# Spectrum Reallocation Final Report

Response to Title VI - Omnibus Budget Reconcilliation Act of 1993

U.S. Department of Commerce
Ronald H. Brown, Secretary

Larry Irving, Assistant Secretary for Communications and Information, and Administrator, National Telecommunications and Information Administration

February 1995

The publication of this report marks the completion of NTIA's tasks that were mandated in Title VI of the Omnibus Budget Reconciliation Act of 1993 (Act). In this report NTIA identifies radio frequency spectrum that will be reallocated from Federal to Non-Federal use. As directed by the Act, the Secretary of Commerce has forwarded this report to the President, to the Congress, and to the Federal Communications Commission.

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# SPECTRUM REALLOCATION FINAL REPORT

*Response to Title VI - Omnibus Budget Reconciliation Act of 1993*

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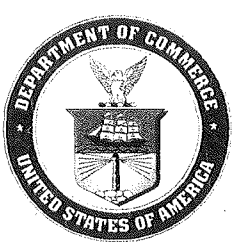


**U.S. DEPARTMENT OF COMMERCE**
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The authors wish to thank the many organizations and persons who contributed to the completion of this report. In particular, we wish to thank the Federal agency representatives on the Interdepartment Radio Advisory Committee for providing vital comments and information used in describing Federal Government radio spectrum use and potential impact of reallocation. We also acknowledge the written and verbal comments provided by industry and amateur radio representatives during the public comment process, open public meetings, and "one-on-one" discussions.

We also wish to thank the many contibuting NTIA employees especially Cesar Filippi, Russ Slye, Fred Matos, and Paul Roosa for many suggested quality improvements to the text, and Betty Bertier and Cathleen Kelly for editorial assistance.

# EXECUTIVE SUMMARY

On behalf of the Secretary of Commerce, the National Telecommunications and Information Administration (NTIA) has prepared this final report as required by Title VI — Communications Licensing and Spectrum Allocation Improvement — of the Omnibus Budget Reconciliation Act of 1993. This report identifies radio spectrum currently used by the Federal Government for reallocation to the private sector.

Title VI requires the Secretary of Commerce to provide from the spectrum allocated for Federal use, an aggregate of at least 200 megahertz (MHz) for allocation by the Federal Communications Commission (FCC) to non-Federal users. This action is intended to benefit the public by promoting the development of new telecommunications technologies, products, and services that use the spectrum. As the first step in that process, NTIA prepared a Preliminary Spectrum Reallocation Report identifying candidate frequency bands for reallocation. That report, released on February 10, 1994, was submitted to the President, the Congress, and the FCC, and made available to the public, in accordance with Title VI.

The Preliminary Report was prepared using the Title VI requirements regarding the amount of spectrum to be provided, the degree of sharing permitted, and the timetable for reallocation. Thus, the Preliminary Report identified 50 MHz for immediate reallocation and proposed 150 MHz for delayed reallocation with an associated schedule.

Upon release of the Preliminary Report, a 90-day period was provided for public comment, followed by a second 90-day period in which the FCC prepared and submitted to the Secretary of Commerce a report, including an analysis of the public comments together with additional comments and recommendations. The table on page iv provides the final list of frequency bands identified for reallocation based on Title VI criteria, the Preliminary Report, comments from Federal agencies and the public, and the FCC Report.

The paragraphs below provide an overview of the reallocated bands, indicating the Federal usage, transition timetable, and any needed sharing requirements for each band identified for reallocation, and an overview of reported Federal implementation costs.

## OVERVIEW OF REALLOCATED BANDS

The radio spectrum allocated for Federal use, especially in bands below 5 GHz, is intensely used for a variety of purposes including support of the private sector. Identifying spectrum for reallocation involved consideration of two overriding and sometimes competing factors: (1) the impact on the Federal agencies, in terms of mission impact, costs, and potential reduction of services to the public, and (2) the benefits expected to be realized by the public. Taken in the aggregate, public comments on the Preliminary Report supported the process established in Title VI, and expressed interest in the following issues: reallocation of additional spectrum for a variety of new technologies; adoption of a more rapid reallocation schedule; and minimization of impact on existing non-Federal use of spectrum currently shared with Federal users.

Responses to the Preliminary Report from Federal agencies, however, raised significant concerns regarding operational impact and implementation costs, which are estimated to exceed $500 million. Significant impediment to the ability of Federal agencies to perform their missions and a reduction in services provided to the public were widely regarded as unacceptable tradeoffs. In complying with the

## Spectrum Reallocation Final Plan

| Bands Identified for Reallocation (MHz)[A] | Reallocation Status[B] | Reallocation Schedule |
|---|---|---|
| 1390 - 1400 | Exclusive | January 1999 |
| 1427 - 1432 | Exclusive | January 1999 |
| 1670 - 1675 | Mixed | January 1999 |
| 1710 - 1755 | Mixed | January 1999/2004[C] |
| 2300 - 2310 | Exclusive | August 1995 |
| 2390 - 2400 | Exclusive | Reallocation Complete |
| 2400 - 2402 | Exclusive | August 1995 |
| 2402 - 2417 | Exclusive | Reallocation Complete |
| 2417 - 2450 | Mixed | August 1995 |
| 3650 - 3700 | Mixed | January 1999 |
| 4635 - 4660 | Exclusive | January 1997 |
| 4660 - 4685 | Exclusive | Reallocation Complete |

A 225 - 400 Although not a part of this reallocation plan, ongoing discussions within the Federal Government regarding long range plans for the 225-400 MHz band will address non-Federal spectrum requirements, including the views expressed by the FCC in its upcoming report to Congress on the spectrum needs of public safety agencies.

3625 - 3650 Expanded non-Federal use of these bands
5850 - 5925 is being addressed jointly by NTIA and the FCC.

B Federal stations that will continue operation in certain bands are listed in Appendices E & F.

C Earlier availability date applies only to the 25 largest U.S. cities and is further subject to timely reimbursement of Federal costs, including reimbursement directly from the private sector. See Section 4 for details.

requirements and band selection criteria of Title VI, this final spectrum reallocation plan establishes a reasonable balance between the spectrum needs of non-Federal users and those of the Federal Government.

In reallocating these bands, several issues are of special importance: costs to Federal agencies, establishment of adequate receiver standards, adequate spectrum to which Federal agency operations can relocate, and implementation of appropriate Federal agency acquistion procedures so that the accelerated reallocation dates can be met. Title VI does not provide statutory authority for reimbursement of Federal agency costs associated with any reallocation of spectrum. However, the displaced Federal functions that result from spectrum reallocation must be preserved in other frequency bands at considerable cost to the Federal agencies. Reimbursement of Federal costs, including reimbursement directly from the private sector, will require Congressional legislation. Timely reimbursement is an essential element of the final plan for bands identified for accelerated reallocation.

Several bands identified for reallocation in the final plan are adjacent to bands that will continue to be used for high-power Federal systems, including megawatt radars. Numerous case histories exist where commercial or consumer radio systems received interference and failed to operate properly because of inadequate receiver filtering. In order to achieve the goals set by Title VI for development of new technologies, adoption of effective receiver standards, either regulatory or established by industry, is essential for bands identified in the final plan that are adjacent to high-power Federal systems.

## 1390-1400 MHz

This band is used by long-range air defense radars, air traffic control facilities, military test range telemetry links, tactical radio relays, and radio astronomy. The band has potential for new non-Federal fixed, mobile, and radiolocation communications technologies and applications. However, high-powered Federal Aviation Administration (FAA) and Department of Defense (DOD) radars must continue to operate in the lower adjacent band, and important radio astronomy observations must continue within the band. Thus, reallocating this band for exclusive non-Federal use would require that: (1) airborne and space-to-Earth transmissions be prohibited to protect radio astronomy; (2) FAA and DOD install filters on their high-powered radar transmitters; and (3) probable re-engineering of the new ARSR-4 joint FAA/DOD long-range radar. In addition, adopting adequate regulatory or industry receiver standards for new non-Federal equipment in this band is essential to assure satisfactory performance of new non-Federal services in bands adjacent to Federal high-power radars. Reallocation of this band is scheduled in 1999 to permit satisfaction of these conditions and completion of Federal reaccommodation efforts. Federal operations at 17 sites will be continued for 14 years. (See TABLE 4-1 in the text for a list of the sites.)

## 1427-1432 MHz

This band is used by military tactical radio relay communications and military test range aeronautical telemetry and telecommand. The band has potential for new non-Federal fixed and mobile communications technologies and applications. In order to protect sensitive radio astronomy observations in the adjacent band, reallocation for airborne or space-to-Earth communications should be avoided. Reallocation of this band for non-Federal use in 1999 is scheduled to permit the orderly phase-out of radio relay communications equipment, the procurement of replacement equipment, and the engineering of associated network systems. In addition, essential military airborne operations at 14 sites will be continued for 9 years. (See TABLE 4-2 in the text for a list of the sites.)

## 1670-1675 MHz

This band is used by meteorological equipment that will have to be redesigned or replaced. The band has potential for new non-Federal fixed or mobile communications. In order to protect sensitive radio astronomy observations in the adjacent band, reallocation for airborne or space-to-Earth communications should be avoided. Reallocation of this band is scheduled in 1999 to permit design and procurement of replacement equipment for meteorological radiosonde systems. However, non-Federal use at a limited number of sites that are engineered to be fully compatible with all Federal operations could be given immediate consideration. Reallocation also requires continued protection of two important meteorological-satellite service earth stations.

## 1710-1755 MHz

This band is currently used extensively for Federal fixed point-to-point microwave communications, military tactical radio relay, and airborne telemetry systems. The band has potential for new non-Federal fixed and mobile communications services. Reallocation of this band is scheduled for 2004 to provide for the orderly phase-out of existing Federal systems, the design and procurement of replacement equipment, and associated systems engineering. However, recognizing the needs of non-Federal users for spectrum, especially in major urban areas, reallocation of the band in four years may be possible for the 25 largest U.S. cities (see Table 4-1 in the text for list of cities), provided that: (1) reimbursement is provided to the affected Federal agencies; (2) appropriate Federal Agency acquisition procedures are implemented in order to support relocation of Federal systems; and (3) suitable and sufficient radio spectrum is available for relocation. The reimbursement could be in the form of direct reimbursement of costs to the Federal agencies by non-Federal entities similar to the process established by the FCC in the adjacent 1850-1990 MHz band. New Congressional legislation would be necessary to effectuate such a process. Title VI requires that all microwave communication systems operated by Federal power agencies in this band continue operation and be protected from interference. In addition, certain other Federal operations that provide safety-of-life and other critical functions, and are located outside of the largest 25 cities, will continue operation and will be protected from interference.

## 2300-2310 MHz, 2390-2400 MHz, and 2402-2417 MHz

These bands are used by the military for radar testing systems, such as target scattering and enemy radar simulators, and telemetry systems. The amateur service is also allocated in these bands on a secondary basis. NASA uses an adjacent band (2290-2300 MHz) for highly sensitive deep space communications and interplanetary research radar operations. The bands have potential for new non-Federal radiolocation and fixed and mobile communications technologies, and are located in close proximity to the 1850-2200 MHz band recently allocated by the FCC for personal communications services (PCS). Action on the 2390-2400 and 2402-2417 MHz bands was completed on August 9, 1994 to remove Federal operations in accordance with the immediate reallocation provisions of Title VI. Based on views expressed by the public, the reallocation date of the 2300-2310 MHz band is accelerated to August 1995 to provide the opportunity for effective pairing with the 2390-2400 MHz band. Reallocation of the 2300-2310 MHz band includes constraints necessary for the protection of NASA's Deep Space Network and Planetary Radar operations at Goldstone, California (See Section 4).

## 2400-2402 and 2417-2450 MHz

These band segments, which are part of the overall 2400-2450 MHz band, are allocated on a primary basis to the Federal Government and used to a limited extent by the military for radar testing systems such as target scattering and enemy radar simulators. The principal uses of these bands are industrial,

scientific, and medical (ISM) devices, the amateur service, and non-licensed devices authorized under FCC Part 15 Rules. The Preliminary Report excluded the 2400-2402 MHz band segment from reallocation, because of its vital importance to amateur-satellite operations. However, comments to NTIA and the FCC from the amateur community argue that 2 MHz is too narrow to accommodate future amateur-satellite growth. The 2417-2450 MHz band segment was previously excluded from reallocation because of the high ambient radio noise levels from ISM devices, mostly microwave ovens. Additional comments to NTIA and the FCC from the Part 15 industry argue that the entire 2400-2483.5 MHz band should remain available for non-licensed use. Based on the public comments, we conclude that subdividing the 2400-2450 MHz band into three parts, as originally proposed, would not best meet the needs of the principal users of the band.

Reallocating the entire 2400-2450 MHz band would provide the FCC with the opportunity to develop a long-term regulatory framework and strategy that meets the needs of the amateur service and addresses the requirements of a robust and growing Part 15 industry. Under a mixed use reallocation, the Federal allocation would be reduced to secondary, with the limited remaining Federal presence posing no impact on non-Federal use. This action creates a sense of stability regarding future non-Federal use and provides the opportunity to have a significant amount of spectrum for long-term development of non-licensed technologies. Furthermore, this would provide significant opportunities for innovators and small companies to make contributions to the overall mix of products and services available to the American public. We therefore include the 2400-2402 and 2417-2450 MHz bands for reallocation beginning in August 1995. The 2 MHz in the first band is proposed for exclusive non-Federal use and the 33 MHz in the second band is proposed for mixed Federal and non-Federal use.

### 3650-3700 MHz

This band is used by Navy air traffic control radars on aircraft carriers; is allocated to a number of different radio services worldwide; and is designated as an expansion band for Federal ground-based radionavigation services which could not be accommodated in the 2700-2900 MHz band. Thus, the band could be used for new non-Federal technologies in the fixed, mobile (except aeronautical), fixed-satellite and radiolocation services. Reallocating this band in 1999 will allow sufficient time to re-engineer Navy radars for operation in coastal waters. In addition, adopting adequate regulatory or industry receiver standards for new non-Federal equipment in this band is essential to assure satisfactory performance of new non-Federal services in bands adjacent to Federal high-power radars. Essential military radar operations will be continued at three sites. (See TABLE 4-4 in the text for a list of the sites.)

### 4635-4660 and 4660-4685 MHz

These bands are used for military airborne telemetry and high-powered tropospheric scatter communications systems. These bands have potential for a variety of new non-Federal fixed, mobile, and fixed-satellite technologies and associated applications. Action on the 4660-4685 MHz band was completed on August 9, 1994 to remove Federal operations in accordance with the immediate reallocation provisions of Title VI. However, reallocating the 4635-4660 MHz band in 1997 is necessary to re-design certain military telemetry systems. Furthermore, essential Federal airborne operations will be continued for 14 years in the 4635-4660 MHz band at three sites. (See TABLE 4-5 in the text for a list of the sites.)

## OVERVIEW OF FEDERAL IMPLEMENTATION COSTS

Every effort has been made to ensure that the bands identified in this report meet the Title VI selection criteria. However, the displaced Federal functions resulting from reallocation must, in most cases, be

preserved in other frequency bands at considerable cost to the Federal Government. The Federal costs associated with the reallocation were addressed in the Preliminary Report in only general terms. Consequently, in releasing the Preliminary Report, the Secretary of Commerce issued requests to each affected Federal agency to provide cost estimates for reallocating the candidate bands. The following list summarizes the Federal reallocation costs based on the responses received from that request. The values represent estimated immediate and recurring costs over the 15-year period defined by Title VI.

| | |
|---|---|
| **Department of Agriculture** | $48 million |
| **Department of the Army** | $33 million |
| **Department of Commerce** | $35-55 million |
| **Department of Energy** | $3-10 million |
| **Department of Justice** | $144 million |
| **Department of Treasury** | $1 million |
| **Department of the Interior** | $8-13 million |
| **Department of the Air Force** | $60 million[a] |
| **Department of Transportation** | $115 million[a] |
| **Department of the Navy** | $30-113 million[a] |

[a] Costs could significantly increase if unacceptable interference to or from non-Federal systems necessitates major hardware changes to Federal systems.

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## APPENDICES

## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AAW | Anti-Air Warfare |
| AFSCN | Air Force Satellite Control Network |
| ARRL | American Radio Relay League |
| ACE | Army Corps of Engineers |
| ACMI | Air Combat Maneuvering Instrumentation |
| ACMR | Air Combat Maneuvering Range |
| ACT | Air Combat Training |
| ACTS | Air Combat Training Systems |
| ADS | Automatic Dependent Surveillance |
| AF SATCOM | Air Force Satellite Communications System |
| AFB | Air Force Base |
| AMRAAM | Advanced Medium Range Air-to-Air Missile |
| AMSAT | Radio Amateur Satellite Corporation |
| AMSC | American Mobile Satellite Corporation |
| APCO | Association of Public-Safety Communications Officials-International, Inc. |
| API | American Petroleum Institute |
| ARIA | Advanced Range Instrumentation Aircraft |
| ARSR | Air Route Surveillance Radar |
| ASD(C3I) | Assistant Secretary of Defense for Command, Control, Communications, and Intelligence |
| ASDE | Airport Surface Detection Equipment |
| ATC | Air Traffic Control |
| ATN | Amateur Television Network |
| ATV | Amateur Television |
| AVI | Automatic Vehicle Identification |
| AVM | Automatic Vehicle Monitoring |
| BAS | Broadcast Auxiliary Service |
| CAMS | Core Automated Maintenance System |
| CIRIS | Completely Integrated Reference Instrumentation System |
| CDA | Command and Data Acquisition |
| CDMA | Code Division Multiple Access |
| COMSAT | Communications Satellite Corporation |
| COPE | Coalition of Private Users of Emerging Multimedia Technologies |
| CSC | Computer Sciences Corporation |
| CSCI | Commercial Satellite Communications Initiative |
| CWS | COMSAT World Systems |
| DEA | Drug Enforcement Administration |
| DES | Digital Encryption System |
| DGPS | Differential GPS |
| DMC | Digital Microwave Corporation |
| DME | Distance Measuring Equipment |
| DMSP | Defense Meteorological Satellite Program |
| DOD | Department of Defense |
| DOE | Department of Energy |
| DOI | Department of Interior |
| DOJ | Department of Justice |

## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| DOT | Department of Transportation |
| DSN | Deep Space Network |
| ECM | Electronic Countermeasures |
| ELV | Expendable Launch Vehicle |
| EM | Electromagnetic |
| EME | Earth-Moon-Earth |
| EMI | Electromagnetic Interference |
| ETSI | European Telecomminication Standards Institute |
| ETTM | Electronic Toll and Traffic Management |
| EVRP | Encrypted Voice Radio Program |
| FAA | Federal Aviation Administration |
| FAR | Federal Acquisition Regulations |
| FBI | Federal Bureau of Investigation |
| FCC | Federal Communications Commission |
| FDD | Frequency Division Duplex |
| FDOT | Florida Department of Transportation |
| FEMA | Federal Emergency Management Agency |
| FIRMR | Federal Information Resource Management Regulation |
| FLEWUG | Federal Law Enforcement Wireless Users Group |
| FPA | Federal Power Agency |
| FPLMTS | Future Public Land Mobile Telecommunications System |
| FRP | Federal Radionavigation Plan |
| FSK | Frequency Shift Keying |
| FSS | Fixed-Satellite Service |
| FWPC | Federal Wireless Policy Committee |
| FWRO | Federal Wireless Review Office |
| FWUF | Federal Wireless Users Forum |
| GES | Ground Earth Station |
| GHz | Gigahertz |
| GMF | Government Master File |
| GOES | Geosynchronous Operational Environmental Satellite |
| GPS | Global Positioning System |
| GSO | Geosynchronous Orbit |
| GVLS | Global Verification and Location System |
| HIPERLAN | High Performance Local Area Network |
| HVTCS | Vega-Hurley Target Control System |
| HySTP | Hypersonic System Technology Program |
| ICAO | International Civil Aviation Organization |
| IEEE | Institute of Electrical and Electronics Engineers |
| INS | Immigration and Naturalization Service |
| INTELSAT | International Telecommunications Satellite Organization |
| IRAC | Interdepartment Radio Advisory Committee |
| ISM | Industrial, Scientific, and Medical |
| ITA | Industrial Telecommunication Association |
| ITCS | Integrated Target Control System |

## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ITS | Intelligent Transportation System (formerly IVHS) |
| ITU | International Telecommunication Union |
| ITU-R | International Telecommunication Union - Radiocommunication Sector |
| ITFS | Instructional Television Fixed Service |
| IVHS | Intelligent Vehicle Highway System |
| JPL | Jet Propulsion Laboratory |
| JSS | Joint Surveillance System |
| LAN | Local Area Network |
| LEO | Low Earth Orbiting |
| LQP | Loral Qualcomm Partnership |
| LMST | Light-Weight Multi-Band Satellite Terminal |
| MAT | Mobile Aeronautical Telemetry |
| MDS | Multipoint Distribution Service |
| Metaid | Meteorological Aids |
| METSAT | Meteorological Satellite |
| MHz | Megahertz |
| MLS | Microwave Landing System |
| MMDS | Multichannel Multipoint Distribution Service |
| MSE | Mobile Subscriber Equipment |
| MSS | Mobile-Satellite Service |
| MTA | Maine Turnpike Authority |
| NABER | National Association of Business and Educational Radio |
| NASA | National Aeronautics and Space Administration |
| NATO | North Atlantic Treaty Organization |
| NAIC | National Astronomy and Ionosphere Center |
| NAVS | Non-cooperative Airborne Vector Scorer |
| NCS | National Communications System |
| NDS | Nuclear Detonation System |
| NEST | Nuclear Emergency Search Team |
| NEXRAD | Next Generation Weather Radar |
| NGSO | Non-Geosychronous-Orbit |
| NGTCS | Next Generation Target Control System |
| NII | National Information Infrastructure |
| NOAA | National Oceanic and Atmospheric Administration |
| NOI | Notice of Inquiry |
| NPRM | Notice of Proposed Rule Making |
| NRC | National Research Council |
| NS/EP | National Security/Emergency Preparedness |
| NSF | National Science Foundation |
| NSSMS | NATO SEASPARROW Surface Missile System |
| NTIA | National Telecommunications and Information Administration |
| NWS | National Weather Service |
| OTH | Over-the-Horizon |
| PCIA | Personal Communications Industry Association |
| PCS | Personal Communications Service |

## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| PDT | Proliferation Detection Technology |
| POFS | Private Operational Fixed Service |
| PSTN | Public Switched Telephone Network |
| R&D | Research and Development |
| RAJPO | Range Joint Program Office |
| RDAVS | Recovered Doppler Airborne Vectoring Scoring System |
| RFI | Radio Frequency Interference |
| RPV | Remotely Piloted Vehicle |
| SATCOM | Satellite Communications |
| SBC | Southwestern Bell Corporation |
| SBMS | San Bernardino Microwave Society |
| SCRRBA | Southern California Repeater and Remote Base Association |
| SGLS | Space-Groundlink Subsystem |
| SPS | Spectrum Planning Subcommittee |
| SPAC | Spectrum Planning and Advisory Committee |
| TACTS | Tactical Air Crew Combat Training System |
| TARS | Tethered Aerostat Radar System |
| TAS | Target Acquistion System |
| TDD | Time Division Duplex |
| TDWR | Terminal Doppler Weather Radar |
| TIA | Telecommunications Industry Association |
| TOSS | Television Ordnance Scoring System |
| TRITAC | Tri-Service Tactical Communications |
| TSPI | Time, Space and Position Information |
| TT&C | Tracking, Telemetry, and Command |
| UHF | Ultra High Frequency |
| US&P | United States and Possessions |
| USAF | United States Air Force |
| USCG | United States Coast Guard |
| USDA | United States Department of Agriculture |
| UT | Universal Time |
| UTC | Utilities Telecommunications Council |
| VHF | Very High Frequency |
| VSAT | Very-Small Aperture Terminal |
| VTS | Vessel Traffic System |
| WAPA | Western Area Power Administration |
| WARC | World Administrative Radio Conference |
| WCDL | Weapon Control Data Link |
| WMC | Western Multiplex Corporation |
| WRC | World Radio Conference |

SECTION 1

# INTRODUCTION

## BACKGROUND

Spectrum management authority in the United States is divided between the Federal Communications Commission (FCC) and the President. The Communications Act of 1934 (Communications Act) established the FCC and provided it the authority to assign frequencies to radio stations in the United States except for those stations belonging to the Federal Government.[1] Under Section 305 of the Communications Act, the President is responsible for assigning frequencies to Federal Government stations. Pursuant to the National Telecommunications and Information Administration (NTIA) Organization Act, the Assistant Secretary of Commerce for Communications and Information has the authority to manage frequencies assigned to Federal Government users.[2]

As part of its responsibility for managing the Federal Government's use of the radio spectrum, NTIA establishes policies concerning the allocation, allotment, and assignment of spectrum for Federal use based, in part, on the advice of the Interdepartment Radio Advisory Committee (IRAC) and the Spectrum Planning and Policy Advisory Committee (SPAC). NTIA also provides guidance to the various Federal agencies and departments to ensure that their radiocommunications activities are consistent with these policies and to allow these agencies and departments to carry out their Congressionally mandated missions. In addition, NTIA serves as the President's principal advisor on telecommunications and information policies. NTIA's functions include providing policy and administrative support to assist in the development of the National Information Infrastructure (NII). NTIA also works with other agencies to develop Executive Branch views on communications issues and ensures that these policies are effectively presented to the FCC, the Congress, and the public.

Today, all of the radio spectrum below 300 gigahertz (GHz) is allocated for various purposes. This spectrum is a valuable but limited resource that has become vitally important to the nation's economic well-being. Commercial activities that depend on the availability of radio spectrum

generate over $100 billion in annual revenues. Advances in telecommunications technologies are spurring economic growth and consumer demands towards improving the quality of life. However, given the current congested state of the spectrum, especially in some frequency bands below 5 GHz, the ability to accommodate new spectrum-dependent technologies is limited for both Federal and non-Federal users.

The Administration and the Congress addressed these issues in Title VI of the Omnibus Budget Reconciliation Act of 1993, signed into law on August 10, 1993.[3] One of the objectives of Title VI is communications licensing and spectrum reallocation improvement to increase the efficiency of spectrum use and the effectiveness of the spectrum management process. Another goal of Title VI is to promote and encourage the use of new spectrum-based technologies in telecommunications applications. To facilitate this goal, Title VI directed the Secretary of Commerce to transfer 200 megahertz (MHz) of spectrum below 5 GHz, currently used by Federal agencies, to the FCC for licensing to the private sector. The transferred spectrum must not be required for the present or identifiable future needs of the Federal Government and should not result in excessive costs to the Federal Government, or loss of services or benefits to the public. Title VI also authorizes the FCC to use competitive bidding (auctions) for the reassignment and licensing of spectrum for certain commercial radio-based services. The first phase of the reallocation process required by Title VI was completed on February 10, 1994, when the Department of Commerce released the Preliminary Spectrum Reallocation Report (hereinafter, "Preliminary Report").[4]

The Preliminary Report provides an overview of Federal spectrum usage below 5 GHz, an assessment of public benefit issues associated with spectrum reallocation, and a band-by-band assessment of reallocation options. This assessment examined Federal investment cost and potential operational impact versus public benefit and impact. A Preliminary Spectrum Reallocation Plan was presented in the Preliminary Report based on these assessments, in accordance with the Title VI criteria and requirements (see TABLE 1-1). Constraints that could affect Federal Government use of the bands identified for mixed use reallocation, or that are necessary to provide protection of high-valued Federal Government systems were also part of the preliminary plan and were described in the Preliminary Report. NTIA believes that such reallocation constraints will not significantly impact the development and use of the bands for non-Federal applications. An analysis of the plan and related issues vis-a-vis the specific criteria and requirements of

**TABLE 1-1**
Preliminary Spectrum Reallocation Plan

| Band (MHz) | Usage* Status | Reallocation Date |
|---|---|---|
| 1390-1400 | exclusive | 1/99 |
| 1427-1432 | exclusive | 1/99 |
| 1670-1675 | mixed | 1/99 |
| 1710-1755 | mixed | 1/04 |
| 2300-2310 | exclusive | 1/96 |
| 2390-2400 | exclusive | 8/94 |
| 2402-2417 | exclusive | 8/94 |
| 3650-3700 | mixed | 1/99 |
| 4635-4660 | exclusive | 1/97 |
| 4660-4685 | exclusive | 8/94 |

* Exclusive = exclusive non-Federal use.
Mixed = shared Federal and non-Federal use.

Title VI were included in the report, which concluded that the plan meets the goals established in Title VI.

The Preliminary Plan included 50 MHz of spectrum available for immediate reallocation and 150 MHz for delayed reallocation. Federal frequency assignments within the 50 MHz designated for immediate reallocation (2390-2400, 2402-2417, and 4660-4685 MHz) were withdrawn on August 10, 1994 as required by Title VI (six months after the Preliminary Report was published).[5] The plan does however, provide for continued Federal use of the 50 MHz of "immediately available" spectrum on a non-interference basis with non-Federal operations as long as it remains unused as a consequence of the FCC's reallocation and assignment plan.[6]

In accordance with the requirements of Title VI, a 90-day period after the release of the report was provided for public comments. An additional 90-day period was established for the FCC to prepare an analysis of the public comments, together with other additional comments and recommendations.

Since the release of the Preliminary Report, NTIA received 51 written comments, conducted 2 public meetings, and met directly with 17 of the commenters to obtain further expert analysis of the technical, regulatory, and commercial issues addressed in the Preliminary Report. The FCC analysis of the public comments was submitted to the Secretary of Commerce on August 9, 1994.[7] The Preliminary Spectrum Reallocation Plan and the FCC report were discussed at several meetings between NTIA and the FCC to provide an opportunity to further consider the public comments and views expressed at the public meetings. NTIA also reviewed comments that were submitted to the FCC Notice of Inquiry (NOI) concerning potential applications for the 50 MHz identified in the Preliminary Report for immediate reallocation.[8]

The report concludes the second phase of the reallocation of spectrum required by Title VI. Title VI requires that the President shall withdraw or limit assignments to Federal stations within six months after receipt of the Secretary's report and provide notice to the Congress and the FCC of actions taken. The President may, however, substitute alternative spectrum or effective dates based on circumstances as specified in Title VI.

## OBJECTIVE

The objective of this report for subsequent submission to the President and the Congress is to identify and recommend a final plan for the reallocation of at least 200 MHz of spectrum from the Federal Government to the private sector, in accordance with the requirements of Title VI. The report is based on the Preliminary Spectrum Reallocation Plan and comments from the public, the FCC, and Federal Government spectrum users.

## APPROACH

The spectrum reallocation plan in Section 5 of this report was based on the preliminary plan, but modified to consider the issues that were identified by the public, the FCC, and Federal Government spectrum users since the release of the Preliminary Report. NTIA analyzed inputs from open public meetings, meetings with individual commenters, Preliminary Report comments, FCC NOI comments,

the FCC Report, and the meetings between the FCC and NTIA. A discussion and summary of the input from these sources is presented in Section 2.

In enacting Title VI, Congress acknowledged that reallocating spectrum used by Federal agencies will not come without financial costs and mission impacts. The displaced Federal functions must be preserved in other frequency bands at some cost to the Federal Government. Title VI did not provide a mechanism to compensate Federal agencies for the costs of moving displaced systems. Also, there are many functions that the Federal Government provides to the entire nation that cannot be performed in other frequency bands. The Preliminary Report only broadly described these costs and the operational impacts of implementing the reallocation. The Federal departments and agencies that will be affected by the reallocation are in the best position to identify specific costs. NTIA asked each affected Federal agency to provide cost estimates for reallocating the candidate bands.[9] The results of such Federal agency input are summarized in Section 3.

A band-by-band discussion of the frequency bands originally proposed for reallocation, as well as the bands that have been proposed by commenters since the release of the Preliminary Report, is presented in Section 4. The final reallocation plan and conditions are presented in Section 5.

## ENDNOTES

Requests for copies of references from Federal departments and agencies should be referred to the originating organization. Parts of the reference material may be exempt from public release.


1. 47 U.S.C. §151 et seq. (1988 & Supp. IV 1992).
2. 47 U.S.C.§§ 901-904 (Supp. V 1993).
3. Omnibus Budget and Reconciliation Act, Title VI, § 6001(a)(3), Pub. L. No. 103-66, 107 Stat. 379, (Aug. 10, 1993) (codified at 47 U.S.C. § 921 et seq. (Supp. V 1993)).
4. NAT'L TELECOMMUNICATIONS AND INFO. ADMIN., U.S. DEP'T OF COMMERCE, SPECIAL PUBLICATION 94-27, PRELIMINARY SPECTRUM REALLOCATION REPORT (Feb. 1994) [hereinafter NTIA PRELIMINARY REPORT].
5. Memorandum from William Gamble, NTIA Deputy Assoc. Adm'r, to NTIA Interdepartment Radio Advisory Comm., IRAC Doc. 28880 (Aug. 9, 1994).
6. *Id.* at 2.
7. REPORT FROM THE FEDERAL COMMUNICATIONS COMM'N, to Ronald H. Brown, Secretary, U.S. Dep't of Commerce, Regarding the NTIA PRELIMINARY REPORT, FCC 94-213 (Aug. 9, 1994) [hereinafter FCC REPORT].
8. Allocations of Spectrum Below 5 GHz Transferred from Fed. Gov't Use, *FCC Notice of Inquiry*, ET Docket No. 94-32, FCC 94-97, 59 Fed. Reg. 6005 (May 4, 1994).
9. Memorandum from William Gamble, NTIA Deputy Assoc. Adm'r, to NTIA Interdepartment Radio Advisory Comm., IRAC Doc. 28740 (March 31, 1994).

