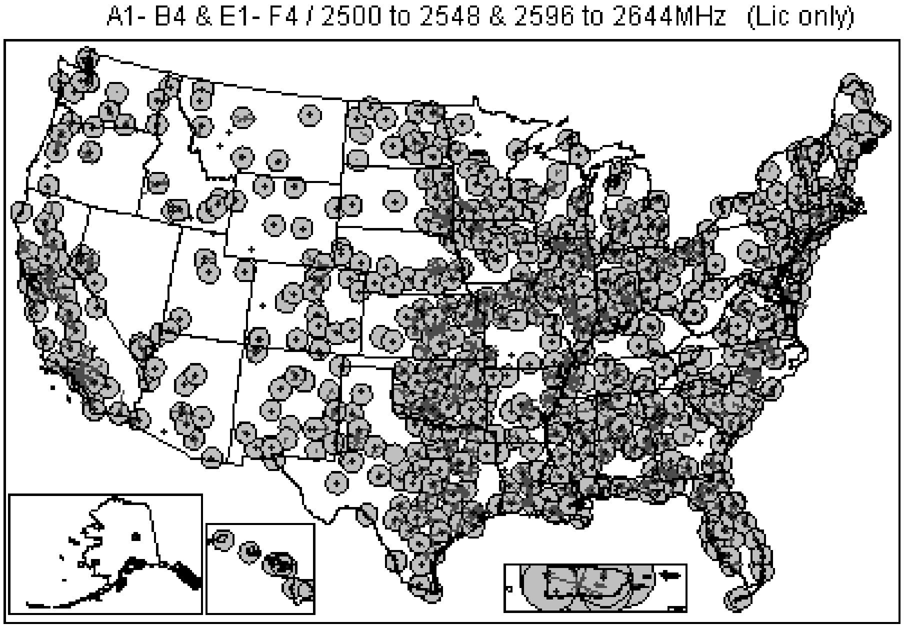
Option 1 provides two 45 megahertz frequency blocks for 3G services and leaves the remaining 100 megahertz for ITFS/MDS in two 50 megahertz segments. A benefit of this option is that it provides frequency separation between paired channel blocks for both 3G and ITFS/MDS operations for FDD technology. Just as important, the ability to implement TDD systems is not precluded by this segmentation plan. An operator may implement TDD technology on any spectrum block for which it is licensed. To accommodate the differences between ITFS/MDS and 3G systems, guard bands between the segments have been included.

Further analysis of this option includes an examination of which current ITFS/MDS channels would be impacted. As can be seen from Figure 5.1, the placement of the 3G channels in this option coincide with the lower portion of the ITFS band (channels A1 through B4) and the MDS band (channels E1 through F4). This is problematic because, as described earlier, all of the MDS channels have been licensed on a geographic basis through the competitive bidding process and these geographic licensees have legal rights to build systems anywhere within their BTA that is not encumbered.

Alternatively, a similar segmentation plan with the 3G segments in the center and upper portion of the band (channels C1 through D4, channels G1 through G4, and channel I) may be considered. Under this scenario, 3G channels coincide with fewer MDS channels that have been sold at auction (the interleaved channels H1, H2, and H3) than the option depicted in Figure 6.1. This option, however, would cede the response channel (channel I) to 3G systems. This channel, is used for interactive systems, such as distance learning, to provide an audio channel so that persons at remote locations can converse with persons located in the studio. The response channel is currently able to be accessed by any licensee in the ITFS/MDS band.

Finally, the examination must assess the number of licensees that may be affected under segmentation Option 1. As can be seen in the following map, there are numerous systems deployed all over the United States that would have to be accommodated.

Figure 5.2: ITFS/MDS Stations Affected by Segmentation Option 1.



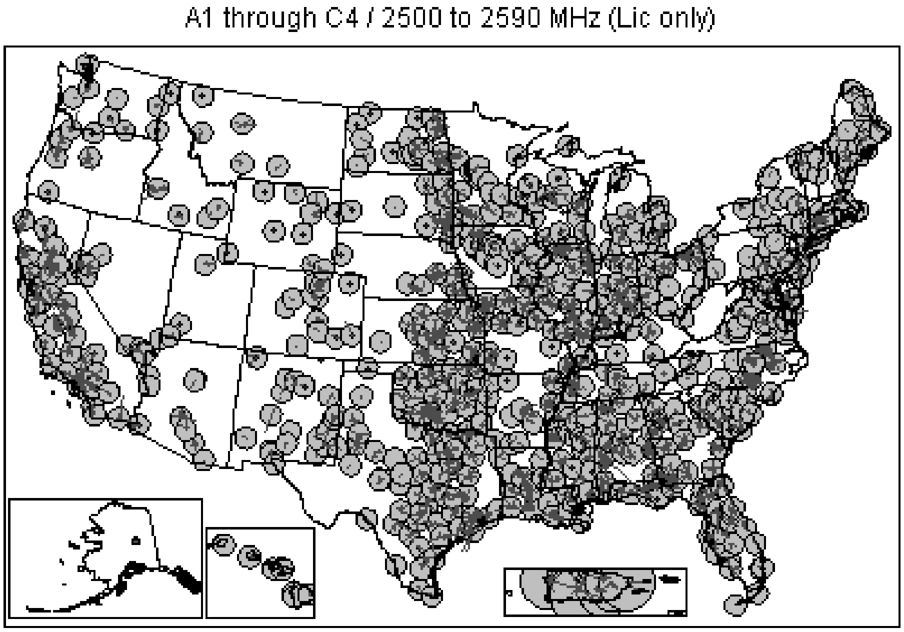
Option 2 provides a segmentation option in which both the 3G and ITFS/MDS spectrum is combined in a contiguous block. As seen in Figure 5.1, 90 megahertz of 3G spectrum is provided at the lower end of the band. The ITFS/MDS spectrum, including a single guard band, is located at the upper end of the band. Under this option, the 3G portion of the band could be divided into six 15 megahertz blocks. These could be paired to provide three 3G licensees with 30 megahertz of spectrum with 30 megahertz separation between blocks for FDD technology (*i.e.*, Block A, Block B, Block C, Block A, Block B, Block C – each block contains 15 megahertz of spectrum). This option also lends itself nicely to TDD technology for both 3G and ITFS/MDS systems. This option provides flexibility for any individual operator to implement the technology of its choice.[85]

Under this option, the spectrum denoted for 3G systems would impact only ITFS channels (channels A1 through C4) and the channels that were auctioned to MDS would remain with that service. Because of this, the option as depicted provides a better choice than reversing the segments (*i.e.*, placing the 3G segment at the upper portion of the band and the ITFS/MDS segment in the lower portion of the band) where the 3G segments would encompass all the MDS channels and the response channel (channel I).

Finally, as with the option presented above, the map shown below depicts the numerous stations that are currently licensed on the channels segmented to 3G systems.

[85] We note that the Interim Report incorrectly concluded that the 3G spectrum under this option could not be paired for FDD operation.

Figure 5.3: ITFS/MDS Stations Affected by Segmentation Option 2.



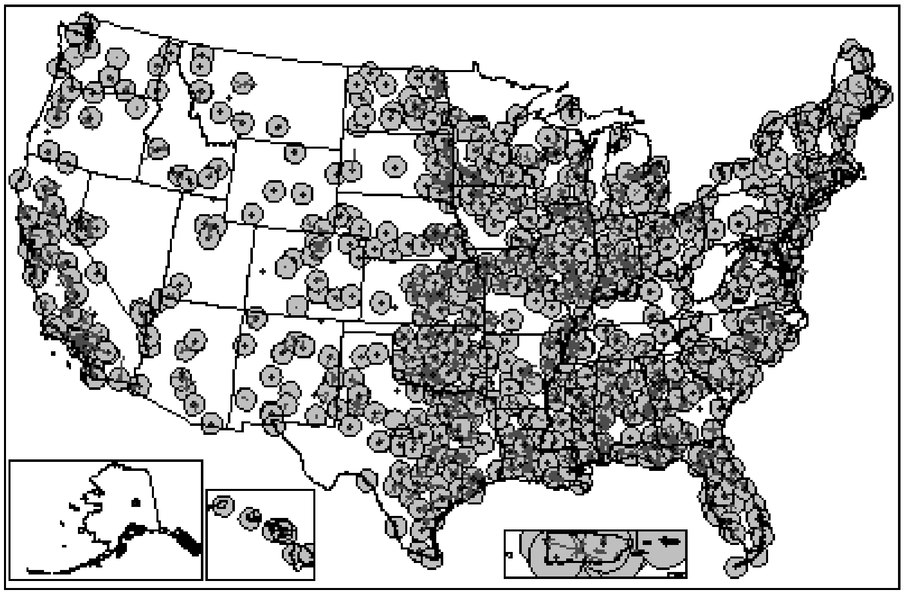
Option 3 provides a combination of options 1 and 2. Under this option, two 45 megahertz frequency blocks would be provided for 3G systems at the extreme upper and lower ends of the band. The ITFS/MDS spectrum is provided between these two 3G spectrum blocks. The frequency separation provided for 3G systems preserves the ability of system operators to implement FDD technology and the ITFS/MDS spectrum can be paired in a similar fashion as the 3G spectrum in Option 2 to accommodate FDD technology.[86]

Under this option, the channels segmented for 3G systems would encompass ITFS channels A1 through B4, and all the ITFS/MDS interleaved channels G1 through G4 plus the response channel (channel I). As described above for Option 1, this is problematic in that auctioned MDS spectrum would need to be retrieved to provide spectrum for 3G operators.

Finally, as with Options 1 and 2, there are numerous ITFS and MDS assignments that would need to be accommodated to implement this segmentation option. This is shown on the map in Figure 5.4.

[86] *Id*.

Figure 5.4: ITFS/MDS Stations Affected by Segmentation Option 3.



IMPACT OF BAND SEGMENTATION ON DEPLOYMENT OF ITFS/MDS SYSTEMS

The flexible use of the 2500-2690 MHz band makes it extremely difficult to assess the actual impact that each segmentation option would have on deployed systems. Such an analysis would entail an examination of the complex interaction of stations in any given geographic area, including the way station operation is influenced by lease arrangements and channel swaps. In light of this situation, we make some assessments below regarding the impact that station relocation within band or more efficient spectrum usage would have on ITFS/MDS operations. Our analysis does not address legal or policy issues concerning leasing arrangements or the acquisition of licenses through competitive bidding or transfer of control, which are beyond the scope of this study.

To obtain a more quantitative evaluation of the effect segmentation would have on licensees, we examined the number of transmitters that would be affected by each option. In the Interim Report we stated that, based on the licensing database, over 60,000 transmitters would need to be accommodated in any 90 megahertz segment of spectrum in the 2500-2690 MHz band that is reallocated to 3G.[87] Because the licensing database has not substantially changed since then, we believe that this conclusion is still valid. The majority of the stations represented in the database are mainly incumbent one-way systems. As geographic MDS licensees begin deploying two-way service, the number of stations will increase considerably because each subscriber's location becomes an additional transmit site for upstream traffic. Thus, for every

[87] The database showed that on average over 4,000 transmitters are licensed nationwide on any given 6 megahertz ITFS/MDS channel. Since 15 channels equates to 90 megahertz of spectrum, over 60,000 (15 channels * 4, 000 transmitters per channel) transmitters would be affected.

transmitter that a geographic MDS licensee currently has licensed, there is the potential for many times that number to ultimately exist.[88] Additionally, educational institutions could continue to license ITFS stations where spectrum is available. Therefore, over 60,000 transmitters would need to be relocated regardless of which segmentation option is considered.

If 90 megahertz of spectrum is reallocated from the 2500-2690 MHz band to 3G systems, the ITFS/MDS would have to provide their services using only 100 megahertz, rather than the 190 megahertz, of spectrum in the band. Such a scenario would require some ITFS/MDS operations to move from the reallocated spectrum to the remaining spectrum. One way to accommodate the influx of stations in the remaining spectrum would be for ITFS/MDS stations to transmit with narrower bandwidths or to reduce power. Thus, options for increasing the spectrum efficiency of ITFS/MDS operations must be explored.

First, we can consider the effect segmentation would have on traditional one-way ITFS/MDS licensees that provide one-way video transmission services. Generally, these systems transmit using standard 6 megahertz composite NTSC video/audio modulation. In addition, the ITFS licensees may use a 125 kHz response station transmitter located at any or all of the receive sites to enable students or faculty at the receive site to communicate with others at the main station site. These response channels typically operate using wideband FM modulation. In recent years, some incumbent MDS systems have converted to digital systems.

If the band was segmented, these stations would presumably convert to digital modulation in order to operate more efficiently. Based on the broadcasting services experience, we know that, when upgrading from analog to digital TV and employing MPEG-2 video compression,[89] efficiencies in the range of 4:1 (*i.e.*, 4 distinct programs can be transmitted over one 6 megahertz channel)[90] up to about 8:1 can be achieved depending on the content and desired picture quality.[91] Under these digital modulation schemes, though, the transmitted signal still occupies a 6 megahertz channel; transmitters broadcasting a single program do not reduce their bandwidth to transmit over 1 or 2 megahertz. Therefore, to accommodate the continued operations of all incumbent ITFS and MDS licensees in any given area, at least 6 megahertz of spectrum per each incumbent user must be dedicated for such use in each area. If any of these

[88] The limit on the number of customers that a two-way MDS system can accommodate cannot readily be estimated. It depends on the amount of spectrum available, the level of service each individual customer contracts for as well as the usage patterns in any specific area.

[89] MPEG is the Motion Picture Experts Group, which has been working to produce standards for digital compression of video signals.

[90] *See, e.g., Advanced Television Systems And Their Impact Upon The Existing Television Broadcast Service,* MM Dockt No. 87-268, *Fourth Report and Order,* 11 FCC Rcd. 17,771 (1996) at ¶ 5.

[91] In general, the compression ratios for program material such as sports for which high quality is desired and which has lots of action and constantly changing video content is much less than what can be achieved for a talk show, where the background does not change much and picture quality is not as important.

licensees typically broadcast more than 6-8 programs simultaneously, additional channels must be set aside. Therefore, in order to maintain the 70 megahertz of spectrum MDS is currently allotted under the existing band plan, there could be no more than 5 incumbent one-way ITFS and MDS licensees in any given area. This could be problematic in many metropolitan areas. For example, in New York City, 6 incumbent ITFS licensees hold 9 licenses, and 4 incumbent MDS licensees hold 5 licenses. Further, many of these licenses are for multiple channels. In contrast, in Buffalo, NY, there are no incumbent ITFS licensees and only 1 incumbent MDS licensee, holding 2 licenses. Analysis of the 50 largest metropolitan areas in terms of population shows that the average and median number of licenses in each area is 8 and the average number of different licensees holding these licenses is 5. Appendix 5.1 shows the number of incumbent ITFS and MDS licensees in metropolitan area.[92]

Licensees may already be using digital modulation techniques to provide data services at high data rates. For example, Nucentrix points out that they and other operators deliver data using efficient OFDM and high-order QAM modulations,[93] and Cisco notes that major MDS licensees are conducting trials using their VOFDM technology.[94] Operators that are already using digital modulation, including both one-way and two-way systems, may not be able to compress their signals to narrower bandwidths and still provide the same grade of service. These operators would have to decrease the size of the service area of each tower in order to continue offering high speed data services with reduced spectrum. This is explored below.

The ITFS/MDS operators argue that to offer acceptable two-way service they need to have access to most of the 190 megahertz of spectrum now allocated for ITFS/MDS in the 2500-2690 MHz band. In commenting on the *Advanced Wireless Services NPRM*, WorldCom states that certain channels are not available in many markets due to co-channel ITFS/MDS operations in adjacent markets, that up to 42 megahertz of separation is needed between upstream and downstream traffic, and that guard bands are needed between high power video downstream and low power data downstream channels to avoid station downconverter overload.[95] Worldcom further states the these constraints result in an average availability of 158 megahertz (including the 10-12 megahertz allocated in the 2150-2160/62 MHz band) of

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[92] *See* Footnote 73, *supra*.

[93] *See* Nucentrix Comments at 11.

[94] *See* Cisco Comments at 5. *See* also, Footnote 30, *supra*.