SECTION 2

# DISCUSSION OF COMMENTS

## INTRODUCTION

NTIA provided opportunities for Federal users, commercial entities, public-safety organizations, and other interested parties to submit comments and recommendations for the development of a final reallocation plan. Public notice of the Preliminary Report and deadlines for the submission of written comments were given on February 9, 1994 by notice in the Federal Register.[1] NTIA received 51 responses to this public notice. For convenience, the comments have been categorized as Federal, amateur, commercial, public-safety/local government, utilities, and manufacturers/users of non-licensed devices. TABLE 2-1 gives an overview of the comments, including the source and the bands specifically discussed. In addition to the public comments, the Air Force, Army, and Navy submitted a joint Department of Defense (DOD) response to NTIA addressing the bands proposed for reallocation. The joint DOD response is treated separately from the other public comments, because it contains information that is for official use only and not available to the general public. NTIA also held two public meetings to discuss the Preliminary Report and the frequency bands proposed for reallocation. NTIA also held individual meetings with many of the commenters.



On May 17, 1994, the FCC published an NOI[2] in the Federal Register that sought comments on potential applications for the 50 MHz of Federal spectrum proposed for immediate reallocation to the private sector.[a] Commenters were given 30 days from the publication date in the Federal Register to submit their comments. A 15-day period was then provided for reply comments. The FCC received 77 comments and 18 reply comments in response to its NOI. TABLE 2-2 gives an overview of the comments including the source and the bands specifically discussed.

[a] The frequency bands released for immediate reallocation in NTIA's Preliminary Report were: 2390-2400, 2402-2417, and 4660-4685 MHz. The FCC subsequently released a Notice of Proposed Rule Making (on October 20, 1994) concerning the three bands.

TABLE 2-1
Overview of Comments on the Preliminary Report

| | COMMENTERS | Bands Discussed in the Comments (MHz) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1390-1400 | 1427-1432 | 1670-1675 | 1710-1755 | 2300-2310 | 2390-2400 | 2402-2417 | 3650-3700 | 4635-4660 | 4660-4685 | Other |
| FEDERAL | Federal Highway Administration | | | | | | | | | | | |
| | Voice of America | | | | | | | | | | | |
| | Department of Veterans Affairs | | | | | | | | | | | |
| | Department of Health & Human Resources | | | | | | | | | | | |
| | Department of the Interior | | | | ■ | | | | | | | |
| | Department of Agriculture | | | | ■ | | | | | | | |
| | Department of Justice | | | | ■ | | | | | | | |
| | Department of the Treasury | | | | ■ | | | | | ■ | | |
| | Department of Energy | | | | ■ | | | | | ■ | ■ | |
| | National Aeronautics and Space Administration | | | | ■ | ■ | | | | | ■ | |
| | Department of Commerce | | | ■ | ■ | | | | | | | |
| | Department of the Army | ■ | ■ | ■ | ■ | | | | | ■ | ■ | ■ |
| | The National Astronomy and Ionosphere Center | ■ | ■ | ■ | ■ | | ■ | ■ | | | | |
| | National Research Council | ■ | ■ | | ■ | ■ | ■ | | | | | |
| | National Communications System | | | | ■ | | | ■ | | | | |
| | Department of Transportation | ■ | | | ■ | | ■ | | ■ | | | |
| | National Science Foundation | ■ | ■ | ■ | ■ | | | | | | | |
| AMATEUR | Palomar Amateur Radio Club | | | | | | | ■ | | | | |
| | Gerald T. White, WB6IZE | | | | | | | ■ | | | | |
| | George E. Dew, KD6FDK | | | | | | ■ | | | | | |
| | Joyce D. Shappee, KD6PNO | | | | | ■ | ■ | ■ | | | | |
| | Cactus Radio Club, Inc. | | | | | ■ | ■ | ■ | | | | |
| | San Bernardino Microwave Society, Inc. | | | | | ■ | ■ | ■ | | | | |
| | Amateur Television Network | | | | | ■ | ■ | ■ | | | | |
| | Western States VHF-Microwave Society | | | | | ■ | ■ | ■ | | | | |
| | Radio Amateur Satellite Corporation | | | | | ■ | ■ | ■ | | | | |
| | James W. Tittle, KC6SOE | | | | | ■ | ■ | ■ | | | | |
| | Terry R. Young, KC6SOC | | | | | ■ | ■ | ■ | | | | |
| | Amateur Radio Council of Arizona | | | | | ■ | ■ | ■ | | | | |
| | American Radio Relay League, Inc. | | | | | ■ | ■ | ■ | | | | ■ |
| | S. California Repeater & Remote Base Assoc. | | | | | ■ | ■ | ■ | | | | ■ |
| | Kitchell F. Brown, WB6QVU | | | | | ■ | ■ | ■ | | | | ■ |
| COMMERCIAL | IVHS America | | | | | | | | ■ | | | ■ |
| | E.F. Johnson Company | | | | | | | | | ■ | ■ | |
| | COMSAT World Systems | | | | | | | | | ■ | ■ | ■ |
| | Loral/Qualcomm Partnership | | | ■ | ■ | ■ | ■ | ■ | | | | |
| | Digital Microwave Corporation | | | | ■ | | | | | ■ | ■ | |
| | GTE Corporation | | | | ■ | ■ | ■ | ■ | | | | |
| | Motorola, Inc. | ■ | | | ■ | | ■ | ■ | | ■ | ■ | ■ |
| | Telecommunications Industry Association | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | |
| | American Mobile Satellite Corporation | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| PUBLIC SAFETY LOCAL GOV. | National Hydrologic Warning Council | | | | | | | | | | | |
| | City of Martinez Police Department | | | | | | | ■ | | | | |
| | Assoc. of Public-Safety Comm. Officials Intl. | | | | ■ | | ■ | ■ | | | ■ | |
| | Florida Department of Transportation | | | | | | ■ | ■ | | | | |
| | Maine Turnpike Authority | | | | | | ■ | ■ | | | | |
| NON-LICENSED | GEC Plessey | | | | | | | ■ | | | | |
| | Larus Corporation | | | | | | | ■ | | | | |
| | Western Multiplex Corporation | | | | | | | ■ | | | | |
| | IEEE Computer Society | | | | | | | ■ | | | | |
| UTIL. | Utilities Telecommunications Council | | | | ■ | | | ■ | | | | |
| | **Comments Per Band** | **8** | **6** | **7** | **19** | **18** | **23** | **29** | **4** | **8** | **9** | **8** |

TABLE 2-2
Overview of Comments on the FCC Notice of Inquiry *(Page 1 of 2)*

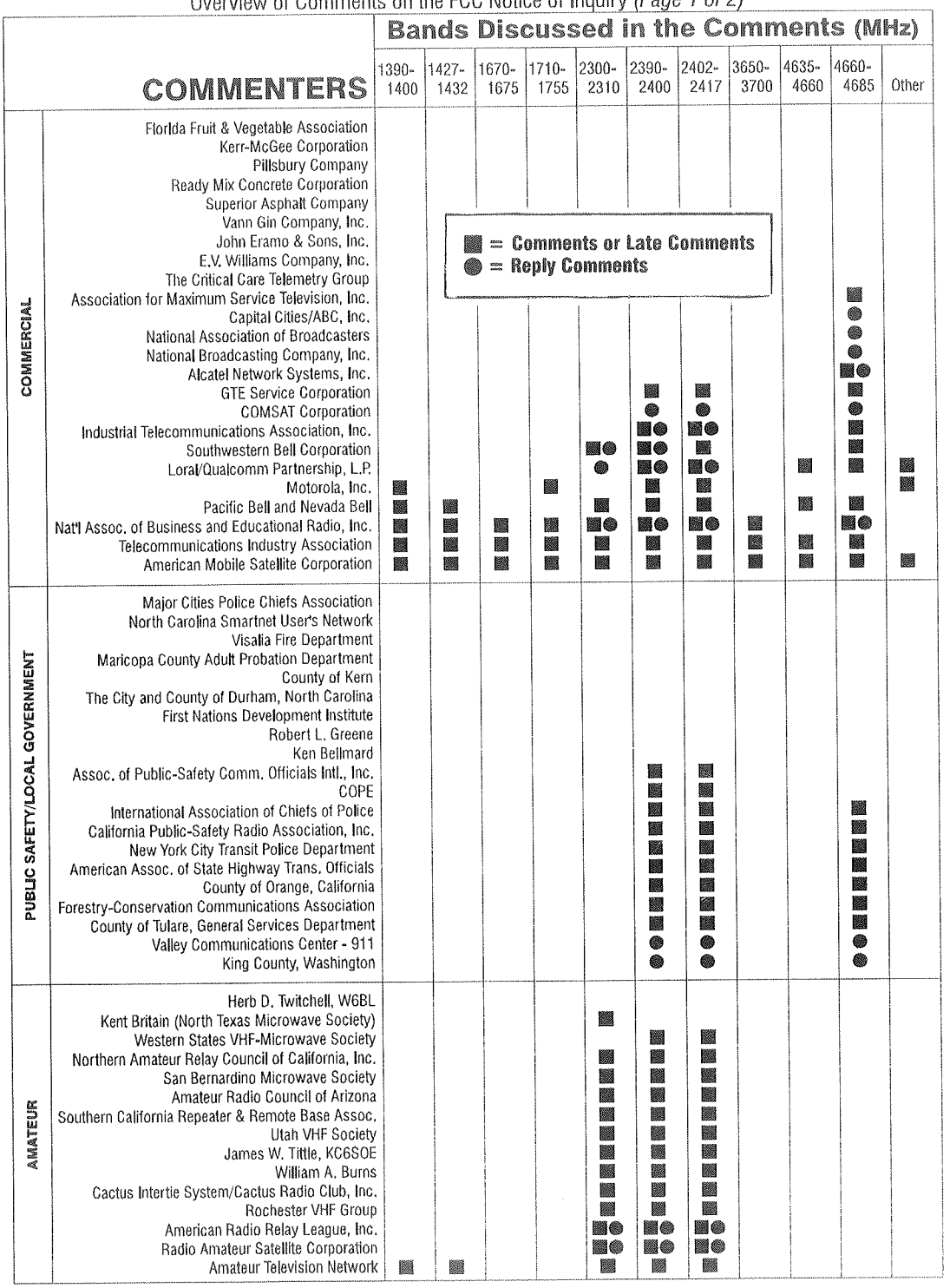

TABLE 2-2
Overview of Comments on the FCC Notice of Inquiry *(Page 2 of 2)*

| | COMMENTERS | Bands Discussed in the Comments (MHz) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1390-1400 | 1427-1432 | 1670-1675 | 1710-1755 | 2300-2310 | 2390-2400 | 2402-2417 | 3650-3700 | 4635-4660 | 4660-4685 | Other |
| NON-LICENSED | Part 15 Coalition<br>Apple Computer Corporation<br>Interdigital Communications Corporation<br>ITRON, Inc.<br>Symbol Technologies, Inc.<br>The Southern Company<br>International Business Machines Corporation<br>Metricom, Inc.<br>AT&T Corporation<br>GEC Plessy Semiconductors<br>Western Multiplex Corporation | | | | | | ■<br>■● | ■<br>■<br>■<br>■<br>■<br>■<br>■<br>●<br>●<br>■●<br>■<br>■● | | | ■● | |
| UTILITIES | Mitchell Energy & Development Corporation<br>National Utility Contractors Association<br>National Propane Gas Association<br>Phelps Sungas, Inc.<br>Weber Energy Fuels<br>Westbank Electric, Inc.<br>Sun Services Corporation<br>Utilities Telecommunications Council<br>LEACO Rural Telephone Cooperative, Inc.<br>American Petroleum Institute | | | | | | ■<br>■<br>■ | ■<br>■<br>■● | | | ■<br>■<br>■ | |
| FEDERAL | National Astronomy and Ionosphere Center/Cornel U.<br>National Research Council<br>National Communications System | | | | ■ | ■ | ■<br>■<br>■ | ■<br>■<br>■ | | | | |
| | **Comments Per Band** | **6** | **5** | **3** | **5** | **24** | **49** | **59** | **3** | **4** | **30** | **3** |

The August 9, 1994 FCC Report submitted to the Secretary of Commerce [hereinafter FCC Report] satisfied Title VI, Section 113(d)(3), which required the FCC to analyze the public comments and provide any comments or recommendations to NTIA that it deemed appropriate in response to the Preliminary Report. The FCC Report included an analysis of the comments, a discussion of possible alternatives, and recommendations for an alternative spectrum reallocation plan.

The following is a band-by-band discussion of all comments received, including the public comments received in response to the Preliminary Report, the issues discussed during individual and public meetings, the analysis and recommendations in the FCC Report, and the comments submitted in response to the FCC NOI. The discussion focuses on the frequency bands identified for reallocation to non-Federal users, although additional bands that were discussed in the public comments are also addressed as appropriate. Federal agency comments regarding specific costs to implement the proposed reallocation plan are discussed in Section 3 and not included herein.

## DISCUSSION OF COMMENTS

### 1390-1400 MHz

NTIA received eight responses on its Preliminary Report that addressed the reallocation of the 1390-1400 MHz band for non-Federal use: five Federal and three commercial (see TABLE 2-1). In addition to these public comments, the joint DOD response, and several FAA responses unrelated to the Preliminary Report, also addressed this band.[3] Although it was not the subject of the FCC NOI, six parties filed comments that addressed this band: five commercial and one amateur (see TABLE 2-2). This band was also discussed in the FCC Report.

**Federal.** The comments submitted by the National Science Foundation (NSF), the National Research Council (NRC), and the National Astronomy and Ionosphere Center (NAIC)[a] support the Preliminary Report's decision not to reallocate those portions of the spectrum currently allocated exclusively to the radio astronomy service.[4] While recognizing the Congressional directives that require the reallocation of other portions of the spectrum, NRC and NAIC remain concerned about the potential impact on radio astronomy and remote sensing.[5] In their comments, NSF, NRC, and NAIC urge NTIA to reiterate the proposed restrictions on reallocation of the 1390-1400 MHz band to protect the passive services.[6] Provided that the restrictions identified in the Preliminary Report are observed, NSF expects no major operational or economic impact as a result of the reallocation.[7]

The comments submitted by Army in response on the Preliminary Report address reallocation of the entire 1350-1400 MHz band (10% of a particular tactical radio 1350-1850 MHz tuning range), but do not specifically discuss the impact of reallocating the 1390-1400 MHz band segment. In their comments, Army states that "Propagation and technical factors support the 1350-1850 MHz band as the optimum band for area-wide network operation."[8] Army also maintains that although tactical radios can tune over a wide range, the availability of authorized frequencies for Army operations has been dwindling.[9] "Further loss or erosion of authorized frequency resources would adversely affect military land forces' ability to provide an adequate command, control communications network."[10]

Department of Transportation (DOT) comments on the Preliminary Report state that joint DOD/Federal Aviation Administration (FAA) long-range radars operate in the 1390-1400 MHz band segment. DOT contends that modification or replacement of the long-range radars operating in the 1215-1400 MHz band will be necessary to preclude harmful interference to non-Federal operations in the 1390-1400 MHz band.[11]

In the joint DOD response to the Preliminary Report, Air Force states that continued access to the 1215-1400 MHz band is essential for Air Force and FAA radars providing long-range anti-jam search and track functions, and to support defense of the national air space, and coastal civil air traffic control. "The 1215-1400 MHz portion of the frequency spectrum is ideal for long-range radar propagation and target detection. Other portions of the spectrum do not have the electromagnetic wave physics

[a] The NRC and NAIC are not Federal agencies but they are affiliated with Federal agencies performing radio astronomy research.

necessary to perform this function effectively."[12] Based on importance to long-range radar operations, specifically the safety-of-life functions they provide and their air defense mission, and the potential for interference between Federal and non-Federal users, Air Force argues that the 1390-1400 MHz band segment should not be reallocated.

The comments submitted by Air Force stated that the jointly developed DOD/FAA Air Route Surveillance Radar Model 4 (ARSR-4) provides air defense and air traffic control for the continental United States, Guam, and Hawaii. Air Force further states that the ARSR-4 is being fielded through a $1 billion joint FAA and Air Force program established and funded by Congress. Air Force goes on to state that the ARSR-4 operates in the 1215-1400 MHz band and requires dual channel frequency hopping technology for its long-range search and track functions. Air Force estimates that reallocation of the 1390-1400 MHz band segment will at a minimum require software modifications, and if spectrum resources are not available, hardware modifications will be necessary.[13] Air Force further adds that reallocation of the 1390-1400 MHz band segment will also degrade the radar's operational anti-jam capabilities.

The comments submitted by Air Force also indicate that several radar systems operating in this band are in remote regions supporting defense of the northern national airspace. Because of the remote locations of these radars, Air Force states that continued operation in 1390-1400 MHz on a secondary basis is an acceptable option only if interference is not likely to occur.[14]

The comments submitted by Air Force also address the Range Joint Program Office (RAJPO) Global Positioning System (GPS) data link. Air Force states that the RAJPO GPS data link is used on Air Force, Army, and Navy test installations to monitor manned and unmanned airborne platforms during testing and training operations. Air Force further states that "RAJPO is critical to ensuring the safety of personnel during training or test operations on ranges."[15] Air Force believes that if additional spectrum is lost in the 1350-1390 MHz band, full scale training operations to verify combat readiness and equipment reliability cannot be adequately supported. Air Force adds that the RAJPO GPS data links also operate in the 1427-1435 MHz frequency band, because more than one channel is needed to ensure data availability in rugged terrain.[16]

Navy states that many of the systems operating in the bands proposed for reallocation have a war reserve mode that is classified and cannot be reflected in the public records. "Consequently, the Navy and other elements of the DOD must be consulted, and must be involved in the selection of any non-Government services proposed for operation in the bands identified for reallocation."[17]

The FCC believes that the 1390-1400 MHz band segment could offer additional spectrum to implement emerging technologies, but adds that its small size may make the development of those new technologies difficult.[18] The FCC maintains that non-Federal users must have access to sufficient spectrum in the 1350-1400 MHz band. Stating that allocating only 10 MHz of this band would severely limit potential uses, and suggesting that NTIA reevaluate this band with a view toward making more of it available for non-Federal use.[19]

**Commercial.** In its comments on the Preliminary Report, Motorola recommended that NTIA reconsider its decision not to propose reallocation of the entire 1350-1400 MHz band.[20] Although the 1390-1400 MHz band segment is proposed to be reallocated in 1999, the comments filed by Motorola and the Telecommunications Industry Association (TIA) stated that it is not clear why the remaining 1350-1390 MHz band segment cannot be reallocated for non-Federal use.[21] Both commenters refer to an NTIA study released in May 1993 that analyzes the spectrum requirements for the fixed services.[22] Motorola and TIA contend that this study indicates there are a total of 582 U.S. frequency assignments within the entire 50 MHz band with only a 1% expected growth rate for assignments in the band.[23]

The comments filed by Motorola and TIA in response on the FCC NOI support the comments filed with NTIA recommending that the entire 1350-1400 MHz band be reallocated for commercial use. Comments submitted on the FCC NOI by the National Association of Business and Educational Radio (NABER) state that the 1390-1400 MHz band segment could be of some limited use for non-Federal applications, even with the constraints placed on it in the Preliminary Report.[24] In its comments to the FCC NOI, Pacific Bell and Nevada Bell disagree with NTIA's suggestion that the 1390-1400 MHz and 1427-1432 MHz band segments can be paired for commercial use.

**Amateur.** In comments submitted on the FCC NOI, the Amateur Television Network (ATN) suggested replacing the 2390-2400 MHz and the 2402-2417 MHz bands (identified for immediate reallocation) with the pair 1390-1400 MHz and 1427-1432 MHz. ATN also suggested that a 1-MHz portion of each band could be used for biomedical telemetry, especially in larger metropolitan areas.[25]

**Summary.** The comments submitted by NSF, NRC, and NAIC indicate that they support the NTIA proposal to reallocate the 1390-1400 MHz band segment for non-Federal use as long as the restrictions protecting the radio astronomy service are included in the final report. The comments submitted by Army on the loss of the entire 1350-1400 MHz band are inconclusive in addressing the issue of reallocating the 1390-1400 MHz band segment. In its comments, DOT opposes reallocation of the 1390-1400 MHz band segment, citing possible loss of the ability to use equipment and restricted operational capability. Motorola's and TIA's comments recommend reallocating the entire 1350-1400 MHz band based on an NTIA fixed service study that indicates light Federal usage in the 1350-1400 MHz band. The FCC agrees with Motorola and TIA, and recommends that NTIA reexamine this band. TIA's comments also state that new equipment designed for use in the 1390-1400 MHz band must be capable, at some expense, of tolerating adjacent-band FAA and DOD high-power radar signals.

## 1427-1432 MHz

NTIA received six responses on its Preliminary Report that addressed this band: four Federal and two commercial (see TABLE 2-1). In addition to the public comments, the joint DOD response also addressed this band. Although it was not the subject of the FCC NOI, four parties filed comments that addressed this band: three commercial and one amateur (see TABLE 2-2). This band was also discussed in the FCC Report.[26]

**Federal.** The comments submitted by NSF, NRC, and NAIC strongly support the Preliminary Report's proposed ban on airborne and space-to-Earth communications in this band. NAIC further advocates

that ground-based services allocated to this band should not interfere with the radio astronomy observations.

Army stated that this particular frequency band is critical for Mobile Subscriber Equipment (MSE) and Tri-Service Tactical Communications System (TRITAC) equipment that is used for communications in the tactical battlefield. At a minimum, Army states there is a requirement for secondary use of this band.[27] Army further states that moving operations to one of the other bands is extremely difficult, not operationally sound, and that further loss or erosion of authorized frequency resources would adversely affect military land forces' ability to provide an adequate command and control communications network.[28]

In the joint DOD response on the Preliminary Report, Air Force maintains that reallocation of this band would result in the need to retune or replace at least four of its video and data link communications systems, ten microwave telemetry and control systems for its Tethered Aerostat Radar Systems (TARS), over 100 Non-cooperative Airborne Vector Scorers (NAVS), eight remote recovery systems, and ten RAJPO[a] data link units.[29] Air Force believes that reallocation of the 1427-1432 MHz band segment will severely limit their ability to effectively schedule test-range events and that loss of frequencies in this band for RAJPO use will result in the need for modifications critical for the control of launched missiles and public safety.

The FCC agrees with commenters that the small size of this proposed allocation, as well as its remoteness from existing non-Federal services, will make it difficult to use this spectrum either as an adjunct to an existing service or to support a new service. "The Preliminary Report's suggestion that this band be combined with the 1390-1400 MHz band would yield an unbalanced allocation of one 5-megahertz wide block with a 10-megahertz block that would not be conducive to channel pairing arrangements and that might still be too small to promote development of new technologies."[30]

**Commercial.** TIA, in its comments on the Preliminary Report, and NABER, in its comments on the FCC NOI, state that satisfying the conditions proposed for the protection of adjacent-band radio astronomy operations could make commercial use of this band difficult.

In their comments to the FCC NOI, Pacific Bell and Nevada Bell point out that most mobile wireless services will require Frequency Division Duplexing (FDD), founded on the ability to balance the frequencies used for both directions of the service. Personal Communications Service (PCS), for instance, will need paired frequencies for the base-to-portable and portable-to-base directions. These services will need to be balanced and separated by a reasonable amount of spectrum for them to operate properly without restricting radio system design. The Pacific and Nevada Bell Companies believe that the 1390-1400 and 1427-1432 MHz bands are small and unbalanced and, for reasons discussed above, may not be capable of providing a commercially viable service using FDD technology. However, the commenters do indicate that certain stationary outdoor or in-building services may be conducive to a Time Division Duplex (TDD) service in this band.

[a] RAJPO receives GPS-based signals and transmits computed real-time position information for manned and unmanned airborne platforms during test and training operations

The comments submitted by American Mobile Satellite Corporation (AMSC) on the Preliminary Report and the FCC NOI suggest that the mobile-satellite service (MSS) is prominent among the services requiring new accommodations, and that the frequencies proposed in the Preliminary Report are not useful for MSS systems. Specifically, AMSC points out that this band is not allocated internationally to MSS and would thus expose U.S. MSS systems operating in this band to interference from foreign systems. Furthermore, AMSC adds that U.S. MSS systems would be required to protect the foreign systems from harmful interference. AMSC also believes that this band is too narrow for accommodation of U.S. and foreign MSS systems, and so International Telecommunication Union (ITU) reallocation is not likely to be salable (some of the 1992 World Administrative Radio Conference (WARC-92) MSS allocations are 32-35 MHz wide). Even if this band were to be approved for MSS use, AMSC believes that systems using frequencies in the adjacent bands would interfere with MSS systems in the proposed band. Alternately, AMSC proposes two alternative Federal bands (1492-1525 MHz for downlinks and 1675-1710 MHz for uplinks) that its analysis indicates can be shared immediately by MSS systems and incumbent Federal users.[31] AMSC claims that Mobile Aeronautical Telemetry (MAT) operations in the 1435-1535 MHz band would be fully protected by MSS downlink power flux-density limits and high satellite elevation angles. AMSC also believes that clustering MSS channels at the boundaries of each standard 1 MHz MAT channel will protect mobile earth station receivers by increasing the frequency dependent rejection. AMSC contends that MSS downlinks can share the upper portion of the 1492-1525 MHz band interstitially if the incumbent MAT service applications are restricted to 1 MHz-channelized narrowband operation.[32] Moreover, AMSC believes that if it can secure a combined total of only 1 MHz of MSS-usable spectrum in the 1492-1525 MHz band through this type of sharing, the effort will have been worthwhile, considering the severe shortage of spectrum.

Motorola and TIA representatives indicate that limited commercial applications in this band are feasible.[33]

**Amateur.** In its response to one of the specific questions in the FCC NOI, ATN indicated that the 1390-1400 MHz band paired with the 1427-1432 MHz band, or a 1-MHz portion of each band, could be used for biomedical telemetry devices, serving to relieve congestion of the existing spectrum currently used for these devices, especially in the larger metropolitan areas.

**Summary.** The comments submitted by NSF, NRC, and NAIC strongly support the Preliminary Report's proposed restrictions on airborne and space-to-Earth communications in this band. The comments submitted by the Army expressed concern with continuing loss of authorized frequency resources, and its adverse impact on their land force operations. The FCC Report stated that this band segment may be too small and segmented from existing non-Federal services to support new commercial applications. The comments submitted by Pacific Bell and Nevada Bell agree that this band is too small to provide a commercially viable service, even if paired with the 1390-1400 MHz band segment. In its comments to the Preliminary Report, AMSC proposed that the 1492-1525 and 1675-1710 MHz bands be allocated for MSS downlinks, which it claims can operate without causing interference to existing Federal aeronautical telemetry operations.

## 1670-1675 MHz

NTIA received seven responses on its Preliminary Report that addressed this band: four Federal and three commercial (see TABLE 2-1). In addition to the public comments, the joint DOD response also addressed this band. Although it was not the subject of the FCC NOI, two parties filed comments that addressed this band, both commercial (see TABLE 2-2). This band was also discussed in the FCC Report.[34]

**Federal.** The comments submitted by NSF and NAIC strongly support the Preliminary Report's proposed ban on airborne and space-to-Earth communications in this band. NAIC further advocates that ground-based services allocated to this band should not interfere with radio astronomy observations.

In its comments, NOAA reports that most of the 111 frequency assignments in this band are for radiosonde stations operated by NOAA within the Department of Commerce. NOAA indicated that one limitation associated with relocating radiosonde frequencies is that the part of the allocated band above 1690 MHz is used by meteorological satellites (metsat) [downlinks], and is therefore largely unavailable for radiosonde use.[35] NOAA further states that "Both radiosondes and metsats have allocations throughout the 1670-1700 MHz band, but a radiosonde flying through a ground station's antenna pattern would disrupt satellite reception. The result is a splitting of the band with radiosondes largely limited to the lower 20 MHz."[36]

In order to achieve the increased frequency stability necessary to permit radiosonde operation in the smaller reallocated band, NOAA states the need to design new radiosondes using crystal controlled transmitters and a new type of modulation.[37] NOAA further states that the technology needed to make these changes is available, but the increased cost has historically made the new technology impractical (see Section 3 for associated reallocation costs and plans). NOAA also notes in its comments that the impending presence of non-radiosonde emitters within what is now the radiosonde band requires replacement of the radiosonde ground tracking equipment as well. NOAA expects that the three types of radiosonde ground tracking equipment currently used in this band could be replaced by a common system.

NOAA stresses in its comments that continued protection of frequencies used at the Wallops Island, Virginia receive site, as proposed in the Preliminary Report, is "absolutely essential." NOAA also recommends that the other Geosynchronous Operational Environmental Satellite (GOES) earth station, at Fairbanks, Alaska, be given the same protection as is proposed for the GOES earth station at Wallops Island. [38]

In the joint DOD response to the Preliminary Report, Air Force reports that it operates an undetermined number of radiosondes and seven MARK IVB Meteorological Satellite Ground Terminals in this band. In order to comply with the reallocation plan, Air Force will phase out of its inventory all radiosondes in this band prior to the planned reallocation date, and retune the MARK IVB receivers.

The FCC Report stated "... we believe that 5 megahertz may be too small an allocation to support development of new broadband technologies or wide-area operations and that this band is not located near enough to current non-Government operations for it to serve as an adjunct to them."[39] The FCC also recommends changing the reallocation schedule for this band from delayed (1/1/99) to immediate.[a]

**Commercial.** TIA, in its comments on the Preliminary Report, and NABER, in its comments on the FCC NOI, states that satisfying the conditions proposed for the protection of adjacent-band radio astronomy operations could make use of this band difficult. Also, "TIA believes that before non-Federal users can use this band, the Federal meteorological services will have to be redesigned or replaced."[40]

Digital Microwave Corporation (DMC) expressed concern about the accommodation of incumbent microwave users who are expected to transition out of the 2 GHz band to make way for PCS and other technologies. DMC expects reallocation of incumbent 2 GHz users to be costly if relocating to the '6 GHz' band or higher. DMC maintains that use of the 1670-1675, 1710-1755, 4635-4660, and 4660-4685 MHz band segments for non-Federal operational-fixed use would minimize costs for some of those incumbents required to relocate from their present 2 GHz frequencies.

AMSC comments on the Preliminary Report and on the FCC NOI suggest that MSS is prominent among the services requiring new accommodations, and that the frequencies proposed in the Preliminary Report are not useful for MSS systems. Specifically, AMSC points out that this band is not allocated internationally to MSS and would thus expose U.S. MSS systems operating in this band to interference from foreign systems. Moreover, AMSC contends that the U.S. systems would be required to protect the foreign MSS systems. AMSC also believes that ITU reallocation is not possible because of incompatible aeronautical mobile allocations adopted by WARC-92.[b] Even if this band were to be approved for MSS use, AMSC believes that systems using frequencies in the adjacent bands would interfere with MSS systems in the proposed band and MSS downlink sharing with radio astronomy below 1670 MHz would be problematic. Alternately, AMSC proposes two Federal bands (1492-1525 MHz for downlinks and 1675-1710 MHz for uplinks) that its analysis indicates can be shared immediately by domestic MSS systems and incumbent Federal users.[41]

A Computer Sciences Corporation (CSC) analysis of possible MSS interstitial sharing with Air Force radiosondes suggested that this type of sharing would be very difficult to achieve. AMSC therefore considers MSS sharing with radiosondes to be possible only in the 1690-1710 MHz segment of the proposed 1675-1710 MHz band.[42]

Motorola and TIA representatives indicate that limited commercial applications in this band are feasible.[43]

[a] No explanation was provided in the FCC Report for this proposed change.

[b] The 1670-1675 MHz band was allocated worldwide for ground-to-aircraft communication to be paired with the 1800-1805 MHz band for aircraft-to-ground, but the U.S. will maintain these operations at 849-851 and 894-896 MHz.

**Summary.** The comments submitted by NSF and NAIC strongly support the Preliminary Report's proposed restrictions on airborne and space-to-Earth communications in this band. The comments submitted by Army express concern with the continuing loss of authorized frequency resources, and the adverse impact on its land force operations. Most of the assignments in this band are for radiosonde stations operated by NOAA. In order to achieve the increased frequency stability necessary to permit radiosonde operation in the smaller reallocated band, NOAA would have to design new radiosondes using crystal-controlled transmitters and a new type of modulation. NOAA believes that the technology needed to make these changes is available, but the increased cost has historically made it impractical. NOAA anticipates replacing the three types of radiosonde ground tracking equipment with a common system. The FCC Report stated that the 5 MHz band segment proposed for reallocation is too small for the development of new broadband systems and is not located near enough to bands currently being used for the development of new technologies to support their development.

The comments submitted by AMSC indicate that the bands proposed for reallocation in the Preliminary Report will not help alleviate the MSS spectrum dilemma. However, AMSC does indicate that there are significant possibilities for MSS sharing with the meteorological services in the 1690-1710 MHz frequency range. AMSC recommends that NTIA consider making this spectrum available for MSS operations.

## 1710-1755 MHz

NTIA received nineteen responses on its Preliminary Report that addressed this band segment: twelve Federal, five commercial, and one each from utilities and public safety/local government (see TABLE 2-1). In addition to the public comments, the joint DOD response, and several FAA responses unrelated to the Preliminary Report, also addressed this band segment. Although it was not the subject of the FCC NOI, five parties filed comments that addressed this band segment: one Federal and four commercial (see TABLE 2-2). This band segment was also discussed in the FCC Report.

**Federal.** The majority of the Federal agency responses on the Preliminary Report discuss the reallocation issues in terms of both operational and cost impact. The cost impact is discussed in Section 3 of this report.