[95] *See* Worldcom Comments at 17-18. Station downconverter overload was explained in the Interim Report. ITFS receive stations are vulnerable to interference from digital MDS response stations. Such interference, intermittent and noise-like in nature, could occur if a transmit site is located nearby an ITFS receive site regardless of the frequency separation between the stations. This situation was addressed in the *Two-Way Order* and certain coordination requirements were placed on MDS licensees to minimize this possibility. *See Two-way Order* at 45-47 and 56. The effect of this situation on 3G systems is that under the contemplated segmentation options, even if there is frequency separation between 3G and ITFS stations, this type of interference could occur from the 3G system to the ITFS system and render it unusable.

spectrum in most markets for use by two-way systems.[96] Similarly, the HAI Study determined that a reasonable estimate of the amount of spectrum to which two-way systems have access is 158 megahertz (26 channels of 6 megahertz each plus an additional 2 megahertz).[97] Finally, Cisco points out that to serve the San Jose-Silicon Valley market, a micro-cell network (3 sectors per cell, 3 cells per cluster) is needed in which each cluster requires 9 sets of frequencies to provide 10.5 megahertz downstream and 7.5 megahertz upstream shared among all customers for a total of 162 megahertz.[98]

Guard Bands

Each of the segmentation options would provide significantly less spectrum for two-way ITFS/MDS systems than is currently available. If 90 megahertz of spectrum was made available for 3G systems, the remaining 100 megahertz of spectrum would have to support incumbent ITFS/MDS systems, geographic area MDS systems, and guard bands. Therefore, the usable spectrum for ITFS/MDS systems would be further reduced from 100 megahertz based on the size of the guard band needed to protect adjacent channel operations. Below, we present an analysis estimating the size of the guard band necessary to ensure interference free operation between ITFS/MDS and 3G systems.

Just as with the analysis to determine distance separations in Section 4, the technical characteristics for this analysis include the five ITU IMT-2000 radio interface standards[99] and the rules for ITFS/MDS interference protection.[100] The analysis calculates the required mileage separation between ITFS/MDS base stations and 3G base stations for various guard band sizes. Calculations of separation distance are made for ITFS/MDS interfering with 3G systems and for 3G systems interfering with ITFS/MDS systems. The analysis looked at interference caused by energy contained in the adjacent channel, and for completeness also looked at energy from the adjacent channel that overlapped the desired channel (spillover).

For the analysis of ITFS/MDS interference to 3G systems, we assume worst case operating parameters. For example, we assume that the main transmitter is operating with a sectored antenna at maximum power. For this type of operation, the rules allow up to 39 dBW (7943 watts) EIRP.[101] A complete list of planning factors used in the analysis is provided in

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[96] *See* Worldcom Comments at 18.

[97] *See* WCA Comments at Appendix B, page 5. Sprint concurs that this is an accurate estimate. *See* Sprint Comments at 22.

[98] *See* Cisco Comments at 7.

[99] *See* Appendix 2.1 for IMT-2000 technical characteristics.

[100] *See* 47 C.F.R. §§ 21.902, 21.909, 21.913, 74.903, 74.939, and 74.985.

[101] *See* 47 C.F.R. §§ 21.904(b) and 74.935(b). Additionally, for completeness, we assume 125 kilohertz bandwidth for the hub receiver bandwidth because many stations continue to use these channels for voice channels on the path. Analysis of these stations using the maximum 6 megahertz allowed under the rules

Appendix 5.2. Also, as with the analysis in Section 4, computed values that exceed the distance to the radio horizon are reduced to the distance to the radio horizon or 161 kilometers (100 miles).

Table 5.1 shows the relationship between guard band size and the distance separation needed between 3G base stations and ITFS/MDS hub and response stations to avoid harmful interference due to the energy present in the adjacent channel.[102] The table shows that for a guard band of 2 megahertz, the distance separation necessary between ITFS/MDS and 3G systems is reduced to almost zero. In fact, from our planning factors in Appendix 5.1, it is easily deduced that each additional megahertz added to the guard band reduces the required separation by a factor of 100.[103] Therefore, for this situation, we conclude that a guard band of at least 2 megahertz seems reasonable to ensure protection of ITFS/MDS stations from 3G base stations.

Table 5.1: Calculation of Separation Distances, 3G Base Station to ITFS/MDS

Guard Band Analysis Based on Interference Power in Adjacent or Nearby Channels

3G System Parameters			ITFS/MDS System Parameters			Required Separation (km)			
Modulation Type	EIRP (dBW)	Bandwidth (kHz)	Protected Receiver	Bandwidth (kHz)	Desired Signal Power Density (dBW/m^2)	Adjacent Channels (No Guard Band)	Guard Band Width (MHz) 0.5	1	2
CDMA	27	1250	Hub	125	-90	161	16	1.6	0.02
CDMA	27	3750		125	-90	161	16	1.6	0.02
W-CDMA	27	5000		125	-90	161	16	1.6	0.02
TDMA	27	30		125	-90	100	10	1.0	0.02
TDMA	27	200		125	-90	161	16	1.6	0.02
CDMA	27	1250	Response Station	6000	-67	6.4	0.6	0.06	0.00
CDMA	27	3750		6000	-67	11.3	1.1	0.11	0.00
W-CDMA	27	5000		6000	-67	12.9	1.3	0.13	0.00
TDMA	27	30		6000	-67	1.6	0.2	0.02	0.00
TDMA	27	200		6000	-67	3.2	0.3	0.03	0.00

(to accommodate two-way systems) would produce results similar to the results shown for the 6 megahertz response stations.

102 A more detailed table is provided in Table 5-A in Appendix 5.3.

103 In the planning factors tables, we assume, that the interference immunity attainable by greater frequency separation is 40 dB per megahertz (based on FCC Laboratory measurements of television receivers). Because received power is proportional to $\frac{1}{\text{distance}^2}$, each megahertz reduces the distance by 20 dB or a factor of 100.

Table 5.2 also shows that only 2 megahertz of guard band is need to account for the 3G system energy that overlaps the ITFS/MDS channel.[104] Therefore, the energy in the adjacent channel is the limiting factor in this case. We conclude that to protect ITFS/MDS stations from harmful interference from adjacent channel 3G systems, a guard band of at least 2 megahertz is needed.

Table 5.2: Calculation of Separation Distances, 3G Base Station to ITFS/MDS

Guard Band Analysis Based on Co-Channel Interference Power (Spill-over)[105]

3G System Parameters			ITFS/MDS System Parameters			Required Separation (km)			
Modulation Type	Off-Channel EIRP (dBW per 100 kHz)	Bandwidth (kHz)	Protected Receiver	Bandwidth (kHz)	Noise Floor (NF), or Desired Signal (DS) Level (dBW)	Adjacent Channels (No Guard Band)	Guard Band Width (MHz) 0.5	1	2
CDMA	-16	1250	Hub	125	-118 (NF)	26	2.6	0.26	0.00
CDMA	-16	3750		125	-118 (NF)	26	2.6	0.26	0.00
W-CDMA	-16	5000		125	-118 (NF)	26	2.6	0.26	0.00
TDMA	-16	30		125	-118 (NF)	26	2.6	0.26	0.00
TDMA	-16	200		125	-118 (NF)	26	2.6	0.26	0.00
CDMA	-16	1250	Response Station	6000	-83 (DS)	161	16	1.6	0.02
CDMA	-16	3750		6000	-83 (DS)	161	16	1.6	0.02
W-CDMA	-16	5000		6000	-83 (DS)	161	16	1.6	0.02
TDMA	-16	30		6000	-83 (DS)	161	16	1.6	0.02
TDMA	-16	200		6000	-83 (DS)	161	16	1.6	0.02

Tables 5.3 and 5.4 show that the interference to 3G systems from ITFS/MDS main and response stations is slightly worse than the interference 3G systems impact on ITFS/MDS.[106] Table 5.3 indicates that an ITFS/MDS main transmitter would need to be 57 kilometers away from a UWC-136 (TDMA) base station to avoid interference if the guard band is 2 megahertz. Since, as explained above, each megahertz decreases this distance by a factor of 100, an additional 2 megahertz will reduce the distance to 0.01 kilometers. Therefore, we conclude that a guard band of up to a 4 megahertz is needed to ensure interference free operation.

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[104] A more detailed table is provided in Table 5-B in Appendix 5.3.

[105] Interference due to the energy from the signal centered in the adjacent channel that is actually transmitted in the desired channel. This is also referred to as front end overload.

[106] More detailed tables are provide in Tables 5-C and 5-D in Appendix 5.3.

Table 5.3: Calculation of Separation Distances, ITFS/MDS to 3G Base Station

Guard Band Analysis Based on Interference Power in Adjacent or Nearby Channels

ITFS/MDS System Parameters			3G System Parameters			Required Separation (km)			
Type of Transmitter	Bandwidth (kHz)	EIRP (dBW)	Modulation Type	Bandwidth (kHz)	Noise in Receive Bandwidth (dBW)	Adjacent Channels (No Guard Band)	Guard Band Width (MHz)		
							0.5	1	2
Main	6000	39	CDMA	1250	-138	161	161	161	4.7
	6000	39	CDMA	3750	-133	161	161	161	2.7
	6000	39	W-CDMA	5000	-132	161	161	161	2.4
	6000	39	TDMA	30	-154	161	161	161	57.1
	6000	39	TDMA	200	-146	161	161	161	20.3
Response Station	125	22	CDMA	1250	-138	161	161	161	2.3
	125	22	CDMA	3750	-133	161	161	161	2.1
	125	22	W-CDMA	5000	-132	161	161	161	2.1
	125	22	TDMA	30	-154	161	161	161	4.0
	125	22	TDMA	200	-146	161	161	161	3.5

Table 5.4: Calculation of Separation Distances, ITFS/MDS to 3G Base Station

Guard Band Analysis Based on Co-Channel Interference Power (Spill-over)

ITFS/MDS System Parameters			3G System Parameters			Required Separation (km)			
Type of Transmitter	Bandwidth (kHz)	EIRP (dBW)	Modulation Type	Bandwidth (kHz)	Noise in Receive Bandwidth (dBW)	Adjacent Channels (No Guard Band)	Guard Band Width (MHz)		
							0.5	1	2
Main	6000	39	CDMA	1250	-138	161	153	75.6	0.1
	6000	39	CDMA	3750	-133	161	101	51.5	0.1
	6000	39	W-CDMA	5000	-132	161	42	20.9	0.05
	6000	39	TDMA	30	-154	161	161	161	0.4
	6000	39	TDMA	200	-146	161	161	161	0.3
Response Station	125	22	CDMA	1250	-138	161	61	30.6	0.06
	125	22	CDMA	3750	-133	161	37	17.7	0.03
	125	22	W-CDMA	5000	-132	90	10	4.8	0.02
	125	22	TDMA	30	-154	161	161	119.1	0.24
	125	22	TDMA	200	-146	161	16	66.0	0.13

From the Tables, the relationship between distance separation and guard band size is apparent. When planning a system, these two parameters can be adjusted to provide the necessary level interference protection. However, as a practical matter, in Section 4, we showed that the 2500-2690 MHz spectrum is so heavily encumbered and the distance separations necessary for sharing are so large, that the only alternative for deploying 3G systems in this band is to clear spectrum and provide an adequate guard band between 3G and ITFS/MDS segments. In this case, we believe that to accommodate each of the ITU IMT-2000 air interface standards, a guard band of up to 4 megahertz may be needed to protect 3G and ITFS/MDS systems from interfering with each other. However, a more modest 2 megahertz guard band could be sufficient to protect most 3G systems.

In its comments to the *Advanced Wireless Systems NPRM*, Verizon asserts that unacceptable interference would occur regardless of the size of the guard band.[107] Their analysis is based on the Commission's emission limits for ITFS/MDS transmitters and assumes maximum out-of-band emissions. Further, Cisco Systems (Cisco), states that its preliminary analysis indicated that its existing equipment could theoretically operate with 18 megahertz guard bands separating fixed broadband and 3G services.[108] Cisco notes that the design of its current equipment is based on tradeoffs it made under the assumption that no mobile services would be permitted in the 2500-2690 MHz band. They acknowledge that a narrower guard band could be accommodated through reengineering of its equipment's channel filtering capabilities and implementing new duplexers.[109] Worldcom, in its comments also claims that a guard band of 12-18 megahertz may be needed to protect against inter-service interference from neighboring allocations.[110]

Upon reviewing Verizon's analysis, we believe that their claim of unacceptable interference regardless of guard band size is greatly exaggerated. They assume that out-of-band emissions adhere exactly to the ITFS/MDS emission mask and continue at 60 dB below the average 6 megahertz channel power level beyond 3 megahertz from the channel edge.[111] However, this analysis does not take into account the behavior of the transmitted energy under real world conditions where the energy will continue to attenuate below the 60 dB level at distances greater than 3 megahertz beyond the band edge. While we acknowledge that with existing equipment, a guard band may be necessary, we believe that this situation could be necessary only for the short-term. Even Cisco admits that a smaller guard band than the 18 megahertz is achievable, but that it would require some equipment redesign. We realize that

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[107] *See* Verizon Comments at 14 and Appendix A.

[108] *See* Cisco Comments at 9-10.

[109] *Id*.

[110] *See* Worldcom Comments at 18.

[111] *See* Verizon Comments at Appendix A. *See also,* 47 C.F.R. § 21.908(d) for a description of the emission limitaitons.

such an endeavor could take as much as a year or more to complete.[112] However, because mobile systems do not currently operate in the 2500-2690 MHz band, and this band is not compatible with existing mobile allocations, such as the PCS band at 1850-1990 MHz, mobile radio equipment manufacturers would also have to undertake a design effort. It is reasonable to assume that if a decision to put 3G systems in the 2500-2690 MHz band is made, it would take several years until the first system is actually deployed. This should provide ample time for ITFS/MDS equipment manufacturers to complete necessary design changes and for service providers to begin replacing equipment. Accordingly, we believe that our conclusion that only a 4 megahertz guard band is necessary to prevent inter-service interference at the allocation edges between 3G and ITFS/MDS systems is reasonable for planning and analysis purposes. Moreover, we believe that equipment manufacturers can adapt to designing equipment around such a guard band in timeframes sufficient to deploy equipment, if a portion of the 2500-2690 MHz band is made available for 3G systems.

Effect of Guard Bands on Band Segmentation Options

In devising our segmentation options, one of our guiding assumptions was that 90 megahertz of spectrum in the 2500-2690 MHz band would have to be made available for 3G services. Therefore, the remaining 100 megahertz in this band would support incumbent ITFS/MDS systems, geographic MDS systems, and the guard bands. Below, we examine, based on our analysis concluding that 4 megahertz guard bands are sufficient, the effect that the guard bands would have on the amount of spectrum available under each option.

Under option 1, the spectrum available for two-way ITFS/MDS systems would be reduced by 12 megahertz of spectrum to accommodate three guard bands of 4 megahertz each. Additionally, we showed that, on average, 30 megahertz of spectrum (five 6 megahertz channels) may need to be set aside for incumbent operators. Depending on how many incumbent one-way systems need to be accommodated, as little as 58 megahertz or as much as 88 megahertz of spectrum would be available for two-way ITFS/MDS systems. Under option 2 (one guard band), the amount of spectrum available for two-way ITFS/MDS systems would range from 66 megahertz to 96 megahertz; and under option 3 (two guard bands), from 62 megahertz to 92 megahertz.

The segmentation options will also effect the way service providers manage their spectrum and assign channels for specific purposes. Two-way ITFS/MDS systems need approximately 30 megahertz of separation between upstream and downstream traffic to accommodate the duplexer. Under option 1, 3G systems would use the spectrum separating the ITFS/MDS spectrum and thus provide ITFS/MDS systems with the needed separation between upstream and downstream traffic. This would allow the ITFS/MDS system to operate, at some times, with almost all of the available 88 megahertz of spectrum. Options 2 and 3, however, do not allow use of the entire available spectrum using a 30 megahertz separation; either some portion of the spectrum would go unused or would need to employ an alternative technology such as TDD.

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[112] *See* Cisco Comments at 10.