In its comments on the Preliminary Report, the United States Department of Agriculture (USDA) states that the Forest Service is one of the Federal Government's largest users of the 1710-1850 MHz microwave radio band. USDA further states that the reallocation will impact the microwave radio systems that provide the backbone communication links supporting land-mobile radio systems on National Forests and other lands managed by USDA for the public. USDA explains that these backbone links provide the primary radio interconnection between mountaintop radio repeaters and the base stations that interconnect with either mobile or portable hand-held radios. USDA adds that these systems are necessary for law enforcement, firefighting, and emergency disaster control (e.g., earthquakes, volcanic eruptions, and hurricanes) public-safety communications. "These microwave links provide substantial benefit to customers of the Forest Service and some links share channels with the U.S. Department of Justice/FBI and the U.S. Customs Service."[44] USDA states that the proposed reallocation of 1710-1755 MHz will disrupt their fixed point-to-point microwave operations that support

these essential functions. USDA asserts that the loss of this spectrum will impact 40% of the over 1,370 Forest Service microwave radio sites.[45]

The comments submitted by DOT state that systems used in FAA and the United States Coast Guard (USCG) programs will be affected by the proposed reallocation of the 1710-1755 MHz band segment. DOT further states that currently USCG uses these frequencies for communications, and FAA uses them to link lower density communications facilities to its nationwide microwave communications system.[46] DOT estimates that impact to these systems could be reduced if FAA and USCG were allowed to retain certain frequencies in the band to support safety-of-life operations. [a]

The comments submitted by the Department of Interior (DOI) include comments from the Bureau of Indian Affairs; the Bureau of Reclamation; the Bureau of Land Management; the National Park Service; and the U.S. Geological Survey, Office of Earthquakes, Volcanoes, and Engineering. In general, the comments addressed the reallocation options and cost that the various organizations are planning to use. However, several comments discussed mission impact. The Bureau of Reclamation states that the spectrum reallocation will impact their radio program in the Mid-Pacific, Great Plains, and Lower Colorado Regions. Reclamation further states that if their current request for a 15-GHz system is approved, it will eliminate the impact to the Lower Colorado Region. Reclamation also requests a waiver for the frequencies that it shares with the Department of Energy (DOE) Western Area Power Administration (WAPA), as WAPA is exempt from moving from this band because of the War Powers Act.[47] The comments submitted by the National Park Service state that the reallocation will adversely impact their telephone and data transmission system which both rely on microwave links utilizing frequencies within the 1710-1755 MHz band segment.[48] The comments submitted by the U.S. Geological Survey Office of Earthquakes, Volcanoes, and Engineering state that its microwave systems are used exclusively for earthquake monitoring and hazards mitigation. "These networks are monitored in real time and are required to be on-line at all times. Any modifications to these networks would require special consideration to assure no loss of data."[49]

The comments submitted by the Department of Treasury (Treasury) discuss the impact to its operations resulting from the loss of the 1710-1755 MHz band segment. Treasury states that one of the affected systems is the Rainbow Microwave System operated and maintained by the United States Customs Service. Treasury further states that this system interlinks the Hawaiian Islands and supports multi-faceted safety-of-life functions. Treasury emphasized that the functions being performed by this system cannot be replaced by satellite operations. Moreover, Treasury had already reconfigured the entire system to the 1710-1850 MHz band from the original 7/8 GHz band where the reliability level proved unacceptable.[50] Based on these arguments, Treasury has recommended in its comments on the Preliminary Report that NTIA include this system in the list of Federal microwave stations to be retained and fully protected from interference in accordance with the mixed use reallocation specified in Title VI.

[a] The USCG also operates Vessel Traffic Systems (VTS) around harbors and coastal areas with a large amount of ship traffic. There are eight VTS locations including New York, Puget Sound, Houston, and San Francisco.

The comments submitted by the Department of Justice (DOJ) represent those of the Federal Bureau of Investigation (FBI), the Immigration and Naturalization Service (INS), and the Drug Enforcement Administration (DEA). In its comments, DOJ stated that FBI, INS, and DEA make broad use of the radio frequencies in the 1710-1755 MHz band segment for Congressional and Federally mandated law enforcement programs, including continuity of law enforcement and national security and emergency preparedness telecommunications services.[51] DOJ stated that FBI operates microwave equipment in the 1710-1755 MHz band segment to relay land mobile radio communications that support safety-of-life operations.[52] The comments submitted by DOJ stated that INS also makes extensive use of the 1710-1755 MHz band segment to support the interconnect requirement of the INS Encrypted Voice Radio Program (EVRP).[53] DOJ further states that DEA uses the 1710-1755 MHz frequency band to support its video transmission system. Although each department has submitted reallocation options, DOJ is concerned that the impact of the reallocation and subsequent spectrum loss is not completely understood. DOJ stated that it is concerned that "the long-term budgetary consequences of band displacement are not fully appreciated."[54]

Army recommends in its comments that the Army Corps of Engineers (ACE) be afforded the same protection that Title VI guarantees for the Federal Power Agencies (FPA).[55] Although the ACE is not an FPA, Army states that the functions they perform and the types of areas they service are comparable to FPA functions and service areas.[56] In addition to the point-to-point microwave systems operated by ACE, the comments submitted by Army stated that currently there are over 2,650 tactical radio relay systems operating in the 1350-1850 MHz band, which is one of the most important spectrum resources for the Army's area-wide integrated communications network.[57] The comments submitted by Army further state that the continued loss of spectrum resources in this band is significant because "... it compresses the authorized frequency bands and complicates the tactical frequency assignments."[58]

DOE believes that there will be minimal impact on existing and planned operations as a result of reallocating the bands identified in the Preliminary Report.[59] DOE also indicates that the reallocation can be accomplished within the time frame proposed in the Preliminary Report.[60] However, there are several areas of concern that DOE indicates should be addressed regarding the reallocation of spectrum in the 1710-1850 MHz band:

- DOE has formal sharing agreements with other Federal agencies, such as the Army Corps of Engineers and the U.S. Bureau of Reclamation, to transfer electrical power distribution information over its existing 1710-1850 MHz microwave systems. Title VI is not clear whether or not the FPA's exception includes these formal sharing agreements. "Therefore, the Department requires assurance that these systems are also included under the exception for FPAs and that they will receive the necessary protection from harmful interference."[61]

- Although the FPA's were granted an exception from reallocation in Title VI and will receive protection from the emerging wireless telecommunications technologies, "... increased usage in the 1710-1850 megahertz band by these new technologies in the future may require more effective national regulatory procedures to ensure continued use of this band."[62]

NAIC and NRC comments on the Preliminary Report urge NTIA to consider improved protection or restrictive sharing requirements of the narrow 1718.8-1722.2 MHz band segment and a prohibition of airborne and space-to-Earth stations in this band, as well as in adjacent bands.

The National Communications System[a] (NCS) expressed concern that "essential operations in both the mixed use of the 1710-1755 MHz band segment and the remaining 1755-1850 MHz band segment following the reallocation will not be able to be carried out in an effective manner due to the crowded conditions that may exist." In its comments on the FCC NOI, NCS states its belief that NTIA has given proper consideration to the importance of this band and to the affected Federal agencies, and urge that the proposed minimum 10-year delayed effective date for reallocation for the 1710-1755 MHz band segment not be shortened.

Air Force states that the Space-Ground Link Subsystem (SGLS) operates in the 1761-1842 MHz band segment. The SGLS provides tracking, telemetry, and command (TT&C) for all operational military communications satellites of the United States and the North Atlantic Treaty Organization (NATO). The SGLS uplink in the 1761-1842 MHz band segment is used for command transmission to control over 90 satellites that are critical to national security. Air Force further states that it is not possible to change the frequency of satellites which have already been launched, and while it may be possible to change the frequency of satellites which have yet to be launched, in the near term this would be prohibitively expensive. "SGLS is the planned standard TT&C system for the next several generations of DOD satellites."[63]

The FCC Report states that although this is a desirable band located relatively close to the 1850-1990 MHz PCS band, and it may be able to support wide-area operations, continued Federal use of this band will severely limit its usefulness for non-Federal operations.[64] The FCC further states that it could not describe this level of usefulness because they lack sufficient information about the actual amount of continued Federal operations proposed for this band to compare the amount of proposed Federal use with potential non-Federal use and to gauge its usefulness for future non-Federal use.[65] The FCC also states that non-Federal use of the 1761-1842 MHz band segment may be compatible with the limited Federal operation currently in the band. "It also appears from the Preliminary Report that Government use is limited to less than 10 locations. These limited Government operations might be able to coexist with some non-Government use."[66] The FCC also questions the guard band requirements for the 1761-1842 MHz band segment given in the Preliminary Report. "The 6 megahertz wide 1755-1761 MHz frequency range and the 8 megahertz wide 1842-1850 MHz frequency range appear to offer excessive protection for space operations."[67]

DOD, however, states that its major concern with the reallocation of additional spectrum in the 1710-1850 MHz band is that high-power DOD satellite uplinks in the 1761-1842 MHz band segment will interfere with adjacent-band non-Federal operations. DOD further states that the FCC does not yet have standards for non-Federal receivers that would enhance sharing possibilities. DOD feels that the interference potential is only exacerbated if the FCC allows mobile systems in the transferred spectrum.

[a] The NCS is not a Federal agency but it is affiliated with Federal agencies.

An additional concern expressed by DOD is the availability of spectrum to accommodate displaced Federal fixed point-to-point microwave users. DOD states that current fixed point-to-point systems require a 70 MHz spacing between the transmit and receive frequencies. DOD asserts that the proposed reallocation of the 1710-1755 MHz segment, and possibly the 1845-1850 MHz band segment, will leave only 90 MHz of spectrum for these fixed point-to-point systems. DOD believes that this could make satisfying Federal requirements difficult, especially when multiple links or operation near DOD satellite uplinks are required.

**Commercial.** In its comments on the Preliminary Report and the FCC NOI, Motorola indicated that the need to coordinate with and protect existing FPA microwave facilities, coupled with the 10-year delay in availability, significantly compromises the utility of the 1710-1755 MHz band segment for wide-area land mobile services.[68] These views were also reflected in comments submitted by TIA, NABER, and the GTE Service Corporation (GTE). TIA further recommends that the remaining Federal users, particularly in urban areas, should be repacked into the remaining spectrum, and the band should be made available in three to five years rather than 10 years as proposed in the Preliminary Report.[69] Alternatively, Motorola indicated that Federal agencies using fixed point-to-point microwave systems in the 1710-1850 MHz band could be reaccommodated in other bands.

In its comments on the Preliminary Report, DMC suggests that the 1710-1755 MHz band segment should be allocated for primary fixed use by microwave operations that were displaced from the 2 GHz band by the FCC PCS proceedings.[70]

**Public Safety/Local Government.** In its comments on the Preliminary Report, the Association of Public-Safety Communications Officials-International Inc. (APCO) stated that the 1710-1755 MHz band segment has significant potential for public safety and other private land mobile operations. According to APCO, the band is sufficiently large to accommodate wide-area mobile use of wide-band technology, and is in the same frequency range as the 1850-1970 MHz PCS band.[71] However, APCO's comments also included some of the same concerns that were voiced by the commercial commenters relating to the decreased usefulness of the band caused by continued Federal use and the delayed effective date for reallocation. APCO claims to have no information that would question the need for restrictions, but feels it is difficult to gauge the viability of that band for other non-Federal operations without knowing the extent of the fixed microwave use or the levels of protection required for the military bases listed in the Preliminary Report.[72]

**Utilities.** In contrast to the majority of commenters in this band, the Utilities Telecommunications Council (UTC) supports NTIA's proposed reallocation of the 1710-1755 MHz band segment on a mixed use basis only while protecting FPA-operated systems. However, UTC questions whether other existing systems in this frequency range should be grandfathered and argues this band can be made available at an earlier date.[73]

**Summary.** The Federal agencies currently using the 1710-1755 MHz band segment, while not specifically opposing reallocation, expressed numerous concerns about the cost to, and operational impact on, their Congressionally mandated missions. The comments submitted by DOT, USDA, DOI,

and DOJ describe the impact that the reallocation of the 1710-1755 MHz band segment will have on these missions. Several commenters indicated that specific operations within their agencies will have to be protected from reallocation. For example, Treasury requests that the Rainbow Microwave System be retained indefinitely and fully protected from interference. The comments submitted by DOE agree with those submitted by Army, which state that ACE systems should be offered the same exemption as FPA systems, since they have a formal agreement to share power distribution information. DOE, as well as several other agencies, expressed concern about the growing congestion in the 1710-1850 MHz band. The comments submitted by NCS urge NTIA not to shorten the 10-year scheduled availability date for the 1710-1755 MHz band segment.

The FCC Report states that the 1710-1755 MHz band segment can be used to support wide-area operations and that more consideration should be given to reallocating a larger portion of the band. The FCC expressed concern that the lack of information about the remaining Federal operations in the 1710-1755 MHz band could limit its usefulness for commercial and public-safety applications. The FCC also states that non-Federal operations may be compatible with the limited Federal use of the 1761-1842 MHz band segment. Moreover, the FCC questions the guard band requirements specified in the Preliminary Report for the existing Federal operations in the 1761-1842 MHz band segment.

In their comments, Motorola, TIA, GTE, and APCO agree that the 1710-1755 MHz band segment can be used for the development of commercial and public-safety applications. However, their comments expressed concern about the remaining Federal users in the band, particularly in the urban areas where they feel spectrum congestion is the greatest. The comments submitted by Motorola, TIA, and APCO also stated that the delay of the scheduled availability date for the 1710-1755 MHz band segment is too long and should be reduced. TIA's comments specifically recommend that this band segment be made available for non-Federal use in three to five years.

### 2300-2310 MHz

NTIA received seventeen responses on the Preliminary Report that addressed this band: three Federal, two commercial, and twelve amateur (see TABLE 2-1). Although it was not the subject of the FCC NOI, twenty-four parties filed comments that addressed this band: one Federal, fifteen amateur and eight commercial (see TABLE 2-2). This band was also discussed in the FCC Report.

**Federal.** While NASA and NRC have no operations within the 2300-2310 MHz band, they state that they do have extremely sensitive operations at 2290-2300 MHz such as the Deep Space Network (DSN) receiver located at Goldstone, California.[74] In its comments, NASA explains how the round-trip transmit time is measured in hours for most of the space research operations and the signals detected are extremely weak.[75] Unless great care is used in the implementation of a new commercial service in the adjacent 2300-2310 MHz band, NASA believes that Deep Space operations could be adversely impacted.[76] NRC and NASA strongly support the restrictions proposed in the Preliminary Report, specifically those prohibiting airborne or space-to-Earth links in the 2300-2310 MHz band.[77]

NASA and Jet Propulsion Laboratory (JPL) representatives state that commercial low-power terrestrial applications could operate in the 2300-2310 MHz band with minimal coordination of operations at

Goldstone.[78] The Preliminary Report proposed a delayed effective date for reallocation of two years for the 2300-2310 MHz band "... to provide sufficient time to study and implement necessary upgrades to preclude adjacent band interference to the NASA Deep Space Network and planetary research radar receivers."[79] Since the release of the Preliminary Report, JPL has investigated the use of filters to decrease adjacent-band saturation of the DSN amplifiers. JPL reported that such filters are not practical for Deep Space application, and cannot be developed without degrading the desired signal and significantly reducing the portion of the 2290-2300 MHz band available for Deep Space probe assignments.[80] NASA and JPL both maintain that if the commercial service is compatible, then moving up the scheduled reallocation date for the 2300-2310 MHz band would not be a problem.[81]

In the joint DOD response on the Preliminary Report, Air Force indicates that the 2300-2310 MHz band is used primarily for electronic warfare training and telemetry systems. Air Force explains that these operations are conducted at specialized training ranges frequently located in areas remote from the general public. Air Force further states that the systems operating in this band have unique frequency requirements which cannot be measured monetarily. "Of greater concern is the inability to perform realistic electronic warfare training due to loss of the reallocated frequencies. The loss of realistic training reduces the probability of survival for personnel in hostile situations."[82] Air Force adds that systems supporting technological research functions require access throughout the radio frequency spectrum on a case-by-case basis. "Frequencies in reallocated bands necessary to support specific missions at specific locations will be requested on a case-by-case basis."[83]

The comments submitted by Navy state that many of the systems operating in the bands proposed for reallocation have a war reserve mode that is classified and cannot be reflected in the public records. "Consequently, the Navy and other elements of the DOD must be consulted, and must be involved in the selection of any non-Federal services proposed for operation in the bands identified for reallocation."[84]

In its comments submitted on the Preliminary Report and on the FCC NOI, NCS supports continued use of this band by the amateur radio service, to provide valuable national security/emergency preparedness (NS/EP) services.

The FCC Report recommends that the reallocation schedule for the 2300-2310 MHz band match the schedule for the 2390-2400 MHz band. "These bands are two of the few bands identified in the Preliminary Report that readily lend themselves to paired operations and simultaneous reallocation of the bands would greatly facilitate paired use of these bands."[85]

**Commercial.** In their comments on the Preliminary Report, GTE and TIA question the commercial viability of the 2300-2310 MHz band. GTE contends that although the 2300-2310 MHz band is located in close proximity to the 1850-2200 MHz band recently allocated by the FCC for PCS, the highly sensitive receivers of NASA's Deep Space Network in the 2290-2300 MHz band make the adjacent 2300-2310 MHz band "ill-suited for non-government use."[86] TIA also cautions NTIA that these highly sensitive receivers may make this band difficult to use.[87] Furthermore, both GTE and TIA expressed concern about sharing spectrum with the amateur radio service. [88]

The comments submitted by Pacific Bell and Nevada Bell on the FCC NOI stated that the 2300-2310 and 2390-2400 MHz bands can be easily paired because they are balanced with sufficient frequency separation, making them appropriate for the development of commercial applications including PCS growth or public-safety services. However, Pacific Bell and Nevada Bell indicate that the differential in timing availability will delay the development of these commercial applications. "The 2300-2310 and 2390-2400 MHz bands could be paired for public safety communications if they were made available for reallocation at the same time."[89] The Southwestern Bell Corporation comments and reply comments on the FCC NOI also support making these bands available at the same time. "The use of the 2390-2400 MHz band, paired with the 2300-2310 MHz band for wireless local loop applications, can improve public safety communications."[90] Along these same lines, the reply comments submitted by the Loral Qualcomm Partnership (LQP) suggest that replacing the 2402-2417 MHz band with the 2300-2310 MHz band could increase the usefulness of the 2390-2400 MHz band. "A paired band could be especially useful to provide additional uplink and downlink capacity in MSS systems."[91] TIA and NABER also expressed concern that protecting NASA's Deep Space Network receivers in the adjacent band and sharing with the existing amateur users may limit commercial development in the 2300-2310 MHz band.

**Amateur.** The comments submitted by the American Radio Relay League (ARRL) and the Radio Amateur Satellite Corporation (AMSAT) indicate that the proposed plan will impact current and future amateur operations. In its comments on the Preliminary Report, ARRL states that three distinct obligations were specified by Congress for NTIA to follow in considering which bands to reallocate for non-Federal use in order to protect amateur use of shared bands. ARRL contends that the proposed reallocation of the 2300-2310 MHz band violates the intention of Congress regarding the amateur service.[92] In their responses on the Preliminary Report, ARRL and AMSAT describe the likely disruption to amateur operations in the 2300-2310 MHz band that include point-to-point linking and weak-signal operations.[93]

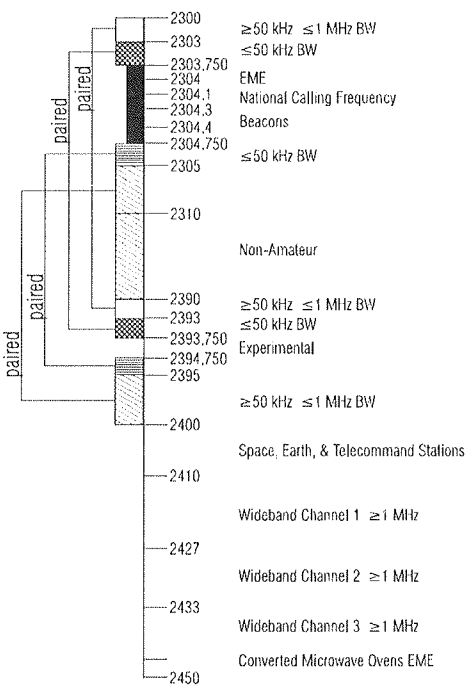


**FIGURE 2-1.** 2300-2450 MHz Amateur Band Plan.

The band plan submitted by the San Bernardino Microwave Society, Inc. (SBMS) for the 2300-2450 MHz band is given in Figure 2-1 and shows how the amateurs plan to use the 2300-2310 MHz band

paired with frequencies in the 2390-2400 MHz band for point-to-point linking.[94] SBMS states that the two bands are required because simultaneous transmission and reception from one site normally involves using different frequencies to increase the isolation between the transmitter and receiver. In this regard, some operators report to ARRL that it would be difficult to compensate for the loss of the 2300-2310 MHz band, since the required degree of frequency separation would not be available between 2417-2450 MHz.[95] This point was further emphasized in ARRL's response on the FCC NOI. The Amateur Radio Council of Arizona adds in its response on the Preliminary Report, "There is no other wide band spectrum available that will accommodate multiple channel per frequency use such as the 2300 MHz band."[96] The general consensus of the commenters on the Preliminary Report and the FCC NOI indicates that the amateurs believe they would not be able to continue point-to-point operations, as planned, if the 2300-2310 MHz band is allocated for commercial use, unless their status is elevated to co-primary.

ARRL reports there are more than 200 stations in the United States that operate at or near the frequency of 2304.1 MHz. ARRL further stated that these amateurs are engaged primarily in the study of unusual over-the-horizon media, such as tropospheric ducting and communicating by reflecting signals off the surface of the moon, referred to as Earth-moon-Earth (EME) communications.[97] In its comments on the Preliminary Report, AMSAT stated that currently most amateur weak-signal work is conducted in the vicinity of 2304 MHz, although in some countries other frequencies are employed due to the non-availability of the 2300-2310 MHz segment for amateur use.[98] A country-by-country list of amateur allocations of the 2300-2450 MHz region of the spectrum is given in TABLE 2-3.[99]

In its responses on the Preliminary Report and the FCC NOI, SBMS suggested that the spectrum from 2448 through 2450 MHz is also of particular interest to amateurs for weak-signal operation. "The use of

**TABLE 2-3**

National Implementations of the Amateur Service in the 2300-2450 MHz Band

| Country | Part of Band Implemented (MHz) |
|---|---|
| Australia | 2300-2450 |
| Austria | 2305-2322 & 2400-2450 |
| Belgium | 2300-2450 |
| Denmark | 2300-2450 |
| Finland | 2310-2450 |
| France | 2300-2450 |
| Germany | 2320-2450 |
| Ireland | 2300-2450 |
| Italy | 2303-2313 & 2440-2450 |
| Japan | 2400-2450 |
| Netherlands | 2320-2450 |
| New Zealand | 2300-2450 |
| Norway | 2300-2450 |
| Poland | 2319-2323 |
| Portugal | 2300-2450 |
| Spain | 2300-2450 |
| Sweden | 2300-2450 |
| Switzerland | 2300-2450 |
| Taiwan | 2440-2450 |
| United Kingdom | 2310-2450 |

easily available microwave oven magnetron tubes is fostering weak signal communications in another part of this band. Earth-moon-Earth communications is of particular interest to this service because it closely approximates the wavelength on which the tubes were intended to operate. Because of the large antennas (and associated narrow beamwidths), combined with the fact that these antennas are aimed up in the air, allows weak-signal activities to share this part of the band with residential microwave ovens."[100] The comments submitted by the Southern California Repeater and Remote Base Association (SCRRBA) on the FCC NOI suggested that other bands may be more appropriate for weak-signal experimentation. "2320 MHz appears to be a center of internationally available amateur frequencies as listed in the ARRL comments appendix."[101] In its comments on the Preliminary Report, ARRL maintains that moving weak-signal operations above 2390 MHz would result in the loss of some existing investment in equipment and antennas.[102]

Almost all of the comments received from the amateur community express concern about sharing with a "yet-to-be-determined" commercial service. Many of the commenters refer to the problems currently encountered between amateurs and the Automatic Vehicle Monitoring (AVM) systems operating in the 902-928 MHz band as a typical example of how sharing with commercial applications simply will not work.[103] In its comments, ARRL stated that Title VI requires the Secretary of Commerce to determine the extent to which, in general, commercial users could share the frequencies to be reallocated with amateur radio licensees. ARRL maintains that the Preliminary Report did not include such a sharing study.[104] ARRL submits that until candidate radio services are selected or at least identified, it is difficult for NTIA to conduct the mandatory sharing study required by Congress in Title VI. In ARRL's opinion, the only practical means for the Secretary to discharge "NTIA's statutory obligation" is to conduct a preclusion study based on possible future amateur uses of the segments proposed for reallocation, and to determine sharing options involving a range of commercial uses.[105]

ARRL further stated, "While there is a possibility of volunteer coordination between licensed commercial users and amateurs, even where there are mobile uses by both, or mixed fixed and mobile users, the fundamental ability of amateurs to continue to use the reallocated bands at all is dependent largely on the characteristics of commercial services to be added to the bands."[106] ARRL and AMSAT both believe amateur operations can effectively share spectrum with low-power commercial services (e.g., some Intelligent Vehicle Highway System (IVHS)[a] applications) or fixed point-to-point microwave systems. ARRL further states that the amateurs currently have a successful sharing arrangement in this band with Federal users. However, ARRL indicates that practical problems are encountered when amateurs attempt sharing bands with commercial services having a relatively high transmitter power, a high number of stations in heavily populated areas, and/or high duty cycle (i.e., AVM systems).

In its comments on the Preliminary Report, ARRL stated that reaccommodation of amateurs displaced by the loss of the 2300-2310 MHz band would lessen the impact on the amateur service. While ARRL does not consider itself in a position to suggest alternatives to the first 50 MHz proposed for reallocation, it does believe there is available spectrum to reaccommodate displaced amateurs, such as 2360-2390 MHz band, which it indicates was removed from amateur allocations for aeronautical flight test

[a] The Intelligent Vehicle Highway System is now called the Intelligent Transportation System (ITS) in an effort to encompass the three basic categories of land transportation: highways, transit, and rail.

telemetry.[107] This point was again emphasized during a meeting with ARRL representatives and at the NTIA sponsored meeting between Federal users of the spectrum and commercial representatives, as well as in ARRL and AMSAT responses on the FCC NOI. "That there may not be alternative bands for reallocation to the private sector does not mean that there is not an innovative means of reaccommodating displaced amateur users, which would have the added benefit of increasing the utility of the reallocated spectrum to the private sector."[108] SBMS suggests that one alternative may be to reallocate the 2417-2422 MHz band segment rather than the 2300-2305 MHz band segment and giving the amateur service a primary status in the 2300-2305 MHz band segment. SCRRBA proposes allocating spectrum in the 2360-2390 MHz band to accommodate amateur operations displaced by the proposed reallocation. "Should the NTIA find, and the FCC allocate, adequate replacement spectrum, we are quite certain that the vast majority of amateurs will support the reallocation plan, rather than strongly oppose it as we do now."[109] AMSAT also urges that a small slice of spectrum (1 to 2 MHz) somewhere in the 2300-2400 MHz region be allocated to the amateur service on a primary basis to accommodate terrestrial and EME weak-signal operations.[110]

**Summary.** The comments submitted by NASA and NRC indicate that they would support the NTIA's proposal to reallocate the 2300-2310 MHz band for non-Federal use as long as the restrictions protecting the Deep Space Network are included in the final report. If the new non-Federal service is compatible, NASA states that advancing the scheduled two year reallocation date for the 2300-2310 MHz band would not be a problem. DOD indicates that its use of this spectrum is largely at specific sites for limited time periods. The FCC recommends that the 2300-2310 and 2390-2400 MHz bands be reallocated at the same time to facilitate paired-use of the bands.

In their comments on the FCC NOI, several commercial commenters suggested reallocating the 2300-2310 and 2390-2400 MHz bands at the same time for the development of PCS applications, wireless local loop applications, and uplinks/downlinks for MSS.

The largest group of comments for the 2300-2310 MHz band were received from the amateur radio community. All of the commenters were concerned about the reallocation of the 2300-2310 MHz band, claiming that it would disrupt current and future amateur point-to-point linking and weak-signal operations unless care is taken in the selection of the new commercial applications. ARRL and AMSAT both believe that amateur operations in the 2300-2310 MHz band can share with low-power commercial services; however, they state that sharing with high-power high-density commercial applications is not practical. Furthermore, ARRL's recommendation to reaccommodate amateur operations to other portions of the Federal spectrum (i.e., 2360-2390 MHz) is also seen by the amateur radio community as a viable alternative that is in accordance with Title VI. AMSAT concludes that if the spectrum is reallocated, amateur weak-signal communications will still require a 1 to 2 MHz primary allocation in the 2300-2400 MHz band.

## 2390-2400 MHz

NTIA received twenty-three responses on the Preliminary Report that addressed this band: three Federal, four commercial, three public-safety/local government and thirteen amateur (see TABLE 2-1). In addition, the joint DOD response also addressed this band in its comments. The FCC received forty-

nine responses on its NOI that addressed this band: three Federal, fifteen amateur, fourteen commercial, eleven public-safety organizations, three non-licensed device, and three utility (see TABLE 2-2). This band was also discussed in the FCC Report.

**Federal.** In their comments on the Preliminary Report, NRC and NAIC express concern about the proposal to reallocate the 2390-2400 MHz band segment for commercial use. In its comments, NAIC stated that they perform important planetary radar research at 2380 MHz using facilities at the Arecibo Observatory in Puerto Rico. As stated in NRC's response to the Preliminary Report, NASA also plans to move the Goldstone planetary radar to the same frequency. NRC and NAIC believe the proposal to reallocate the 2390-2400 MHz band segment poses a substantial threat to these facilities, and accordingly support prohibiting airborne or space-to-Earth links in the 2390-2400 MHz band segment and placing limitations on terrestrial operations in Puerto Rico in that band segment.[111] In their comments on the Preliminary Report as well as those on the FCC NOI, NRC and NAIC urge NTIA to strongly recommend that the proposed conditions on reallocation of the 2390-2400 MHz band segment, designed to protect the passive services, be included in the final reallocation report.[112] "In the case of the 2390-2400 MHz band, the limited restrictions proposed in the Report will have little impact on any new terrestrial uses of that band, but will produce the substantial benefit of protecting valuable planetary research facilities in Arecibo, Puerto Rico."[113]

In the joint DOD comments on the Preliminary Report, Air Force indicated that the 2390-2400 MHz band segment is primarily used for electronic warfare training, telemetry or telecommand, and other scientific and technological research. Air Force further states that the equipment used to support these applications requires access throughout the spectrum. "Inability to accomplish special research projects impacts advances in science and technology for both the Government and non-Government sectors."[114]

Navy adds that many of the systems operating in the bands proposed for reallocation have a war reserve mode that is classified and cannot be reflected in the public records. "Consequently, the Navy and other elements of the DOD must be consulted, and must be involved in the selection of any non-Government services proposed for operation in the bands identified for reallocation."[115]

The comments submitted by NCS on the Preliminary Report and the FCC NOI restate its view that the amateurs provide valuable NS/EP services in times of crisis, and they should continue to have access to 2390-2400 MHz (at least on a secondary basis) if it is reallocated for commercial use.

The FCC Report states that if the availability of the 2300-2310 MHz band is changed to match the schedule for the 2390-2400 MHz band it would better lend itself to paired commercial and public-safety applications. The FCC also agrees with many of the commenters that the reallocation of the 2390-2400 MHz band segment to commercial or public-safety use could cause serious disruption to amateur service use of this band.[116]

**Commercial.** In its comments on the Preliminary Report, Motorola claims that the 2390-2400 MHz band segment suffers because of its close proximity to the 2450 MHz Industrial, Scientific, and Medical (ISM) band. "Thus devices operating in this band will also suffer a cost and size penalty with respect to

other competing services."[117] Motorola further states that the 2390-2400 MHz band segment may only be of practical use for low-powered localized systems, such as those currently occupying the adjacent ISM band, unless significant limitations are imposed on existing non-Federal users to make the band more suitable for wide-area communications.[118] In their comments on the Preliminary Report and the FCC NOI, GTE and TIA question the viability of developing commercial systems in the 2390-2400 MHz band segment. Both refer to the close proximity of NASA's highly sensitive receivers and the uncertainty of sharing the spectrum with the amateur radio service as possible deterrents.[119] NABER's comments and reply comments on the FCC NOI reiterate the concerns expressed by GTE and TIA.

Many of the commercial commenters on the FCC NOI recommend that in order to increase the usefulness of the 2390-2400 MHz band segment, it should be paired with the 2300-2310 MHz band. In its comments and reply comments, LQP suggests that the 2390-2400 MHz band segment could be used for MSS uplinks. "... this band may be more useful for new commercial communications service because it is not planned for use by the Part 15 systems under development and because it can be paired with the 2300-2310 MHz band, proposed by NTIA to be made available for commercial use in January 1996."[120] COMSAT supports the comments of LQP, and urges that "... some portion of the initial 50 MHz be released by the Federal Government for use by Mobile Satellite Service (MSS) systems."[121]

Several commenters also recommend licensing the 2300-2310 and 2390-2400 MHz bands for wireless local loop applications. "The wireless local loop system would also be highly resilient in situations of natural disasters, and repair or recovery time would be much faster. The application would also simplify the establishment of temporary high capacity access to the PSTN for public safety works, while still allowing those workers to be mobile."[122]

The comments and reply comments submitted by the Industrial Telecommunications Association Inc. (ITA) on the FCC NOI suggest that privately operated emerging technology systems as proposed in the Coalition of Private Users of Emerging Multimedia Technologies (COPE) Petition for Rule Making will prove to be more compatible with the existing geographic restrictions affecting the 2390-2400 MHz band segment than commercial communications systems. "With commercial consumer-oriented systems, there are no restrictions on the size, intensity of use, and scope of system. Commercially operated systems grow in response to consumer demand. In contrast, privately operated communication systems do not expand beyond the licensee's internal needs. In situations where there are geographical limitations, that must be imposed, the Commission can simply require the licensee to abide by the geographic restrictions as a condition of licensing."[123]

In addition, some TIA members believe that the 2390-2400 MHz band segment may be useful for short-range signaling or other communications integral to IVHS networks. However, TIA states that sharing with the amateur service could have a negative effect on public-safety use, particularly in larger urban areas. "It is apparent that amateur radio interest will oppose any reallocation of the band to new non-Federal services. Even if this opposition is not successful, it will be difficult to arrange sharing with amateur licensees in this band ..."[124]

**Amateur.** The comments submitted by the licensees and organizations representing the amateur radio community oppose the reallocation of the 2390-2400 MHz band segment if the proposed new application disrupts existing amateur users. ARRL argues that while it is currently accurate to characterize this band as lightly used, the trend of amateurs migrating to higher frequencies as lower bands become congested is nevertheless clear.[125] This point is further emphasized in the comments submitted by SBMS. "Since the new band plan for 2300 to 2450 was adopted an aggressive effort was made to encourage 420 to 431 MHz users to move up to the clear spectrum."[126] SCRRBA contends that the band plan presented in Figure 2-1 shows that the 2390-2400 MHz band segment is required for the frequency pairing that is used in point-to-point linking. "The point-to-point allocation needs to be two portions of spectrum separated by at least 40 MHz and less than 140 MHz. These segments need to be at least 6 MHz wide each. If a few smaller segments are available, the spectral efficiency will be less but the task can be accomplished if the total amount of the spectrum is at least 6 MHz per region. The minimum effective size for a segment is 1 MHz."[127] SCRRBA further states that the original band plan for the 2300-2450 MHz band became unusable for most point-to-point or fixed relay services with the loss of the 2310-2390 MHz band segment which was allocated to the amateur service on a secondary basis.[128] In its comments on the FCC NOI, ARRL adds that while it is not an immediate disaster to lose this spectrum, it sets a precedent whereby more spectrum may be taken in the future.

The general consensus among the amateur radio commenters on the Preliminary Report and the FCC NOI is that sharing with commercial services will be difficult. Specifically, SCRRBA refers to the current problems with Pacific Teletrac in the 902-928 MHz band as a typical example of how sharing with commercial applications will not work. "Commercial entities see the Amateur Service as an easily ignored annoyance."[129] SCRRBA describes the Pacific Teletrac system as an AVM system that uses high-power transmitters in high-density configurations. The potential problems of amateurs sharing with such commercial applications was also emphasized in a separate meeting with ARRL representatives. However, in ARRL's comments on the FCC NOI, they state that amateurs can share with certain types of commercial users. "The simplest type of commercial use to accommodate in these allocations would be licensed terrestrial point-to-point stations, or services not routinely located in, or proximate to, residential areas. Services with low duty cycles would be more likely to avoid interference to and from amateur operations in the same bands, and digital operations would be preferred over analog technologies. Wide bandwidth and spread spectrum users are particularly suitable to sharing with amateur operations in these segments."[130] Several commenters on the FCC NOI stated that NTIA should consider the reaccommodation of amateurs displaced by the loss of the 2390-2400 MHz band segment.[131] SCRRBA specifically suggests that amateur point-to-point operations be reallocated a portion of the 2310-2390 MHz band. "The guard band areas from 2300 through 2316 MHz and 2384 through 2390 MHz would seem workable."[132] SCRRBA indicates that this would provide a controlled guard band for flight test telemetry operations without wasting spectrum on an empty guard band. Furthermore, SCRRBA suggests that point-to-point operations could also be placed in other guard bands which may exist in the 2200-2300 MHz region.[133] In any event, ARRL recommends that if commercial users are added to the 2390-2400 MHz band segment, then the amateur status should be elevated to co-primary.

**Public-Safety/Local Government.** In general, APCO is concerned that NTIA's reallocation proposal does not include any frequencies below 1 GHz, where public-safety land mobile systems currently operate. "While spectrum above 1 GHz will provide frequencies for future public safety communications, especially new technologies, spectrum below 1 GHz is needed now to alleviate current spectrum shortages facing public safety communications."[134] In addition to the reallocation of frequencies below 1 GHz, APCO states that NTIA should allow public-safety agencies to share certain Federal frequencies in the VHF and UHF bands which are adjacent to FCC-allocated land mobile frequencies.[135] APCO also maintains that the preliminary reallocation proposal does not include sufficient blocks of contiguous frequencies below 3 GHz. "Larger frequency blocks and/or blocks adjacent to existing mobile bands would be more useful for wide-area mobile applications, especially for newer technologies (such as video and high resolution imagery) likely to require wide band channels."[136] Furthermore, APCO contends that the 2390-2400 MHz band segment is subject to significant limitations on additional non-Federal use. APCO is particularly concerned that microwave oven emissions in the 2400 MHz bands will prevent significant wide-spread land mobile use.[137] Taking the above factors into consideration, APCO suggests that NTIA revisit its proposal and reallocate Federal spectrum that would provide more immediate relief for State and local government public-safety agencies.[138]

The Florida Department of Transportation (FDOT) and the Maine Turnpike Authority (MTA) support the reallocation of the 2390-2400 MHz band segment for IVHS use.[139] FDOT conducted field performance evaluation of several automatic vehicle identification and electronic toll and traffic management systems (AVI/ETTM) technologies to determine the best features of those systems. In their comments, FDOT and MTA state that technologies operating in the 902-928 and 2435-2465 MHz bands were observed. FDOT states that a significant conclusion of its field performance evaluations was that the analysis of the spectrum around 915 MHz revealed that a great deal of electromagnetic interference already exists.[140] On the other hand, FDOT states that an analysis of the spectrum around 2450 MHz revealed "... little if any potential for interference."[141] MTA adds that the analysis performed by its consulting engineers reached similar conclusions.[142] Based on their analysis results, FDOT and MTA request that the 2390-2400 MHz band segment be reallocated to serve the needs of IVHS and they encourage NTIA to reallocate this band at the earliest possible date. "An early reallocation would facilitate our selection of frequency-specific technology currently under consideration in our SunPass[a] procurement."[143] Members of the American Association of State Highway and Transportation Officials Special Committee on Communications stated that the restrictions suggested in the Preliminary Report for the 2390-2400 MHz band segment appear to be reasonable and should not present a negative effect on competition or access to new services. In its comments on the Preliminary Report and the FCC NOI, Motorola also supports reallocation of Federal spectrum for IVHS use.

Thirty-seven commenters on the FCC NOI supported the COPE request for 75 MHz of spectrum below 3 GHz to establish a Private Land Mobile Advanced Communications Service. In its comments submitted on the FCC NOI, COPE stated that the 2390-2400 MHz band segment can be used to meet some of its public-safety requirements. "Of the three bands recommended for immediate reallocation, it is believed that the 2390-2400 MHz band segment would best meet the needs of private system

[a] FDOT's AVI/ETTM system will be known as SunPass. The principal purpose of SunPass will be to operate as an electronic toll collection system augmenting conventional toll collection equipment.

licensees as outlined in the COPE petition."[144] COPE further states that this band is available in Region 2 for fixed, mobile, and radiolocation use and would therefore be available for the types of operations proposed by COPE. "Similarly, the restrictions proposed in NTIA's Preliminary Report for the 2390-2400 MHz band would not impose a significant limitation on the utility of this spectrum for private communication systems."[145] The comments submitted on the FCC NOI by API, UTC, and APCO urge the FCC to begin the allocation process described in the COPE petition by allocating the 2390-2400 MHz band segment for non-Federal use.

**Non-Licensed.** The comments submitted by GEC on the FCC NOI suggest that the 2390-2400 MHz band segment be combined with the 2402-2417 MHz band segment for non-licensed device development. "Combining the two bands would increase the spectrum available offsetting some of the interference issues resulting from the ISM band."[146] Furthermore GEC believes that combining the two bands would allow the development of more competitive applications, thereby enhancing the value of the spectrum. Western Multiplex Corporation (WMC) holds an opposing view, and feels that the 2390-2400 MHz band segment is unsuitable for the development of non-licensed devices. "Therefore, WMC proposes that this spectrum be made available for urgently needed new private services with channelization plans capable of multiple users."[147]

**Utilities.** In its response on the FCC NOI, the Rural Telephone Cooperative (LEACO) maintains that the 2390-2400 MHz band segment is technically suitable for the provision of interactive video, voice and data services in rural areas. "The advantages of specifically allocating 2390-2400 MHz for interactive video, data, and voice use is that it is in close proximity to other compatible spectrum and could be used in conjunction with this existing spectrum to build a larger interactive network."[148]

**Summary.** NRC and NAIC support the restrictions proposed in the Preliminary Report that prohibit airborne or space-to-Earth links in the 2390-2400 MHz band segment and limit terrestrial operations in Puerto Rico near the Arecibo Observatory. Motorola claims that due to its proximity to the 2450 MHz ISM band, the 2390-2400 MHz band segment is impractical for wide-area communications, and that commercial applications would be limited to low-powered localized systems. DOD indicates that its use of this spectrum is largely at specific sites for limited time periods.

APCO agrees with Motorola, and is particularly concerned that the wide-spread use of microwave ovens in the 2400 MHz band will prevent significant wide-spread land mobile use. On the other hand, public-safety users responding to the FCC NOI believe that the 2390-2400 MHz band segment would meet the needs of private system licensees as outlined in the COPE petition. ITA also suggests that privately operated emerging technology systems will prove more compatible with the existing operations and limitations of the 2390-2400 MHz band segment than commercial communications systems. The general consensus among amateur radio commenters is that sharing with commercial services will be difficult. However, several of the comments submitted by representatives of the amateur radio service indicate that they are able to share with certain commercial and public-safety applications. FDOT and MTA support the reallocation of the 2390-2400 MHz band segment for IVHS use.

on the 2400-2483.5 MHz frequency band because it is the only spectrum widely available on an international basis with reasonably consistent regulation. "The Committee is concerned that the intended use of this portion of the 200 MHz spectrum freed for non-Governmental use would form a threat to the current and millions of future users of this band because devices, built according to the Committee's standard, would be interferers to the users."[161] The IEEE 802 Committee urges NTIA to reconsider reallocating the 2402-2417 MHz band segment and replace it with another band that does not conflict with existing ISM allocations.[162]

GEC and the Larus Corporation (Larus) stated that many of the non-licensed products that operate in the 2400-2483.5 MHz band are either in the early design/development stage or are in the process of being field tested. Many commenters on the Preliminary Report and the FCC NOI maintain that component costs are on the decline, making the 2400 MHz band even more attractive to companies developing non-licensed devices. Larus asserts that non-licensed devices could be developed in the 5725-5850 MHz band, but cost would be 20% to 30% more than devices in the 2400 MHz band. Larus also claims that they cannot use the FCC's newly allocated non-licensed PCS band for systems development, because the bandwidth and data rate requirements of its system are much greater than those envisioned for this band. GEC stated that its system architecture could be modified to operate in the newly allocated non-licensed PCS band, but it believes there is an overriding issue of global compatibility that must be considered. Regardless of the outcome, the majority of the commenters on the FCC NOI believe that use of the 2400-2483.5 MHz band for the development of spread spectrum communications will increase in the future. "... the Commission should authorize services at 2402-2417 MHz that are compatible with Part 15 spread spectrum operations — which include virtually all conventional narrowband services — and should refrain from authorizing services that cannot withstand even very slight interference potential of Part 15 spread spectrum technologies."[163]

**Commercial.** TIA' comments express concern that the microwave oven emissions in the 2402-2417 MHz band segment will limit its commercial usefulness. "TIA believes that the noise from ISM devices, including microwave ovens, and from non-licensed RF devices, makes NTIA's assessment, at best, overly optimistic."[164] Although the 2402-2417 MHz band segment is in a relatively quiet part of the microwave oven band, TIA maintains that the graphs shown in Appendix E of the Preliminary Report indicate a substantial noise floor. TIA agrees with the statements in the Preliminary Report that robust communications techniques may be available to overcome the noise in the band; however, these techniques are not without their costs. "TIA estimates that current and predicted future interference in the band will cause the infrastructure to cost between 2.2 and 50 times the cost of the same system implemented without interference."[165] Motorola agrees with TIA, and further adds that the level of interference in the 2402-2417 MHz band segment will necessitate high-powered devices to overcome the ambient noise, reducing its utility for wide-area use. "The net result is higher cost and size of equipment and poorer quality communications services."[166] GTE also believes that commercial applications in the 2402-2417 MHz band segment will be hampered by non-licensed devices and the noise generated by ISM devices.[167] In their comments on the FCC NOI, TIA and NABER agree that the 2402-2417 MHz band segment has several inherent problems including: microwave oven emissions, sharing with the amateur radio service, and non-licensed device operation. However, NABER believes

that some private users can coexist with the existing microwave oven and ISM equipment in the 2402-2417 MHz band segment.[168]

TIA and GTE question the ability of commercial services to share spectrum with amateur radio licensees. Furthermore, with the exception of non-licensed devices, TIA is unaware of any previous experience of commercial sharing with amateurs.[169] The 2402-2417 MHz band segment is a small portion of the 2400-2483.5 MHz band that is allocated on a secondary basis for use by the amateur service. As stated in the Preliminary Report and substantiated by ARRL, current amateur usage in the 2400 MHz band is light.[170] However, TIA maintains that judging from the comments received from the individual amateur radio operators, this claim is not accurate and it is TIA's opinion that amateurs will oppose any reallocation of the band to new non-Federal services. "Even if their opposition is not successful, surely it will be difficult to arrange sharing with amateur licensees in this band."[171] Moreover, GTE and Motorola reiterate their position that the amateur radio service will significantly hamper commercial applications in the 2402-2417 MHz band segment.

Motorola and TIA recognize that the manufacturers of non-licensed devices have made possible a host of useful products for consumers, businesses, and public-safety agencies. Given the fact that the 2400-2483.5 MHz band is already supporting a significant non-Federal industry, both Motorola and TIA question whether any additional benefits would be gained through the reallocation of the 2402-2417 MHz band segment.[172]

In its comments on the FCC NOI, LQP states that the 2402-2417 MHz band segment could be used for MSS uplinks. "LQP believes that its MSS uplinks would not be substantially affected by either ISM or Part 15 systems in the band."[173] LQP bases this conclusion in part on tests conducted to determine the impact of ISM emissions on MSS downlinks. LQP also indicates in its response on the FCC NOI that they are planning to conduct tests in the near future to determine the impact of ISM or non-licensed devices on MSS uplinks. However, after reviewing other comments in this proceeding, LQP withdrew its support.[174] LQP now believes that the spectrum proposed for immediate reallocation would be more useful for MSS if the 2300-2310 MHz band is substituted for the 2402-2417 MHz band segment. On the other hand, COMSAT supports LQP's original recommendation, adding that the 2390-2430 MHz band, which includes the 2390-2400 and 2402-2417 MHz band segments, was proposed by the U.S. delegation at WARC-92 for primary (Earth-to-space) MSS systems.

The comments and reply comments submitted by ITA on the FCC NOI state that the 2402-2417 MHz band segment will satisfy part of the future emerging technology requirements of private users. "With privately operated systems there is greater flexibility in use of the spectrum. Consumer-oriented services will find their greatest value in the urbanized areas of the country. However, urbanized areas will also tend to have the greatest concentration of microwave ovens and other non-licensed devices."[175] ITA further states that by contrast, many private users will need to establish their own internal emerging technology systems away from the nation's largest population centers. "Historically, private users have always had a need to establish reliable communications systems in remote and sparsely populated areas. The band 2402-2417 MHz may be ideally suited to accommodate this need."[176]

**Amateur.** The comments submitted on the Preliminary Report and the FCC NOI by ARRL, AMSAT, regional amateur groups, and several amateur operators oppose the reallocation of the 2402-2417 MHz band segment for commercial use if it disrupts existing amateur operations. In their responses, representatives from the amateur radio community describe the possible disruption to current and future amateur television (ATV) and amateur-satellite downlink operations if the 2402-2417 MHz band segment is reallocated. AMSAT confirms that although current ATV and satellite use may be light by standards used to judge other parts of the spectrum, it expects usage to increase in the next few years. "Like other users of the radio spectrum, amateurs tend to move from lower frequencies to higher frequencies as time passes and the state-of-the-art advances."[177]

ARRL states in its comments on the Preliminary Report that ATV will occupy three channels: 2410-2427, 2427-2433, and 2433-2450 MHz (as shown in Figure 2-1). ARRL further states that television transmission often requires wider bandwidths than do other forms of amateur communication.[178] For this reason, amateur television experimenters have an especially strong incentive to use the higher-frequency bands such as 2400 MHz.[a] ARRL also reports that ATV is currently being used in the Chicago area, northern and southern California, Arizona, and Nevada. In separate comments, the Chief of Police of Martinez, California describes the importance of his ATV repeater network to public-safety operations in his jurisdiction.[179] The comments submitted by ATN on the FCC NOI also discussed the expanding public service applications of amateur television. "This is one of the best areas for the Amateur radio community to help the public safety workers to communicate by use of the Amateur Television Repeaters during disasters."[180] ATN agrees that the reallocation of the 2402-2417 MHz band segment will primarily affect the first ATV channel (2410-2427 MHz), but they are more concerned that a loss of spectrum at the lower part of the 2400 MHz band would force other displaced amateur activities into the ATV channels. "Although our repeater is on 2441.5 MHz, the loss of the lower part of the 2.4 GHz band would force other amateur mode activity that would be displaced to share the only clear repeater input channel suitable."[181]

In its comments on the Preliminary Report, AMSAT supports NTIA's proposal to exclude the 2400-2402 MHz band segment from reallocation, stating that these frequencies are of vital importance to spacecraft operations in the amateur-satellite service, for satellites in current use as well as those under construction.[182] However, in the readily foreseeable future, "AMSAT anticipates an increased demand for amateur satellite operations in this portion of the spectrum, far greater than can reasonably be accommodated within a 2 MHz band."[183] AMSAT believes that the 2 MHz band segment is too narrow to accommodate such wide-band techniques as fast-scan television, even if compression techniques are employed. AMSAT hopes to employ such modes on future spacecraft. ARRL agrees with AMSAT, that while the 2400-2402 MHz band segment takes into consideration existing occupancy of the band by amateur satellites, it provides little room for future requirements, and does not satisfy the need to have comparable spectrum for uplinks and downlinks as indicated in the band plan shown in Figure 2-1.[184] AMSAT argues that the 10 MHz-wide 1260-1270 MHz uplink-only amateur service allocation is available and a similar bandwidth is needed as a downlink at 2400 MHz.[185] TABLE 2-4 lists the amateur satellites that use the 2400 MHz band.

[a] Amateurs transmit both AM and FM in this band. AM video has a bandwidth of approximately 6 MHz and FM video, approximately 17 MHz.

In its comments on the Preliminary Report, AMSAT stated that the transmitter for the French-built Arsene amateur satellite failed several months after launch. However, before the failure, AMSAT states that a number of amateurs around the world reported hearing this downlink at 2446.5 MHz indicating that it may be viable to operate satellite downlinks and possibly uplinks in the upper portion of the 2400 MHz band.[186]

**TABLE 2-4**
Amateur Satellite Usage in the 2400 MHz Band

| Amateur Satellite | 2400 MHz Band Usage |
|---|---|
| AMSAT-OSCAR 13 | downlink on 2400.711-2400.747 MHz<br>beacon on 2400.650 MHz |
| UOSAT-OSCAR 11 | beacon on 2401.5 MHz |
| PACSAT (AO-16) | beacon on 2401.1 MHz |
| DOVE (DO-17) | beacon on 2401.22 MHz |
| Arsene | downlink on 2446.5 MHz |
| Phase 3D<br>*scheduled launch: 4/96* | downlink on 2400.5-2400.9 MHz<br>Uplink on 2400.1-2400.5 MHz |

The comments and reply comments submitted by the amateur radio community and in particular the amateur-satellite community on the FCC NOI expressed concern about the proposed reallocation of the 2402-2417 MHz band segment for commercial use. ARRL and AMSAT stated that the 2400-2450 MHz band is primarily used for amateur-satellite operations and wide-band amateur television operations. In the Preliminary Report, NTIA's assessment of this band concluded that "... amateur use of these bands is believed to be very light in comparison to the lower amateur radio frequency bands."[187] Several of the commenters agree with NTIA's initial assessment; however, the amateur commenters maintain that usage of these bands is expected to change in the future. In order to meet the anticipated near-term future needs of the amateur-satellite service, AMSAT recommends that a 10 MHz-wide portion of the existing amateur-satellite band from 2400-2410 MHz be allocated on a primary basis to the amateur service, with no sharing partners except for the existing ISM assignments.

The comments received from the amateur radio community on the Preliminary Report and the FCC NOI also expressed concern about the possibility of sharing the 2402-2417 MHz band segment with high-density commercial applications, referring to the on-going events in the 902-928 MHz band. However, AMSAT does believe that amateur-satellite operations could share with point-to-point microwave links, since interference could be dealt with on a case-by-case basis. One commenter on the FCC NOI suggests that the proposed bands could be modified to 2393-2400 and 2409-2427 MHz, providing for both a 3 MHz high-band pairing slot and increased bandwidth for amateur satellite activities in the 2400-2409 MHz slot.[188] Several commenters believe another viable alternative is to return several megahertz at the high end of the 2310-2390 MHz band to shared-use with the amateur radio service.[189] "It was taken away to accommodate aeronautical flight test telemetry. To our knowledge, there is no current use of the spectrum for that purpose. The re-utilization of empty spectrum is clearly in the public interest."[190]

**Public-Safety/Local Government.** In addition to the disruption of non-licensed device operation, APCO's comments on the Preliminary Report express concern that microwave oven emissions in the upper portion of the band will prevent significant wide-spread land mobile use in the 2402-2417 MHz

band segment.[191] The general consensus among the public-safety commenters to the FCC NOI is that microwave oven emissions will hinder to some extent the operation of wide-area mobile public-safety systems in the 2402-2417 MHz band segment. However, many of the commenters agree with the suggestion made by the American Petroleum Institute (API), that some public-safety use may be possible. "Some limited applications could possibly be met in the 2402-2417 MHz band although it is congested with Industrial, Scientific and Medical (ISM), and Part 15 devices."[192] The comments submitted by APCO, COPE, and the Utilities Telecommunications Council (UTC) on the FCC NOI indicate that there may be methods to avoid microwave oven interference, either through geographic limitations, power levels, or advanced technological approaches such as spread spectrum. "APCO urges the Commission and the manufacturing community to explore these and other techniques that might expand possible uses of the 2.4 GHz band. This spectrum is too valuable to be left for the near exclusive use of microwave ovens."[193] Moreover, APCO suggests that for the purpose of long-range planning "... the Commission may also want to impose additional technical restrictions on microwave oven signal leakage to expand the potential for future use of the 2.4 GHz band."[194]

The comments submitted by COPE suggest that the 2402-2417 MHz band segment may also be suitable spectrum for licensing certain types of private communications systems. "Whereas commercial carriers generally require expansive, ubiquitous coverage in order to market their services, private users are able to develop more localized systems and are therefore better able to engineer in their systems."[195] APCO supports COPE's position, and suggests that the Commission explore the possibility of allocating the band for private operational fixed service (POFS) microwave operation. "While in urban areas POFS microwave may be difficult due to aggregate microwave oven interference, the band could be used for POFS microwave at isolated mountaintop transmitter/receiver sites with high elevation paths over sparsely populated areas."[196] Commenters also suggest that the 2402-2417 MHz band segment could also be used to alleviate some of the public-safety microwave frequency shortages caused by the reallocation of the 2 GHz band for PCS applications. COPE adds that the spread spectrum systems currently operating in the 2402-2417 MHz band segment are primarily used by public-safety and industrial users. "It is therefore possible that this spectrum could be allocated for use by private users with technical parameters that are consistent with the existing Part 15 systems."[197]

In their comments on the Preliminary Report, both FDOT and MTA supported the reallocation of the 2402-2417 MHz band segment for IVHS use. FDOT's comments indicate that this choice of bands was a result of field tests conducted using several AVI/ETTM systems operating within the 902-928 and 2435-2465 MHz bands. From these field tests, FDOT states that its consultants determined that the spectrum around 915 MHz was too congested and would only get worse over time. On the other hand, FDOT states that analysis of the spectrum around 2450 MHz revealed that there was little if any potential for interference.[198] MTA stated that its consulting engineers came to a similar conclusion. Based on their analyses, FDOT and MTA recommend reallocating the 2402-2417 MHz band segment for use by IVHS. FDOT maintains that reallocation at the earliest possible date is important because it would facilitate their selection and procurement of equipment.[199] In addition, Motorola's comments on the Preliminary Report and the FCC NOI recommend that Federal spectrum be reallocated to support the needs of IVHS. "In this regard, Motorola envisions IVHS will require spectrum to accomplish both wide area communications as well as limited or short range messages."[200] Motorola

further states that short range communications will be used for electronic fee payments at toll booths or parking lots, in-vehicle signing, and commercial vehicle clearances.

**Utilities.** The comments submitted by UTC on the Preliminary Report and the FCC NOI expressed concern that the reallocation of the 2402-2417 MHz band segment to the private sector could be construed as a policy determination that this band should be allocated by the FCC for licensed radio services.[201] UTC contends that many utilities currently employ spread spectrum equipment developed under the FCC's Part 15 rules for automatic meter reading, demand side management, and point-to-point communications to pipelines. "In short, the Part 15 spread spectrum bands, including the proposed 2402-2417 MHz, are used for important applications that cannot, and should not, be dismissed as unnecessary or unimportant merely because they are unlicensed."[202] UTC therefore questions the commercial viability of the 2402-2417 MHz band segment for new, licensed radio services given the significant current and projected use of this band by spread spectrum operations under Part 15 rules. API's comments on the FCC NOI reiterated UTC's concern that non-licensed spread spectrum operation in the 2402-2417 MHz range should not be curtailed.

LEACO suggests in its comments on the FCC NOI that the 2402-2417 MHz band segment could be used in conjunction with the existing spectrum to build a larger interactive network in rural areas.[a] "When considering spectrum suitable for rural areas, the distance a transmitter is capable of covering is critical since it is uneconomical to install large numbers of transmitters with small service areas in sparsely populated areas. The reallocated spectrum is both economically and technically suited for rural areas because the range of a single transmitter is far greater than the range of a transmitter operating at 28 GHz or greater spectrum. The typical range for the 28 GHz band is six miles while the typical range of the 2.4 GHz is thirty miles. Thus the reallocated spectrum is best suited for rural areas."[203]

**Summary.** NAIC recommends that restrictions be added to the final reallocation plan to prohibit airborne or space-to-Earth links and to place constraints on terrestrial operations near the Arecibo University in the 2402-2417 MHz band segment. DOD indicates that its use of this spectrum is largely at specific sites for limited time periods. The FCC Report expressed concern about the disruption of present and future amateur operations in this band segment if allocated for commercial use.

The comments submitted by the non-licensed device manufacturers oppose the reallocation of the 2402-2417 MHz band segment to licensed users not willing to adhere to rules comparable to the present Part 15 spread spectrum rules. The general consensus among commercial entities is that microwave oven emission, non-licensed device operation, and sharing with amateurs make this band difficult for a licensed service to use. However, ITA indicated that the 2402-2417 MHz band segment could satisfy part of the future emerging technology requirements of private users.

The amateur radio community is opposed to any reallocation of the 2402-2417 MHz band segment that disrupts its existing satellite and television operations. ARRL and AMSAT anticipate that the increased

[a] The Multipoint Distribution Service (MDS) spectrum is located at 2150-2162, 2650-2656, 2662-2668, and 2674-2680 MHz; the Multichannel Multipoint Distribution Service (MMDS) spectrum is located at 2596-2644 MHz and the Instructional Television Fixed Service (ITFS) spectrum is located at 2500-2644 MHz.

demand for amateur-satellite operations cannot be accommodated in the 2 MHz band segment reserved in the Preliminary Report. AMSAT recommends a primary allocation in the 2400-2410 MHz band for amateur-satellite operations. From the standpoint of the amateur community, sharing has not been successful with high-density commercial users under any circumstances. However, AMSAT does believe that amateur-satellite operations could share with point-to-point microwave links, since interference could be handled on a case-by-case basis.

UTC and APCO question the commercial viability of the 2402-2417 MHz band segment for a licensed commercial service. UTC states that many utilities are planning to use non-licensed spread spectrum systems, and the reallocation of the 2402-2417 MHz band segment would only serve to disrupt the services to be provided by these devices. APCO is concerned that the emissions generated by wide-spread microwave oven use will prevent the commercial development of wide-area mobile systems. However, APCO suggests that the FCC explore the possibility of allocating this band for private operational fixed service microwave operation in rural areas. COPE believes that this spectrum could be allocated for use by private users with technical parameters that are consistent with the existing Part 15 systems. FDOT and MTA support the reallocation of the 2402-2417 MHz band segment for use by emerging IVHS technology.

### 3650-3700 MHz

NTIA received four responses on its Preliminary Report that addressed the 3650-3700 MHz band segment: one Federal and three commercial (see TABLE 2-1). In addition to the public comments, the joint DOD response discussed the reallocation of this band segment. Although it was not the subject of the FCC NOI, three parties, all commercial, filed comments that addressed this band segment (see TABLE 2-2). This band was also discussed in the FCC Report.

**Federal.** As stated in DOT's comments, the 3650-3700 MHz band segment is part of the larger 3600-3700 MHz band that the FAA was planning to use for expansion of the terminal radars used to support air traffic control at airports. DOT stated that the "FAA is not currently using this band, but future air traffic growth, which is likely, could require additional frequencies to support the radar surveillance that is critical to air traffic control."[204]

In the joint DOD response to the Preliminary Report, Air Force states that this band is used for satellite augmentation and target cross section and scatter tests on military ranges. Air Force recommends a 50 MHz guard band for adjacent-band protection from mobile high-powered radar systems. Air Force believes that continued encroachment on the adjacent-band will increase potential electromagnetic interference (EMI). Air Force further states that non-Federal users will need to develop and promote strict receiver and transmitter standards to prevent EMI to or from critical radar systems in the adjacent-band.[205]

Navy states that it has an extensive investment in air traffic control radars that operate in the 3500-3700 MHz band. This radar utilizes 15 or more channels throughout the 3500-3700 MHz band for optimum operation.[206] Navy also states that its new mission concept emphasizes "littoral" operations (i.e., operations close to land that is presumed to be occupied, at least in part, by hostile forces). "Given

the shift of Navy warfare doctrine into littoral operations which require locating ships closer to shore than blue water operations, it is expected that this vital system will experience a significant increase in interference."[207]

The FCC Report states that the reallocation of the entire 3600-3700 MHz band for non-Federal use could provide much needed spectrum for the fixed-satellite service (FSS). "Although this band is already used by non-Government users, we believe that elimination of allocation footnote US245, which limits FSS satellite use to international inter-continental systems subject to a case-by-case interference analysis, would provide potential for increased non-Government use."[208] The FCC Report also states that reallocation of additional spectrum adjacent to this band is justified for non-Federal use. "We believe it would be very useful to fully examine the possibility of reallocating the entire band for non-Government use."[209]

**Commercial.** In its response to the Preliminary Report, the Communications Satellite Corporation (COMSAT) World Systems (CWS) supports the reallocation of the 3650-3700 MHz band segment for commercial fixed-satellite use. CWS points out that the 3600-3700 MHz band is available internationally for fixed-satellite without the same constraints that confront domestic users. CWS states that within the International Telecommunications Satellite Organization (INTELSAT) system alone, 28 countries use the 3625-3700 MHz band.[210] CWS asserts that its experience with international satellite operations in the 3500-3700 MHz band demonstrates that use of the 3650-3700 MHz band segment is technically feasible and economical, particularly for large earth stations, but also for Very Small Aperture Terminals (VSATs), in providing digital voice, video, and data services. At a minimum, CWS urges the reallocation of the 3650-3700 MHz band to non-Federal use with a primary allocation for FSS, and a secondary allocation for radiolocation services.[211] CWS believes that the proposed January, 1999 time frame for such a reallocation is reasonable.

In addition, CWS recommends that NTIA consider the reallocation of the lower 50 MHz portion from 3600 to 3650 MHz, for non-Federal use with a primary allocation for FSS, and a secondary allocation for radiolocation services. The comments submitted by CWS emphasize "In view of the demand for C-band capacity, and the experience CWS and its customers already have had in using 3625-3700 MHz, use of this spectrum is clearly commercially viable."[212] If reallocation for non-Federal use is not deemed feasible upon consultation with Federal users of the 3600-3700 MHz band, CWS believes NTIA should consider extending the current sharing between Federal and non-Federal users of the 3600-3700 MHz band to include the 3500-3600 MHz band as well.[213]

Comments submitted by TIA and NABER on the FCC NOI recommend adopting regulatory or industry receiver standards for new equipment in the reallocated band to enhance sharing.

**Summary.** The comments submitted by DOT stated that the 3650-3700 MHz band segment is not currently being used. However, the anticipated growth in air traffic control could necessitate its use at a later date. Air Force emphasized the need of a 50 MHz guard band to prevent EMI to and from DOD radars that are adjacent to non-Federal applications. Air Force further stated that the adoption of transmitter and receiver standards for commercial equipment is essential. Navy indicates that its training

operations will be moving closer to shore increasing the potential of interference with non-Federal users. The FCC Report recommends that the entire 3600-3700 MHz band be reallocated for non-Federal use in order to provide much needed spectrum for FSS. The FCC also recommends that allocation footnote US245 be eliminated.