Impact of Band Segmentation on Data Rates

In each segmentation option, the amount of spectrum available for two-way ITFS/MDS systems is sharply reduced from the approximately 156 megahertz that these systems have under the current allocation and channel plan. This reduction in spectrum will effect two-way service by either reducing data speeds, which may in turn limit the type of service that these systems can provide or forcing MDS providers to reduce the coverage area of each cell to keep data rates at their current level. The latter situation is discussed in the section below. The HMI study lists data rates for MDS service up to 512 kbps downstream and up to 256 kbps upstream for residential service.[113] Clearly, if the amount of spectrum is reduced, these data rates would have to be scaled back. To understand how such a reduction in data speeds would affect the marketability of two-way wireless broadband service a comparison must be made with the services with which it will compete: digital subscriber line (DSL) and cable modems. As an example, in Los Angeles County, California, Pacific Bell offers standard residential and business DSL service with speeds of between 384 kbps and 1.5 Mbps downstream and 128 kbps upstream.[114] GTE offers DSL packages ranging from 256 kbps to 1.5 Mbps downstream and from 64 kbps to 768 kbps upstream; with its Bronze Plus service (768 kbps downstream and 128 kbps upstream) being the most popular.[115] Cable modem service in Los Angeles is offered by a number of providers. As an example, Media One/AT&T offers service with up to 1.5 Mbps downstream and up to 300 kbps upstream.[116] Time Warner also offers cable modem access with speeds ranging from 2 Mbps to 10 Mbps downstream to up to 384 kbps upstream.[117] While we are unable to ascertain the exact decrease in data rates that a reduction in spectrum would have, we can make certain observations regarding its effect on the marketability of two-way service. It is evident that under current or projected service offerings two-way wireless broadband service offers downstream data rates in the low to mid range of DSL and at the low end of cable modem service. Upstream data rates compare very favorably with the best rates offered for DSL and slightly below those of cable modems. Based on these observations, it is likely that any decrease in two-way service data rates could reduce or eliminate that services' ability to compete in the marketplace.

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[113] *See* WCA Comments at Appendix B, Page 17. These are the data rates offered to each customer. The channel can support higher data rates. Data rates for commercial customers are higher: 1,024 kbps downstream and 512 kbps upstream.

[114] *See Deployment fo Advanced Telecommunications Capability: Second Report*, Federal Communications Commission, rel. August 2000 at C-1. This report is available on the internet at: http://www.fcc.gov/broadband.

[115] *Id*. at C-2.

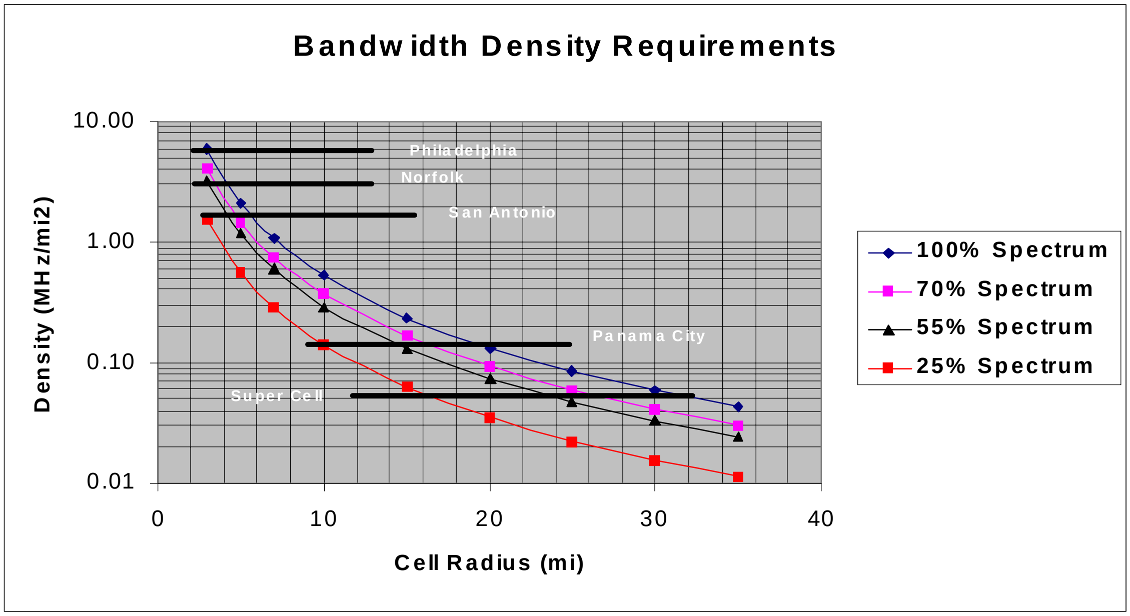
[116] *Id*. at C-5.

[117] *Id*.

Impact of Band Segmentation on Cell Size

As described above, the net effect of segmentation would be to reduce the amount of spectrum available for ITFS and MDS operations. The section above describes the effect such a reduction would have on data rates. In this section we explore the effect that reduced spectrum would have on cell size if providers, under segmentation, opted to keep data rates at current levels. Figure 5.5 below[118] indicates the amount of spectrum needed per cell site to serve customers within a specified distance from that site. As illustrated by the figure, if the total amount of spectrum available for two-way ITFS/MDS systems is reduced, the cell size of the ITFS/MDS system must be reduced to continue providing the same service. Thus, the licensee can continue operating the site with reduced grade of service to its customers, continue operating the site with the same grade of service but serving fewer customers (most likely rural and underserved areas), or construct and maintain new transmit sites to continue serving all its current customers with the same grade of service. For example, the figure shows that a single main transmitter operating with its full complement of spectrum (approximately 160 megahertz)[119] can serve a cell with a 32 mile radius.

Figure 5.5: Cell Size As A Function of Available Spectrum



[118] This figure was provided by Worldcom in a presentation to the FCC on October 11, 2000. It has been used with the permission of Worldcom.

[119] In this case, the MDS operator needs appoximately 160 MHz total (32 miles x 32 miles x π =3217 square miles x 0.05 megahertz/square mile) to serve customers in this cell. The 160 megahertz compares favorably with the commenters statements that approximately 156 megahertz of spectrum is needed.

Based on Figure 5.5 and the amount of spectrum we determined would be available for geographic MDS licensees under each segmentation option, we present the effect each segmentation option would have on cell size in the Tables below. Our calculations are based on an existing MDS system using 160 megahertz (including the 10-12 megahertz allocated in the 2150-2160/62 MHz band) of spectrum[120] over a cell with a 32 mile radius.

Table 5.5: Effect of Segmentation Options on Cell Size for Minimum Available Spectrum

Option	Minimum Spectrum Available in the 2500-2690 MHz Band (MHz)	Minimum Total Spectrum Available (MHz)*	% of Total Spectrum Available for Use	Cell Size (mi.)#	Cell Area (sq. mi.)	% of Original Area
1	58	70	43.8	21.0	1385	43.1
2	66	78	48.8	22.3	1562	48.6
3	62	74	46.3	21.7	1479	46.0

* Includes 12 megahertz from the 2150-2162 MHz band.
\# Assumes linear interpolation between curves in Figure 5.5.

Table 5.6: Effect of Segmentation Options on Cell Size for Maximum Available Spectrum

Option	Maximum Spectrum Available in the 2500-2690 MHz Band (MHz)	Minimum Total Spectrum Available (MHz)*	% of Total Spectrum Available for Use	Cell Size (mi.)#	Cell Area (sq. mi.)	% of Original Area
1	88	100	62.5	25.0	1963	61.0
2	96	108	67.5	25.7	2075	64.5
3	92	104	65.0	25.3	2011	62.5

* Includes 12 megahertz from the 2150-2162 MHz band.
\# Assumes linear interpolation between curves in Figure 5.5.

The data contained in the tables show that to maintain the same grade-of-service under each segmentation, the area served by any one transmitting site is significantly reduced. Even in the best case, cell size is reduced by almost forty percent. Under these conditions, we expect that a licensee could require 3-5 transmitter sites to cover the same geographic area as the single main transmitter.[121] Thus, the MDS operator either must incur the cost of building additional sites to

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[120] 160 megahertz is used for our analysis rather than the full 202 megahertz available to ITFS/MDS serivces (190 megahertz available in the 2500-2690 MHz band and 10-12 megahertz available in the 2150-2160/62 MHz band). According to commenters this is typical of the amount of spectrum they have available in each market.

[121] This assumes leaving the existing transmitter in its current location. However, it may be possible to reduce this to 2-3 additional transmitter sites, if the existing transmitter is relocated. HAI, in its study, determined that a 90 MHz reduction in spectrum available to MDS would increase the number of cell sites by a factor of 2.7 for the larger markets. *See* WCA Comments at Appendix B, page 25.

continue serving its current customer base or cease providing service to customers in outlying areas. The economic impact of these choices are examined in Section 7.

MIGRATION SCHEDULE

A number of factors would influence the amount of time needed to implement any of the segmentation options studied. First, as discussed above, some incumbent one-way systems would need time to convert from analog to digital modulation. The use of more spectrally efficient technology for these types of systems would provide maximum spectrum for introducing two-way ITFS/MDS systems in the band. Second, implementation of any of the segmentation options would require manufacturers to reengineer planned two-way systems for operation using reduced spectrum in the band. Manufacturers and ITFS/MDS operators would have to reconfigure network design and deploy new equipment. Cisco estimates that it would need a year or more to complete and test fully new equipment for use in band if segmentation were implemented.[122] Cisco states that it would need to revisit the entire design and manufacture cycle; redesign both hardware and software; revisit component supply chains and partner agreements; duplicate lab and field trials; and reinitialize manufacturing plants.[123] The introduction of guardbands also would require equipment modifications. Cisco states that it would have to reengineer channel filtering technology to achieve more robust adjacent channel rejection, design new duplexers to accommodate different transmit and receive capabilities, and assume new reuse and deployment patterns.[124]

Given the complex interference environment already present in the 2500-2690 MHz band, accommodating additional ITFS/MDS operations in only certain portions of the band will take considerable time and effort if such an approach is undertaken. Both site-specific one-way and two-way systems and wide-area two-way systems will have to be coordinated. Furthermore, in any geographic area, adjacent channel use by wide-area 3G systems also will need to be coordinated.

Because of the localized nature of sharing and leasing agreements between geographic MDS licensees and incumbent ITFS and MDS licensees, migration schedules will likely be different for each area. Also, because all channels in the 2500-2690 MHz band are licensed in or near the top 50 metropolitan areas,[125] the relocation of any specific station will need to be closely coordinated with all other nearby stations. And migration may not be able to occur until the equipment needed for two-way systems is redesigned, tested, and available to licensees. Although it may be possible for some incumbent ITFS and MDS systems to relocate within band by 2003, large-scale band reorganization may be necessary before all incumbent systems, two-way systems, and 3G systems could operate under band segmentation. Thus, accommodation of all systems would not likely occur until 2010 or beyond.

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[122] *See* Cisco Comments at 10.

[123] *Id.*

[124] *Id.*

[125] *See* "ITFS/MDS Channel Licensing" on page 32.

SUMMARY

Based on our analysis of various segmentation options for the 2500–2690 MHz band, we find that the conclusions made in the Interim Report remain valid. Any segmentation option would need to take into account the flexible service configurations and offerings that ITFS and MDS licensees are now implementing. Further, the number of guard bands affects the impact that band segmentation has on spectrum available for ITFS/MDS operations. While Option 2, with only one guard band, provides the most spectrum for ITFS/MDS operations, it may require more equipment redesign than Option 1 where 3G systems and ITFS/MDS systems are interspersed. Additionally, under any of the options a substantial number of licensees would need to be accommodated. Also, if segmentation is pursued, ITFS/MDS service providers may need to reduce their service areas and services to customers in outlying areas or add more transmitter sites to maintain services. Finally, because of the complex licensing scheme present in this band (*e.g.*, the mix of site-specific and wide-area licensing, channel swaps, and lease agreements), we cannot describe uniform impacts for each of the segmentation options studied. To fully understand the implications of any segmentation plan on the ITFS/MDS, one would need to analyze each geographic area individually.

SECTION 6
IDENTIFICATION AND ANALYSIS OF POTENTIAL ALTERNATE FREQUENCY BANDS FOR ITFS/MDS

The Study Plan calls for the identification of alternate frequency bands for incumbent users of the candidate bands being studied for possible 3G system use. The Study Plan sets forth certain criteria for identifying alternate frequency bands: (1) consideration should first be given to those bands in which no, or minimum, disruption would occur to the incumbents of the identified alternate bands; and (2) potential alternate bands should afford candidate band incumbent systems that may require replacement spectrum the capability to function without loss of functionality or necessary interoperability in the alternate band(s).

The Study Plan also states that any study of alternate bands will describe the alternate band(s) as to: (1) existing rules and regulations that govern the use of the bands; (2) the changes in allocation rules and regulations that would be necessary to make them acceptable to the candidate band incumbent users; (3) the relocation of alternate band incumbents if necessary; (4) the operational constraints on the alternate band incumbents or on the candidate band systems; and (5) any other considerations, including national security and public safety, in the use of the alternate bands that would have a negative effect on candidate band incumbent users.

This section identifies and analyzes potential alternate frequency bands that could be used by ITFS/MDS systems if spectrum in the 2500-2690 MHz band were reallocated for use by 3G systems. The analysis states the assumptions made, identifies potential alternate frequency bands, and analyzes the bands in accordance with the Study Plan criteria listed above.

ASSUMPTIONS

For purposes of this study, we have made certain assumptions in identifying potential alternate frequency bands for ITFS/MDS systems. These assumptions are as follows:

- Relocation of ITFS and MDS systems would likely be based on policies similar to those established in the *Emerging Technologies* proceeding), which allow new entrants to provide incumbents with comparable facilities using any acceptable technology, and some services could be relocated from spectrum-based networks to wireline-based networks.[126] For purposes of this study, we assume that all ITFS/MDS operations would continue as spectrum-based networks.

- ITFS/MDS is in a state of rapid evolution to offer high-speed, two-way access to the Internet. We assume that any relocation would minimize any loss of functionality to ITFS and MDS licensees of analog and digital one-way and two-way services, which

[126] *See Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum at 2 GHz for Use by the Mobile Satellite Service,* ET Docket No. 92-9, *Second Report and Order,* 8 FCC Rcd 6495 (1993) ("*Emerging Technology Proceeding*").

are provided on a wide-area, ubiquitous basis in both urban and rural areas, and would allow for future deployment of two-way systems.

- ITFS and MDS operations would not be relocated to separate frequency bands. The two services currently have extensive and complex channel leasing arrangements that provide benefits for education, businesses and consumers. Separation of these operations would have extensive policy ramifications beyond the scope of this study. It is not clear that either service would be viable if they were separated into different frequency bands, even if this were technically possible.

- Alternate frequency bands would need to provide at a minimum 90 megahertz of contiguous spectrum for ITFS/MDS to replace the 90 megahertz of spectrum in the 2500-2690 MHz band that would be made available for 3G use under the segmentation analysis of this study.

- Alternate frequency bands may need to provide for the relocation of the entire 202 megahertz of spectrum currently occupied by ITFS/MDS to assure the continued functionality of ITFS and MDS that is one of the criteria for the Study Plan.[127] The actual amount of spectrum needed to relocate ITFS/MDS could be affected by other factors that were not taken into account here. For example, it may be necessary to provide a greater amount of spectrum at higher frequencies to offset the impact of increased propagation losses.

- When considering relocation bands, first preference is for the ITFS/MDS operation (incumbents A) to be compatible with existing operations in the alternate bands and not displace any existing operations in the alternate bands. However, if the incumbents in the alternate band (incumbents B) have to be relocated to another band, incumbents B cannot displace any other existing operations in which they are relocated. We assume that more than one relocation move is too disruptive to existing operations and therefore we have not explored such possibilities in this study.

Based on these assumptions, we identified the frequency bands listed in Table 6.1 for further analysis as potential alternate frequency bands for ITFS/MDS. These are bands that are already allocated for Fixed Services and that could satisfy the amount of spectrum assumed for our analysis.

[127] ITFS/MDS currently occupies a total of 202 megahertz of spectrum (12 megahertz from 2150-2162 MHz and 190 megahertz from 2500-2690 MHz).