CWS supports reallocation of the 3650-3700 MHz band segment for the FSS, citing the current technical and economical success of INTELSAT, indicating that its current international operations in the 3500-3700 MHz band are commercially viable. CWS also believes the proposed time frame for reallocation (5 years) is reasonable. In addition to the reallocation of the 3650-3700 MHz band segment, CWS suggests several other alternatives that would extend the reallocation to include 3600-3650 and 3500-3600 MHz. TIA and Naber recommend adopting receiver standards to enhance sharing in the band.

### 4635-4660 and 4660-4685 MHz

NTIA received ten responses on its Preliminary Report that addressed these bands: four Federal, five commercial, and one public safety/local government (see TABLE 2-1). In addition to the public comments, the joint DOD response discussed the reallocation of this band. The FCC received 30 responses on its NOI that addressed these bands: sixteen commercial, nine public safety/local government, three utilities, and two non-licensed (see TABLE 2-2). These bands were also discussed at separate meetings between NTIA and DOI as well as in the FCC Report.[214]

**Federal.** In its response on the Preliminary Report, Treasury stated that it operates nine aerostat wideband downlinks in the 4635-4660 MHz band segment: four in Texas, and one each in Puerto Rico, Arizona, Louisiana, Florida, and the Bahamas. Treasury feels that the costs for changeout of frequencies at these sites will be negligible if substitute frequencies within the tuning range of the equipment can be successfully coordinated, as is anticipated.

DOE stated in its comments that it is authorized to use the 4400-4990 MHz band for the Nuclear Emergency Search Team (NEST) equipment in any operating environment throughout the United States. DOE further states that this team has the responsibility to search, detect, and locate nuclear materials, and to respond to nuclear-related emergencies to protect the safety and health of life and property. While the radio equipment is frequency agile and can be tuned to any frequency in the 4400-4990 MHz band, DOE maintains that operational use of this equipment should not be restricted in any operating environment if its use is required in response to emergencies. DOE stated that NEST currently coordinates on a case-by-case basis prior to the use of its equipment in any operating environment to avoid causing harmful interference to other operations. DOE adds that it has also received spectrum support for new microwave systems in support of a new, very large trunked land mobile system. DOE believes that these microwave systems can be reprogrammed to operate in the remaining portions of the 4400-4990 MHz band at negligible cost.

In its comments, NASA stated that it operates aeronautical video telemetry link transmitter equipment in the 4660-4685 MHz band that can be replaced for use in another band at a minimal cost.

The comments submitted by Army stated that its tactical radio relay systems are authorized in these bands and are extensively used within the United States for comprehensive realistic training, humanitarian relief, natural disaster operations, and for maintenance of combat readiness. Army's comments also stated that the 4400-4990 MHz band supports unmanned aerial vehicle and mobile video units, and is the only band used by the Army for transportable, fixed tropospheric scatter (troposcatter) communications systems. The comments submitted by Army also indicated several areas of concern regarding the reallocation of this band: "This band is an important spectrum resource for the Army's integrated communications networks. ...Of the 3 frequency bands used to link the integrated area-wide network, this band is used for major Army headquarters nodal connectivity.... Previous reallocations have effectively removed land forces tactical networks from two of the 6 bands normally used. Options of moving operations into one of the other bands are extremely difficult and not operationally sound. Other frequency bands are fully used and very congested. Moving to a lower band creates technical problems from larger bandwidths and operational distance requirements. Moving to a higher band creates similar problems.... Further loss or erosion of authorized frequency resources would adversely affect military land forces' ability to provide an adequate command, control communications network."[215]

In the joint DOD response on the Preliminary Report, Air Force states that the reallocation of this band will result in the need to retune one video downlink communications system, ten microwave telemetry and control systems for its TARS, one over-the-horizon tropospheric radio system, an undetermined number of digital tactical tropospheric systems, and to relocate its Television Ordnance Scoring System (TOSS) equipment to the 7 GHz band, if possible. Air Force also states that dual channel operation of the digital tactical tropospheric systems will require at least 100 MHz of frequency separation. Moreover, Air Force stated that loss of frequencies for these tropospheric systems will significantly increase congestion, reduce flexibility, make co-sited operations more difficult to support, and increase the potential for interference.

Navy states in its comments that many of the systems operating in the bands proposed for reallocation have a war reserve mode that is classified and cannot be reflected in the public records.

DOI stated that the 4400-4990 MHz band was discussed as a possible alternative for reallocated 1710-1755 MHz Federal fixed point-to-point microwave systems, but indicated that there may not be many commercial systems available and that interference is possible because of the aeronautical mobile operations currently in the band.[216]

The FCC Report states that although these bands are already allocated for non-Federal use for FSS (space-to-Earth) on a co-primary basis with Federal fixed and mobile use, there is currently no non-Federal use of these bands. The FCC believes that this spectrum would be useful in providing non-Federal services, provided that the domestic allocation footnote that limits use of these bands to international inter-continental systems be eliminated (although such use would still be constrained by the international allotment plan contained in Appendix 30B of the ITU Radio Regulations).[217] The FCC also states that new technologies will likely require greater than the 50 MHz identified for reallocation. Specifically, "...it appears that significant opportunities for additional non-Government use exist,

considering that many of the Government operations appear to be in either remote areas or at sea. Accordingly, further consideration should be given to reallocation of a significantly greater portion of the 4400-4990 MHz band for exclusive non-Government use as well as to the potential for sharing all of this spectrum with non-Government services."[218]

**Commercial.** LQP suggests in its comments on the Preliminary Report that the 50 MHz segment of spectrum offered for non-Federal use in these bands could be used for MSS feeder uplinks, and could be even more useful if combined with 150 MHz of additional adjacent spectrum.[219] In its comments on the FCC NOI, LQP expands the list of suggested uses for the band to include not only MSS feeder uplinks, but service and feeder uplinks and/or downlinks as well.[220] As stated in LQP's comments on the Preliminary Report, the adjacent spectrum could be made available to commercial systems on either an exclusive or shared basis with Federal systems, and LQP would work with NTIA and the users of these bands to determine the feasibility and mechanisms for sharing. LQP believes that the few gateway earth stations (less than 10 in the U.S.) needed for its system could be located so as to prevent harmful interference to Federal operations.[221] COMSAT also supports allocation of these bands for MSS use: "COMSAT agrees with LQP, and other MSS commenters ... that the 50 MHz of spectrum proposed for immediate transfer from the Federal Government to the private sector merits consideration by the Commission as candidate bands for additional global MSS spectrum....[these bands] would be extremely useful for designation as non-geostationary satellite feeder link bands."[222]

In its comments on the Preliminary Report and the FCC NOI, AMSC states that MSS is prominent among the services requiring new accommodations, and that the frequencies proposed in the Preliminary Report are not useful for MSS systems. Specifically, AMSC points out that ITU reallocation of these bands is not feasible due to the need for and the use of current fixed-satellite service allocations and allotments in Appendix 30B of the ITU Radio Regulations.

In its comments on the Preliminary Report, Motorola contends that "...due to its location in the spectrum, the 4660-4685 MHz band is not usable for cost-effective wide area mobile communications."[223] Several other commercial, public safety/local government, and utilities commenters to the FCC NOI agree with Motorola indicating that the use of this band for wide-area private land mobile systems is well beyond the capabilities of the current technology.[224] The comments submitted by TIA and APCO express concern about the limitations that were proposed in the Preliminary Report for the 4635-4660 and 4660-4685 MHz bands.[225]

Several commenters to the FCC NOI and the Preliminary Report suggest that the 4660-4685 MHz band should be allocated for primary fixed use by microwave operations that were displaced from the 1.8 and 2.2 GHz bands by the FCC PCS proceedings.[226] However, Alcatel warns that although the band is suitable for fixed microwave use, at least 100 MHz is needed for a viable microwave channel plan (transmitter and receiver channels each must be at least 10 MHz with a 5 MHz guard band) and that the proposed amount of spectrum (25 MHz initially) is therefore inadequate.

Several commenters on the FCC NOI agree that the 4660-4685 MHz band should be reserved for wide-band advanced digital video services (ATV) and allocated to the terrestrial fixed and mobile broadcast

auxiliary service (BAS).[227] "... the public faces a real risk of significant disruptions in the delivery of television news unless steps are taken to alleviate the BAS spectrum congestion, even before demand is increased precipitously with the advent of ATV services."[228]

In their comments on the FCC NOI, Pacific Bell and Nevada Bell state that the 4660-4685 MHz band is too close to the 4635-4660 MHz band to be easily paired and would have to be used as a contiguous block. Pacific Bell and Nevada Bell believe this arrangement could be useful for in-building, TDD applications, and limited outdoor applications such as wireless coin phones, but most mobile wireless services will require a paired-frequency FDD technology. The commenter insists that without pairing, many commercial applications will not be possible in this band.

Southwestern Bell Corporation (SBC) comments on the FCC NOI argue that use of the 4660-4685 MHz band for wireless local loop applications would present difficult coverage and service problems. SBC states that equipment for this band is more expensive than the lower band equipment because it is not as available and it requires complicated high-frequency circuitry. SBC adds that such applications should operate below 3 GHz to take advantage of the favorable frequency propagation characteristics of that part of the spectrum.[229]

NABER believes that new private services can obtain some shared use with the FSS in the 4660-4685 MHz band through exclusive use licensing on certain applications and by grandfathering existing and licensing future users.[230]

**Public-Safety/Local Government.** Several public safety/local government, commercial, and utilities commenters to the FCC NOI agree with Motorola by stating that the use of this band for wide-area private land mobile systems is well beyond the capabilities of the current technology.[231] APCO and TIA state in their comments on the Preliminary Report that they are concerned about the limitations that were proposed in the Preliminary Report for these bands.[232]

**Utilities.** API and two commercial commenters on the FCC NOI and the Preliminary Report suggest that the 4660-4685 MHz band should be allocated for primary fixed use by microwave operations that were displaced from the 1.8 and 2.2 GHz bands by the FCC PCS proceedings.[233] UTC agreed with Motorola and several public safety/local government and commercial commenters on the FCC NOI by stating that the use of this band for wide-area private land mobile systems is well beyond the capabilities of the current technology.[234]

**Non-Licensed.** In its comments to the FCC NOI, WMC concludes that the 4660-4685 MHz band would not be suitable for non-licensed use and recommends allocation of this band to the fixed service for private land mobile communications applications.

**Summary.** Treasury, DOE, NASA, Army, and Air Force stated that they have operations in the 4635-4660 and 4660-4685 MHz bands. The reallocation of these bands will primarily affect the flexibility of Army and Air Force fixed troposcatter communications systems. Options of moving operations into other bands are viewed by Army personnel as extremely difficult. The FCC believes that these bands

would be useful in providing non-Federal services; however, any new technology will likely require more than 50 MHz.

Several commenters suggested that these bands could be useful for MSS feeder uplinks, especially if combined with 150 MHz of additional adjacent spectrum. However, many of the commercial and public-safety commenters feel that use of these bands is not cost-effective for wide-area mobile communications. In addition, several commenters suggested that these bands could be reallocated to accommodate the fixed microwave operations that were displaced by the PCS proceedings.

## ENDNOTES

Requests for copies of references from Federal departments and agencies should be referred to the originating organization. Parts of the reference material may be exempt from public release.

1. 59 Fed. Reg. 6005 (1994).
2. Allocations of Spectrum Below 5 GHz Transferred from Fed. Gov't. Use, *FCC Notice of Inquiry*, ET Docket No. 94-32, FCC 94-97, 59 Fed. Reg. 6005 (May 4, 1994) [hereinafter *FCC NOI*].
3. Letter from Deborah R. Castleman, Deputy Assistant Secretary of Defense for Command, Control, and Communications, U.S. Dep't of Defense, to Richard Parlow, Assoc. Adm'r, Nat'l Telecommunications and Info. Admin. (NTIA), (Sept. 1, 1994) [hereinafter Joint DOD Response].
4. *See* Comments filed in response to NAT'L TELECOMMUNICATIONS AND INFO. ADMIN., U.S. DEP'T OF COMMERCE, SPECIAL PUBLICATION 94-27, PRELIMINARY SPECTRUM REALLOCATION REPORT (Feb. 1994) [hereinafter NTIA PRELIMINARY REPORT]:Nat'l Science Found. (NSF), at 1 (Apr. 15, 1994); Nat'l Astronomy and Ionosphere Ctr. (NAIC), at 1 (May 9, 1994); and Nat'l Research Council Comm. on Radio Frequencies (CORF), at 5 (May 11, 1994). [hereinafter all comments cited, refer to NTIA PRELIMINARY REPORT, unless otherwise stated].
5. NAIC, *supra* note 4, at 3; CORF, *supra* note 4, at 9.
6. NSF, *supra* note 4, at 1; NAIC, *supra* note 4, at 3; CORF, *supra* note 4, at 10.
7. NSF, supra note 4, at 1.
8. U.S. Dep't of the Army Comments, at 6 (May 9, 1994) [hereinafter Army].
9. *Id.* at 7.
10. *Id.* at 6.
11. U.S. Dep't of Trans. (DOT) Comments, at 1 (June 1, 1994).
12. Joint DOD Response, supra note 3, at 2.
13. *Id.* at 3.
14. *Id.* at 2.
15. *Id.* at A-10.
16. *Id.*
17. *Id.* at 5.
18. REPORT FROM THE FEDERAL COMMUNICATIONS COMM'N, to Ronald H. Brown, Secretary, U.S. Dep't of Commerce, Regarding the NTIA PRELIMINARY REPORT, FCC 94-213, at 26 (Aug. 9, 1994) [hereinafter FCC REPORT].
19. *Id.*
20. Motorola Comments, at 14 (May 11, 1994).
21. *Id.*; Telecommunications Indus. Ass'n (TIA) Comments, at 15 (May 11, 1994).
22. Institute for Telecommunication Sciences (ITS), U.S. Dep't of Commerce, ITS Staff Study, *A Preliminary Look at Spectrum Requirements for the Fixed Services*, (May 1993) [hereinafter *ITS Study*].
23. *Id.* at 32-33.
24. Nat'l Ass'n of Business and Educational Radio Inc. (NABER) Comments, at 17 (June 15, 1994), filed in response to *FCC NOI*, *supra* note 2.
25. Amateur Television Network (ATN) Comments, at 2 (June 7, 1994), filed in response to *FCC NOI*, *supra* note 2.
26. FCC REPORT, *supra* note 18, at 26.

## ENDNOTES

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27. Army, *supra* note 8, at 5.
28. *Id.* at 6.
29. Joint DOD Response, *supra* note 3, at ATTACHMENT 2, 6-7.
30. FCC REPORT, *supra* note 18, at 13-14.
31. American Mobile Satellite Corp. (AMSC) Comments, at 2 (May 11, 1994).
32. Meeting between NTIA and American Mobile Satellite Corp. (AMSC) on July 18, 1994.
33. Meeting between NTIA and Motorola on July 13, 1994.
34. FCC REPORT, *supra* note 18, at 14.
35. U.S. Nat'l Oceanic and Atmospheric Admin. (NOAA) Comments, at 2 (May 11, 1994).
36. Memorandum from D. James Baker, Under Secretary and Adm'r, NOAA to Larry Irving, NTIA Assistant Secretary for Communications and Info., at 1 (Oct. 18, 1993).
37. *Id.*
38. *Id.*
39. FCC REPORT, *supra* note 18, at 15.
40. TIA, *supra* note 21, at 16.
41. AMSC, *supra* note 31, at 2.
42. AMSC Meeting, *supra* note 32.
43. Motorola Meeting, *supra* note 33.
44. U.S. Dep't of Agric. (USDA) Comments, at 2 (May 11, 1994).
45. *Id.*
46. DOT, *supra* note 11, at 2.
47. U.S. Dep't of Interior (DOI) Comments, at 2 (May 4, 1994).
48. Meeting between NTIA and Dep't of Interior on June 23, 1994.
49. DOI, *supra* note 47, at 3.
50. Meeting between NTIA and the Dep't of Treasury on June 28, 1994.
51. U.S. Dep't of Justice (DOJ) Comments, at 2 (May 31, 1994).
52. *Id.*
53. Meeting between NTIA and Dep't of Justice on July 26, 1994.
54. DOJ, *supra* note 51, at 2.
55. Army, *supra* note 8, at 5-6; Meeting between NTIA and Dep't of the Army on June 28, 1994.
56. Army, *supra* note 8, at 5.
57. *Id.* at 12.
58. *Id.* at 7.
59. Dep't of Energy (DOE) Comments, at 1 (May 19, 1994).
60. *Id.*
61. *Id.*

## ENDNOTES

Requests for copies of references from Federal departments and agencies should be referred to the originating organization. Parts of the reference material may be exempt from public release.

62. *Id.* at 2.
63. U.S. Air Force Comments on the Space-Ground Link Subsystem, Air Force Frequency Management Office, December 12, 1994.
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68. Meeting between NTIA and Motorola on June 29, 1994.
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72. APCO, *supra* note 71, at 7.
73. Utilities Telecommunications Council (UTC) Comments, at 3 (May 11, 1994).
74. Nat'l Aeronautics and Space Admin. (NASA), Comments, at 3 (May 8, 1994).
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76. *Id.*
77. *Id.*; CORF, *supra* note 4, at 14.
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88. *Id.*; GTE, *supra* note 86, at 4.
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91. Loral Qualcomm Partnership (LQP) Reply Comments, at 3-5 (June 30, 1994), filed in response to *FCC NOI*, *supra* note 2.
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103. *Id.* at 5; Southern California Repeater Remote Base Ass'n (SCRRBA) Comments, at 3 (May 10, 1994).
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106. *Id.* at 7.
107. *Id.* at 8.
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124. TIA, *supra* note 21, at 11; Telecommunication Industry Ass'n (TIA) Comments, at 10 (June 15, 1994), filed in response to *FCC NOI*, *supra* note 2.

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126. SBMS, *supra* note 94, at 4.

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132. SCRRBA, *supra* note 103, at 8.

133. *Id.* at 7.

134. APCO, *supra* note 71, at 5.

135. *Id.*

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137. *Id.* at 7.

138. *Id.* at 8.

139. Florida Dep't of Transportation (FDOT) Comments, at 1 (May 17, 1994); Maine Turnpike Authority (MTA) Comments, at 1 (May 26, 1994).

140. FDOT, *supra* note 139, at 2.

141. *Id.*

142. MTA, *supra* note 139, at 1.

143. FDOT, *supra* note 139, at 3.

144. The Coalition of Private Users of Emerging Multimedia Technologies (COPE) Comments, at 5 (June 15, 1994), filed in response to *FCC NOI*, *supra* note 2.

145. *Id.*

146. GEC Plessey Semiconductors (GEC) Comments, at 1 (May 15, 1994), filed in response to *FCC NOI*, *supra* note 2.

147. Western Multiplex Corp. Comments, at 8 (June 15, 1994), filed in response to *FCC NOI*, *supra* note 2.

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**156.** Symbol Technologies Comments, at 6 (June 15, 1994), filed in response to *FCC NOI*, *supra* note 2.

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**161.** The Institute of Electrical and Electronics Engineers (IEEE) Computer Society Comments, at 1 (July 25, 1994).

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**163.** Symbol Technologies, *supra* note 156, at 9.

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**168.** NABER, *supra* note 24, at 16.

**169.** TIA, *supra* note 21, at 10.

**170.** NTIA PRELIMINARY REPORT, *supra* note 4, at 4-16; ARRI, *supra* note 92, at 9.

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231. Motorola, *supra* note 20, at 16.

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233. TIA, *supra* note 21, at 18; APCO, *supra* note 71, at 12.

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SECTION 3

# FEDERAL GOVERNMENT REALLOCATION COSTS AND OPERATIONAL IMPACT



## INTRODUCTION

Title VI addresses the concern of avoiding excessive costs and minimizing the operational impact on Federal Government missions during the reallocation process. Title VI provides five criteria for selecting frequency bands for reallocation from Federal Government to non-Federal sector use. Of the five band selection criteria specified in Title VI, three include a specific Federal Government cost or operational impact factor that must be considered, including the following specific requirements:

- "... the Secretary shall ... seek to avoid ... serious degradation of Federal Government services and operations [and] excessive costs to the Federal Government and users of Federal Government services,"

- "... the Secretary shall ... consider the immediate and recurring costs to reestablish services displaced by the reallocation of spectrum," and

- "... the Secretary shall ... [recommend] for reallocation bands of frequencies ... the transfer of which (from Federal Government use) will not result in costs to the Federal Government, or losses of service or benefits to the public, that are excessive in relation to the benefits to the public that may be provided by non-Federal licensees."[1]

All of the bands being considered for reallocation are used by Federal Government agencies, in varying degrees, to support Congressionally mandated missions. Thus, all reallocation options will entail cost and/or

operational impact to the Federal Government agencies. For example, the Federal Government has invested over $9 billion[2] in radiocommunications equipment capable of operating in the bands identified in the preliminary reallocation plan. In general, alternative bands entail even higher investment costs. Simply identifying the bands that have a minimum impact on the Federal Government agencies would not meet the intent of Title VI with regard to the public benefit. The final spectrum reallocation plan must strike a reasonable balance with respect to the impact on Federal Government users and potential benefits to the public. However, Federal Government agencies must continue to perform their mandated missions.

The final spectrum reallocation plan must ensure that the bands identified meet the Title VI selection criteria. However, the displaced Federal Government functions that result are to be preserved in other frequency bands at considerable cost to the Federal Government. The costs associated with this reaccommodation were addressed in the Preliminary Report in general terms, since the data required for a detailed evaluation was not then available. Subsequent to the release of the Preliminary Report, the Secretary of Commerce asked that each Federal Government agency affected by the preliminary reallocation plan provide cost estimates for reallocating the candidate bands. The cost impacts are preliminary estimates only based on the reallocation of frequency bands recommended in the Preliminary Report. Final cost impacts will be determined based on the final spectrum reallocation plan, extensive engineering studies and cost analysis on data provided by the Federal Government agencies.

This section documents the available data regarding specific Federal Government costs and/or operational impact associated with the spectrum reallocation process. While the data addresses only the bands identified in the preliminary plan, the data can also serve, in some cases, to extrapolate the results to other bands. The discussion that follows draws from information provided in the Preliminary Report as well as from the specific data provided during the public comment period. An overview of Federal Government reallocation costs is provided first, followed by an in-depth, band-by-band discussion of Federal Government reallocation impact and costs.

## OVERVIEW OF FEDERAL GOVERNMENT REALLOCATION COSTS

Ten Federal Government agencies, including a joint DOD input, responded to the Secretary's request for cost data. TABLE 3-1 summarizes the data provided. In some cases where specific reallocation cost data were not available, agencies provided additional data on investment costs that is not reflected in this table. It should be emphasized that this table addresses only direct costs and does not address additional operational impact, program delays, etc., that may also result. These factors are discussed in more detail in the subsequent portions of this Section.

In general, reallocation costs to the Federal Government can be reduced through a variety of approaches, such as: (1) reallocating only portions of bands and retuning existing equipment into the remaining portions of the band, where possible; (2) reallocating only portions of bands and retuning some existing equipment into the remaining portions of the band, and relocating the remaining equipment to other bands, where possible; (3) retaining Federal Government assignments in bands reallocated for mixed use, in critical geographic areas; and (4) adopting reallocation timetables based on the useful remaining life of the equipment.

TABLE 3-1

Summary of Federal Government Reallocation Costs Data for the Bands Identified in the Preliminary Report

| Agency | Frequency Band (MHz) | Costs Data (Millions) |
|---|---|---|
| Agriculture | 1710-1755 | 48 |
| Air Force | All bands | 60[a] |
| Air Force/FAA | 1390-1400 | 35[b] |
| Army/ACE | 1710-1755 & 4635-4685 | 33 |
| Commerce | 1670-1675 | 35-55 |
| Energy | 1710-1755 | 2.4-9.8[c] |
| Interior | 1710-1755 | 8-13 |
| Justice | 1710-1755 | 144 |
| NASA | 1710-1755 & 4660-4685 | 0.04 |
| Navy | Various bands | 30-113[d] |
| Treasury | 1710-1755 | 0.5 |
| Transportation | 1390-1400 & 1710-1755 | 115 |

Unlike some other radiocommunications functions that might use commercial alternatives, the functions performed by radio astronomy, radars, and military tactical radio systems cannot be replaced by commercial resources. Many of the latter (non-military) requirements, formerly met by specialized systems, may be met by new and emerging commercial technologies, including digital cellular and PCS systems. However, certain tactical communications functions, which include point-to-multipoint, priority access, wide-area coverage, and security, cannot be supported by the existing commercial services. Until these capabilities can be demonstrated there still exists a requirement for the continued use of specialized systems for tactical communications.

## FEDERAL GOVERNMENT OPERATIONAL IMPACT AND COSTS ASSESSMENT

This subsection contains a description of the Federal Government systems that are potentially impacted because of the reallocation process. The discussion is based on data provided in the Preliminary Report, additional Federal Government agency inputs provided during the public comment period, and views expressed by IRAC members.

[a] Costs could increase by up to $123 million if unacceptable interference to or from non-Federal systems necessitates major hardware changes or replacement of Air Force telemetry and data link systems.

[b] Costs could increase by up to $500 million if unacceptable interference to or from non-Federal users necessitates major hardware changes or replacement of joint FAA/AF ARSR-4 radars.

[c] The higher range is required if an exception is not provided to other Federal agencies carrying DOE electrical power distribution information.

[d] Costs could increase by up to $63 million if unacceptable interference to or from non-Federal users necessitates retrofit of Navy carrier landing system radars.

## 1390-1400 MHz Band

An overview of the Federal Government agencies affected by the proposed reallocation of the 1390-1400 MHz band segment, the types and functions of the systems operating in the band, the reallocation impact, and the reallocation approach to be taken by the agencies is given in TABLE 3-2. The following paragraphs will discuss the reallocation impact and options for each of the agencies affected by the reallocation of the 1390-1400 MHz band segment.

**Navy.** The reallocation of the 1390-1400 MHz band segment will primarily impact Navy shipboard radars, resulting in a 6% loss of frequencies available for operation. The reaccommodation approach that could be taken by Navy is to retune within the 1215-1390 MHz frequency band. The overall economic impact of restricting the tuning range of these radars cannot be measured simply by the initial spectrum loss. Reducing the available bandwidth will reduce the anti-jamming/interference margin of the radar and make it more susceptible to interference from new and existing systems within the remaining portion of the band. The high-power requirements of shipboard radars, combined with the physics of over-water radio propagation, result in an interference range extending several hundred kilometers. The resulting increase in radar-to-radar interference would reduce the number of ships that could operate in close proximity within Naval task force formations. Engineering studies would be necessary to analyze the specific impact and provide guidance on measures to avoid electromagnetic interference.

Navy presented an example of the types of interference problems that can occur as a result of the loss of the 1390-1400 MHz band. Navy's MK 23 Target Acquisition System (TAS) provides target information to the NATO SEASPARROW Surface Missile System (NSSMS). Navy states that the proposal to reallocate the 1390-1400 MHz band segment will reduce the number of available unique channels for TAS from 28 to 25 in blue water operations, and to as few as two channels in operations within 200 nautical miles (nmi) of the United States. The Navy states also that "The reduction of available channels when operating within 200 nmi off shore is because of radiation restrictions already imposed on MK 23 TAS to prevent interference to FAA air traffic control radars."[3]

The Navy further states that the impact of reallocating additional spectrum in the 1350-1390 MHz band is particularly severe if two or more of the ships are operating within 200 nmi of each other. According to the Navy, electromagnetic (EM) energy from one MK 23 TAS [the EM interference (EMI) source] couples into the receiver of another MK 23 TAS (the EMI victim) and the interference can be of such severity as to render the MK 23 TAS incapable of detecting targets and performing its mission.[4]

The Navy also reports that there are many systems operated by Navy and DOD that have a war reserve mode. Although there is an occasional need to test this mode in peacetime, it is particularly important that the wartime mode of operation be taken into account so as to preclude disruption of any vital civil services that may be placed into the reallocated bands, as a result of Title VI.[5]

**Army.** The Army uses the 1350-1400 MHz band mainly for tactical transportable radio relay systems linking the various headquarters and functional nodes into an area-wide integrated network, for such systems as MSE and TRITAC. The loss of 1390-1400 MHz will have a long-term impact on military training using tactical radio relay systems at most Army bases. Previous reallocation has effectively re-

## TABLE 3-2

Overview of Reallocation Impact for the 1390-1400 MHz Band (*page 1 of 2*)

| Affected Agency | Type | Function | # of units | Tuning range (MHz) | Reallocation impact | Reallocation Approach |
|---|---|---|---|---|---|---|
| AF | FPS-117 | Air Defense Radar | 32 | 1215-1400 | Radar sites are protected in Alaska | Radar operations can continue in Alaska on a secondary basis, however if interference occurs modification or replacement may be necessary. The modification costs are estimated at $100M and will take 5 years. Replacement costs are estimated at $350 M and will take 15 years. |
| AF | FPS-124 | Air Defense Radar | 42 | 1218-1398 | Radar sites are protected in Alaska | Radar operations can continue in Alaska on a secondary basis, however if the radars must be replaced their cost is estimated to be between $100-130 M, and will take 5 years. |
| AF | PPQ-2(V)1 | Tactical Radar | 11 | 1220-1400 | Loss in tuning range | Redesign radar to operate in the 1220-1390 MHz band. R&D will require an estimated $5 M in FY96. |
| AF | ARSR-1,2,3, TPS-63 FPS-20,90,93A | Air Traffic Control & Air Defense Radars | 113 | 1215-1350 | Design and install Filters | The design frequency range for these radars is 1215-1350 MHz. These radars are scheduled to be replaced by the ARSR-4 radars. |
| AF | CAMS | Wireless Maintenance System | 1 | 1215-1400 | Vendor must re-license | Vendor to re-license this equipment. Estimated cost is $50,000. |
| AF | NGTCS | Target Control System | 5 | 1350-1400 | None | Still in the design phase. Cost impacts may arise due to the 1390-1400 MHz loss, but specific costs are unknown at this time. |
| AF | NDS | Nuclear Detonation System | 24 | 1381.05 ± 2 MHz | None | Receiver tunes at 1381.05 ± 2 MHz. |
| N | MK-23 | Shipborne Radar | 58 | 1215-1400 | Loss in tuning range | Restrict tuning to below 1390 MHz. |
| N | TPS-59 | Tactical Radar | 15 | ---------- | Loss in tuning range | Restrict tuning to below 1390 MHz. |
| AR | MPQ-49 TPQ-32 | Tactical Radar | 180 | ---------- | Loss in tuning range | Restrict tuning to below 1390 MHz. |
| AR | GSS-1 | Transportable Radar | 10 | 1215-1400 | Loss in tuning range | Restrict tuning to below 1390 MHz. |
| AR & AF | GRC-226, 103(V)4 | Tactical Radio Relay | 2650 | 1350-1850 | Loss in tuning range | Federal operations will continue at 17 locations listed in the Preliminary Report. Modifications to restrict tuning in the reallocated band segment will cost $125,000 per radio relay as needed. |

**TABLE 3-2**

Overview of Reallocation Impact for the 1390-1400 MHz Band (*page 2 of 2*)

| Affected Agency | Type | Function | # of units | Tuning range (MHz) | Reallocation impact | Reallocation Approach |
|---|---|---|---|---|---|---|
| T | L-88 | Aerostat Radar | 15 | 1215-1400 | Loss in tuning range | Restrict tuning to below 1390 MHz. |
| FAA | ARSR-1,2,3 | Air Traffic Control Radar | 200 | 1215-1350 | Need new filters | Design and install filters if interference develops. |
| FAA & AF | ARSR-4 | Air Traffic Control & Air Defense Radar | 44 | 1215-1400 | Available channel pairs reduced by 4 | Reallocation will, at a minimum, require software modifications estimated at $35 M. If available frequencies cannot support the dual-channel hopping requirement, hardware modifications estimated at $525 M and taking 5 years to complete will be necessary. |
| AF | RAJPO | Air/Ground Data Link | 18 | 1350-1400 & 1427-1435 | Loss in tuning range | Hardware modification may be necessary if spectrum loss limits schedule for test events. Estimated cost is $23M and will take 5 years. |
| NSF | RA | Spectral Line Observations | 4 | 1350-1400 | None | Include reallocation constraints from the Preliminary Report to restrict adjacent band emissions. |

moved land forces tactical networks from two of the six bands normally used. Options of moving operations into one of the other bands are extremely difficult, because these bands are also fully used and very congested.[6]

The tactical radio relay systems used by the Army are tunable over the entire 1350-1850 MHz frequency range. Although the proposed reallocation of 1390-1400 MHz represents only a small portion of the operational bandwidth of these systems (2%), the availability of authorized frequencies has continued to dwindle.[7] The reallocation approach that could be taken by Army is to restrict tuning in the reallocated band segment (1390-1400 MHz). In order to lock-out the reallocated band segment, modifications will have to be made to technical specifications and software support for each radio relay system. Detailed cost estimates for these modifications were not available.

**Air Force.** The Air Force operates an extensive network of radars that have the capability to tune in the 1215-1400 MHz band. The various radars are used for search, acquisition and surveillance, perimeter defense of the United States and Canada, drug interdiction support, and tactical command and control. The Air Force states that, "the 1215-1400 MHz portion of the spectrum is ideal for long-range radar propagation and target detection. Other portions of the spectrum do not have the electromagnetic wave physics necessary to perform this function effectively."[8]

Two Air Force radars that could be impacted by the reallocation of 1390-1400 MHz are the AN/FPS-117 and AN/FPS-124. Together these systems form an array of radars stretching across North America from Alaska via Canada to Greenland, and are designed to provide long-range detection and coverage against hostile low-flying aircraft and missile attacks. Due to the extreme northern locations of these radars, the physics of radiowave propagation is even more critical.[9] In an attempt to avoid unnecessary and costly disruption of Federal operations in remote locations, the Preliminary Report recommended that the Federal radiolocation service will continue on a secondary basis in Alaska.[10] Air Force states that operation of the AN/FPS-117 in the 1390-1400 MHz band segment on a secondary basis is an acceptable option only if interference is not likely to occur. If this is not possible, Air Force states that the following transition actions will be necessary:[11]

- *Transmission requirements.* The last two of the 19 channels will be affected by the reallocation of the 1390-1400 MHz band segment. Software modifications will be required to disable these two channels.