Table 6.1: Bands for Further Assessment

Frequency Band	Size (MHz)	Allocation	Radio Services
3700-4200 MHz	500	NG	Fixed, Fixed-Satellite (space-Earth)
5925-6425 MHz	500	NG	Fixed, Fixed-Satellite (Earth-space)
6425-7125 MHz			
6425-6525	100	NG	Fixed-Satellite (Earth-space), Mobile
6525-6875	350	NG	Fixed, Fixed-Satellite (Earth-space)
6875-7075	200	NG	Fixed, Fixed-Satellite (Earth-space), Mobile
7075-7125	50	NG	Fixed, Mobile
7125-8500 MHz	Federal Government "Fixed Band"		
10.7-13.25 GHz			
10.7-11.7	1000	NG	Fixed, Fixed-Satellite (space-Earth)
11.7-12.2	500	NG	Fixed-Satellite (space-Earth)
12.2-12.7	500	NG	Fixed, Broadcasting-Satellite
12.7-13.25	550	NG	Fixed, Fixed-Satellite (Earth-space), Mobile
G = Federal Government		NG = Non-Federal Government	

ASSESSMENT OF THE BANDS 3700–4200 MHz and 5925–6425 MHz

Allocation Description

The bands 3700-4200 MHz and 5925-6425 MHz (500 megahertz each) are allocated on a primary basis to the non-Federal Government for the fixed service (FS) and fixed-satellite service (FSS). An excerpt from the Table of Frequency Allocations for this portion of the spectrum is provided below in Table 6.2.[128] The applicable service definitions and associated footnotes for this portion of the Table are provided in Appendix 6.2 and 6.3 respectively. These bands are paired for fixed-satellite purposes, and collectively are known as the "C-band." For FSS, the band 3700-4200 MHz supports space-to-Earth (downlink) operations and the band 5925-6425 MHz supports Earth-to-space (uplink) operations. These bands may also be used by stations in the international fixed public and international control services for operations located in the U.S. Possessions in the Caribbean area.

[128] *See* 47 C.F.R. § 2.106.

Table 6.2: Table of Frequency Allocations for 3700-4200/5925-6425 MHz
(See Appendix 6.3 for footnote text.)

Federal Government	Non-Federal Government	FCC Rule Part(s)
3700-4200	3700-4200 FIXED NG41 FIXED-SATELLITE (space-to-Earth)	International Fixed (23) Satellite Communications (25) Fixed Microwave (101)

5925-6425 MHz

Federal Government	Non-Federal Government	FCC Rule Part(s)
5925-6425	5925-6425 FIXED NG41 FIXED-SATELLITE (Earth-to-space)	International Fixed (23) Satellite Communications (25) Fixed Microwave (101)

Description of Current and Planned Band Use (3700-4200/5925-6425 MHz)

The bands 3700-4200 and 5925-6425 MHz are heavily used by both the fixed-satellite service (FSS) and the terrestrial fixed service (FS). The FCC rules and regulations for fixed-satellite and fixed services are contained in 47 C.F.R. Parts 23, 25, and 101.

C-band fixed-satellite systems provide private and commercial communication links for various businesses and industries, feeds to terrestrial television and radio broadcast networks and to cable headends, programming directly to customers with home satellite receivers[129] and tracking, telemetry, and control (TT&C) operations for U.S. and non-U.S. satellites. C-band satellites are being used to provide two-way, broadband data backbone and services via satellite.). Currently, there are 35 U.S. licensed geo-stationary (GSO) satellites providing international and/or domestic service to the United States in the C-band. More than 15 additional satellites are planned to operate in conjunction with the existing satellites and eventually replace the currently operating satellites once they reach their end of life. The satellites are generally spaced at orbital separations of two degrees around the GSO. A typical C-band transponder uses 36 megahertz bandwidths. Transponder loading depends on the type of service offered over the transponder (*i.e.*, few video channels versus hundreds of low data rate channels can be offered over one transponder).

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[129] There are also proposals to use Fixed-satellite networks to provide internet services to rural and un-served areas directly to end users. *See FWCC Request for Declaratory Ruling on Partial-Band Licensing of Earth Stations in the Fixed Satellite Service that Shared Terrestrial Spectrum*, IB Docket No. 00-203, *Notice of Proposed Rule Making*, 15 FCC Rcd. 23127 (2000). ("*FWCC/ONSAT NPRM*")

There are approximately 13,500 registered earth station antennas within the United States and its possessions that operate through the C-band fixed-satellites. Further, we estimate that there are tens of thousands of unregistered receive-only earth stations in the C-band used by the general public for direct-to-home (DTH) video programming reception. Registered earth stations cover the entire country but are concentrated more heavily in urban areas.[130] (*See* map in Appendix 6.4) There is no information on the geographical distribution of the unregistered earth stations, but historically they have been used in all areas of the country. In particular, they are used in rural areas where conventional broadcasting was not available and the potential to receive interference from other licensed users is relatively lower than in urban areas. The Commission has proposed to streamline its earth station application filing requirements to facilitate blanket authorization of satellite data terminals in the C-Band (with appropriate coordination and reporting requirements).

The 3700-4200 and 5925-6425 MHz bands also support a number of fixed point-to-point operations. These bands provide "backbone" and "long-haul" operations for common-carrier and private business, industry, utilities and public safety communications networks.[131] There are currently over 11,000 point-to-point links in the 3700-4200 MHz band, and over 38,500 point-to-point links in the 5925-6425 MHz band. For the 3700-4200 MHz, the average path length is 43 km (26.7 miles) and, for the 5925-6425 MHz, the average path length is 39 km (24.2 miles). The current fixed, point-to-point channeling plan for the band 3700-4200 MHz provides for paired 20 megahertz channels with 40 megahertz separation between the transmit and receive channels. However, there are a number of grandfathered systems in this band with different channel bandwidths and separations. The current fixed point-to-point channeling plan for the band 5925-6425 MHz provides for a varied bandwidths from 0.4 to 30 megahertz channels with 250 megahertz separation between the transmit and receive channels. Both the channel loading and the geographical distributions of the point-to-point facilities in these bands are fairly uniform across the band and across the country, respectively. *See* the maps in Appendix 6.4.

Recently, the fixed service community has expressed concern that the proliferation of satellite earth stations in the C-Band is freezing any future growth of fixed operations in this range.[132] The problem is worse in the 3700-4200 MHz portion due to the protection of video distribution operations to cable head ends and television stations. The 5925-6425 MHz portion is also impacted and the problem of coordinating with new fixed operations.

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[130] The purpose of registration is to receive protection from interference from terrestrial Fixed service operations. Receive-only earth stations used for cable head-ends and feeds to terrestrial broadcast networks are registered particularly in congested urban areas to avoid the possibility of receiving interference that would result in disruption of service to their end users.

[131] *See Emerging Technology Proceeding*.

[132] *See Request of Declaratory Ruling and Petition for Rule Making* filed on May 5, 1999 by the Fixed Wireless Communication Coalition, RM-9649; *see also, Notice of Proposed Rule Making*, IB Docket No. 00-203, 15 FCC Rcd 23127 (2000).

Finally, we note that while there are no Federal Government services allocated in these bands, the band 5925-6425 MHz is used by Federal Government agencies (*e.g.*, USIA, FAA, and Navy) for FSS operations. These operations are on a case by case, coordinated basis to operate earth stations that transmit voice, data, video signals through the non-Federal Government GSO satellite systems. Additionally, there are several Federal Government operations in both bands that operate on a non-interference basis. Specifically, NASA operates downlink telemetry, on a non-interference basis, during launch and emergencies in support of the NASA Advanced Communications Technology Satellite Space Program. Further, various Federal Government agencies also operate test stations of radiolocation systems on a non-interference basis.

Assessment for ITFS/MDS Operations (3700-4200/5925-6425 MHz)

These bands are closest to the current ITFS/MDS bands among those considered for relocation. These bands appear to hold the least technical impact for the viability of ITFS/MDS operations. Signal propagation losses would increase somewhat, but the effect would not be as significant as higher bands.[133] The cost and availability of electronic components and antennas may also increase somewhat, but would benefit from the extensive development that has already occurred for this band.

With regard to the sharing between ITFS/MDS and the FSS downlink band 3700-4200 MHz, satellite earth stations would be susceptible to receiving harmful interference from ITFS/MDS transmitters, and highly susceptible to receiving interference from subscriber based ITFS/MDS transmitters deployed for two-way service. Interference could occur if an ITFS/MDS transmitter were located within approximately 200 km (124 miles) of a receiving satellite earth station.

With regard to the sharing in the FSS uplink band 5925-6425 MHz, because ITFS/MDS are ubiquitous wide-area systems with broad-beam and omnidirectional antennas and deployed ubiquitously, the ITFS/MDS system would be highly susceptible to receiving harmful interference from thousands of earth stations currently operating in this frequency band. Sharing between these services on a geographic basis does not appear feasible because they are both effectively ubiquitous. *See* the map in Appendix 6.4.

Segmenting either of these frequency bands to accommodate ITFS/MDS does not appear feasible. Satellites are designed to make use of the entire 500 megahertz of spectrum in both the downlink and uplink bands. Any reduction in spectrum would have a severe impact on existing satellite operations. There are no frequency bands where C-band satellite operations might be reaccommodated.

[133] The greatest impact of using higher frequencies would be on the return link from the subscriber location, particularly in rural deployments where longer distance communication is necessary. We note that the higher frequency bands support various fixed services that are different from the residential and educational services provided by ITFS/MDS, especially in rural areas and smaller markets.

Neither sharing nor segmentation appears feasible relative to existing fixed operations. This problem is exacerbated by the fact that this spectrum was identified for relocation of existing fixed operations in the 2 GHz region to accommodate personal communications services and other emerging technologies as laid out in ET Docket 92-9.[134] (*See* the maps in Appendix 6.5.). Higher frequency bands that are available for fixed operations are also becoming increasingly congested.

Summary (3700-4200/5925-6425 MHz)

Our analyses indicate that ITFS/MDS operations could not share with the existing operations in the bands 3700-4200 MHz and 5925-6425 MHz. As demonstrated above, both the FSS and FS heavily use these bands. The wide-area, ubiquitous coverage characteristics of ITFS and MDS are not compatible with either fixed point-to-point or fixed-satellite operations in any geographic area. Segmenting either band to accommodate ITFS/MDS operations also does not appear viable because this could not be accomplished without significant harm to current and future uses of the FSS and FS. Therefore, reallocation of spectrum to accommodate ITFS/MDS does not appear feasible for either the 3700-4200 MHz or the 5925-6425 MHz band.

ASSESSMENT OF BAND 6425 – 7125 MHz

Allocation Description

The 6425-7125 MHz band is allocated on an exclusive basis to the non-Federal Government and consists of four bands. An excerpt from the Table of Frequency Allocations for this portion of the spectrum is provided below in Table 6.3.[135] The applicable service definitions and associated footnotes for this portion of the Table are provided in Appendices 6.2 and 6.3, respectively. The band 6425-6525 MHz (100 megahertz) is allocated on a primary basis to the fixed-satellite and mobile services. The band 6525-6875 MHz (350 megahertz) is allocated on a primary basis to the fixed and fixed-satellite services. The band 6875-7075 MHz (200 megahertz) is allocated on a primary basis to the fixed, fixed-satellite, and mobile services. The band 7075-7125 MHz (50 megahertz) is allocated on a primary basis to the fixed and mobile services. In the band 6875-7125 MHz, television translator relay station licensees may be authorized to use frequencies on a secondary basis to other stations in the television broadcast auxiliary service.

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[134] *See Emerging Technology Proceeding*.

[135] *See* 47 C.F.R. § 2.106.

Table 6.3: Table of Frequency Allocations for 6425-7125 MHz
(See Appendix 6.3 for footnote text.)

Federal Government	Non-Federal Government	FCC Rule Part(s)
6425-6525 S5.440 S5.458	6425-6525 FIXED-SATELLITE (Earth-to-space) MOBILE S5.440 S5.458	Auxiliary Broadcasting (74) Cable TV Relay (78) Fixed Microwave (101)
6525-6875 S5.458	6525-6875 FIXED FIXED-SATELLITE (Earth-to-space) 792A S5.458	Satellite Communications (25) Fixed Microwave (101)
6875-7125	6875-7075 FIXED FIXED-SATELLITE (Earth-to-space) 792A MOBILE S5.458 NG118	Auxiliary Broadcasting (74) Cable TV Relay (78)
S5.458	7075-7125 FIXED MOBILE S5.458 NG118	

Description of Current and Planned Band Use (6425 – 7125 MHz)

The 6425-7125 MHz spectrum is used by the fixed-satellite, fixed, broadcast auxiliary, and mobile services. We will evaluate each of these bands below to determine the viability of ITFS/MDS operations in this range. For the purposes of analysis of assignments, we have divided the band into three separate portions: 6425-6525, 6525-6875, and 6875-7125 MHz. (*See* Table 6.4:Band Usage 6425-7125 MHz.) Each is discussed below.

6425-6525 MHz portion. As indicated above, the band 6425-6525 MHz (100 megahertz) is allocated to FSS and mobile services. In addition to providing uplinks for the FSS, licensed under Part 25 of the Commission’s Rules, this band is used primarily for television related services. Currently, it supports remote pickup in the broadcast auxiliary service (BAS), licensed under Part 74 of the Commission’s Rules. BAS offers service to television broadcast stations, television network entities, cable system operators, and cable network entities via common carrier providers in the local television transmission services (LTTS) licensed under Part 101 of the Commission's Rules. The band also accommodates mobile operations in the cable antenna relay services (CARS), licensed under Part 78 of the Commission's Rules.

There are currently 304 broadcast auxiliary links, 33 cable relay links, and 501 temporary fixed links for local television transmissions in the 6425-6525 MHz band. This band also contains 16 fixed point-to-point microwave links. The Earth-to-space (uplinks) configuration supports 522 links associated with licensed earth stations and an unknown number of unregistered receive only earth stations. The Commission's Rules allow BAS and LTTS bandwidths of 1, 8, or 25 megahertz, while CARS may employ bandwidths of 25 megahertz. The fixed rules provide for operations of 1, 8, or 25 megahertz bandwidths with 50 megahertz separation between transmit and receive channels. Both the channel loading and the geographical distributions of licensed links in this band are shown in maps in Appendix 6.4.

6525-6875 MHz portion. As mentioned above, the band 6525-6875 MHz (350 megahertz) is allocated to the FSS and FS, licensed respectively under Parts 25 and 101 of the Commission's Rules. The band 6525-6875 MHz supports general-purpose fixed microwave FS operations for a variety of public and private entities, such as, non-Federal Government, industrial, common carrier, and transportation licensees. For the FS, the average path link is 32 km (19.9 miles). The channeling plan provides for varied bandwidths from 0.4 to 10 megahertz channels with 250 megahertz separation between transmit and receive channels. In addition to the FS operations, the band 6525-6875 MHz (extending through to 7075 MHz) also provides feeder uplinks (Earth-to-space) including tracking, telemetry, and control of satellites, for "Big LEO" and digital audio radio services (DARS) satellites.

The band 6525-6875 MHz currently supports 4 U.S. licensed geo-stationary (GSO) satellites and 6 feeder links associated with U.S. licensed non-geo-stationary (NGSO) satellites. Moreover, the band supports fixed microwave operations with over 25,000 point-to-point links. Both the channel loading and the geographical distributions of the point-to-point facilities in this band are fairly uniform across the band and across the country, respectively. *See* the map in Appendix 6.4. Additionally, the band 6525-6875 MHz was identified in 1993 in the Emerging Technologies proceeding as a future home for fixed point-to-point operations to be relocated from the 2 GHz band.[136] (*See* the maps in Appendix 6.5.) The band 6700-7075 MHz also is the subject of a proposal to add feeder downlinks for NSGO satellites in support of mobile satellite service (MSS) satellites ("Big LEOs").[137] The frequency 6427 MHz (along with 4202 MHz) is available, but unused, for two-way satellite time signal communications.

6875-7125 MHz portion. The band 6875-7125 MHz (250 megahertz) is allocated to the fixed and mobile services, and 200 megahertz of this band, *i.e.*, 6875-7075 MHz, is shared on a co-primary basis with the fixed-satellite service. At present the band 6875-7075 MHz supports

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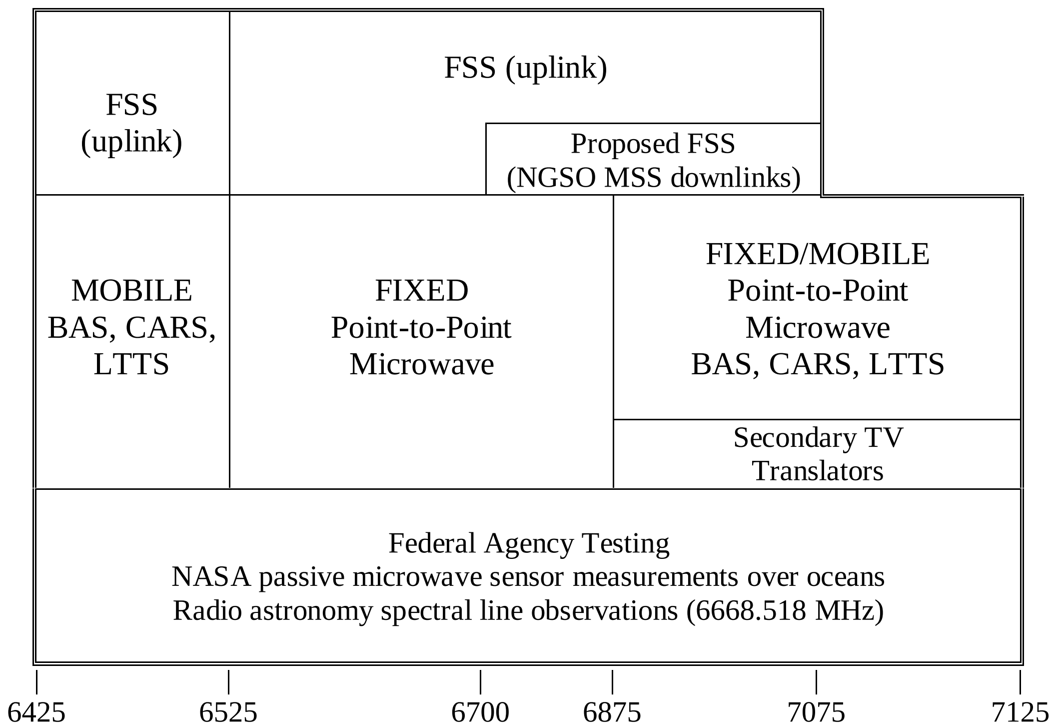
[136] *See Emerging Technology Proceeding*.

[137] *See Amendment of Parts 2,25, and 97 of the Commission's Rules with Regard to the Mobile Satellite Service above 1 GHz*, ET Docket No. 98-142, *Notice of Proposed Rule Making*, 13 FCC Rcd 17107 (1998). ("*MSS FeederLlinks*")

approximately 120 uplinks for the FSS. The 6875-7125 MHz provides for television related services similar to the mobile band 6425-6525 MHz discussed above, but on both a fixed and mobile basis. For the 6875-7125 MHz band, there are currently approximately 6,000 fixed links and 1,700 mobile operations licensed for the BAS. This band also supports about 10 fixed and 9 mobile links for CARS, and approximately 27 temporary fixed and 250 mobile links for LTTS. The bandwidths for one-way, fixed BAS operations are 16, 17, or 25 megahertz channels. The average path length is 42 km (26.1 miles). The bandwidth for BAS mobile operations is 25 megahertz. The CARS use bandwidths of 12.5 or 25 megahertz for fixed and 25 megahertz for mobile operations, and the average path length for fixed links is 40 km (24.9 miles). The LTTS uses bandwidths of 16, 17, or 25 megahertz for both fixed and mobile operations. The channel loading and the geographical distributions of licensed links in this band are shown in maps in Appendix 6.4.

Table 6.4: Band Usage 6425-7125 MHz



Assessment for ITFS/MDS Operations (6425 – 7125 MHz)

The technical characteristics of this band would be somewhat more challenging for ITFS/MDS, but would not be insurmountable. However, because ITFS and MDS use is ubiquitous in nature, these services will not be able to share with the current users of the band. The mobile and fixed operations of BAS, CARS, and LTTS would pose particular problems to the bands 6425-6525 and 6875-7125 MHz, as well as the extensive deployment of fixed point-to-point operations in the band 6525-6875 MHz. Therefore, to provide for ITFS/MDS, 202 megahertz of spectrum will have to be cleared by relocating or segmenting all of the incumbent users in that spectrum.

6425-6525 MHz (100 megahertz) Reaccommodating ITFS/MDS in the 6425-6525 MHz band is impractical due to the international nature of fixed-satellites and operational characteristics of mobile services. As discussed in Section 4 above, sharing between ITFS/MDS and mobile operations in the same geographic area is not feasible. ITFS/MDS are ubiquitous wide-area systems with broad-beam and omnidirectional antennas. As mentioned above, there are over 800 licensed stations with an unknown number of mobile units that could operate anywhere. Because the incumbent mobile services could be dispersed throughout the country and ITFS/MDS cannot coordinate with these incumbent operations to avoid interference, sharing between ITFS/MDS and mobile service is not feasible. Additionally, sharing between ITFS/MDS and FSS is also impractical. Because the band 6425-6525 MHz supports over 500 uplink facilities for the FSS, ITFS/MDS stations would receive interference from these earth stations if located within approximately 200 km (124 miles) of each other. Again, due to the wide-area deployment of ITFS/MDS throughout the country sharing with FSS does not appear to be feasible. With regard to segmentation of the band, we note that this band would only provide 100 megahertz of the 202 megahertz that may be needed to accommodate the ITFS/MDS service. Therefore, we conclude that if ITFS/MDS were to be relocated into the band 6425-6525 MHz, the incumbent FSS and mobile operations would have to be relocated to other bands and an additional 102 megahertz of nearby spectrum would need to be found.

6525-6875 MHz (350 megahertz) Relocating ITFS/MDS into the band 6525-6875 MHz would be extremely difficult due to the very extensive use of this band by fixed point-to-point microwave services (over 25,000 licensed links). As shown in the other band assessments, sharing between ITFS/MDS and the fixed service is not practical in most situations.[138] While it may be possible for co-channel sharing in remote areas, most fixed, point-to-point microwave operations in this band are located in areas where ITFS/MDS operations will operate. Additionally, this band also is allocated to the FSS. Although this band currently is lightly used for FSS (6 feeder links), half the band (175 megahertz) is the subject of current examination to permit feeder downlinks for MSS NSGO satellites (Big LEOs).[139] Again we note that sharing between ITFS/MDS and FSS incumbents is impractical due to technical characteristics of ITFS/MDS operations, which provide ubiquitous wide-area systems using broad-beam and omnidirectional antennas. Therefore, sharing is not possible and if ITFS/MDS were to be accommodated in this band, the incumbent services would have to be relocated into the remaining spectrum or to higher frequency bands. Segmentation of the band 6525-6875 MHz for ITFS/MDS would also be difficult due to the paired nature of satellite operations in the band and the congestion that already exists in this band.

6875-7125 MHz (250 megahertz) Accommodation of ITFS/MDS into this band would create severe disruption to the incumbent services. As noted above, the 6875-7125 MHz band is heavily used by fixed and mobile services, and by the fixed-satellite service particularly for feeder links. The band 6875-7125 MHz is used extensively for both fixed (over 6,000 links) and

[138] *See* Assessment for bands 3700-4200 and 5925-6425 MHz, as discussed above.

[139] *See MSS Feeder Links.*

mobile operations (almost 2,000 licenses) to support television and cable stations. As shown previously, sharing between ITFS/MDS and fixed and mobile operations are not feasible in the same geographic area. Additionally, a portion of this band 6875-7075 MHz (200 megahertz) is shared with the FSS. Again we note that this band is the subject of a proceeding to permit feeder downlinks for MSS NSGO satellites (Big LEOs),[140] and that sharing between ITFS/MDS and FSS impractical. Segmentation of the band also is not feasible due to the heavy use by fixed and mobile operations that would have to be accommodated within the remaining 48 megahertz of spectrum.

Other matters. In addition to the points discussed above, while there are no Federal Government services allocated in this band, there are several Federal Government operations that operate on a non-interference basis. Specifically, NASA operates downlink telemetry, on a non-interference basis, during launch and emergencies in support of the NASA Advanced Communications Technology Satellite Space Program. Further, various Federal Government agencies also operate test stations of radiolocation systems on a non-interference basis. For radio astronomy, the frequency 6668.518 MHz is an important tracer of star formation activity.

Summary (6425 – 7125 MHz)

As discussed above, the propagation characteristics and technical considerations start to affect the design of the incumbent system as frequency increases. While the 6-7 GHz range could technically accommodate ITFS/MDS operations, the impact on coverage and equipment design begins to be more complicated at higher frequency ranges. Moreover, we have determined from the above investigation that ITFS/MDS operations would not be compatible with incumbent FS, FSS, and mobile operations. ITFS and MDS are two-way, point-to-multipoint operations that are designed to provide ubiquitous coverage over a wide area. Such operations would not be capable of sharing with either fixed point-to-point or fixed-satellite operations in any geographic area. As discussed above, sharing between ITFS/MDS and mobile operations in the same geographic area also is not practical. Because the incumbent mobile services could be dispersed throughout the country and ITFS/MDS cannot coordinate with these incumbent operations to avoid interference, sharing between ITFS/MDS and mobile service is not feasible. Our analysis indicate that both of these bands are extensively used by fixed-satellite, fixed and mobile operations across the United States with concentrations in populated areas where ITFS and MDS deployment is desired and likely. Therefore, sharing between ITFS/MDS and the incumbent services in the 6425-7125 MHz spectrum range is not possible.

As indicated above, if ITFS/MDS was to be relocated into the 6425-7125 MHz range, perhaps 202 megahertz of spectrum would have to be cleared by segmentation and reaccommodation of the incumbent users to higher frequency bands. However, our investigations indicate that removing any significant amount of spectrum to accommodate ITFS/MDS would have a significant impact to the incumbent fixed and mobile services due to their extremely heavy use. Relocation of the satellite links to other spectrum would also be

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[140] *Id.*

extremely disruptive, would take several years, and be extremely costly due to the need to construct new satellites and replace earth stations that are extensively deployed. While relocation of terrestrial fixed and mobile operations could be done in shorter time and at lesser costs, identification of alternative spectrum would be extremely difficult as discussed above. Accordingly, relocating ITFS/MDS systems into the 6425-7125 MHz would significantly impact the incumbent fixed-satellite, fixed and mobile operations in this frequency band.

ASSESSMENT OF THE BAND 7125 – 8500 MHz

The band 7125-8500 MHz is currently restricted exclusively for Federal Government operations and is allocated on a primary basis to the fixed, fixed-satellite and other services. This spectrum is included in this report because it has technical and propagation characteristics that potentially could accommodate ITFS/MDS similar to the bands 5925-6425 and 6425-7125 MHz described above. However, because these bands are allocated for exclusive Federal Government use and because the Commission only has limited information about their loading, this will be a cursory review of this spectrum.

This spectrum is divided into 13 bands and each band is shared with one or more other Federal Government services. The other Federal Government allocations and uses in this spectrum include space research, mobile-satellite, meteorological-satellite, and Earth exploration-satellite. Many Federal Government agencies use this spectrum for fixed, point-to-point microwave links, including "long-haul" and "backbone" systems, for their internal communication. The NTIA's March 2000 Report on "Spectrum Usage for the fixed services" indicates that there are 8226 Federal Government fixed assignments listed in the Government's master frequency (GMF) file in this band.[141] The largest listing of fixed assignments is held by the Federal Aviation Administration (FAA), which has over 4,000 assignments in a nationwide network to support air traffic control with communications and radar data from remote sites. The Department of Defense (DoD) agencies have about 2,000 fixed assignments to support their voice and data networks, and the Department of Energy (DoE) has 1,200 fixed assignments used for system control and data acquisition (SCADA) for electric power distribution networks.

With regard to FSS operations in the 7125-8500 MHz spectrum, the DoD uses portions of this spectrum for military satellite communications, such as the Defense Satellite Communications Systems (DSCS) for voice and data communications including NATO communication requirements. The FAA also uses this spectrum for the FSS Radio Communication Link (RCL) network connecting air traffic and radar sites. Other uses include deep space communications, such as the NASA's Mars Pathfinder program in the 7190-7235 MHz (uplink) and 8400-8450 MHz (downlink) bands. The band 7450-7550 MHz is used by the meteorological-satellite service to downlink weather data. Further, the band 8025-8400 GHz is allocated for earth exploration-satellite service and is used for land remote sensing to deliver images and some satellite telemetry and control.

[141] *See* NTIA Report 00-378, *Spectrum Usage for the Fixed Services*, March 2000.

This description attempts to note some of the major uses of the band 7125-8500 MHz; however, it is neither exhaustive nor complete. Specifically no attempt has been made to investigate incumbent use other than the fixed operations or numbers of assignments within this spectrum. Nevertheless, this cursory review indicates that the number of fixed assignments for this 1375 megahertz of spectrum is far less per megahertz than is found in the non-Federal Government fixed bands. While this fact alone is not sufficient to conclude that ITFS/MDS systems could be relocated to this band it may warrant further consideration if ITFS/MDS systems are to be relocated from the 2500-2690 MHz band.

ASSESSMENT OF THE BAND 10.7 – 13.25 GHz

Allocation Description

The spectrum between 10.7-13.25 GHz is allocated exclusively to the non-Federal Government and consists of five bands. An excerpt from the Table of Frequency Allocations for this portion of the spectrum is provided below in Table 6.5.[142] The applicable service definitions and associated footnotes for this portion of the Table are provided in Appendices 6.2 and 6.3, respectively. The 10.7-11.7 GHz (1000 megahertz) band is allocated on a co-primary basis to the fixed and fixed-satellite services. This band may also be used by stations in the international fixed public and international control services for operations located in the U.S. Possessions in the Caribbean area.[143] The band 11.7-12.2 GHz (500 megahertz) is allocated on a primary basis to the fixed-satellite service and secondarily to mobile services (except for aeronautical mobile). In the band 11.7-12.2 GHz, transponders on space stations in the fixed-satellite service may be used additionally for transmissions in the broadcasting-satellite service, provided that certain limitations are met. The satellite community refers to this spectrum range as the "Ku-band." The band 12.2-12.7 GHz (500 megahertz) is allocated on a primary basis to the fixed and broadcasting-satellite services, but licensing of fixed stations in the United States has been frozen to protect Direct Broadcast Satellite (DBS) operations. The bands 12.7-12.75 GHz (50 megahertz) and 12.75-13.25 GHz (500 megahertz) are allocated on a primary basis to the fixed, fixed-satellite, and mobile services. In the band 12.7-13.25 GHz (along with bands 2025-2110 MHz, 6875-7125 MHz), television translator relay stations may be authorized on a secondary basis to other services. Further, the band 12.75-13.25 GHz is also allocated to the space research service (deep space, space-to-Earth) for reception only at Goldstone, California.

[142] *See* 47 C.F.R. § 2.106.

[143] *See* Appendix 6.3, footnote NG41.

Table 6.5: Table of Frequency Allocations for 10.7-13.25 GHz
(See Appendix 6.3 for footnote text.)

Federal Government	Non-Federal Government	FCC Rule Part(s)
10.7-11.7 US211	10.7-11.7 FIXED NG41 FIXED-SATELLITE (space-to-Earth) S5.441 US211 NG104 US355	International Fixed (23) Satellite Communications (25) Fixed Microwave (101)
11.7-12.1 S5.486	11.7-12.2 FIXED-SATELLITE (space-to-Earth) NG143 NG145 Mobile except aeronautical Mobile S5.486 S5.488	Satellite Communications (25) Fixed Microwave (101)
12.1-12.2		
12.2-12.7 S5.490	12.2-12.7 FIXED BROADCASTING-SATELLITE S5.487A S5.488 S5.490	International Fixed (23) Satellite Communications (25) Direct Broadcast Satellite (100) Fixed Microwave (101)
12.7-12.75	12.7-12.75 FIXED NG118 FIXED-SATELLITE (Earth-to-space) MOBILE NG53	Satellite Communications (25) Auxiliary Broadcasting (74) Cable TV Relay (78) Fixed Microwave (101)
12.75-13.25 US251	12.75-13.25 FIXED NG118 FIXED-SATELLITE (Earth-to-space) S5.441 NG104 MOBILE US251 NG53	

Description of Current and Planned Band Use (10.7-13.25 GHz)

The band 10.7-13.25 GHz has a variety of operations including fixed point-to-point operations, DBS, intercontinental FSS and VSAT FSS, broadcast auxiliary links and cable system backbone links. We also note that this frequency range is the subject of an ongoing Commission proceeding to allow non-geostationary orbit (NGSO) FSS and terrestrial multichannel video distribution and data service (MVDDS) operations on these and other bands through out the Ku-band.[144] We have evaluated each of these bands below to determine the viability of ITFS/MDS operations in this range. For the purposes of this analysis, we have divided the band into four segments: 10.7-11.7, 11.7-12.2, 12.2-12.7, and 12.7-13.25 GHz (*See* Table 6.6: Band Usage 10.7-13.25 GHz).