- *Reception requirements.* A hardware modification will be required to select filters that eliminate the 1390-1400 MHz band segment.

- *Mission requirements.* Target detection will not be affected by civil sources transmitting in 1390-1400 MHz; however, commercial sources could possibly be reported as false detections. If this occurs, a hardware modification will be required to eliminate the problem.

- *Calibration and maintenance requirements.* The loss of 1390-1400 MHz band segment will require modification of the software used for calibration, monitoring, and fault isolation.

Radar operations can continue in Alaska on a secondary basis; however, air force states that if interference occurs, modification or replacement will be necessary. The modification cost is estimated at $100 million and will take 5 years. Replacement cost is estimated at $350 million and will take 15 years.[12]

The AN/FPS-124 is a multichannel frequency-agile radar also supporting the Alaskan air defense network. This radar is located in Alaska (3 units) and in Canada (39 units). In the joint DOD response to the Preliminary Report, Air Force states that the loss of 1390-1400 MHz band segment reduces the probability of target detection resulting in redesign of the radar. Loss of spectrum in this band will also make interference resolution with similar systems in Canada and Iceland more difficult. Radar operations can continue in Alaska on a secondary basis; however, if replacement is deemed necessary the estimated cost will be between $100-130 million, and will take 5 years. [13]

The RAJPO is a new data link in the 1350-1400 MHz band that Air Force began using in January 1994. This data link rebroadcasts real-time position information of high-velocity manned and unmanned airborne platforms during test and training operations. RAJPO is critical to ensuring the safety of personnel during these operations, and is designed to be interoperable at all Air Force, Army, and Navy test installations.[14] A total procurement of 719 units has been authorized for use at 18 sites throughout

the United States and possessions. Each airborne RAJPO unit rebroadcasts satellite-derived time and location information via a pair of frequencies in the 1350-1400 MHz and/or 1427-1435 MHz bands. The two frequencies are required to support the probability of reception especially in test areas over large bodies of water, where multipath effects may be more pronounced. The number of channel pairs required varies with the scale of the operations.

The Air Force believes that Federal investment in RAJPO will be jeopardized if continued access to the entire 1350-1400 MHz band is not available. Spectrum for RAJPO operation will remain only in the 1350-1390 MHz band after the reallocation. The western United States presents the most critical RAJPO operation area. There are six sites within range of each other, thus six frequency pairs for simultaneous operations. The reallocation could limit the ability to effectively schedule test events, and hardware modifications would be required. Costs due to delays in aircraft testing can exceed $1 million per occurrence. Flight test and range personnel, as well as specialized hardware, must be idle during delays in testing. Estimated costs for various platforms are: Advanced Range Instrumentation Aircraft (ARIA), $5,000/hour flying time ($1 million minimum); B-1, $1 million if 3-4 hour delay causes missions cancellation; B-2, $500,000/day (delay); F-15, $4,500/hour plus $4,000 range cancellation; and F-16, $5,000-$10,000.[15] Modifications will result in an estimated nonrecurring cost of $10 million and an estimated recurring cost totaling $13 million, and will take 5 years.[16]

**Federal Aviation Administration.** The ARSR-4 is the newest radar in the nationwide Joint Surveillance System (JSS) providing air defense and air traffic control for the continental United States, Guam, and Hawaii. The ARSR-4 is being fielded through a Congressionally-mandated joint FAA and Air Force program. The radar has an operational frequency range of 1215-1400 MHz and uses dual-channel frequency hopping technology for long-range anti-jam search and tracking, and is capable of detecting small objects by minimizing clutter, and weather and multipath effects. The radar supports defense of the national airspace and provides initial coastal civil air traffic control.[17]

As stated in the joint DOD response, reallocation of the 1390-1400 MHz band segment reduces the number of available channels by four out of the 44 frequency pairs. With the additional loss of frequencies to other systems, the reallocation of 1390-1400 MHz will impact the dual-channel frequency hopping capability that is key to the ARSR-4 design. Reallocation will, as a minimum, require software modifications. If available frequencies cannot support the dual-channel hopping requirement, hardware modifications will be required.[18] FAA stated in their comments to the Preliminary Report, that the reallocation of a smaller portion of the band will have a lesser, yet significant impact on ARSR-4 operations, particularly in high-density environments.[19] Reallocation will, as a minimum, require software modifications estimated to cost $35 million. If the available frequencies cannot support the dual-channel hopping requirement, hardware modifications estimated at $525 million and taking 5 years to complete will be required.[20]

Another concern expressed by FAA relating to the loss of the 1390-1400 MHz band segment is the existing spectrum congestion in the 1215-1400 MHz band.[21] This congestion is, in part, a function of the choice of power output tube used in the radar design, and by any post-power tube output filtering. The measured ARSR emission spectrum illustrates this fact well. The ARSR-1 and 2, which use crossed-

field amplifiers (amplitrons) as their final output stage, produce relatively high-amplitude extended emission spectra, measurable at frequencies up to 4400 MHz. These radars utilize output filtering after the amplitron stage to improve their spectral occupancy characteristics. The ARSR-3, in contrast, uses a klystron amplifier and produces a much lower-amplitude extended emission spectrum. The ARSR-4, which utilizes solid-state technology, is expected to also produce a low-amplitude extended emission spectrum. The Air Force states that FAA and DOD have firm plans to replace aging ARSR-1,2,3 joint surveillance radars with the ARSR-4. The Air Force states also that "the ARSR-1,2,3 radars are currently beyond their design life and are maintained only at great effort and expense."[22]

The spurious emissions of all existing FAA radar systems in the 1215-1400 MHz band are high and the radio frequency filters for these radars use an upper band edge cut-off of 1400 MHz. Reallocation of the 1390-1400 MHz portion of the band will require that these radars be retrofitted with new filters. The cost would be at least $6 million, depending on the radio service allocated in the adjacent-band.

A concern in reallocating this band for commercial or public-safety applications is that high-power radar systems will be in the adjacent band. Numerous case histories exist of interference from adjacent-band, high-power, radar systems due to insufficient receiver selectivity. In general, the FCC declines to establish receiver standards, opting to let the marketplace determine the receiver design. This approach is in contrast to the approach taken by the Federal Government and by most governments worldwide, where receiver interference immunity standards are commonplace. The Federal Government has recognized the importance of having receiver standards for the effective management of spectrum resources, and has adopted receiver standards for most Federal radio systems.

**Treasury.** Treasury maintains 13 tethered aerostats along the southwest border from Arizona into the Caribbean. Each aerostat includes an L-88 radar with a tuning range of 1215-1400 MHz.[23] From a review of the Government Master File (GMF) frequency assignment data base, it was determined that all of Treasury's aerostat radars operate below 1314 MHz, and will not be directly impacted by the 1390-1400 MHz reallocation. However, the loss of spectrum may contribute to the overall congestion currently experienced in the 1215-1400 MHz band, and electromagnetic interference may become more prevalent among systems in the remaining spectrum. Engineering studies may be required to analyze the impact in detail, and provide guidance to resolve any interference problems.

**Energy.** The Global Verification and Locations System (GVLS) is a new system being developed under DOE's Satellite Instrumentation Program. The main purpose of this program is to develop, design, implement, and support space-based nuclear explosion sensors for detection, identification, location, and characterization of nuclear detonations in the atmosphere and in space. GVLS is being developed to perform the nuclear explosion detection function and to augment the DOD's Nuclear Detonation System. GVLS discrete frequencies have not been selected as yet but the frequency preferences include: 1371 MHz, 1373 MHz, and 1377 MHz. The reallocation of the 1390-1400 MHz band segment could impact future GVLS operation.[24]

**National Science Foundation.** As stated in the Preliminary Report, the 1350-1400 MHz band is important for radio astronomy observation of red-shifted hydrogen spectral lines. Most of the galaxies

limit its ability to effectively schedule test-range events.[30] Redesign of the system in an alternative band to regain full capability is estimated to cost DOD $23 million over 5 years.[a]

**National Science Foundation.** The National Science Foundation (NSF) operates radio astronomy receivers in the lower adjacent band. NSF expects no major operational or economic impact as a result of the reallocation, provided that the restrictions identified in the Preliminary Report are observed.

**Summary for the 1427-1432 MHz Band.** NSF has indicated that no significant operational or economic impact would result from implementation of the preliminary reallocation plan. Air Force transition plans call for retuning or replacing its current equipment in this band at a minimum cost of $24,000 to $100,000. Transition costs for the DOD-sponsored RAJPO system, if replacement is found to be necessary, are an estimated $23 million. Also, significant impact on the training of Navy and Air Force pilots in the use of sophisticated weaponry will occur, unless operations are permitted to continue at test and training ranges specified in Appendix F.

## 1670-1675 MHz Band

The Federal Government agencies primarily affected by the reallocation of this band are the Department of Commerce, Air Force, and NSF. The following paragraphs describe the systems operating in the band and transition plans, costs, and options for each of the affected agencies.

**Commerce.** Most of the 111 frequency assignments in this band are for radiosonde stations operated by NOAA. The preliminary reallocation plan for this band recommends that agencies redesign, procure, and deploy a national radiosonde network that will operate solely within the 1675-1690 MHz band. A minimum reallocation delay of 5 years was stated as a sufficient amount of time to accommodate the change-over.

In order to achieve the frequency stability necessary to permit radiosonde operation in the smaller reallocated band, the new radiosondes would need to use crystal-controlled transmitters and a new type of modulation.[31] The technology needed to make these changes is reported by NOAA as available, but the increased cost has historically made the new technology impractical. NOAA estimates the increase in yearly recurring costs for the 80,000 radiosondes launched each year to be $1 million.[32] NOAA also notes that the impending presence of non-radiosonde emitters within what is now the radiosonde band requires replacement of the radiosonde ground tracking equipment as well. NOAA expects that the 3 types of radiosonde ground tracking equipment currently used in this band could be replaced by a common system for a one-time cost of $20-40 million, and will require up to 5 years to design, procure, and deploy.[33] NOAA estimates the 15-year cost for all of the necessary changes is $35-55 million.[34]

Termination of the GOES weather satellite transmissions is not feasible and continued operation of the Earth stations in Alaska and Virginia is required at least through the completion of the GOES-NEXT program.

[a] The proposal in the Preliminary Report to reserve the 1432-1435 MHz portion of the band for continued exclusive Federal use is designed to minimize these operational and cost impacts.

**Air Force.** The Air Force reports that it operates an undetermined number of radiosondes (including AN/GMD-5 receivers) and seven Mark IVB Meteorological Satellite Ground Terminals in this band. The cost to modify the AN/GMD-5's and all radiosondes in order to comply with the reallocation plan is approximately $500,000. The estimated total cost to retune the Mark IVB receivers is $15,000.

**National Science Foundation.** NSF expects no major operational or economic impact as a result of the reallocation, provided that the restrictions on airborne and space-to-Earth links identified in the Preliminary Report are observed.

**Summary for the 1670-1675 MHz Band.** NSF indicated that no significant operational or economic impact would result from implementation of the preliminary reallocation provided the restrictions identified for this band are observed. NOAA estimates that it will cost $35-55 million over the next 5 years to implement the changes required as a result of the reallocation plan for this band. The Air Force estimates that it will cost $515,000 to make the necessary modifications for this band.

## 1710-1755 MHz Band

The 1710-1755 MHz segment of the 1710-1850 MHz band is currently allocated to the Federal Government exclusively for fixed and mobile services on a primary basis. Being extensively used by the Federal Government, reallocation will impact, in varying degrees, most major Federal Government agencies. The following paragraphs describe the systems operating in the band and transition plans, costs, and options for each affected agency. Appendix A provides a broad examination of the feasible transition options to implement reallocation of this band.

**Army.** Among the three DOD services, Army is the most significantly impacted by the potential reallocation of the 1710-1755 MHz band. The ACE uses the 1710-1755 MHz frequency range for its fixed microwave radio systems serving backbone communications in the Continental United States Engineer Districts. Functions include remote controlled hydropower generating stations; communications support of the Federal Emergency Management Agency (FEMA) and emergency civilian relief; flood control and sensor telemetry; and maintenance and traffic control along 50,000 km of inland waterways, harbors, locks and dams.

Although the ACE is not a Federal power agency (FPA), as defined by Title VI, the functions they perform in this band are viewed by Army as similar to that of an FPA. Because of this, Army suggests that, "the Corps of Engineers should be afforded the same power agency protection [and] that [their] assignments shall not be modified nor receive unacceptable interference from future non-Federal users." If such protection is not adopted, Army estimates the cost to recrystal and realign approximately 260 sites to operate in the remaining 1755-1850 MHz portion of the band to be in excess of $23 million.[35]

The second major Army use of the band is to support its tactical radio relay proficiency training activities. Specifically, Army uses the 1710-1755 MHz frequency range extensively for headquarters nodal connectivity within their area-wide integrated communications networks. The Army reports that this equipment is transportable to support a fast moving network and flexible to the tactical tempo and operational conditions. Lightweight, transportable equipment is stated by Army to be a fundamental

requirement for rapid installation, break down, and camouflage. The transmitter power, propagation, available bandwidth, and other technical factors support 1350-1850 MHz as the optimum band for use on the dynamic air-land battlefield. The Army further states, "Options of moving into one of the other bands are extremely difficult and not operationally sound... . Further loss or erosion of authorized frequency resources would adversely affect military land forces' ability to provide an adequate command, control communications network." While noting the equipments' 1350-1850 MHz tuning range, Army states, "This 10% loss is significant because it compresses the authorized frequency bands and complicates the tactical frequency assignments." Specific costs associated with this 10% loss in tuning flexibility were not available.

**Air Force.** Air Force microwave operations in this band include provisions for communications link connectivity between geographically separated gap-filler radar sites, medical facilities and test or training areas. In addition, encrypted communications links connectivity are employed for command and control of forces between headquarters and wing commanders. A secure communications system employed by Air Force in the 1710-1755 MHz band is the Weapon Control Data Link System which provides a two-way anti-jam data link for command signals and video data. A microwave system used to conduct air traffic control at Hill AFB would also be affected by the reallocation with an estimated total retuning costs in excess of $20,000. A less impacted Air Force operation is the narrowband air-to-ground telemetry link that provides control communications between airborne and ground equipment via the TARS. The Aerostats could be retuned to other portions of the band. The Air Force estimates the cost to reallocate the 1710-1755 MHz band to non-Federal use in excess of $8.3 million.

This band is also utilized for guided weapon missile systems. These systems are used to provide radionavigation, radiolocation, and guidance of Air Force weaponry. Air Force reports that reallocation of this band could reduce the anti-jamming capability by almost 40%, and render the guidance links useless in the presence of jammers should modifications to the system be necessary. A total re-engineering of approximately 1000 units would be required at an estimated cost of over $100 million.

**Transportation.** FAA and the United States Coast Guard (USCG) enforce rules and safety for air and waterways navigation. These agencies provide not only navigational aids but assist or support in missions such as emergency rescue. FAA uses fixed microwave links in this band as part of a nationwide radiocommunication link network to interconnect the nation's air traffic control facilities. The 1710-1755 MHz frequency range is used by the USCG for vessel traffic control and safety operations, communications support of the VHF National Distress System, and remote distress and safety communications and control networks.

The reallocation cost for FAA alone to relocate its existing fixed microwave stations in the 1710-1755 MHz band to the 7/8 GHz band is estimated at $96 million.[36] For the CG, the most probable cost impact from the reallocation process is the loss of its microwave links in the 1710-1755 MHz band. CG provides an estimated relocation cost at $10.6 million non-recurring and $2.3 million recurring costs.[37] However, both FAA and USCG reallocation costs for the 1710-1755 MHz band could be reduced if they are allowed to retain certain frequencies in the band.

**Interior.** DOI operates about 110 fixed microwave links in this band for a variety of functions including: control of land mobile radio systems necessary in firefighting, law enforcement, disaster control within national forest and parks, communications services to Indian reservation areas, and earthquake monitoring and hazards mitigation. In accordance with Federal regulations, Federally owned communications are used only where commercial service is not available, not technically adequate, or significantly more expensive. In the 1710-1755 MHz frequency range, DOI shares some frequencies with DOE for the distribution and maintenance of electrical power energy. The DOI estimated the direct dollar costs associated with implementing Title VI is in the range of $8-13 million.[38] The variation in the estimated reallocation costs is a function of whether: (1) microwave frequencies will be available within the remaining segment (i.e., 1755-1850 MHz) at specific locations; (2) new frequencies in the band 2200-2290 MHz can be coordinated; or (3) new fixed microwave links in the 7/8 GHz band can be engineered and installed. Other tangibles associated with the costs include: purchase of interim equipment to temporarily maintain microwave links during 2 to 4-weeks factory modification periods at locations where "hot-standby" equipment is not installed; and cost of contracted technical assistance to augment limited staff personnel.

DOI manages its natural resource programs using radiocommunication to accomplish Congressionally-mandated missions. These operations are spread throughout the United States, in suburban, urban, and rural areas, some of which are remote and almost inaccessible areas where commercial service is not currently available. Some of DOI's communication systems encompass only a few buildings in a city or a small wildlife refuge where commercial service is not always reliable. Others encompass large geographical areas, such as national forests and Indian reservations. Because of its diverse mission requirements and the need for coverage in unpopulated areas, the use of currently available commercial services to provide cost effective communication services was not considered a viable option by DOI for these applications.

**Energy.** The majority of DOE's fixed microwave operations in the 1710-1755 MHz frequency range are in support of the Electrical Power Marketing Program. FPAs use this portion of the spectrum for wide-area fixed networks to support the supervision, control, and protection of electrical power transmission. The channels are used for high-speed relaying, supervisory control, load control, telemetering, data acquisition, land-mobile radio dispatching, operations and maintenance. Some of the present FPA systems connect, via wireline and radio, all Federal power marketing control facilities in certain regions of the United States. Common equipment exists between the Federal and non-Federal users allowing interconnectivity for critical communications dealing with all aspects of generating and distributing power. Title VI includes a specific provision that frequencies assigned to these FPAs may only be eligible for reallocation on a mixed use basis, and any non-Federal user shall not cause harmful interference to existing FPA operations. In complying with this provision, reallocation of the band on a mixed use basis will not result in operational or cost impact to any existing FPA uses.

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

Noting the protected status of FPA operations, DOE estimates that there will be minimal impact on existing and planned operations as a result of reallocating the bands identified in the Preliminary Report. DOE estimates that the reallocation cost to replace non-FPA systems in the 1710-1755 MHz band with equipment in the 7/8 GHz band is $2.4 million and can be accomplished within the timeframe proposed in the Preliminary Report. However, DOE states that there are areas of concern with the proposed reallocation plan that may increase this estimated reallocation cost by an additional $7.4 million.[39] This additional cost would result if the ACE and the United States Bureau of Reclamation frequencies in the 1710-1755 MHz band supporting power transmissions are not exempted for reallocation. Although the FPAs were granted an exception from Title VI and will receive protection from the emerging wireless telecommunications technologies, increased usage in the 1710-1850 MHz band by these new technologies in the future may require more effective national regulatory procedures to ensure continued use of this band by FPAs. The cost impact to DOE if these microwave systems are not protected and must be relocated to another frequency band or transmission media in the future will be greatly increased. Also, because planned additions will have to be located in the remaining portion of the 4400-4990 MHz band or the 7/8 GHz band, additional costs will be required. Microwave systems whose links are scattered across various frequency bands may result in lower reliability and higher costs.

**Justice.** DOJ makes broad use of radio frequencies in the 1710-1755 MHz band for Congressionally-mandated enforcement programs, including the continuity of law enforcement and National Security Emergency Preparedness telecommunications services. The principal bureaus affected by the potential reallocation of this band are the Federal Bureau of Investigation (FBI), Immigration and Naturalization Service (INS), and Drug Enforcement Administration (DEA). FBI has 427 microwave sites operating in this band to relay land-mobile radio traffic throughout its district communications networks. INS operates 90 fixed point-to-point digital microwave systems in the band to support the interconnect requirements of INS Encrypted Voice Radio Program. DEA uses the 1710-1755 MHz frequency band to support their video transmission systems, and operates approximately 500 transportable video transmission links for nationwide law enforcement activities.

Bureaus within DOJ have proposed a variety of transition options to effect the reallocation of the 1710-1755 MHz band. For example, FBI began a program in 1991 to convert its microwave links in the 1710-1850 MHz band to leased wireline. FBI estimates the 15-year costs for the conversion of the 427 sites operating in the 1710-1755 MHz portion of the band to exceed $121 million.[40] INS proposes to relocate the existing point-to-point microwave systems to higher frequency bands (e.g., 7/8 GHz band) at an estimated cost of $23 million. DEA proposes to recrystal and realign its communications links at an estimated per unit cost of $350 for a total cost of $180,000. Summing these costs, the total DOJ estimated reaccommodation cost of its operations in this band exceeds $144 million.

Several factors dictate that certain land mobile communications requirements of Federal law enforcement agencies cannot be met by existing commercial services. First, most Federal law enforcement communications must be immediate; the delays associated with call setup of the commercial Public Switched Telephone Network is unacceptable in certain life-threatening situations. Second, most Federal law enforcement agencies have area offices that are responsible for activities throughout a large geographic area, in many cases where commercial services are not available. Finally,

Federal law enforcement systems require secure communications. The monitoring of clear voice commercial communications by the general public, the news media, foreign intelligence agents, and criminals has disrupted investigations and caused life-threatening situations for law enforcement personnel. As stated earlier, FBI is currently converting to leased wireline services that will replace its fixed microwave backbone network.

**Treasury.** The United States Customs Service of the Department of Treasury (Treasury) operates and maintains an inter/intra-island backbone fixed microwave system between the Hawaiian Islands commonly known as the Rainbow Microwave System. This fixed microwave system, which includes two of the longest known over water fixed links in the world, cannot be technically supported at higher frequency bands. Treasury reports that the system was reconfigured from the 7/8 GHz band to the 1710-1850 MHz band to achieve the required reliability. The system evolved from a few user owned fixed microwave links connected back-to-back into a conglomerate of shared Federal Government and non-Federal sector segments which now constitute a 120-channel backbone system. It provides complete inter and intra-island linkage of multiple Federal, state and local law enforcement, maritime safety, and public service systems. The system carries USCG search, rescue, calling and distress traffic, Emergency Medical Service Support traffic, fire, police, National Weather Service, and Civil Defense emergency communications. It also carries high priority communications pertinent to agent safety related to drug interdiction, counterfeit, fraud, and forgery investigations, and protective communications required for visits by the President or Vice President and their families as well as foreign heads of state and government. Although replacement could conceivably cost upwards to $25 million,[41] Treasury emphasizes that alternatives such as use of higher frequency bands, satellite links, or undersea cable are not technically or economically viable. Treasury urges that this system be included in the list of Federal stations that will remain in the band and protected from interference under the mixed use criteria as mandated in Title VI. The most critical discrete frequencies used for the over water fixed links are 1711, 1719, 1729, and 1735 MHz.

Treasury also uses the band for a variety of other functions including aerostat data links, and air-to-ground video links used in surveillance operations. Treasury estimates the reallocation cost impact on these systems is approximately $500,000.

At this time, it is not known whether the microwave links that comprise the essential Rainbow Microwave System could be technically or economically substituted with commercial satellite communications services. However, since this system represents the only linkage of multiple Federal/state/local law enforcement, maritime safety, and public service systems, resulting in a requirement for a high reliability of service, the replacement of this system by a currently available commercial service is not seen as acceptable option by Treasury.

**Commerce.** NOAA is responsible, inter alia, for the collection of meteorological data and the preparation of weather forecasts that affect the health, safety and economic well being of the public. NOAA's data collection efforts involve weather radars and other ground-based systems, as well as meteorological satellites. NOAA operates eleven microwave links in the 1710-1755 MHz band for

tsunami warning, radar-remoting and other meteorological purposes. Detailed NOAA cost impact data for this band was not available.

**Agriculture.** The Forest Service of the USDA is one of the Federal Government's largest users of the 1710-1850 MHz radio band. Reallocation of the 1710-1755 MHz band will impact 40% of the 1,370 Forest Service fixed microwave radio sites, the majority of which were installed between 1981 and 1986. These sites provide backbone communications links supporting land mobile radio systems on National Forest and other lands managed by USDA for the public. The backbone links provide the primary radio interconnection between mountaintop radio repeaters and the base stations, which further interconnects with either mobile or portable hand-held radios. These systems are essential for law enforcement, firefighting, and emergency preparedness disaster control (e.g., earthquake, volcanic eruption and hurricane) communications. Some USDA microwave links are shared with other Federal agencies such as the DOJ. In order to meet the requirements of the proposed reallocation plan, USDA recommends obtaining new frequencies in other bands such as the 4.4/4.99 GHz or 7/8 GHz bands and procuring new equipment at an estimated cost of $48 million.[42] Other alternatives that would have involved acquisition of commercial leased services, or modification of existing equipment for operation in the 1755-1850 MHz portion of the band, were deemed by USDA as unacceptable.

As stated in the comments submitted by USDA, "The fixed microwave systems under consideration were reviewed under the OMB Circular No. A-76 process to assess if there were reasonable commercial services available in place of Federal owned facilities. All systems installed met the criteria allowing for Federal owned procurement. One of the major decision factors was that the systems are in remote National Forest areas having a single user (USDA Forest Service) controlling remote land-mobile radio communications systems. Commercial investments are predominantly associated with dense population in order for there to be financial incentive. As a result, commercial suppliers were unable to cost effectively provide acceptable facilities. Except for a small number of locations, the original decision criteria remains unchanged." Based on these factors, USDA indicates that they will not obtain leased services.

**Summary for the 1710-1755 MHz Band.** The 1710-1755 MHz segment of the 1710-1850 MHz band is currently allocated to the Federal Government exclusively for fixed and mobile services on a primary basis. This band segment is used, in varying degrees, by all major Federal Government agencies for medium-capacity (e.g., 24-300 voice channels) fixed microwave communications, as well as a variety of special fixed and mobile applications. Tactical radio relay systems are also used extensively in this band to support proficiency training and to maintain combat readiness. The majority of the fixed microwave systems operated by the Federal Government agencies for voice, data, and/or video communications are located in remote areas where commercial service is unavailable, excessively expensive, or cannot meet required reliability. There are, however, some heavy uses by DOJ, FAA, USCG and Army in certain urban areas. The majority of the Federal Government fixed microwave systems employed in the 1710-1755 MHz band are commercial off-the-shelf systems.

Although there are mobile systems that will be impacted, the predominant direct costs will result from the potential displacement of the fixed microwave systems because of their preponderance in this band.

There are approximately 1,700 affected fixed microwave stations supporting critical and important Federal Government missions such as national defense, law enforcement, provision of navigation services to ships and planes, management of public forests and parks, military command and control communications network, and the control links for wide-area networks for various power, land and water management systems. While most major Federal Government agencies will be affected, the agencies potentially most significantly affected will be Army, USDA, DOI, DOT, DOJ, DOE and Air Force. Estimated costs for implementing the reallocation vary from $343 million to nearly $356 million.

## 2300-2310 MHz Band

An overview of the Federal Government agencies affected by the reallocation of the 2300-2310 MHz band for non-Federal sector use is given in TABLE 3-3. The following paragraphs will discuss the reallocation impact and the options for each of the agencies affected by the loss of 2300-2310 MHz band.

**TABLE 3-3**

Overview of Reallocation Impact for the 2300-2310 MHz Band

| Affected Agency | Type | Function | # of units | Tuning range (MHz) | Reallocation impact | Reallocation Approach |
|---|---|---|---|---|---|---|
| N & AF | MPS-38 | Radar simulator | 3 | 2300-2450 | Loss in tuning range | Restrict 2300-2310 MHz band use to coordinated operations at selected test ranges. |
| AF | DSQ-X | Miss-distance measurement | 4 | 2300-2450 | Loss in tuning range | Restrict tuning in the 2300-2310 MHz band segment. |
| AF | NAVS | Test & evaluation | 100 | 900-3000 | Loss in tuning range | Contractor plans to use bands below 2300 MHz. Estimated reallocation impact is expected to be minimal. |
| AF | RDAVS | Test & evaluation | 132 | 2300-2450 | Loss in tuning range | The equipment will have to be tuned to the 2360-2390 MHz band which will require modification of internal components and new crystals. At least 60 beacons will have to be replaced. Estimates are $300,000 for modifications and $665,000 to replace beacons. A more advanced system is planned to replace RDAVS in FY98. |
| AF | Test | Misc. test range & telemetry equipment | 36 | 2300-2450 | Loss in tuning range | Restrict tuning in the 2300-2310 MHz band segment. |
| NASA | DSN | Deep Space Network & associated satellites | 3 | 2290-2300 | None | Include reallocation constraints in the Preliminary Report to restrict adjacent band emissions. If the new non-Federal service is compatible, the reallocation cost will be minimal. |
| NASA | Research | Planetary mapping radar | 1 | 2320 | None | Include reallocation constraints in the Preliminary Report to restrict adjacent band emissions. |

**Air Force and Navy.** The 2300-2310 MHz band is used primarily for radar target scatter and identification systems, and threat simulators and test equipment used in training exercises. This band is also adjacent to the band used for the Air Force Satellite Control and Defense Meteorological Satellite networks. The Air Force and Navy systems that use this band are primarily located on various military test ranges throughout the United States.[43]

The radar target scattering test systems operating in the 2300-2310 MHz band can be tuned over a wide range of frequencies and are thus capable of operating in other bands. However, data across a broad range of frequencies is required for certain target scattering studies. Radar simulators are also tunable, but frequencies that are required for testing are determined by the threat emission being simulated.[44]

The Non-cooperative Airborne Vector Scorer (NAVS) is a new system, with more than 100 units scheduled to be fielded in 1997. This system will detect scoring for live-fire test and evaluation against aerial targets. The equipment tunes from 900 MHz to 3000 MHz. The reallocation of the 2300-2310 MHz band will have little operational impact on this system.[45]

The Recovered Doppler Airborne Vectoring Scoring (RDAVS) System is used exclusively to support Advanced Medium Range Air-to-Air Missile (AMRAAM) testing at the USAF Air Warfare Center. The system, which tunes over the 2300-2390 MHz range, consists of a drone-mounted receiver and a missile-mounted beacon. Currently there are 22 aircraft and 110 beacon units. Some of the beacon units are fixed-tuned to the 2300-2310 portion of the band. Reallocating 2300-2310 MHz will require these equipment to be retuned to the remaining 2310-2390 MHz band segment. Retuning will require modification of internal components and new crystals. The reallocation costs are estimated at $20,000/unit for modifications of all beacon units, if it is determined to be necessary. Because of funding constraints, receivers may have to be reduced to 15 units by January 1996 for a total cost of $300,000. However, an additional 60 units will be in stock and usable if normal operations are not allowed while the beacons are phased out. The total expense considering only rework and loss/acquisition of beacons is in excess of $1.63 million. A more advanced system is planned to replace RDAVS in the FY98 time frame. If RDAVS is permitted to be phased out, no costs will be incurred due to the reallocation of the 2300-2310 MHz band.[46]

**National Aeronautics and Space Administration.** The main concern expressed by NASA regarding the reallocation of the 2300-2310 MHz band is the potential interference from a yet to be determined non-Federal application to adjacent-band Federal operations. NASA operates a Planetary Radar at 2320 MHz and the Deep Space Network (DSN) radar receiver at 2290-2300 MHz, both located in Goldstone, California. The very low received signal levels and the state-of-the-art sensitivity limits of these receivers make them extremely susceptible to interference from even low-level radio frequency signals. This high susceptibility dictates that even distant interference must be taken into consideration when selecting the commercial applications that are to operate in the reallocated 2300-2310 MHz band.

During discussions with NASA representatives, it was stated that NASA's position regarding the 2300-2310 MHz band continues to be that DSN operations can co-exist with certain types of commercial applications. For example, aeronautical or space-to-Earth links will have a high probability of causing

harmful interference. Conversely, low-power, licensed, terrestrial applications can be coordinated and are not expected to be a problem. Given that the restrictions identified in the Preliminary Report are observed, and adequate consideration is given to the type of non-Federal applications implemented, NASA anticipates no major operational or economic impact from the proposed reallocation of the 2300-2310 MHz band.[47]

**Summary for the 2300-2310 MHz Band.** Federal Government usage of the 2300-2310 MHz band is light compared to many of the other Federal Government bands. Therefore the disruption of Federal government operations resulting from the reallocation of this band to non-Federal sector use is expected to be minimal. The Air Force and Navy systems that occupy this band are primarily used for research and development and test purposes, and by the nature of their design have a great deal of flexibility in frequency selection. However, DOD needs to have continued use of this spectrum at selected locations because it is critical for National Security.

Provided that adequate consideration is given to the type of non-Federal applications implemented and the restrictions on airborne and space-to-Earth links are observed, NASA expects no major operational or economic impact as a result of the proposed reallocation of the 2300-2310 MHz band.

## 2390-2400 and 2402-2417 MHz Bands

An overview of the Federal Government agencies affected by the reallocation of the 2390-2400 and 2402-2417 MHz bands for non-Federal sector use is given in TABLE 3-4. The following paragraphs will discuss the reallocation impact and the options for each of the agencies affected by the loss of the 2390-2400 MHz and 2402-2417 MHz bands.