10.7-11.7 GHz portion. As indicated above, the band 10.7-11.7 GHz is currently allocated on a co-primary basis to the FS, licensed under Part 101 of the Commission's Rules; and to the FSS for international systems (downlinks),[145] licensed under Part 25 of the Commission's Rules.[146] The FS links in this band support a wide array of communication services used by utilities, railroads, telephone companies, state and local governments, public safety agencies, and others. There are currently over 31,000 point-to-point links licensed in this band. The average path length is 32 km (19.9 miles). The channeling plan provides for varied bandwidths from 1.25 to 40 megahertz channels with 500 megahertz separation between the transmit and receive channels. There are also several GSO FSS earth stations for international systems in this band. Currently, there are 10 U.S. licensed geo-stationary (GSO) satellites providing international service and almost 600 downlinks associated with licensed earth stations. Further, this band is also used for telemetry, tracking, and control ("TT&C") functions for the GSO FSS satellites authorized within this band.[147] In 2000, the Commission authorized NGSO

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[144] *See Amendment of Part 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range, et al,* ET 98-206, *First Report and Order and Further Notice of Proposed Rule Making,* 66 Fed. Reg. 10601 (February 16, 2001). ("*NGSO FSS Proceeding*")

[145] *See* 47 C.F.R. § 2.106, footnote NG104.

[146] The GSO FSS operations in the 10.7-10.95 GHz and 11.2-11.45 GHz bands must adhere to the requirements specified in Appendix 30B of the ITU Radio Regulations and are referred to as "planned band" operations. GSO FSS operations are typically less extensively deployed in the Appendix 30B planned bands, as compared to non-planned bands. *See* 47 C.F.R. § 2.106 of the Commission's Rules, footnote 792 A; and ITU RR Footnote No. S5.441 and Appendix 30B of the ITU-R Radio Regulations *Provisions and Associated Plan for the Fixed-Satellite Service in the Frequency Bands 4500-4800 MHz, 6725-7025 MHz, 10.70-10.95 GHz, 11.20-11.45 GHz and 12.75-13.25 GHz*. Use of these frequency bands is also governed by Resolution 130 (WRC-97).

[147] The GSO FSS operations in this band perform TT&C communications to provide data on the spacecraft's functions via a two-way telemetry link between the satellite and the controlling earth station. TT&C communications are used throughout the satellite's life, including the launch and deployment phase. The TT&C function allows the earth station to control both the physical orbital position and internal functioning of the spacecraft.

FSS downlink gateway earth stations in this frequency range.[148] Both the channel loading and the geographical distributions of the incumbent facilities in this band are fairly uniform across the band and across the country, respectively. *See* the map in Appendix 6.4. Moreover, the band 10.7-11.7 GHz was identified in 1993 in the Emerging Technologies proceeding and in 1997 in the mobile-satellite service ("MSS") 2 GHz allocation proceeding as a future home for fixed point-to-point operations to be relocated from the 2 GHz band.[149] (*See* the maps in Appendix 6.5.)

__11.7-12.2 GHz portion__. As mentioned above, the band 11.7-12.2 GHz is allocated in the U.S. on a primary basis for FSS downlinks and is heavily used by television program distribution and VSAT operations. The downlink FSS band 11.7-12.2 GHz is paired with the uplink FSS band 14.0-14.5 GHz. These bands accommodate 25 U.S. licensed GSO satellites, including VSAT operations. Transponders on space stations in the FSS may be used, depending upon certain limitations, for Direct-to-Home (DTH) transmissions. The Commission has also authorized NGSO FSS service downlink operations in this band to user terminals. The band 11.7-12.2 GHz supports over 4,200 links associated with licensed earth stations. We also note that mobile operations are permitted in the band on a secondary basis, but there are only a few mobile operations in the band.

__12.2-12.7 GHz portion__. The band 12.2-12.7 GHz is allocated on a primary basis to BSS for use by DBS systems. The DBS service provides for direct reception of radiocommunications signals by the general public and DBS programming typically includes video distribution, pay-per-view movies, and CD-quality audio channels. The two domestic DBS licenses are DirecTV and EchoStar's DISH Network, which combined service in excess of 15 million customers using 11 U.S. licensed GSO satellites. The FCC rules and regulations for DBS are contained in 47 C.F.R. Part 100. While the band has a primary allocation for the FS, fixed systems licensed in the band after September 9, 1983 must operate on a non-harmful interference basis to the BSS.[150] Currently, there are approximately 400 links in the terrestrial fixed services, with an average path length of 15 km (9.3 miles). In ET Docket 98-206, the Commission allocated this spectrum band for NGSO FSS service downlinks to user terminals and concluded that one-way terrestrial point-to-multipoint operations could be designed around incumbent BSS operations if technical parameters are constrained and systems were designed to protect BSS or mitigate any harmful interference. The specific method of protecting DBS systems from terrestrial interference is the subject of an ongoing proceeding.[151]

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[148] *See NGSO FSS Proceeding*.

[149] *See Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum at 2 GHz for Use by the Mobile Satellite Service*, ET Docket No. 92-9, *Second Report and Order*, 8 FCC Rcd 6495 (1993) ("Emerging Technology proceeding"). *See also First Report and Order & Further Notice of Proposed Rule Making*, ET Docket No. 95-18, 12 FCC Rcd 7388 (1997) ("2 GHz MSS allocation proceeding").

[150] *See* 47 C.F.R. § 101.147(p).

[151] *See NGSO FSS Proceeding*.

12.75-13.25 GHz portion. The band 12.75-13.25 GHz band is allocated on a co-primary basis to fixed, FSS uplink, and mobile operations. This band is primarily used by Part 74 broadcast auxiliary services (BAS), Part 78 cable relay services (CARS), and Part 101 FS operations. Television stations use the fixed allocation for BAS studio-transmitter links and the mobile allocation for electronic news gathering ("ENG"). CARS licensees use this band to send video signals between points in their networks.[152] GSO FSS operations in this band must meet the requirements of the ITU Appendix 30B plan, and Part 2 of the Commission's Rules limits these operations to international systems.[153] Similar to the 10.7-11.7 GHz band, the international system only requirement for GSO FSS uplink operations has limited the number of earth stations in this band.[154] Further, our rules do not currently address coordination between FSS operations and BAS operations, but this is the subject of an upcoming proceeding. The band may also be used for vital TT&C functions for GSO FSS satellites. ET Docket No. 98-206 permitted NGSO FSS uplink gateway operations in this band subject to appropriate coordination and sharing criteria.

This band is used primarily by CARS operations plus BAS, LTTS, and fixed, point-to-point microwave. For the CARS, there are currently 145,281 fixed and 725 mobile links licensed in this band. The fixed operations' bandwidths ranges are 6, 12.5, or 25 megahertz, while the mobile operations use 25 megahertz channel bandwidths. The average path length for fixed operations is 20 km (12.4 miles). The band 12.7-13.25 GHz also supports 2,069 fixed and 2,779 mobile links for BAS, and 636 fixed and 988 mobile links for LTTS. For BAS, the fixed bandwidths are 10 and 20 megahertz channels, and the mobile bandwidth is 25 megahertz, with a 250 megahertz separation between transmit and receive operations. The average path length for fixed operations is 15 km (9.3 miles). The LTTS uses bandwidths of 16, 17, or 25 megahertz for both fixed and mobile operations and an average path length of 21 km (13.0 miles). The band 12.7-13.25 GHz provides 116 uplinks for the 10 GSO satellites mentioned above in the 10.7-11.7 GHz discussion. The channel loading and the geographical distributions of licensed links in this band are shown in maps in Appendix 6.4.

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[152] *See also Petition for Rulemaking To Amend Eligibility Requirements in Part 78 Regarding 12 GHz Cable Television Relay Services*, CS Docket No. 99-250, *Notice of Proposed Rule Making*, 14 FCC Rcd 11,967.

[153] *See* ITU Radio Regulations, Appendix 30B and 47 C.F.R. § 2.106 footnote NG104. We note that there is one licensee using the U.S. Appendix 30B assignment in this band for domestic feeder links for a GSO MSS system.

[154] Our database indicates that there are 9 authorizations issued for GSO FSS earth stations in the 12.75-13.25 GHz band. These authorizations do not indicate the actual number of earth stations or antennas that a licensee might deploy. Additionally, this number may not include several international earth station authorizations issued before 1995 when the IBFS database was created.

Table 6.6: Band Usage 10.7-13.25 GHz

FSS (downlink) International Sat. only	FSS (downlink) VSATs	Direct Broadcast Satellite	FSS (up)	FSS (uplink) International Sat. only
FIXED Point-to-Point Microwave LTTS	Secondary mobile	FIXED Point-to-Point Microwave	FIXED/MOBILE Point-to-Point Microwave BAS, CARS, LTTS	
				Secondary TV Translators
Federal Agency Testing (10.7-11.7 and 12.2-13.25 GHz) Radio Astronomy (passive sensing 12-14 GHz)				NASA space research at Goldstone, CA

10.7 | 11.7 | 12.2 | 12.7 | 12.75 | 13.25

Assessment for ITFS/MDS Operations (10.7-13.25 GHz)

The technical characteristics in the 10-13 GHz spectrum range are significantly different from that experienced at the 2500-2690 MHz band. Consequently, relocation of the ITFS/MDS systems from the 2.5 GHz band to 10-13 GHz would require major changes to ITFS/MDS equipment and network design.

10.7-11.7 GHz (1000 megahertz). Accommodation of ITFS/MDS in the band 10.7-11.7 GHz would be extremely difficult due to the heavy use of FS and the international nature of FSS operations. As noted earlier, this band currently supports over 31,000 FS links and almost 600 FSS downlinks. Sharing between ITFS/MDS and the incumbent users is not feasible because ITFS/MDS are ubiquitous, wide-area systems using broad-beam and omnidirectional antennas, which are not compatible with other operations in the same geographical markets. Segmenting the band into 202 megahertz for ITFS/MDS and 798 megahertz also is impractical due to the heavy use by the incumbent services. Thus, relocating ITFS/MDS into the band 10.7-11.7 MHz would require reaccommodating a portion of the incumbent users into other higher frequency bands. This would be very disruptive to the FS due to the varied bandwidths and the paired operations used by the FS operations. Relocation of the FSS would also need to accommodate the cross-band pairing of this band with the FSS 14 GHz band and would have a significant cost impact to deploy new satellites and earth stations.

11.7-12.2 GHz (500 megahertz) Accommodating ITFS/MDS in the band 11.7-12.2 GHz would be very disruptive to the fixed-satellite services. As mentioned above, this downlink band supports the VSAT, DTH, and NGSO FSS services and the wide-area, ubiquitous nature of

ITFS/MDS services are not compatible with the broad deployment of FSS terminals. If 202 megahertz of spectrum were to be cleared for ITFS/MDS, the incumbent services would have to be relocated into the remaining 298 megahertz of spectrum or be reaccommodated in higher frequency bands. For FSS purposes, this band is paired with the band 14.0-14.5 GHz. Therefore, relocating the FSS operations either into the remaining 298 megahertz of spectrum or relocating into higher bands would require a full realignment of this spectrum. This would create considerable disruption to the incumbent services. Additionally, consideration would have to be made regarding the Commission's recent decision to allow NGSO FSS service downlinks in this spectrum range (ET 98-206). Finally, although not protected, some accommodation of the secondary mobile use in the band 11.7-12.2 GHz band would need to be examined further.

12.2-12.7 GHz (500 megahertz). This band supports the deployment of the DBS operations. (*See* discussion above.) Relocation of ITFS/MDS services into the 12.2-12.7 GHz band would be a severe hardship to the current and future deployment of DBS in this country. Again, sharing of this band between ITFS/MDS and broadcasting-satellites is not feasible due to the inability to coordinate ubiquitous DBS use with a two-way service. Further, we note that segmentation of this band or relocation of the incumbents into higher bands is fraught with difficulty due to the international nature of the broadcasting-satellite services. Recently, there has been considerable growth in the DBS services. Relocation of these incumbent DBS services would require a reconfiguration of the satellites and millions of home terminals. Additionally, further consideration is needed regarding the NGSO FSS downlink proceeding ET 98-206.

12.7-13.25 GHz (550 megahertz) Reaccommodation of ITFS/MDS into the 12.7-13.25 GHz band is impractical due to the band's heavy use by fixed, fixed-satellite, and mobile services. With regard to mobile operations, BAS, CARS, and LTTS pose particular difficulties to sharing between these incumbent services and ITFS/MDS. As discussed in Section 4 above, sharing between ITFS/MDS and mobile operations in the same geographic area is not feasible. Because the incumbent mobile services are dispersed throughout the country, ITFS/MDS could not share with these incumbent operations. Segmentation of the band into 202 megahertz for ITFS/MDS and the remainder for the incumbent services also is not reasonable due to the extensive use of the entire spectrum band by the incumbent services. The band 12.7-13.25 GHz supports approximately 148,000 fixed and 4,500 mobile links licensed in this band. Thus, relocating ITFS/MDS into this band would require reaccommodating a large portion of the incumbent users into higher frequency bands. Due to the propagation characteristics at these higher frequencies (18 GHz or above), the relocated fixed services would require additional facilities to provide the equivalent service ranges. The mobile services would be severely impacted and may not be operational at all due to multipath and signal fading. Such action also would exacerbate current difficulties that already exist with relocating fixed links from the 2 GHz band as laid out in ET Docket 92-9, and those fixed services relocating from the DBS band 12.2-12.7 GHz as noted above. (*See* the maps in Appendix 6.5.)

Other matters. In addition to the points discussed above, there are several Federal Government operations that operate on a non-interference basis. Specifically, NASA operates downlink telemetry, on a non-interference basis, during launch and emergencies in support of the NASA Advanced Communications Technology Satellite Space Program. In the bands 10.7-11.7

and 12.2-13.25 GHz, federal agencies use this spectrum on a non-interference basis for experimental testing for such studies as millimeter wave propagation studies. For radio astronomy, the FSS and FS that operate in the 10.7-11.7 GHz band are urged to take all practicable steps to protect the passive sensing and radio astronomy studies of quasars that are conducted in the adjacent band 10.68-10.7 GHz. Further, the band 12.75-13.25 GHz also is allocated on a primary basis to space research for reception only at NASA's Goldstone, California facility.

Summary (10.7-13.25 GHz)

As described above, ITFS and MDS is not compatible with the incumbent services in the 10.7-13.25 GHz spectrum. The extensive deployment of fixed point-to-point operations in the band 10.7-11.7 GHz poses particular problems to relocation in this band. The growing deployment of VSATs and DBS terminals throughout the country also creates difficulties with relocating ITFS/MDS in either the 11.7-12.2 GHz or 12.2-12.7 GHz bands. The mobile and fixed operations of BAS, CARS, and LTTS also create problems with relocating operations in the band 12.7-13.25 GHz as well. Due to the technical characteristics of ITFS/MDS services, sharing with the incumbent services is not possible in most geographic areas. Therefore, to provide for ITFS/MDS, 202 megahertz of spectrum will have to be cleared by relocating or segmenting all of the incumbent users in that portion of the spectrum. As discussed above, reaccommodating these services in higher bands would severely impact the incumbent users. Moreover, the spectrum in the 10-13 GHz range cannot provide functional equivalency for the ITFS/MDS services due to the considerable technical differences from the 2.5 GHz spectrum range. Therefore, we believe the 10.7-13.25 GHz spectrum is not practical as an alternate band for ITFS/MDS services.

MIGRATION SCHEDULE (2003, 2006, 2010)

If the ITFS/MDS services are relocated to any of the Non-Federal Government bands except the 50 megahertz in the band 7075-7125 MHz, a substantial amount of time would be needed to relocate incumbent satellite operations.[155] Any relocation of FSS or BSS will entail the design, construction, and launch of new satellites at higher satellite frequency bands, which, alone, would take a number of years. GSO satellites are constructed with an expected lifetime of 15 years, and NGSO satellites have a life expectancy of 7 years. Once the satellites are launched, however, there is no way to "relocate" them to different frequency bands. It is therefore not possible to meet a migration schedule that is less than the expected lifetime of the currently operating satellites. Otherwise an existing and valuable resource would be wasted.

On the other hand, relocation of the FS point-to-point operations could start as early as 2003 because each facility could be relocated on an individual, as needed, basis. This is similar to the process being used for the 2 GHz fixed microwave point-to-point operations that are being relocated for emerging technologies, such as PCS, but as fixed operations are forced to higher

[155] All the bands studied have a satellite allocation (*i.e.*, fixed-satellite or broadcasting-satellite), except the band 7075-7125 MHz. *See* Table 6.1, *supra*.

frequencies the technical impact and challenges increase substantially. Mobile operations also could be relocated on an individual as needed basis; however, the technical challenges for mobile communications at higher frequencies is even greater than fixed services and it is highly unlikely that suitable spectrum in nearby frequency bands could be located for these incumbent services.

SECTION 7
ANALYSIS OF COSTS AND BENEFITS

The Study Plan states that for each band option being analyzed (*i.e.*, sharing, segmentation and relocation), the study will estimate and describe the costs to implement each option and any associated assumptions. The estimates should address implementation of the options in 2003, 2006, 2010 or at times where there is a potential cost advantage to do so (*e.g.*, if costs can be mitigated by ceasing further deployment of incumbent systems in the band under study, thereby reducing costs to relocate incumbent systems to alternate bands). The Study Plan also states that the study should estimate and describe the benefits (including assumptions), if any, including potential auction receipts that could be realized as a result of making spectrum available for 3G systems in the frequency band under study. Finally, the study should include a cost and benefit analysis for each option and implementation timeframe under consideration.

In this section, we describe the costs and benefits for ITFS/MDS and future 3G systems if spectrum were made available for 3G systems either through segmentation of the 2500-2690 MHz band or relocation of ITFS/MDS systems to alternate bands, as addressed in Sections 5 and 6, respectively. We identify the types of cost and benefit factors that we considered in our analysis, and we discuss some of these factors in more detail vis-à-vis the segmentation and relocation options that we considered in this study. The analysis in this section is based on information received in response to the *Advanced Wireless Services NPRM*[156] and our independent study. We do not analyze the cost and benefit of making spectrum available for 3G systems by sharing the 2500-2690 MHz band with ITFS/MDS, because, as discussed in Section 4, we conclude that sharing the band among these services would be extremely problematic.

COST AND BENEFIT FACTORS

We have identified certain cost and benefit factors that could reasonably be included in this study, and these are discussed below.

In considering the cost impact to ITFS/MDS to implement any of the segmentation or relocation options under study, we focused primarily on prospective costs to maintain functionality and services. We note, for example, that the relocation policy used to accommodate new PCS entrants in the 1850-1990 MHz bands requires that the new entrants provide incumbent users, who are being moved out of the band, with comparable facilities, which are evaluated in terms of throughput, reliability and operating costs.[157] This approach assumes a continuing public benefit by maintaining ITFS/MDS functionality and services, and focuses on the costs necessary to maintain this benefit. We did not analyze what benefits, if any, might accrue to ITFS/MDS entities under the segmentation or relocation options. For example, we considered the cost to deploy additional cell sites to maintain a desired service area and the

[156] *See* Section 1, *supra*.

[157] *See, e.g.*, 47 C.F.R. §§ 101.69-101.83.

cost to acquire new equipment, which may not yet be available, at higher frequency bands. To the extent possible, we considered costs for analog and digital, one-way and two-way systems. If functionality could not reasonably be maintained (*e.g.*, segmentation of the 2500-2690 MHz band), we considered lost opportunity costs from fewer customers or fewer services. In the segmentation and relocation discussions that follow, we explain in more detail the cost factors used in analyzing those options.

We recognize that by focusing on prospective costs to maintain functionality and services, our analysis does not include certain costs incurred by ITFS/MDS entities for the current and planned deployment of services in the 2500-2690 MHz band. For example, the auction of MDS wide-area licenses in 1995-1996 generated winning net bids of $216.2 million. Sprint and WorldCom have spent over $2 billion to acquire numerous incumbent MDS licenses after the FCC decided to allow the deployment of two-way systems in the 2500-2690 MHz band.[158] MDS entities also have numerous lease arrangements with ITFS licensees. If these lease arrangements are not maintained, ITFS licensees could lose significant revenues and in-kind compensation to support their educational missions.[159] These cost factors present legal and policy issues that are beyond the scope of this proceeding and estimates of the costs cannot reasonably be made at this time. Therefore, we do not include them in our analysis for purposes of this study.

Our analysis did not consider the costs to deploy 3G systems in the 2500-2690 MHz band nor the potential benefits to prospective providers of 3G services. At this time, we do not have a record on which to base cost estimates for different types of systems or different types of services that may be deployed. Further, we can only speculate on the potential public benefits that could be realized as a result of making spectrum available for 3G systems in the 2500-2690 MHz band. For example, we assume that if spectrum in the 2500-2690 MHz band were made available for 3G use, the spectrum would be licensed under competitive bidding processes. The amount of revenue that might be generated by any auction depends on a number of factors, including the amount of spectrum made available, the state of technology, the extent to which the spectrum is encumbered, and volatility in capital markets. Other factors also may affect the proceeds generated by a spectrum auction.

We have not attempted to estimate the amount of revenue that might be generated if spectrum in the 2500-2690 MHz band were made available for 3G use, but some information is available that suggests auctions of spectrum for 3G use could generate significant revenue. The Congressional Budget Office (CBO), for example, has provided projections of receipts from FCC spectrum auctions[160] likely to occur between now and 2007 when the FCC's statutory

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[158] Sprint has spent $1.24 billion to acquire MDS licenses in 90 markets; WorldCom has spent $1.1 billion to acquire licenses in 78 markets.

[159] The National ITFS Association (NIA) estimates that typical lease arrangements between ITFS licensees and MDS operators could generate earning of approximately $7.2 billion over the next 15 years for ITFS licensees. *See* NIA Supplemental Comments (filed March 20, 2001) at 6-7.

[160] This information is available at the CBO's webpage, www.cbo.gov.

authority to conduct spectrum auctions expires.[161] The CBO's recent projections, which are based on past auctions and private sales of comparable licenses, were recently revised upward based on higher prices paid recently for spectrum licenses.[162] The CBO projects that spectrum auctions will bring in $1 billion in 2001, between $4 billion and $10 billion each year from 2002 to 2004, and smaller amount in subsequent years. These projections assume that some of the auctions will be for spectrum for 3G use. We also note that the FCC recently completed an auction for certain PCS spectrum, which could be used for 3G systems, and a total of $16.8 billion in net high bids was received.[163] Thus, this auction alone exceeded the CBO projection for 2001.

Finally, both advanced wireless mobile and fixed services have the potential to provide numerous benefits to the public. The FCC noted in its *Fifth Competition Report* on commercial mobile services[164] that although only about two percent of mobile traffic is currently data, substantial growth is expected in the future. The *Fifth Competition Report* pointed to one forecast that wireless data subscribers will outnumber wireline data subscribers by 2002 and another that predicts at least $35-$40 billion in revenues by 2007—an annual growth rate of 25 to 30 percent—and 100 million subscribers using some form of mobile data.[165] An October 2000 Council of Economic Advisers' Report estimates the annual consumer benefits of 3G services to be in the range of $53-111 billion.[166]

The potential market for fixed wireless services also is promising. We noted in the Interim Report that available evidence indicates that over the next several years the demand for affordable broadband services in the United States will far outpace the ability of incumbent local exchange carriers and cable operators to provide those services.[167] The U.S. market for fixed

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[161] *See* 47 U.S.C. § 309(j).

[162] *See* "Military, Industry Not In Lockstep On 3G Spectrum Issue" *Communications Daily*, February 16, 2001. The article states that the "Senate Budget Committee bulletin this week said Congressional Budget Office (CBO) had 'dramatically' raised its estimate of spectrum auction receipts by $10 billion over previous baseline. CBO increased baseline 55% to $28 billion over 2002-2007. It attributed change to 'market enthusiasm' for 3G and cited $17 billion generated by FCC's C-block auction last month."

[163] This auction was for C and F Block broadband PCS licenses that were in default. The auction began on December 12, 2000 and closed on January 26, 2001. *See* http://www.fcc.gov/wtb/auctions/

[164] *See Annual Report and Analysis of Competitive Market Conditions with Respect to Commercial Mobile Services*, *Fifth Report* (*Fifth Competition Report*), FCC00-289, released August 18, 2000.

[165] *Id.* at 34-35.

[166] *See The Economic Impact of Third-Generation Wireless Technology.*

[167] Analysts estimate that for a variety of technical, financial and operations reasons, cable modem and xDSL services cannot or will not meet the increasing demand for broadband by themselves. *See, e.g., The Wall Street Journal*, "[t]he cable industry's rush to wire up America with high-speed Internet access is running into a serious problem: Too many heavy Internet users are crowding online at once, in some cases creating major bottlenecks and slowdowns." Cauley, "Heavy Traffic is Overloading Cable Companies'

wireless broadband services is expected to increase from $767 million in 1999 to $7.4 billion by 2003,[168] with the total number of fixed wireless broadband subscribers predicted to increase from 200,000 this year to 9.4 million in 2005.[169]

SEGMENTATION

In Section 5, we analyzed the effect on ITFS/MDS of segmenting the 2500-2690 MHz band if 90 megahertz of spectrum were reallocated for 3G systems use. We considered three optional band plans for making this spectrum available for 3G systems. Our analysis shows that each of the optional band plans would have significant impacts on ITFS/MDS if the 90 megahertz of spectrum were not replaced with spectrum from another band, and ITFS/MDS entities had to operate on no more than 100 megahertz of remaining spectrum in the band. First, incumbent one-way ITFS/MDS systems, both analog and digital, would have to be accommodated in the remaining 100 megahertz of spectrum. Second, segmentation would have one of two results for two-way ITFS/MDS systems: either ITFS/MDS deployment would be significantly constrained with substantial reductions in customers served or services provided, or additional cell sites would have to be deployed to maintain service areas. Our analysis is consistent with views expressed by several commenters in response to the *Advanced Wireless Services NPRM.*[170]

New Internet Lines," *The Wall Street Journal*, at B1, B16 (Mar. 16, 2000). In addition, the need for cable operators to upgrade their plant for two-way capability (particularly in less densely populated areas) and the business strategies of the large cable MSOs suggest that cable modem service will not be ubiquitously available. *See Broadband! - A Joint Industry Study by Sanford C. Bernstein & Co., Inc. and McKinsey & Company, Inc.*, at 25-26 (January 1999). ("The nature of smaller and more rural systems -- often with less access to capital; less threat of competition; and less dense and, therefore, more expensive plant to upgrade -- keeps our forecast for [non-MSO] systems at about 15% upgraded. . . It's worth pointing out that many of the cable upgrades to date appear to be targeted at the most attractive neighborhoods (*i.e.*, high densities and high household incomes). On a homes-passed basis, we estimate that about 60% (12 million) of all high-income households in the U.S. are passed by upgraded cable plant.") (the "Bernstein/McKinsey Study"). Ubiquitous xDSL services are unavailable due to factors that include "loop length (if loops are too long), presence of non-DSL compatible remote terminal technology (such as nearly all the legacy variety of digital loop carrier systems) as well as other aspects of deployed line electronics, such as load coils and bridge taps." Bernstein/McKinsey Study at 25. Indeed, it has been estimated that existing telephone plant is "DSL capable" in only 44% of the residential market. *Id.* at 26. *See also Next-Generation Networks Exploit Last-Mile Bandwidth*, *TR's Last-Mile Telecom Report* (Feb. 24, 2000) <http://www.tr.com/newsletters/lmtr/sample.html> (quoting officer of Bell Atlantic Network Services as referring to DSL as an "interim strategy"); Cauley, "For Phone Companies Wiring the Web, a Surprising Speed Bump," *The Wall Street Journal*, at B1 (Feb. 17, 2000).

168 "The Broadband Fixed Wireless Services Market Gains Momentum, According to IDC," *PR Newswire* (Dec. 13, 1999). All totaled, it has been estimated that by the year 2005, seventy percent of the nearly 10 million estimated fixed wireless broadband subscribers will be served via ITFS/MDS.

169 Smith, "Wireless Rides To The Rescue," *Wireless Week*, at 16 (Feb. 7, 2000).

170 *See, e.g.*, Comments filed by The Wireless Communications Association, Inc. (WCAI), Sprint Corporation (Sprint), Cisco Systems, Inc. (Cisco). WCAI submitted a study prepared by HAI

As we have noted throughout this study, the current use of the 2500-2690 MHz band by ITFS/MDS is very complex and is not uniform from one geographic area to another. Consequently, each of the segmentation options considered in this study would have different impacts on ITFS/MDS, depending on the geographic area under review. Thus, it is not possible to provide one cost estimate to implement each of the segmentation options considered. Rather, we have looked at several specific cost factors, which would apply in most cases, and in each geographic area the implementation costs would reflect the types of use that exist.

Under each of the segmentation options, some traditional one-way ITFS and MDS operations would have to be moved into the remaining spectrum. We noted in Section 5 that approximately 60,000 transmitters would be affected by the segmentation options studied. Generally, these systems transmit using standard 6 megahertz composite NTSC video/audio modulation. ITFS licensees may use a 125 kHz response station transmitter at receive sites, which operate using wideband FM modulation. Based on information provided by one commenter to the *Advanced Wireless Services NPRM*, the cost to relocate this type of facility could be approximately $500,000.[171] We also noted in Section 5 that if some ITFS/MDS operators using multiple channels converted their systems to digital modulation, spectrum use in the band would be more efficient. Digital modulation may be a viable option only for those operators using multiple channels, so the ability to compress these uses into the least number of channels will vary from one geographic area to another. Of course, converting one-way systems to digital modulation would entail another cost to ITFS/MDS operators.

The relocation of incumbent one-way systems into the remaining spectrum is only one factor that would exacerbate the difficulty of operators of two-way digital systems in the band finding sufficient spectrum. Each of the segmentation options also would require guardbands between ITFS/MDS and 3G operations, further reducing the amount of spectrum available for

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Consulting, Inc. titled "MDS/MMDS/ITFS Two-Way Wireless Broadband Service; Spectrum Requirements and Business Case Analysis" (HAI Study).

[171] The Association of American Public Television Stations ("APTS") states that WITF, a public television ITFS licensee in Pennsylvania with 16 ITFS channels and 4 sites, calculates that its total costs to relocate would be $420,500. This includes the cost of transmitters, combiners, feed lines, antennas, and receive equipment. APTS states that because these costs represent only replacing certain analog equipment, they do not necessarily provide a complete assessment of the equipment costs that would be incurred upon relocation of an ITFS licensee to some other band where equipment has not yet been developed and propagation characteristics and other engineering factors may be different. Also, APTS states that there may be additional relocation costs attributable to professional or other personnel costs; securing additional transmitter sites, transmission equipment and backhaul links, or more expensive receive site equipment; loss of operational and maintenance support; lost revenues from the invalidation of excess capacity agreements that would otherwise be used to support a station's educational mission; and costs related to the impairment of the station's educational services during the time of transition and thereafter. *See* APTS *ex parte* communication, ET Docket 00-258, March 20, 2001.

two-way ITFS/MDS systems.[172] As noted in Section 5, the amount of spectrum available for two-way systems would vary depending on the size and number of guardbands. Taking into account accommodation of incumbent one-way systems (which would vary depending on geographic area) and guardbands, the amount of spectrum available for two-way systems would range from 52-82 megahertz for option 1, 64-94 megahertz for option 2, or 58-88 megahertz for option 3.

Guardband requirements themselves impose additional equipment costs on both manufacturers and service providers, since manufacturers would have to modify, for example, channel filtering, duplexers, and cellular reuse patterns.[173] In addition to the costs to manufacturers to reengineer equipment for use in the band, operators would be penalized by the one or more years needed to redesign and deploy new equipment.[174] This would delay the introduction of new broadband services in many markets and to many educational users. At a time when the provision of high-speed data services to residential and business users is expected to increase rapidly, MDS entities may lose the opportunity to enter some markets as a competitor to DSL and cable modem services.[175]

The significant reduction in spectrum available to deploy two-way systems in the band would impair the ability of ITFS/MDS operators to deploy service as planned. Operators would either have to accept the reduction in system capacity and thus serve fewer customers or provide fewer services, or increase system capacity by adding additional cells. With reduced spectrum and system capacity, operators may not be able to offer data services at speeds sufficient to compete with alternative technology such as DSL or cable modem service.[176] If the number of subscribers is significantly reduced, operators would not have a sufficient revenue source to make the systems profitable. For example, Cisco studied the impact on two markets if 90 megahertz of spectrum were no longer available for two-way ITFS/MDS systems. In one large market, the system would experience nearly a 71 percent loss of capacity, reducing the number of subscribers reached from 84,000 to 24,000 households; in a small market, system capacity would be reduced by one-half, with subscribers reached decreasing from 7,500 to 3,8000 households.[177]

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[172] Cisco estimates that guardbands could reduce spectrum availability for ITFS/MDS by up to 54 megahertz.