**Air Force and Navy.** The 2390-2400 MHz band is primarily used by Air Force and the Navy for target identification, range telemetry and measuring systems, radar target scattering measurements and threat simulator radars. The lower adjacent band of 2360-2390 MHz is used exclusively for telemetry. The Federal Government primarily uses the 2402-2417 MHz band for test and training range instruction, telemetry control and data links, and threat simulation.[48]

Target scattering and identification radars as well as radar simulators in the 2390-2400 MHz and 2402-2417 MHz bands are tunable. However, specific frequencies are required for obtaining quantifiable data, and simulating threat emissions. Modifications to electronic warfare equipment to lock-out the band segments planned for reallocation are estimated to total $1 million for software changes.[49]

Ground-based telemetry systems are capable of being tuned. Flexibility in airborne units is limited and will require redesign or recrystallization in most cases. The conversion of telemetry receivers and autotracking antenna systems will cost approximately $2.5 million.[50] Modification and/or replacement of various telemetry equipment is estimated at $600,000.[51] The Completely Integrated Reference Instrumentation System (CIRIS) is used by DOD to certify navigation systems. It is the only source of continuous (i.e., range dependent) time, space and position information (TSPI) for DOD test programs. In addition, CIRIS is reported by Air Force as the only real-time source of velocity reference data with an accuracy of 0.1 feet per second.[52] CIRIS is fixed-tuned on 2412.4 (interrogator) and 2347.2 MHz

**TABLE 3-4**

Overview of Reallocation Impact for the 2390-2400 and 2402-2417 MHz Bands

| Affected Agency | Type | Function | # of units | Tuning range (MHz) | Reallocation impact | Reallocation Approach |
|---|---|---|---|---|---|---|
| N | MPS-38 | Radar simulator | 5 | 2300-2450 | Loss in tuning range | Restrict tuning in the reallocated band segments. |
| N | DSQ-50 | Miss-distance measurements | 200 | 2300-2400 | Loss in tuning range | Restrict tuning in the reallocated band segments. |
| N | CTS-515 | Telemetry | 200 | 2300-2450 | Loss in tuning range | Restrict tuning in the reallocated band segments. |
| A | APR-9B | Aircraft radar warning receiver | 1 | 2390-2450 | None | Reallocation will have minimal impact |
| AF | Range test equipment | Telemetry | 34 | 2300-2450 | Loss in tuning range | The conversion of 36 telemetry receivers and 4 auto tracking antenna systems is estimated to cost $2.5 M. Modification and/or replacement of various telemetry equipment is estimated at $600,000, and $650,000 to replace each Range Data and Range Timing system. |
| AF | URQ-30, 38 | Airborne interrogator CIRIS | 199 | 2412.4 & 2347.2 | Interrogator transmitter impacted | CIRIS interrogators will require redesign. Estimated reallocation cost: FY94-$125,000; FY95- $450,000; FY96- $10M; FY97- $14M; and FY98- $11 M. |
| AF | URQ-30, 38 | Ground transponder CIRIS | 199 | 2347.2 & 2412.4 | Transponder receiver impacted | CIRIS interrogators will require redesign. Estimated reallocation cost: FY94-$125,000; FY95- $450,000; FY96- $10M; FY97- $14M; and FY98- $11 M. |
| AF | MST-T1A | Training | 36 | 2300-2450 | Loss in tuning range | Modifications to electronic warfare equipment to lock-out the band segments planned for reallocation are estimated to total $1 M in software changes. |
| NSF | Research | Planetary mapping radar | 1 | 2380 | None | Include reallocation constraints in the Preliminary Report to restrict adjacent band emissions in the vicinity of the observatory. |

(transponder). Reallocation of the 2402-2417 MHz band segment will impact the CIRIS interrogators. Estimated reallocation costs are: FY94-$125,000; FY95-$450,000; FY96-$10 million; FY97-$14 million; FY98-$11 million.[53]

**National Science Foundation.** The 2390-2400 and 2402-2417 MHz bands are adjacent to the 2370-2390 MHz band used for planetary radar research. NAIC operates a planetary research radar at Arecibo, Puerto Rico, on the frequency of 2380 MHz. Research conducted with the Arecibo radar has resulted in major contributions to knowledge of the solar system, including most recently the mapping of the surface of Venus. This installation is one of the few available worldwide to keep watch on near-Earth objects posing a potential threat to the Earth. The Arecibo planetary radar operates at 2380 MHz with a required bandwidth of 20 MHz.[54] The radar detects extremely weak return signals; consequently, it is extremely vulnerable to spurious emissions from systems operating in adjacent bands that fall within the radar's bandwidth.

As stated in the Preliminary Report, the 2390-2400 and 2402-2417 MHz bands are available for immediate reallocation for exclusive non-Federal use.[55] Unrestricted use of the 2390-2400 MHz and 2400-2410 MHz bands could necessitate retuning the NAIC Arecibo Planetary radar to a different operating frequency. The cost of this shift is currently estimated to be $4 million. However, if restrictions similar to those proposed for the 2300-2310 MHz band are observed, impact on the facility should be minimal.[56]

**Summary for the 2390-2400 & 2402-2417 MHz Bands.** The Air Force and Navy systems that occupy this band are primarily used for research, development, test, and evaluation purposes and, by the nature of their design, have some flexibility in the selection of operating frequencies. The Air Force and Navy usage and investment in the 2390-2400 and 2402-2417 MHz bands is light compared to many of the other Federal Government bands. The major system impacted by the reallocation is the CIRIS. The 15-year costs reported by Air Force and Navy to implement the reallocation plan is approximately $40 million.

The 2390-2400 MHz and 2402-2417 MHz bands are adjacent to the Arecibo planetary radar system operating at 2380 MHz. Reception of the very weak signals inherent to this type of work are vulnerable to out-of-band emissions from adjacent bands. However, if constraints on airborne and space-to-Earth links are observed, the impact on this important research tool should be minimal.

## 3650-3700 MHz Band

An overview of the Federal Government agencies affected by the reallocation of the 3650-3700 MHz band segment is given in TABLE 3-5. The following paragraphs will discuss the reallocation impact and options for each of the agencies affected by the loss of the 3650-3700 MHz band segment.

**Navy.** The major systems operating in the 3600-3700 MHz band are Navy shipborne radars that serve as the primary ATC radar aboard aircraft carriers, and also serve as an interface with other precision carrier approach radars for carrier landing operations. The AN/SPN-43 radars have a tuning range of 3590-3700 MHz. The 45 operational radars have a scheduled equipment life that extends to at least 2010.[57] An additional factor limiting non-Federal sector use of this band is the Navy's AEGIS AN/SPY-1 high powered radar. Although the AN/SPY-1 operates in a lower frequency band and complies with the radar engineering spectrum requirements of the NTIA Manual of Regulations and Procedures for Radio Frequency Management, it makes use of this band impractical for many commercial purposes within a

considerable distance of the coast. Satellite receivers operating above 3700 MHz, without adequate desired signal margins and interference rejection mechanisms, presently suffer interference from AEGIS operating at distances as great as160 km.

**TABLE 3-5**

Overview of Reallocation Impact for the 3650-3700 MHz Band

| Affected Agency | Type | Function | # of units | Tuning range (MHz) | Reallocation impact | Reallocation Approach |
|---|---|---|---|---|---|---|
| N | SPN-43 | Shipborne radar | 45 | 3590-3700 | None | Re-engineer channel plan for the band. |
| N | SPN-6 | Shipborne radar | 1 | 3600-3700 | None | SPN-6 being replaced by the SPN-43. |
| N & AF | SPQ-11 | Shipborne radar | 1 | 2000-4000 | None | Restrict tuning in the reallocated band segment. |
| AR | Various | Ground based equipment | 1680 | 3675-3700 | None | Intercept receivers have an operational tuning range of 500-40000 MHz and ECM intercept receivers have an operational tuning range of 20-4000 MHz. The spectrum reallocation will have minimal impact on these systems. |
| AF | Training | ECM training | ---- | 3625-3650 | Loss in tuning range | Restrict tuning in the reallocated band segment. This frequency band is utilized by several ECM training devices. These devices are crucial to maintain the combat readiness of our pilots. It would cost Edwards AFB $100,000 to perform studies required to ensure compatibility of conducting ECM in spectrum adjacent to reallocated spectrum. |
| AF | HySTP | Research | ---- | 3600-4200 | Loss in tuning range | Restrict tuning in the reallocated band segment. This band is used by the Hypersonic system technology program (HySTP). HySTP will telemeter data from the experimental vehicle and to track the flight with radar. The reallocation will reduce the HySTP's ability to acquire data. The necessary frequency bandwidth might not be available in another band on the Western Range. |

As stated in the Preliminary Report, reallocation of the entire 3600-3700 MHz band is not considered feasible because of the daily need for carrier take-off and landing proficiency training operations involving the radar controllers and aircraft pilots. However, as stated in the Preliminary Report, the reallocation of the 3650-3700 MHz band on a mixed use basis is possible and provides a reasonable

compromise between the needs of the non-Federal users and the requirements by Navy to use the radar in this band. The cost of replacement radars operating in an alternative band, if one is available, is estimated to be $350 million.[58] The use of the 3650-3700 MHz band on a mixed use basis would eliminate need for replacement of the radars, but would require detailed engineering analysis to re-design the Navy's current channeling plan for the 3590-3700 MHz band. The implementation of new operating procedures for Navy radars operating in coastal waters and the modification of documentation including, logistics plans, training, and operator manuals will also be necessary. The proposed five-year delay in reallocation for the 3650-3700 MHz should provide sufficient time for the DOD budget cycle to provide funding to accomplish the necessary engineering studies and operational changes. It also provides time for the development of non-Federal receiver standards and criteria to allow non-Federal sharing of the band without further restrictions on Navy operations. In addition, to lessen the impact to the Navy, radar operations in the 3650-3700 MHz band will continue at three specified locations given in the Preliminary Report.[59]

Two additional shipborne radar units operated by Navy in this frequency range, an AN/SPN-6 and an AN/SPQ-11, are not expected to be impacted by the reallocation.

**Army.** The Army has approximately 1700 equipment operating in this band. The systems primarily operating in this band are intercept receivers that are able to tune from 500 MHz to 40 GHz. Most of this equipment is restricted to operating on Army bases throughout the United States and should not be impacted by the reallocation of the 3650-3700 MHz band segment. [60]

**Summary for the 3650-3700 MHz Band.** The Navy shipboard radars that operate in the 3590-3700 MHz band perform essential mission functions that cannot be eliminated. Reallocation of the 3650-3700 MHz band segment for non-Federal sector use is a reasonable compromise between the needs of the Federal Government users and those of future non-Federal sector users. The reallocation of the 3650-3700 MHz band segment instead of the entire 3600-3700 MHz band eliminates procuring a new radar system in another frequency band to perform this function and will allow Navy to continue operations. Funding for engineering studies to develop new channeling plans, analyze potential interference problems with other systems operating on the same ship, and implement changes to Navy operating procedures and manuals will be required. The delayed mixed use reallocation schedule of five years will give Navy and the DOD budget cycle time to apportion funding and implement these changes with minimal impact to daily Navy carrier operations and allow development of non-Federal standards and limitations to allow compatible sharing in this band.

## 4635-4660 and 4660-4685 MHz

The Federal Government agencies primarily affected by the reallocation of these bands are Air Force, Army, Navy, Treasury, and DOE. The following paragraphs describe the major systems operating in these bands and transition plans, costs, and options for each of the affected agencies.

**Treasury.** Treasury operates nine aerostat wideband downlinks in the 4635-4660 MHz band: four in Texas and one each in Puerto Rico, Arizona, Louisiana, Florida, and the Bahamas. Treasury expects

that the costs for changeout of frequencies at these sites will be negligible if substitute frequencies within the tuning range of the equipment can be successfully coordinated, as is anticipated.

**Energy.** DOE uses the 4400-4990 MHz band for operations of the NEST equipment during emergencies in any operating environment throughout the United States and possessions. DOE has also recently received NTIA approval for microwave systems in support of a new large trunked land- mobile system. They indicated that the cost to retune these and other equipments to operate in the remaining portions of the 4400-4990 MHz band would be $600,000 and could be accomplished prior to the proposed January 1997 reallocation schedule.

**Army.** The Army reports that this band is important for its area-wide integrated communications networks. Land forces command, control and communication systems tie the various operational and functional nodes into an integrated area-wide network. Tactical radio relay systems, using both line-of-sight and tropospheric scatter propagation, are extensively used within the United States for comprehensive realistic training, humanitarian relief, natural disaster operations, and to maintain combat readiness. The Army states, "options of moving into one of the other bands are extremely difficult and not operationally sound. Other frequency bands are fully used and very congested. Moving to a lower band creates technical problems from larger bandwidths and operational distance requirements. Moving to a higher band creates similar problems... Further loss or erosion of authorized frequency resources would adversely affect military land forces' ability to provide an adequate command, control communications network." Reallocation options, transition plans, or specific reallocation cost estimates for these systems were not available.

The Army also operates an unmanned aerial vehicle and mobile video system at the National Training Center in Ft. Irwin, California. Preliminary Army cost estimates of the reallocation impact to this system are in excess of $10 million.

**Navy.** Major Navy programs that have frequency assignments in these bands include the LAMPS III and RPV control systems such as the Integrated Target Control System, and similar control systems for the PIONEER RPV. Also being developed for this band is the next-generation wide band anti-air warfare and ship defense system. Reallocation options, transition plans, or specific reallocation cost estimates for these systems were not available; although, a significant amount has been spent for the research, design and early development of this defense system.

**Air Force.** Air Force frequency assignments in this band primarily support point-to-point tactical line-of-sight and troposcatter systems whose functions include testing, training, and tactical communications. Video links, data links, and threat simulators are also used in these bands. The Air Force states that reallocation of this band would require retuning one video downlink communications system, ten microwave telemetry and control systems for its TARS, one over-the-horizon (OTH) tropospheric radio system, an undetermined number of digital tactical tropospheric systems, and to relocate its TOSS equipment to the 7/8 GHz band, if possible.

The Air Force estimates that retuning its digital tactical tropospheric systems will cost $3.5 million, retuning its OTH tropospheric radio system will cost $120,000 and relocating its TOSS systems will cost $30,000. Retuning costs for the video downlink and TARS systems are expected to be minimal.

**Summary for the 4635-4660 & 4660-4685 MHz Bands.** DOE and Treasury operate a limited number of fixed microwave and aeronautical mobile systems in these bands. DOE requires $600,000 to retune its equipment in these bands while Treasury has indicated that no significant economic impact would result from implementation of the preliminary reallocation plan for these bands. Army estimates a $10 million impact to its unmanned aerial vehicle and mobile video units at the National Training Center. The Air Force estimates that retuning various tactical tropospheric and target scoring systems will cost $3.7 million.

## ENDNOTES

Requests for copies of references from Federal departments and agencies should be referred to the originating organization. Parts of the reference material may be exempt from public release.

1. Omnibus Budget and Reconciliation Act, Title VI, § 6001(a)(3), Pub. L. No. 103-66, 107 Stat. 379, § 113(c)(1)(C)(i) & (ii), (c)(2)(D), and (a)(4), respectively (codified at 47 U.S.C. § 923(c)(1)(C)(i) & (ii), (c)(2)(D), and (a)(4), respectively (Supp. V 1993)).
2. NAT'L TELECOMMUNICATIONS AND INFO. ADMIN., U.S. DEP'T OF COMMERCE, SPECIAL PUBLICATION 94-27, PRELIMINARY SPECTRUM REALLOCATION REPORT, at 5-14 (Feb. 1994) [hereinafter PRELIMINARY REPORT and all comments cited refer to this report, unless otherwise stated].
3. Fax from B. Swearingen (Naval Electromagnetic Spectrum Ctr) to E. Drocella (NTIA), Subject: Additional Bands Proposed for the Final Spectrum Reallocation Report, at 8 (Dec. 5, 1994).
4. *Id.*
5. Letter from Deborah R. Castleman, Deputy Assistant Secretary of Defense for Command, Control, and Communications, U.S. Dep't of Defense, to Richard Parlow, Assoc. Adm'r Nat'l Telecommunications and Info. Admin. (Sept.1 1994) [hereinafter Joint DOD Response], U.S. Dep't of the Navy Enclosure at 1 (May 18, 1994).
6. U.S. Dep't of the Army Comments, at 5 (May 9, 1994), *in* Joint DOD Response, *supra* note 5.
7. *Id.* at 7.
8. U.S. Dep't of the Air Force Enclosure, at 2 (June 8, 1994), *in* Joint DOD Response, *supra* note 5.
9. *Id.*
10. NTIA PRELIMINARY REPORT, *supra* note 2, at 5-4.
11. Air Force Enclosure, *supra* note 8, at 2.
12. *Id.* at 3.
13. *Id.* at 4.
14. Air Force Enclosure, *supra* note 8, at 5.
15. Air Force Comments on Title VI of the Omnibus Budget Reconciliation Act (OBRA) of 1993, at 4-3 (Jan. 5, 1995).
16. Air Force Enclosure, *supra* note 8, at 6.
17. *Id.* at 3.
18. *Id.*
19. NTIA PRELIMINARY REPORT, *supra* note 2, at 4-11.
20. Air Force Enclosure, *supra* note 8, at 4.
21. Dep't of Transportation (DOT) Comments, at 1 (June 1, 1994).
22. Air Force Enclosure, *supra* note 8, at 11 ATTACHMENT A.
23. Treasury IRAC Representative, U.S. Dep't of Treasury, *Subject: Emerging Telecommunications Technology Act of 1993*, at 3 (Oct. 25, 1993).
24. U.S. Dep't of Energy Briefing, *Remote Sensing Systems Research and Development Programs*, Bob Waldron (June 1, 1994).
25. Nat'l Science Foundation (NSF) Comments, at 1 (Apr. 15, 1994).
26. *Id.*
27. Army Comments, *supra* note 6, at 5.
28. *Id.* at 6.

## ENDNOTES

Requests for copies of references from Federal departments and agencies should be referred to the originating organization. Parts of the reference material may be exempt from public release.

29. Air Force Enclosure, *supra* note 8, at ATTACHMENT 2, 6-7.
30. *Id.* at ATTACHMENT 2, 6.
31. Meeting between NTIA and Nat'l Oceanic and Atmospheric Admin. (NOAA), on June 27, 1994.
32. U.S. Dep't of Commerce Comments, at 2 (May 11, 1994).
33. *Id.*
34. *Id.*
35. Army Comments, *supra* note 6, at 5.
36. Fax from D. Willis (FAA/Office of Spectrum Policy and Management, ARS-1) to E. Cerezo, (NTIA) Subject: FAA Reallocation Cost in the 1710-1755 MHz Band, at 3 (Jan. 25,1995).
37. Fax from E. Brady (USCG/Chief, Frequency Assignment Staff) to E. Cerezo, (NTIA) Subject: USCG Reallocation Cost in the 1710-1755 MHz Band, at 4 (Feb. 1, 1995).
38. U.S. Dep't of Interior Comments, at 2 (May 4, 1994).
39. U.S. Dep't of Energy Comments, at 1 (May 19, 1994).
40. U.S. Dep't of Justice Comments, at 4 (May 31, 1994).
41. U.S. Dep't of the Treasury Comments, at 2 (May 10, 1994).
42. U.S. Dep't of Agric. Comments, at 3 (May 11, 1994).
43. NTIA PRELIMINARY REPORT, *supra* note 2, at 4-15.
44. AF Frequency Management Agency, U.S. Dep't of the Air Force, *Air Force Band Use Analysis*, at A-21, (Nov. 5, 1993).
45. Air Force Enclosure, *supra* note 8, at 10.
46. *Id.* at 11.
47. NTIA PRELIMINARY REPORT, *supra* note 2, at 14
48. *Id.* at 4-14.
49. *Air Force Band Use Analysis*, *supra* note 42, at A-22.
50. *Id.* at A-23.
51. Air Force Enclosure, *supra* note 8, at 1.
52. *Id.* at 11.
53. *Id.*
54. The Nat'l Astronomy and Ionosphere Ctr. Comments, at 5 (May 9, 1994).
55. NTIA PRELIMINARY REPORT, *supra* note 2, at 5-9.
56. NSF Comments, *supra* note 24, at 1.
57. NTIA PRELIMINARY REPORT, *supra* note 2, at 4-18.
58. *Id.*
59. *Id.* at 5-9.
60. Letter from U.S. Dep't of the Army, to IRAC, Doc. 28510/1, Subject: *Army Comments on NTIA Report*, at 8 (Oct. 21, 1993).

SECTION 4

# ASSESSMENT OF REALLOCATION PROPOSALS

## INTRODUCTION

This section provides an assessment of the reallocation proposals discussed in Section 2. The proposals submitted by the FCC and public commenters provided recommendations regarding the spectrum identified in NTIA's Preliminary Reallocation Plan. Several of the proposals recommended increasing the size of the spectrum blocks and accelerating the availability dates for the bands identified in the Preliminary Plan. In addition to these modifications, several proposals also suggested adding new bands to the final reallocation plan.

The 50 MHz identified for immediate reallocation will not be impacted by these spectrum proposals. However, a discussion of NTIA and FCC responsibilities regarding the spectrum identified for immediate reallocation is provided below.

The proposals for the bands identified for reallocation by a delayed effective date will be discussed in this section. Proposals to modify the bands identified in the Preliminary Reallocation Plan will be discussed first, followed by proposals to add new bands to the bands identified in the Preliminary Reallocation Plan.

## IMMEDIATE REALLOCATION

### NTIA Responsibilities for Immediate Spectrum Reallocation

The bands identified in the Preliminary Report for immediate reallocation are 2390-2400, 2402-2417 and 4660-4685 MHz. Sec. 114 (a) of Title VI requires the President to withdraw the frequency assignment to any Federal Government station for the spectrum that was identified for immediate reallocation within 6 months after the receipt of the Preliminary Report.

To implement the reallocation to non-Federal users, the Federal Government provisions of the National Table of Frequency Allocations were changed, effective August 10, 1994. As a result, all Federal allocations in the three bands were deleted. A special note was appended to existing Federal frequency assignments in those bands. This note indicates that the Federal assignments are permitted to remain in the reallocated bands on a non-interference basis to non-Federal operations.

### FCC Responsibilities for Immediate Spectrum Reallocation

Title VI requires that the FCC allocate, and propose regulations to assign, the 50 MHz of spectrum that is immediately available no later than 18 months after its enactment on August 10, 1994. Accordingly, on May 4, 1994, the FCC released an NOI in this proceeding seeking information on potential applications for the 50 MHz of spectrum that is being transferred immediately. Several suggestions were put forth by various commenters responding to the NOI in this proceeding. These comments included recommendations for an aeronautical audio/video service to provide real-time information and entertainment aboard aircraft, wireless local loop service, low-power public-safety applications, and continued use of some of this spectrum by the amateur community and non-licensed users under the FCC's Part 15 rules.

On October 20, 1994, the FCC adopted a Notice of Proposed Rule Making (NPRM) that proposes allocations to the fixed and mobile services for all three frequency bands identified for immediate reallocation. The FCC believes such an approach allows for flexible use of these bands so that licensees would be able to offer a wide range of services, employing a variety of technologies. As stated in the NPRM, this approach would benefit the public by providing for the introduction of new services or the enhancement of existing services.

The FCC also believes that most of the services to be provided in this spectrum would likely meet the statutory criteria for auctions. Therefore, the FCC is proposing to make licenses for this spectrum available through competitive bidding to the extent practicable. Title VI requires the FCC to adopt rules by February 10, 1995, to allocate the spectrum identified for immediate transfer.

## DELAYED REALLOCATION

### Proposed Modifications to the Bands Identified in the Preliminary Reallocation Plan

**1390-1400 MHz.** In their comments on the Preliminary Report and the FCC NOI, both Motorola and TIA recommend that NTIA reconsider its decision not to propose reallocation of the entire 1350-1400 MHz band.[1] Although the 1390-1400 MHz band segment is proposed to be reallocated, Motorola and TIA indicate that it is not clear why the remaining 1350-1390 MHz band segment cannot be reallocated for non-Federal use. Both commenters refer to an NTIA study released in May 1993 that analyzes the spectrum requirements for the fixed services.[2] This study concludes that there are a total of 582 U.S. assignments within the entire 50 MHz band with only a 1% expected growth rate for assignments in the band.[3]

The FCC Report supports the views expressed by Motorola and TIA, specifically recommending that "NTIA reevaluate this band with a view toward making more of it available for non-Government use."[4]

The report referenced in both the Motorola and TIA comments addresses only the fixed service and does not include the other radio services that operate in this band. As discussed in detail in the Preliminary Report, the 1350-1400 MHz band is allocated in various parts to the fixed, mobile, radiolocation, fixed-satellite, mobile-satellite, space research, and earth exploration-satellite services.[5] Moreover, the NTIA fixed service report does not include the 2,650 tactical radios reported by the Army to operate in the 1350-1850 MHz band or the current DOD and FAA radar usage in the 1350-1400 MHz band.[6]

Two major systems currently being fielded that operate in this band are the joint DOD/FAA ARSR-4 and the RAJPO GPS data link. The ARSR-4 is a dual-channel, frequency-hopping system with a tuning capability of 1215-1400 MHz, that FAA and Air Force maintain is necessary to achieve its full operational capability. Air Force states that each channel pair requires 83 MHz of frequency separation to maintain its highest possible reliability. Air Force adds, "This requirement, the need to have frequency-hopping, anti-jam capabilities and the use of ATC and other radars will make retuning and/or restricted use extremely difficult if not impossible in some areas."[7] The ARSR-4 was Congressionally mandated for national air defense surveillance and ATC missions and is currently being fielded at Joint Surveillance System sites around the perimeter of the United States. Loss of the 1390-1400 MHz band segment will require software and hardware changes, while further spectrum loss in the 1350-1390 MHz band segment would require that the ARSR-4 be completely redesigned.[8]

In January 1994, Air Force began fielding of the RAJPO GPS data link, which operates in the 1350-1400 MHz and/or 1427-1435 MHz bands. A total procurement of 719 units have been authorized for use at 18 sites throughout the United States and possessions.[9] This system is critical to ensuring the safety of personnel during training or test operations on ranges. Dual frequency operation is required to ensure data availability in rugged terrain and to overcome multipath problems encountered during combat training exercises. Air Force maintains that any additional loss of spectrum in the 1350-1390 MHz band would affect the future support of full scale training exercises necessary to verify combat readiness and equipment reliability.[10]

The frequency 1381.05 ± 12 MHz is allocated for the fixed- and mobile-satellite services (space-to-Earth) for the relay of nuclear burst data, in accordance with Federal Government footnote G114. Nuclear detonations around the world are detected by DOD satellites, relayed to Earth and received at numerous fixed, transportable and mobile locations. Recent improvements in technology and equipment modernization have reduced the bandwidth necessary for this function to 5 MHz, centered on the frequency 1381.05 MHz. Alternative frequencies for this function are not practical since the transmitters are located on satellites and cannot be changed.[11] Reallocation of the entire 1350-1400 MHz band would disrupt the essential function performed by this system.

TIA's comments also state that new equipment designed for use in the 1390-1400 MHz band must be capable, at some expense, of tolerating adjacent-band FAA and DOD high-power radar signals.[12] Reallocating the entire 1350-1400 MHz band would only intensify this problem, since FAA also operates approximately 200 high-power long-range air route surveillance radars in the adjacent 1215-1350 MHz band.[13] Reallocating only the 1390-1400 MHz band segment does not eliminate the problem of high-

power adjacent-band interference, but it does provide a guard band between new commercial users and the existing FAA radars. To achieve a satisfactory commercial service that is immediately adjacent to a band used by megawatt radar systems, the adoption of effective receiver selectivity and transmitter emission standards is essential to minimize interference to and from these radar systems.

In Section 2, Pacific Bell and Nevada Bell state that most of the mobile wireless services will use FDD technology, which is based on the ability to balance the frequencies used for both directions of service. Pacific Bell and Nevada Bell maintain that the 1390-1400 MHz band segment would only be viable for technologies employing TDD.[14] However, it may be possible to pair 5 MHz of the 1390-1400 MHz band segment with the 5 MHz in the 1427-1432 MHz band segment for FDD applications. The remaining 5 MHz in the 1390-1400 MHz band segment could then be used for applications employing TDD technology or Code Division Multiple Access technology since paired frequency bands are not required.

From the preceding discussion, it can be seen that there is a misunderstanding in the public's assessment of Federal usage in the 1350-1400 MHz band. It is anticipated that DOD and FAA radiolocation operations will continue in this band for at least the next 10 years.[15] As stated in Section 3, the 1390-1400 MHz band segment also has a potentially high reallocation cost as compared with the other bands proposed for reallocation. We continue to believe that reallocation of a larger portion of the 1350-1400 MHz band is not a practical option and consequently retain the reallocation of the 1390-1400 MHz band segment as proposed in the Preliminary Report subject to the following constraints:

- To minimize the impact on the radio astronomy service, reallocation for space-to-Earth links must not be permitted, and protection of radio astronomy would be in accordance with footnote US311 of the National Table of Frequency Allocations;
- To achieve a viable non-Federal service adjacent to high-power radars, adoption of effective receiver selectivity and transmitter emission standards is essential;
- To avoid unnecessary disruption of Federal operations in isolated remote locations, the Federal radiolocation service will be continued on a secondary basis in Alaska;
- To protect essential operations, Federal systems at the sites listed in TABLE 4-1 will be continued for 14 years.

**1427-1432 MHz.** TIA, in its comments on the Preliminary Report, and NABER, in its comments on the FCC NOI, state that satisfying the conditions proposed for the protection of adjacent-band radio astronomy operations could make commercial use of this band difficult. Pacific Bell and Nevada Bell believe that the 1390-1400 and 1427-1432 MHz bands are too small and unbalanced to use in a channel-pairing arrangement and therefore may not be capable of providing a commercially viable service. The FCC Report supports these views and adds that the small size of this proposed allocation, as well as its remoteness from existing non-Federal services, will make it difficult to use either as an adjunct to an existing service or to support a new service. The FCC also states that the proposed

continued Federal use of this band (at 14 sites for 15 years) could adversely affect the ability of non-Federal entities to use this spectrum.[16]

**TABLE 4-1**

Sites at Which Federal Systems in the 1390-1400 MHz Band will be Continued for 14 Years

| Location | Coordinates | Radius of Operation (km) |
|---|---|---|
| Eglin AFB, FL | 30°28'N 86°31'W | 80 |
| Dugway Proving Grounds, UT | 40°11'N 112°53'W | 80 |
| China Lake, CA | 35°41'N 117°41'W | 80 |
| Edwards AFB, CA | 34°54'N 117°53'W | 80 |
| Ft. Huachuca, Az | 31°33'N 110°18'W | 80 |
| Cherry Point, NC | 34°57'N 76°56'W | 80 |
| Patuxent River, MD | 38°17'N 76°25'W | 80 |
| Aberdeen Proving Ground, MD | 39°29'N 76°08'W | 80 |
| Wright-Patterson AFB, OH | 39°50'N 84°03'W | 80 |
| Ft. Greely, AK | 63°47'N 145°52'W | 80 |
| Ft. Rucker, AL | 31°13'N 85°49'W | 80 |
| Redstone, AL | 34°35'N 86°35'W | 80 |
| Utah Test Range, UT | 40°57'N 113°05'W | 80 |
| White Sands Missile Range, NM | 32°10'N 106°21'W | 80 |
| Holloman AFB, NM | 33°29'N 106°50'W | 80 |
| Yuma, AZ | 32°29'N 114°20'W | 80 |
| Pacific Missile Range, CA | 34°07'N 119°30'W | 80 |

Navy and Air Force have stated that reallocating the 1427-1432 MHz band segment will have a serious impact on the training of pilots in the use of sophisticated weaponry unless these frequencies are available for continued use at the test and training ranges specified in the Preliminary Report.

NTIA believes that the concerns expressed above and described fully in Section 2 have merit but fail to address the consequences in terms of how a new commercial service will impact incumbent Federal systems. NTIA selected the 1427-1432 MHz band for reallocation only after considerable analysis of existing Federal use of the entire 1400-1525 MHz band. The 1400-1525 MHz band falls between bands used for radio astronomy in the lower-adjacent band and aeronautical telecommand and telemetering systems in the upper-adjacent band. In addition, the 1400-1525 MHz band must also accommodate the RAJPO GPS data link system.

Because of the importance of the frequencies allocated on an exclusive primary basis in the lower-adjacent band for radio astronomy observations, and the extreme sensitivity of the receivers, reallocation of these bands for non-Federal use were found to have a significant detrimental effect on national radio

astronomy operations.[17] For this reason, the bands allocated for exclusive radio astronomy use were not considered for reallocation.

The upper-adjacent bands are co-equally shared between Federal and non-Federal users and are designated to support flight test telemetering for the military and aerospace industry. In recent years, the bands available to support these flight test telemetry operations have been reduced by over 30%. The cost and operational impact, to both Federal and non-Federal users, of any additional reallocation were found in the Preliminary Report to outweigh any positive public benefits. For this reason, these bands were not considered for reallocation.

An additional concern in reallocating the 1427-1435 MHz band involved the RAJPO GPS data link. To achieve the designed communications reliability under low-level flight conditions, simultaneous dual frequency operation is required, with adequate frequency separation to assure reliable communications. Since adequate frequency separation is not available solely within 1350-1400 MHz, continued primary access to a minimum of 3 MHz in the 1429-1435 MHz band is essential, if this $70 million Federal investment is to be preserved. Major redesign of this system to operate with the required reliability in alternative bands would cost an estimated $23 million,[18] but alternative bands allocated for Federal use at an acceptably low frequency may not be available. In balancing the public benefits and Federal impact, a feasible option was proposed in the Preliminary Report to reallocate the 1427-1432 MHz portion of this band for exclusive non-Federal use and retain the 1432-1435 MHz portion for continued primary Federal use.