[173] *See, e.g.,* Cisco Comments at 9-11. Cisco states that its equipment, which was designed without taking into account adjacent mobile operations, would need 18 megahertz of guardband and thus would have to be reengineered.

[174] *See, e.g.,* Cisco Comments at 10. Cisco cites the need to redesign both hardware and software; revisit component supply chains and partner agreements; duplicate lab and field trials; and reinitialize manufacturing plants.

[175] *See, e.g.,* Cisco Comments at 11.

[176] *See, e.g.,* HAI Study at 6.

[177] *See* Cisco Comments at 11-13.

As already noted, an ITFS/MDS two-way system could add cells in order to maintain functionality and services under any of the segmentation options. As noted in Section 3, two-way ITFS/MDS systems have been designed to use a variety of network configurations. Generally, operators intend to use one supercell in small markets or rural areas, and sectorized cells or additional cells in large markets. System capacity can be increased in most markets to meet increased demand by sectorized cells or additional cells. Several commenters to the *Advanced Wireless Services NPRM* addressed the costs, both to ITFS/MDS operators and to the public, to add additional cells to address spectrum reduction rather than increased demand.[178] The consensus of these commenters is that the deployment of additional cells would increase operators' costs significantly, reduce profitability, and jeopardize the ability to introduce broadband services in rural or smaller markets.

The HAI Study presents analysis developed from an engineering-economic model that calculated capital investment requirements, operating expenses and revenue projections for a "normalized" two-way ITFS/MDS operation in a given market over a ten-year study period. The HAI Study examined the impacts for five sample markets of varying sizes[179] using a generic business case. The key drivers for the model were investment costs, market size as measured by households in the sample markets; 10th year subscriber penetration targets (the demand function); subscriber service levels and pricing; and the amount of spectrum available in the market.[180] The penetration targets drive subscribership and capacity requirements, which in turn generate investment requirements and operating expenses.

The HAI Study reached the following conclusions. Except for the smallest sample market, all sample markets had to be multi-cell markets to have enough capacity to meet subscriber targets, and in larger markets the number of cell sites increased by a factor of 2.7.[181] Capital investment requirements increased in all sample markets, and the total capital requirement for the industry would increase from $2.705 billion to $8.975 billion, a threefold increase. Operating expenses also would increase significantly, so that over a 10-year period cumulative operating expenses would rise from $5.3 to $6.5 million in the smallest sample market and from $43.3 to $74.9 million in the largest sample market. Further, the 10-year rate of

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[178] *See, e.g.*, Comments filed by WCAI, Cisco, Sprint and WorldCom.

[179] The sample markets, based on BTA population, ranged in size from 100,000 to 18,750,000 POPS and from 38,206 to 7,156,489 households.

[180] As noted in Section 5, HAI assumed that 158 megahertz of spectrum (26 six megahertz channels, plus an additional 2 megahertz) would be available to each ITFS/MDS two-way system. Reducing the amount of available spectrum by 90 megahertz reduces the available spectrum to 11 six megahertz channels. *See* HAI Study at 5-6. Cisco states that its network design assumed 162 megahertz of spectrum available in dense urban markets using a micro-cell architecture, and 132 megahertz in small markets using a single super-cell configuration. *See* Cisco Comments at 7.

[181] In the large market they studied, Cisco found that base station deployment would triple. *See* Cisco Comments at 12.

return on investment for all sample markets would be negative.[182] Finally, the net present value of costs that would be incurred by ITFS/MDS operators over the ten-year period as a result of a 90-megahertz spectrum reduction would be about $19 billion.[183]

Cisco performed a cost analysis for one large market, estimating the increased capital and operational expenses over a five year period, and extrapolated these figures to the top 100 Metropolitan Statistical Areas (MSAs). Cisco states that the capital and operational expenses to deploy broadband fixed wireless in the top 100 MSAs would increase by $5.19 billion over the first five years, from $12.15 billion to $17.34 billion.[184]

These studies have significant implications for future deployment of two-way ITFS/MDS in the 2500-2690 MHz band if the band was segmented and spectrum made available for 3G systems. In the remaining spectrum, two-way systems would not likely be deployed in most small markets or rural areas, and, depending on the circumstances, two-way systems may not be profitable in some large markets as well. By and large, two-way systems have not yet been deployed in the 2500-2690 MHz band, although operators have plans to begin deployments later this year once the initial application processing for two-way systems is complete. If the band was segmented and new two-way system applications were limited to certain portions of the band, the relocation expenses that new entrants in the band would have to pay would be mitigated. Under the Commission's current relocation policy, incumbents are entitled to relocation costs only for those links that pose an interference problem, and thus incumbents would not receive compensation for future systems for which they have not applied or which have not been licensed.[185] On the other hand, if it were not profitable for incumbents to assume the costs to deploy two-way systems in the remaining spectrum, the public would lose the benefits that could be realized by introducing competitive broadband services, especially in many small markets or rural areas.

RELOCATION

In Section 6, we identified and analyzed potential alternate frequency bands for ITFS/MDS: 3700-4200 MHz, 5925-6425 MHz, 6425-7125 MHz, 7125-8500 MHz, and 10.7-13.25 GHz. Our analysis shows that each of these bands is already heavily utilized by other services, and that relocating ITFS/MDS operations anywhere in this spectrum would be highly problematic. Relocating ITFS/MDS to any of these alternate bands would require that incumbent operations in these bands also would have to be relocated. This secondary relocation,

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[182] *See* HAI Study at 24-28.

[183] *See* WCA Supplemental Comments, March 21, 2001, at 4-5.

[184] *See* Cisco Comments at 12.

[185] *See, e.g.*, 47 C.F.R. § 101.75. *See also* 47 C.F.R. § 101.79, which specifies sunset provisions for incumbent licensees in the 1850-1990 MHz, 2110-2150 MHz, and 2150-2160 MHz bands. In those bands, emerging technology licensees are not required to pay relocation costs to incumbents ten years after the voluntary negotiation period begins for the first emerging technology licensees.

plus the time needed to develop ITFS/MDS equipment for use in any of the alternate bands, would add costs and delays to implementation of the relocation option.

Few comments filed in response to the *Advanced Wireless Services NPRM* addressed ITFS/MDS relocation cost issues, and only one provided cost estimates for relocating traditional ITFS facilities. The National ITFS Association ("NIA") estimates that relocation costs for traditional ITFS facilities, which are generally one-way analog systems used for distance learning, would be approximately $19 billion over 15 years.[186] Although NIA's cost estimates are not band-specific, NIA assumes that any ITFS relocation band would be above 3 GHz and, because of differences in propagation characteristics as compared to the 2500-2690 MHz band, numerous additional transmitter sites would be needed. NIA also assumes that equipment would have to be developed to operate in a higher band, and that the cost of this equipment would be significantly higher than current equipment for video/data transmission and reception.

NIA breaks its estimates into facility replacement costs, increased operation and maintenance costs, and lost lease revenues. With respect to facility replacement costs, NIA assumes that at least three transmitter sites would be required to replicate current ITFS coverage at 2500-2690 MHz, thus increasing all costs related to transmitter sites, as well as adding new tower and backhaul costs. NIA further assumes that equipment costs would be higher due to the technical challenges of the higher band and the lack of opportunity of joint development with MDS operators. Finally, NIA assumes that substantial costs would be involved for removal and reconstruction of existing sites, including engineering, shipping and insurance, and removal and installation of transmitters. NIA estimates the total cost of replacing 2400 existing ITFS stations[187] as $3.7 billion.[188]

Unlike our relocation analysis in Section 6, NIA assumes that any relocation would result in the termination of the ITFS/MDS partnership, thereby increasing ITFS licensees' costs and decreasing their revenues.[189] With respect to ITFS operation and maintenance costs, NIA assumes that ITFS licensees would have to bear several costs that are now being borne by their MDS partners such as transmitter site rental costs, utilities, and other non-personnel and depreciation costs for transmitter sites. NIA estimates that these costs would total about $7.9 billion over the 15-year lease period that typically exists at present between ITFS licensees and MDS operators.[190] NIA also assumes that, over the typical 15-year lease period, ITFS licensees would lose significant revenues, which are used to support ITFS operations and other

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[186] *See* NIA Supplemental Comments of March 20, 2001, at 4.

[187] NIA states that 2400 existing ITFS stations account for 8000 licensed ITFS channels with 8000 transmitters, 2000 combiners (one for every four channels), and 1200 transmission lines and antennas (two for each site). NIA also states that there are approximately 700,000 ITFS receive sites. *Id.*

[188] *Id.*

[189] *Id.* at 3-4.

[190] *Id.* at 5-6.

educational endeavors. NIA assumes that ITFS licensees would collect 5% of the revenues of broadband wireless systems in the 2500-2690 MHz band, and if those lease revenues are foregone, NIA estimates the loss to ITFS licensees over 15 years to be $7.2 billion.[191]

In addition to NIA's cost estimates for relocating traditional ITFS systems, we make the following general observations about the potential costs to implement the relocation option for ITFS and MDS in any of the frequency bands studied.

If relocation of ITFS/MDS incumbents were attempted, it is likely that relocation costs would be lowest in the 3700-4200 MHz band, but they still could be significant. Both Cisco and the HAI Study note that the ITFS/MDS equipment for two-way systems now being used in the 2500-2690 MHz band has been adapted from designs used in the 1.9 GHz and 2.4 GHz bands, and could not be used beyond 3 GHz, thereby requiring equipment reengineering above 3 GHz.[192] Cisco considered the impacts on equipment reengineering and deployment if ITFS/MDS lost 100 megahertz of spectrum in the 2500-2690 MHz that was replaced with 100 megahertz in the 3700 MHz band.[193] This switch to dual-band operation would impose costs on equipment manufacturers and service providers, as well as delay market entry by one to two years. Cisco notes that the RF components for both the base stations and subscriber units would have to be reengineered, and, for example, that the cost of customer premises equipment ("CPE") would rise by about 25 percent.[194] Cisco further contends that because of changes in signal propagation, the coverage area of a cell with a 20 mile radius at 2500-2690 MHz, would shrink to less than a 14 mile radius at 3700 MHz.[195] This reduction in coverage would negatively affect provision of service in smaller markets and rural communities.

The HAI Study provides cost estimates for some of the above functions in the 2500-2690 MHz band.[196] While that study did not examine the costs of relocating ITFS/MDS users from the 2500-2690 MHz band, we believe the study has some relevance since costs for some of the following representative items would likely be more at higher frequency bands.

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[191] *Id.* at 6-7.

[192] *See* HAI Study at 9; Cisco Comments at 14.

[193] Cisco Comments at 13.

[194] *Id.* at 13-14.

[195] *Id.* at 15.

[196] *See* HAI Study at 19-22.

- Supercell fixed site investment for upstream sectorization: $700,000 for omnidirectional antennas, $1.1 million for four sectorized antennas, and $1.7 million for ten sectorized antennas (does not include radios).[197]
- Multicell fixed site investment: $850,000 (plus another $150,000 per market for Internet Protocol switching/routing).[198]
- Backhaul microwave system (dedicated) between the hub site and the local exchange carrier ("LEC"): $145,000 for a DS-3 system with hot-standby redundancy.
- Backhaul system (leased): monthly lease of $3000 per DS-3, and a monthly charge of $20,000 per high-speed (OC-3) connection between the LEC and the Internet Service Provider.
- Residential subscriber acquisition cost: $700 for CPE initially, declining to $350 in the tenth year; and $350 for installation, declining to $200 in the tenth year.
- Commercial subscriber acquisition cost: $700 for CPE initially, declining to $350 in the tenth year; and $500 for installation, declining to $300 in the tenth year.

While it is not possible to estimate what the above costs would be in other bands, it is likely that in general they would be higher in the 3700-4200 MHz band, and significantly higher above 6 GHz. Because of poorer propagation in higher bands, more cells would have to be added to maintain the same quality of service, and such an addition would cause investment costs to be multiplied by however many additional cells were required. Additionally, subscriber acquisition costs would likely be higher in each of the candidate relocation bands.

Further, since all of the candidate relocation bands are heavily utilized, secondary relocation costs would have to be taken into account, *i.e.*, incumbents in the relocation bands would themselves have to be relocated to accommodate ITFS/MDS users. We believe that these secondary costs can be very roughly estimated by looking at past and anticipated future relocation costs for fixed, mobile, and GSO satellite systems. We estimate these costs as follows: for fixed point-to-point systems, we use a cost of $250,000 per link; for fixed point-to-multipoint systems, we use a cost of $3,500 per link; for mobile systems, we use a cost of $150,000 per link; and for GSO satellite systems, we use a cost of $450 million per satellite.[199]

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[197] This estimate includes towers, antennas, transmission lines, transmitter combiners, receive multicouplers, duplexers, backup power, network management and monitoring equipment, and IP switching/routing. *Id*. at 19.

[198] This estimate includes towers, antennas, transmission lines, transmitter combiners, receive multicouplers, duplexers, backup power, network management and monitoring equipment, and fixed investment for the radio system. *Id*. at 20.

[199] For fixed point-to-point links, we use the $250,000 per link figure specified for Personal Communications Services relocation; *see* 47 C.F.R. § 24.243(b). For fixed point-to-multipoint links, our research indicates that the cost of approximately 70-72 point-to-multipoint links equals the cost of one point-to-point link, and $250,000 divided by 70-72 equals about $3,500. For mobile links, our research indicates that such links are generally about $100,000 less expensive than fixed point-to-point links; therefore, we use a figure of $150,000 per mobile link. For GSO satellite systems, our research indicates that an average system costs about $400-500 million to construct and launch; therefore, we use a figure of $450 million per GSO satellite. All of these figures are rough approximations that we feel are adequate

These cost assumptions result in the following total relocation cost estimates for each band, except for the 7125-8500 MHz band, which is used by Federal Government systems.

3700-4200 MHz band:
Total relocation estimate is approximately $10.625 billion.

- Fixed Systems (approximately 11,000 point-to-point links)--$2.75 billion;
- Satellite Systems (35 GSO satellites)--$15.75 billion, including companion 5925-6425 MHz band, or $7.875 billion per band.

5925-6425 MHz band:
Total relocation estimate is approximately $17.5 billion.

- Fixed Systems (approximately 38,500 point-to-point links)--$9.625 billion;
- Satellite Systems (35 GSO satellites)--$15.75 billion, including companion 3700-4200 MHz band, or $7.875 billion per band.

6425-7125 MHz band:
Total relocation estimate is approximately $10.2 billion.[200]

- Fixed Systems (approximately 32,000 point-to-point links)--$8 billion;
- Mobile Systems (approximately 2,800 links)--$0.4 billion;
- Satellite Systems (4 satellites) -$1.8 billion.

10.7-13.25 GHz band:
Total relocation estimate is approximately $30.4 billion.

- Fixed Systems (approximately 34,000 point-to-point links at $8.5 billion and approximately 145,000 point-to-multipoint links at $0.5 billion)--$9.0 billion;
- Mobile Systems (approximately 4,500 links)--$0.7 billion;
- Satellite Systems (46 GSO satellites)[201]--$20.7 billion.

SUMMARY

Deployment of both 3G and fixed wireless broadband systems will provide considerable benefits to prospective users and the national economy. Implementation of either the segmentation or relocation options analyzed in this band study, however, would significantly affect ITFS/MDS deployment and impose considerable costs on both private entities and the public. Segmentation would require considerable time and costs to reengineer and deploy systems utilizing much less spectrum than is now allocated. Furthermore, delivery of fixed

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for the purposes of this report, but that should not be used in other contexts where greater accuracy is required.

[200] This estimate does not include an estimated cost of a number of low-earth orbit and digital audio radio satellite services feeder links that operate in the 6700-7075 MHz band, which would be significant.

[201] We note that this number includes 25 satellites that operate in the 11.7-12.2 GHz band, which is paired with the 14.0-14.5 GHz band.

wireless broadband services to the public and educational users would be delayed and, in rural areas or smaller markets, may never be realized. Relocation also would require considerable time and costs to reengineer and deploy systems in alternate frequency bands. Again, delivery of service would be delayed or never realized. The relocation option also would require other services to relocate, and the time and costs to move those additional services would be significant.