As discussed in Section 2, Pacific Bell and Nevada Bell believe that most mobile wireless services will require FDD technology based on the ability to balance the frequencies used for both directions of service. Without sufficient balance and separation, the 1390-1400 and 1427-1432 MHz band segments would only be viable for other technologies such as TDD. They also point out that some stationary outdoor or in-building services may be conducive to a TDD service in this band. TDD technology currently presents a number of disadvantages in outdoor environments, including greater sensitivity to delay-spread and wide-area synchronization requirements. However pairing this band segment with 5 MHz in the 1390-1400 MHz band segment for FDD applications could still be a viable option.

For the reasons discussed above, NTIA reaffirms the choice made in the Preliminary Reallocation Plan to reallocate this band for exclusive non-Federal use on January 1999. In order to protect essential Federal operations, the final reallocation plan will retain the 14 sites listed in TABLE 4-2 for extended use until January 2004. Reallocation of the band for airborne and space-to-Earth links must still be avoided as stated in the Preliminary Report.

**1670-1675 MHz.** TIA and AMSC in their comments on the Preliminary Report, and NABER in its comments on the FCC NOI state that satisfying the conditions proposed for the protection of adjacent-band radio astronomy operations could make commercial use of this band difficult. The FCC stated "...we believe that 5 megahertz may be too small an allocation to support development of new broadband technologies or wide-area operations and that this band is not located near enough to

current non-government operations for it to serve as an adjunct to them."[19] The FCC also suggests changing the reallocation schedule for this band from delayed (January 1999) to immediate.[20]

**TABLE 4-2**

Sites at Which Federal Systems in the 1427-1432 MHz Band will be Continued for nine Years

| Location | Coordinates | Radius of Operation (km) |
|---|---|---|
| Patuxent River, MD | 38°17'N 76°24'W | 70 |
| NAS Oceana, VA | 36°49'N 76°02'W | 100 |
| MCAS Cherry Point, NC | 34°54'N 76°52'W | 100 |
| Beaufort MCAS, SC | 32°26'N 80°40'W | 160 |
| NAS Cecil Field, FL | 30°13'N 81°52'W | 160 |
| NAS Whidbey Is., WA | 48°19'N 122°24'W | 70 |
| Yakima Firing Ctr AAF, WA | 46°40'N 120°15'W | 70 |
| Mountain Home AFB, ID | 43°01'N 115°50'W | 160 |
| NAS Fallon, NV | 39°24'N 118°43'W | 100 |
| Nellis AFB, NV | 36°14'N 115°02'W | 100 |
| NAS Lemore, CA | 36°18'N 119°47'W | 120 |
| Twenty Nine Palms, CA | 34°15'N 116°03'W | 80 |
| China Lake, CA | 35°29'N 117°16'W | 80 |
| Yuma MCAS, AZ | 32°39'N 114°35'W | 160 |

NTIA believes that the concerns expressed above and described fully in Section 2 have merit but fail to address the consequences in terms of how a new commercial service will impact incumbent Federal systems. NTIA selected the 1670-1675 MHz band segment for reallocation for non-Federal use only after considerable analysis of existing Federal use of the entire 1660-1710 MHz band. Arguments from the Preliminary Report that discourage expansion of the 1670-1675 MHz band include the need to protect the adjacent-band radio astronomy service, the inability to relocate the radiosondes to another band, and the resulting need for the radiosondes to share the 1670-1690 MHz band with the meteorological satellite service.

Because of the importance of the frequencies allocated on a primary basis in the lower adjacent-band for radio astronomy observations and the extreme sensitivity of the receivers, reallocation of this band for non-Federal use was predicted in the Preliminary Report to have a significant detrimental effect on national radio astronomy operations. For this reason, the bands allocated for exclusive radio astronomy use were not considered for reallocation.

Since there exists no alternative method to obtain the data provided by radiosondes, and the other band allocated for radiosondes is plagued with interference from weather radars, the radiosondes in the 1670-1690 MHz band cannot be replaced or moved to another band.[21]

NOAA has stated that "Both radiosondes and metsats have allocations throughout the 1670-1700 MHz band, but a radiosonde flying through a ground station's antenna pattern would disrupt satellite reception. The result is a splitting of the bands with radiosondes largely limited to the lower 20 MHz."[22] In order to achieve the increased frequency stability necessary to permit radiosonde operation in the smaller reallocated band, NOAA would have to design new radiosondes using crystal-controlled transmitters and a new type of modulation.[23] The technology needed to make these changes is available, but the increased cost has historically made the new technology impractical (see Section 3 for associated reallocation costs and plans).

For the reasons discussed above, NTIA reaffirms the choice made in the Preliminary Report for this band which includes a reallocation availability date of January 1999 and protection of the GOES site at Wallops Island, Virginia. In addition, NOAA has recommended, and NTIA agrees, that a second GOES earth station at Fairbanks, Alaska be given similar protection.[24] Reallocation of the band for airborne and space-to-Earth links must still be avoided and sites engineered to be fully compatible with all Federal operations may still be given immediate consideration as stated in the Preliminary Report.[25] Non-Federal operations applying for immediate shared-use of this band must follow the criteria provided in Appendix C for sharing the band with Federal operations prior to January 1999.

**1710-1850 MHz Band.** The 1710-1850 MHz band is exclusively allocated for Federal fixed and mobile services on a primary basis, and in the 1761-1842 MHz band segment for space services and combat training systems. Because of the varying spectrum usage of the 1710-1850 MHz band, the band will be assessed in four segments: 1710-1755, 1755-1761, 1761-1842, and 1842-1850 MHz.

***1710-1755 MHz Segment.*** The Preliminary Report identified the 1710-1755 MHz band segment for reallocation for non-Federal use on a mixed use basis available in January 2004. This band is used, in varying degrees, by all major Federal agencies for medium-capacity (e.g., 24-300 voice channels) fixed microwave communications, as well as a variety of special fixed and mobile applications. Tactical radio relay systems are also used extensively in this band to support proficiency training and maintain combat readiness. The majority of the fixed microwave systems operated by the Federal agencies for voice, data, and/or video communications are located in remote areas where commercial service is either unavailable, excessively expensive, or cannot meet the specified reliability requirements. Functions supported by the fixed microwave systems in the 1710-1755 MHz band segment include: national defense, law enforcement, provision of navigation services to ships and planes, management of public forests and parks, military command and control communications, tactical and air combat training, natural disaster response and recovery operations, and the control links for wide-area networks for various power, land and water management systems.

For currently available technologies many of the areas where Federal agencies require communication services to support Congressionally mandated missions are remote and logistically difficult to access with commercial communications services. Commercial service carriers generally require expansive, ubiquitous coverage in order to market their telecommunication services, and are unable to cost effectively provide communications services in these remote areas. OMB Circular No. A-76 establishes a Federal policy to assess if there are reasonable commercial services available in place of Federally

owned and operated facilities. For example, USDA states that all of its fixed microwave systems meet the criteria for Federal owned procurement. According to USDA, the primary criteria used to determine whether or not it was eligible to operate its own communications system was that its systems operated in remote areas with single user control. Based on the comments submitted by USDA and other Federal agencies, many of the fixed microwave systems in this band are operated to support missions that must operate in remote, less populated areas where a leased commercial service would not be cost effective. The introduction of new technologies, such as satellite based communication services, will allow fixed microwave communications links to be reexamined in the future.

Twelve Federal agencies and seven non-Federal commenters submitted responses regarding the 1710-1755 MHz band segment in response to the Preliminary Report. In addition, five responses were received by the FCC in response to their NOI. The Federal agencies, while not specifically opposing the reallocation of the 1710-1755 MHz band segment, expressed a broad range of concerns about costs, reallocation time frame and operational impact to their Congressionally-mandated missions. Total estimated costs to the Federal agencies to effect the reallocation of the 1710-1755 MHz band segment were discussed in Section 3 and are reported to be in excess of $300 million.

Several of the public commenters expressed concern about the amount of continued operations of certain Federal systems and the protection to be afforded to these systems. They also emphasized that some of the 17 sites where Federal operations will continue are in or near metropolitan areas. Several commenters expressed concern that "grandfathering" these systems and the operations at the 17 sites will compromise and restrict the utility of this band for non-Federal use. Other commenters argued that by not knowing the amount and exact locations of the protected systems, they are unable to fully identify the scope of effort involved in sharing this spectrum with the incumbent Federal fixed and mobile services.[26]

Another concern expressed by the public commenters is the 10-year availability date proposed in the Preliminary Report for the 1710-1755 MHz band segment. APCO with the support of Motorola and TIA contend that since this band segment is the largest spectrum block below 3 GHz, and the only reallocated spectrum that can potentially meet the partial requirements of wide-area mobile applications, it should be available sooner than the 10-year reallocation plan.[27]

The FCC in its report reiterated many of the issues raised by the public commenters. The FCC stated, "NTIA has not indicated the locations and number of Federal power and safety-of-life microwave systems that must be protected. The lack of specific information on continued Federal use of this band makes it difficult for the FCC to determine whether this band should be counted toward the minimum spectrum requirements under the terms of Title VI."[28]

In the Preliminary Report, NTIA recognized the potential value of this band to the public, noting, "This band would have a very high public benefit if reallocated to the private sector for non-Federal use... Rapid adoption of existing technology for use in this band would be likely, leading to early marketing of equipment for any new technology."[29]

In addressing the reallocation of spectrum in the 1710-1850 MHz band for non-Federal use, we recognize the opposing factors of the need for more rapid non-Federal access to the band while at the same time the very high cost of rapid removal of Federal systems and the potential disruption of the operations these systems support. As discussed in Section 2, several commercial and public-safety commenters suggested making the 1710-1755 MHz band segment available earlier than the proposed reallocation date of January 2004 (10 years from the release of the Preliminary Report). The FCC Report supports the views of the commenters and recommends that the 1710-1755 MHz band segment be made available for non-Federal use in January 1999 (5 years from the release of the Preliminary Report). The Federal agencies as a whole are opposed to accelerating the scheduled availability citing budget and personnel constraints as well as potential impact to their Congressionally-mandated missions. Moreover, the Federal agencies state that since the 1995 budget has already been submitted, they cannot request additional funding until the 1996 budget is submitted. This would reduce the time from 5 to 4 years to appropriate the necessary funding through the normal budget process to relocate their operations. In metropolitan areas it is possible that existing or emerging commercial technology and services may meet some Federal Government communication requirements. This may not be true in less populated areas where commercial service is generally not available and often unreliable. New and emerging commercial applications are on the horizon that could be used to facilitate the relocation of Federal users. However, these commercial services are generally not available and are not expected to be available within the accelerated time frame. Until these emerging services are available in remote areas, the Federal use of fixed microwave systems is expected to continue.

Several Federal agencies indicate that they may be able to vacate the 1710-1755 MHz band segment at specific locations sooner with some type of reimbursement. Early reallocation of this band may be a practical option if reimbursement of reallocation costs to Federal agencies is provided. New legislation would be necessary because the current law requires Federal agencies receiving non-appropriated funds to deposit the money in the U.S. Treasury rather than into agency accounts. The spectrum reimbursement proposal may make Federal spectrum available to non-Federal users more quickly than currently proposed in the Preliminary Report.

In addition to legislative initiatives that will permit non-Federal sources to reimburse Federal agencies for systems displaced by the accelerated availability dates, the agencies indicate that changes in the appropriation and acquisition procedures used by each agency must occur to make reallocation prior to the proposed date of 2004 possible. For example, USCG states that their appropriations process normally take three years, specification development one year, acquisition two years, and contract completion two years.[30] USCG further states that these tasks must be accomplished serially. USCG, with the support of several other Federal agencies, stated that if it is determined to be in the national interest to reallocate spectrum proposed for delayed reallocation prior to the date proposed in the Preliminary Report, modifications will have to be made to each agency's appropriation and acquistion procedures, including possible relaxation of certain elements of Federal Information Resource Management Regulations (FIRMR) and Federal Acquisition Regulations (FAR).

FAA agrees with the concern expressed by USCG and other Federal agencies, that the current acquistion process will not permit them to meet the requirements of the accelerated schedule for transfer of Federal radio spectrum.[31]

Based on the comments submitted in response on the Preliminary Report and the FCC NOI, we recognize that the non-Federal need for spectrum is, and will continue to be, most acute in major urban areas. As a result, we are proposing a two-phase reallocation process wherein the 1710-1755 MHz band segment will be available for reallocation in the 25 largest cities in 1999, contingent on timely reimbursement of Federal costs directly from non-Federal sources. The 1710-1755 MHz band segment will then be available outside of the 25 largest cities in 2004 as proposed in the Preliminary Report. We believe this approach provides the best compromise of providing spectrum when and where it is needed, yet minimizing additional Federal cost. TABLE 4-3 lists the number of Federal frequency assignments on a per agency basis that will be impacted by the reallocation of the 1710-1755 MHz band segment. In cases where cities are within close proximity to each other, the frequency assignments listed in TABLE 4-3 for a city could be the same frequency assignments as listed for the other city (i.e., San Francisco and San Jose, Baltimore and Washington, DC). The only Federal systems that will continue operation within 150 km of the 25 largest cities will be stations operated by Federal power agencies as mandated by Title VI and Federal stations used for limited times during emergency and disaster response. In order to protect certain essential Federal operations outside these areas, including certain safety-of-life communications, Federal stations identified in Appendix E will continue operations and be protected from interference in the band.

***1761-1842 MHz Segment.*** While this portion of the band is allocated and extensively used for fixed microwave systems, the dominant reallocation issues involve the mobile and space applications that currently operate throughout this band segment.

Air Combat Training (ACT) systems are used extensively in this band segment. ACT systems are more complex by the nature of their operations, as both fixed and aeronautical mobile equipment are used.[32] ACT systems that operate in this band segment include: Air Force's ACMI and Navy's ACMR and TACTS. "These systems are in operation at all test and training ranges as well as other bases including Reserve and Air National Guard locations (i.e., civilian airports)."[33] Air Force and Navy ACT systems employ factory preset frequencies throughout the 1761-1842 MHz band segment that are used to transmit information to and from training aircraft. DOD has stressed that training support systems such as these are key elements in the military's effort to provide realistic simulation and combat preparedness for pilot training in a peacetime environment.

The 1761-1842 MHz band segment also supports the tracking, telemetry and command (TT&C) for all DOD satellites, in addition to NATO and British military satellites, space and ballistic missile test programs, and telemetering reception for launches. The major system operating in this band segment that provides the TT&C functions is the Space Ground Link Subsystem (SGLS). SGLS is currently used

## TABLE 4-3

Total Number of Affected Federal Frequency Assignments in the 1710-1755 MHz Band Segment within a 150 km Radius of the 25 Largest United States Cities[a]

| Rank | City/State | Frequency Assignments By Federal Agency | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | AF | Ar | CG | DOE | FAA | FPA | I | J | N | T | Total |
| 1 | New York, NY | | | 15 | 4 | | 11 | | | 10 | 1 | | 41 |
| 2 | Los Angeles, CA | 31 | 5 | 7 | | | 11 | | 3 | 6 | 14 | 2 | 79 |
| 3 | Chicago, IL | | | 1 | | | 1 | | | 9 | 3 | | 14 |
| 4 | Houston, TX | | | 1 | 1 | 1 | 9 | | | 9 | | | 21 |
| 5 | Philadelphia, PA | | | 28 | 4 | | 12 | | | 8 | 1 | | 53 |
| 6 | San Diego, CA | 3 | 1 | 1 | | | 7 | | 2 | 19 | 9 | | 42 |
| 7 | Detroit, MI | | | | | | 1 | | | 8 | | | 9 |
| 8 | Dallas, TX | | 2 | 4 | | | 15 | | | 10 | | 1 | 32 |
| 9 | Phoenix, AZ | 30 | 6 | 5 | | 11 | 1 | | 2 | 2 | | | 57 |
| 10 | San Antonio, TX | | 1 | 22 | | 1 | 1 | | | 4 | | | 29 |
| 11 | San Jose, CA | 3 | 1 | 3 | 15 | 2 | 10 | | 2 | 12 | 2 | | 50 |
| 12 | Indianapolis, IN | 1 | | | | | | | | 2 | | | 3 |
| 13 | Baltimore, MD | | | 19 | | | 8 | | | 10 | 9 | | 46 |
| 14 | San Francisco,CA | | 1 | 3 | 15 | 3 | 11 | | 2 | 13 | 2 | | 50 |
| 15 | Jacksonville, FL | | | 2 | | | 1 | | | 6 | 1 | | 10 |
| 16 | Columbus, OH | | 1 | | | | | | | 2 | | | 3 |
| 17 | Milwaukee, WI | | | | | | | | | 9 | 3 | | 12 |
| 18 | Memphis, TN | | | 16 | | 6 | 1 | 6 | | | | | 29 |
| 19 | Washington DC | | | 13 | | | 8 | | | 6 | 9 | | 36 |
| 20 | Boston, MA | | | 2 | 2 | | | | | 9 | 2 | | 15 |
| 21 | Seattle, WA | | | 18 | 14 | 5 | 4 | | | | 3 | | 44 |
| 22 | El Paso, TX | 6 | 1 | 13 | | | 3 | | | 14 | | | 37 |
| 23 | Nashville, TN | | | 7 | | | | 5 | 1 | | | | 13 |
| 24 | Cleveland, OH | | | | | | 1 | | | 12 | | | 13 |
| 25 | New Orleans, LA | | 5 | 18 | 5 | | | | | 4 | 2 | | 34 |
| **Total:** | | 74 | 24 | 198 | 60 | 29 | 116 | 11 | 12 | 184 | 61 | 3 | 772 |

**Key:** **A** - Agriculture; **AF** - Air Force; **Ar** -Army; **CG** - Coast Guard; **DOE** - Energy; **FAA** - Federal Aviation Administration; **FPA** - Federal Power Agency; **I** - Interior; **J** - Justice; **N** - Navy; **T** - Treasury

[a] The largest 25 cities ranked by population as reported in the 1990 census by the Department of Commerce Census Bureau.

to support 96 DOD satellites valued at $115 billion that are critical to national security. To perform their mission SGLS uses 20 discrete, preset frequencies which are distributed within the 1761-1842 MHz band segment beginning at 1763.721 MHz and ending with 1839.795 MHz. Although the TT&C operations are provided at five fixed sites (i.e., Hawaii, New Hampshire, Colorado and two in California) within the United States, DOD also uses transportable SGLS-compatible earth stations to provide additional visibilities during launches, early orbit operations, and critical orbit insertion maneuvers.[34] Air Force maintains it is not possible to change the frequencies for satellites which have already been launched, and while it may be possible to change the frequency of satellites which have yet to be launched, in the near term this would be prohibitively expensive.[35] Air Force adds that SGLS is the planned TT&C system for the next several generations of DOD satellites.

In addition to performing TT&C for military satellites, the 1761-1842 MHz band segment supports TT&C for the cooperative DOE/DOD Proliferation Detection Technology (PDT) Program. The PDT Program will demonstrate advanced system technologies for remotely monitoring declared nuclear facilities and for identifying and characterizing undeclared and clandestine nuclear facilities. Although this program is directed at nuclear proliferation monitoring, the technology could potentially serve a variety of other national security and civilian needs.[36]

The Preliminary Report noted the extensive studies conducted on the possible interference to space research and space operations from terrestrial systems. These studies, which specifically included studies of interference to satellite uplinks, concluded, "that the introduction of ...land mobile systems in the frequency bands used by the space service would cause unacceptable interference to the space services."[37] Although those studies were focused on the 2025-2110 MHz (uplink) and 2200-2300 MHz (downlink) bands, the results apply equally for the 1761-1842 MHz band segment.

We continue to believe that reallocation of this band segment, even on a mixed use basis, may jeopardize these important satellite and combat readiness functions and reaffirm the view expressed in the Preliminary Report that reallocation of the 1761-1842 MHz band segment is not a viable option.

***1755-1761 & 1842-1850 MHz Segments.*** As stated in the Preliminary Report, NTIA did not propose reallocation of the 1755-1761 and 1842-1850 MHz band segments in order to provide "...a guard band around the 1761-1842 MHz band to provide adequate interference protection for Federal satellite and certain wideband mobile systems."[38] While these two band segments are used extensively by the Federal agencies for various fixed and mobile applications, an adequate guard band from ubiquitous use typical of commercial land mobile systems was deemed necessary. The FCC Report notes the potential benefit to the public of access to the entire, or at least a larger portion, of the 1710-1850 MHz band and questions why such large guard bands are needed. The FCC includes the 1755-1760 and 1845-1850 MHz bands in its alternative spectrum reallocation plan.

In their comments to the Preliminary Report, Air Force reaffirmed its requirement for adequate guard band protection surrounding the 1761-1842 MHz band segment to provide adequate interference protection to the SGLS. The Air Force Satellite Control Network (AFSCN) frequently operates at low elevations in a high-power mode and often with mobile stations (over 30 systems in use). Air Force

stresses that frequency separation is the primary method that can be used to ensure that relatively high-power transmissions do not interfere with each other. If adjacent-band non-Federal use results in either unacceptable interference to or from the space command links, Air Force estimates that necessary equipment modification costs could exceed $430 million. Air Force adds, "Of equal or greater concern is the possibility that reports of EMI to non-Federal receivers could lead to requests for reallocation of spectrum below 1842 MHz."[39]

The Preliminary Report proposed guard bands of 6 and 8 MHz around the lower and upper frequency limits of the 1761-1842 MHz band segment. In Appendix D, NTIA further examines the issues surrounding the proposed guard bands. The study in Appendix D confirms the need for adequate guard bands to preclude interference to critical Federal space and mobile operations. Based on these results, we conclude that reallocating the 1755-1760 and 1845-1850 MHz band segments for non-Federal mobile applications could result in degradation to the uplink transmissions of transportable SGLS earth stations jeapordizing important satellite control functions.

Moreover, Air Force maintains that the loss of both the 1710-1755 and 1845-1850 MHz band segments will limit the effectiveness of ACT systems and could lead to a lack of proper training and a decreased level of preparedness for DOD combat pilots as well as reduced combat capabilities of operational units. Air Force further states, "Inadequate combat experience in air-to-air and air-to-ground tactics would severely endanger personnel. Continued access to this spectrum for use by ACT systems must be available."[40] Air Force adds that a redesign of their ACMI system would take 10 years and cost an estimated $1.5 billion.

DOI strongly objects to the reallocation of the 1845-1850 MHz band segment, stating that if additional spectrum were taken from the 1755-1850 MHz band segment, it would render the remainder of the band virtually unusable for fixed microwave operations.

USDA also objects to reallocation of the 1845-1850 MHz band segment. "As one of the larger users of this band, USDA is acutely aware of the existing saturated assignment situation. We find it unrealistic to consider that there would be replacement spectrum available for all the Federal departments being displaced."[41] Many of the Federal agencies agree with these comments and question whether suitable alternative radio spectrum exists to support Federal fixed microwave operations.

FAA does not support the addition of the 1845-1850 MHz band segment in the final reallocation plan. Furthermore, FAA questions the availability of alternate spectrum for displaced systems. "Based on FAA's preliminary assessment of point-to-point safety-of-life communications requirements, current FAA needs cannot be satisfied in the remaining segment of the 1755-1845 MHz band or the expansion band for point-to-point services, 7125-8500 MHz."[42]

Based on the preceding discussion, the potential disruption to fixed microwave operations affecting most of the Federal agencies and the increased risk of interference to the SGLS uplink transmissions and ACT systems, we continue to believe that reallocation of the 1755-1760 and 1845-1850 MHz band

segments is not a viable option. Therefore, NTIA reaffirms the choice made in the Preliminary Report for these band segments.

**2300-2310 MHz.** Several responses on both the Preliminary Report and the FCC NOI indicate that greater commercial use could be made of the 2390-2400 MHz band (scheduled for immediate reallocation) if it were paired with the 2300-2310 MHz band (scheduled for reallocation in 1996).[43] The FCC also recommends that the reallocation availability date for the 2300-2310 MHz band should be the same as the 2390-2400 MHz band. The FCC states that "These bands are two of the few bands identified in the Preliminary Report that readily lend themselves to paired operations, and simultaneous reallocation of the bands would greatly facilitate paired use of these bands."[44]

The main concern expressed by NASA regarding the reallocation of the 2300-2310 MHz band is the risk of interference caused by operation of non-Federal systems in the adjacent-band. This risk cannot be evaluated at this time, since the type of non-Federal system has not been identified. NASA operates a Planetary Radar at 2320 MHz and the Deep Space Network receiver at 2290-2300 MHz, both located in Goldstone, California.[45] The very-low received signal levels and the state-of-the-art sensitivity limits of these receivers make them extremely susceptible to interference from even low-level radio frequency signals. The high susceptibility to even distant interference must be taken into consideration when selecting the commercial applications that are to operate in the reallocated 2300-2310 MHz band.[46] Currently, harmful interference is minimized during routine deep space communications at NASA's Goldstone Tracking Site, while none is permitted during critical activities. This is a direct result of extensive and effective coordination of activities by Jet Propulsion Laboratory (JPL) staff and the Mojave Coordinating Group established by DOD and NASA.[47]

NASA's position on this band continues to be that sharing with certain types of commercial applications is feasible. Representatives from NASA and JPL believe that there are four radio frequency interference (RFI) paths to the Goldstone receivers from an adjacent band source as shown in Figure 4-1.[48]

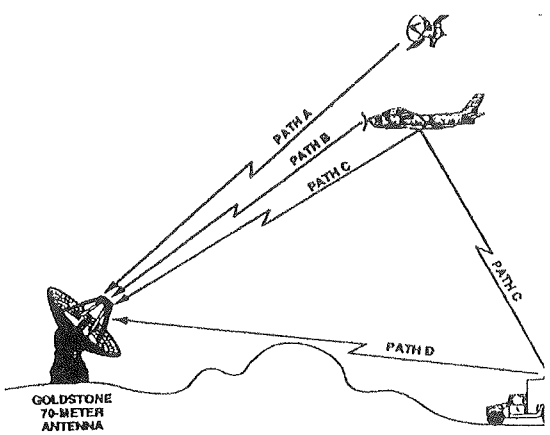



**Figure 4-1.** Goldstone RFI paths.

Transmissions from satellites and aircraft are considered the primary concern (Path A and B). A terrestrial signal that is reflected off an aircraft can also impact Deep Space Network antennas (Path C). Transmissions from a terrestrial source (e.g., mobile vehicle, hand-held portable, or a point-to-point fixed link) in general have less potential for causing unwanted interference since the RFI path is often blocked by terrain (Path D). In any event, limited coordination would still be required between these terrestrial non-Federal applications in the vicinity of Goldstone.[49]

The Preliminary Report proposed a delayed reallocation date of two years for the 2300-2310 MHz band "to provide sufficient time to study and implement necessary upgrades to preclude adjacent-band interference to NASA deep space network and planetary research radar receivers."[50] Since the release of the Preliminary Report, JPL has investigated the use of filters to decrease adjacent-band interference. JPL has determined that the use of such filters for deep space application is not practical without degrading the desired signal and significantly reducing the band available for deep space probe assignments.[51] Since filters will not solve the adjacent-band interference problem, NASA and JPL believe that if the type of commercial application is compatible, accelerating the scheduled availability date of the 2300-2310 MHz band should not be a problem. JPL also stated that restrictions would have to be placed on any commercial device operating in the 2300-2310 MHz band in the vicinity of Ft. Irwin itself.[52]

The largest group of comments on the Preliminary Report for the 2300-2310 MHz band were received from the amateur radio community. Many of the commenters were concerned about the reallocation of the 2300-2310 MHz band, claiming that it would disrupt current and future amateur point-to-point linking and weak-signal operations unless care is taken in the selection of the new commercial application.[53] The sharing options for the amateur radio community are discussed in more detail in Appendix B.

Taking the above factors into consideration, we are proposing to advance the reallocation schedule for the 2300-2310 MHz band from January 1996 to August 1995. Reallocation of the 2300-2310 MHz band for exclusive non-Federal use must include the following constraints:

- Protection of critical, highly-sensitive deep space communications and interplanetary research radar operations in adjacent bands(thus, reallocation of this band for airborne or space-to-Earth links must be avoided);
- Commercial applications will be limited to less than 1 watt of power in this band;
- Unwanted emission levels of commercial applications on any freqency below 2300 MHz must be attenuated below the mean power of the unmodulated carrier output by -70 dB;
- Operation of commercial devices in the 2300-2310 MHz band will not be permitted on Ft. Irwin, CA.

**3650-3700 MHz.** The Preliminary Report proposed reallocating the 3650-3700 MHz band segment for non-Federal use. "Reallocation of 50 MHz on a mixed use basis would be a reasonable compromise between providing the non-Federal users with additional spectrum resources while permitting continued Federal use of radars in this band."[54] Expanding the reallocation of the 3650-3700 MHz band segment to include an additional 25 MHz (3625-3650 MHz) is under consideration because of the comments submitted in response to the Preliminary Report and the FCC NOI. These commenters emphasized that there is a demand for fixed-satellite spectrum, and their international experience using 3625-3700 MHz has proven it to be technically feasible and commercially viable.[55] Currently, 28 countries use frequencies

in the 3625-3700 MHz band for the International Telecommunications Satellite Organization (INTELSAT) system.[a] The FCC Report also recommends pairing the 3625-3700 MHz and 5850-5925 MHz bands for non-Federal fixed-satellite use.[56] In addition to extending the reallocation of 3650-3700 MHz to include 3625-3650 MHz, another reallocation proposal suggested extending the mixed use sharing arrangement between non-Federal and Federal users to include the 3500-3600 MHz band. As stated in CWS's comments, "These frequencies already are allocated internationally to fixed, fixed-satellite, and mobile (except for aeronautical mobile) services on a primary basis and to radiolocation service on a secondary basis."[57] The United States, however, limits non-Federal allocations in the 3500-3600 MHz band to the radiolocation service.

In the Fiscal Year 1992 Defense Appropriation Act, Congress directed DOD to study its long-term communications needs and to determine to what degree and how industry believes these needs could be met by projected commercial systems. In response, DOD carried out the Commercial Satellite Communications Initiative (CSCI) under the executive direction and management of the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence (ASD(C3I)) during the period November 1991 to December 1993.[58]

As a result of the CSCI, it was determined that industry's FSS and MSS network designs can be used to meet many of DOD's projected requirements. Furthermore, it was determined that significant opportunity exists to incorporate commercial satellite communications (SATCOM) as a major, cost effective component of its telecommunications investment strategy. Based on the recommendations of the CSCI, DOD, through ASD(C3I), established a policy on commercial SATCOM to integrate DOD's efforts in implementing commercial capabilities, guide its investment strategy, and ensure cost effective augmentation of military SATCOM capabilities.[59]

To accomplish the goals established by the CSCI, DOD will require both commercial fixed-satellite and mobile-satellite communications services. The CSCI policy specifically requires that, to the extent practical, all new military transportable and deployable earth stations shall have access to the 6/4 GHz commercial frequency bands. In compliance with the CSCI's policy, DOD is developing the Light-Weight Multi-Band Satellite Terminal (LMST) and the Transportable TROJAN SPIRIT II Satellite Communications Terminal. As required by the CSCI, both of these satellite terminals access the 6/4 GHz commercial bands and can be configured to operate over military and commercial satellites.[b]

Presently the fixed-satellite and mobile-satellite services in the bands 3600-4200 MHz are limited to non-Federal users. Therefore, Federal agencies that operate earth stations in this band are on an unprotected non-interference basis.[c] If there is interference to a non-Federal earth station from a Federal earth station, the Federal earth station is subject to immediate shut-down. Moreover, if a non-Federal

[a] INTELSAT currently has satellites at three orbital locations visible to the U.S. that use frequencies in the 3625-3700 MHz band.

[b] The proposed frequency bands for the LMST and TROJAN satellite terminals are: 3625-4200, 5850-6425, 7250-7750, 7900-8400, 10950-12750, and 14000-14500 MHz.

[c] Except for frequency assignments with special note S164.

program that Air Force states will be impacted by the reallocation of the 3625-3650 MHz band segment is the Hypersonic System Technology Program (HySTP). Air Force explains that this program is used to help understand the technologies associated with hypersonic propulsion and aircraft systems. Air Force believes that the additional reallocation of the 3625-3650 MHz band segment will "... reduce the HySTP's ability to acquire data."[72] Air Force also maintains that a 50 MHz guard band in additon to implementation of strict non-Federal receiver selectivity and transmitter emission standards are essential to minimize interference to and from the Federal radar systems in this band. Air Force adds that "the public and industry should be made very aware that the above measures will only reduce, not eliminate, all potential interference from high-powered DOD radars performing missions crucial to the national security and welfare of the Nation."[73]

The Preliminary Report recommends reallocating 50 MHz (3650-3700 MHz) on a mixed used basis as "...a reasonable compromise between providing the non-Federal users with additional spectrum resources while permitting continued Federal use of radars in this band."[74] Given the objectives of DOD's CSCI and the reallocation proposals of the private sector and the FCC, sharing the 3625-3650 MHz band segment for FSS operation would appear to be a reasonable arrangement should Federal earth stations be co-primary with non-Federal earth stations. This would allow DOD access to SATCOM services, a primary objective of the CSCI. The private sector will benefit since they will be the provider of these satellite services.

Taking the above factors into consideration, we are recommending that modifications to the proposed reallocation of 3650-3700 MHz be consistent with the outcome of the discussions between DOD, NTIA, and the FCC. The spectrum will be used for Federal/non-Federal FSS operations. Reallocation of the 3650-3700 MHz band segment as well as any modifications to the original reallocation proposal must include the following constraints:

- Modifications to the proposed reallocation of 3650-3700 MHz will be consistent with the outcome of the discussions between DOD, NTIA, and the FCC;
- To achieve a satisfactory commercial service which is immediately adjacent to a band used by multi-megawatt mobile radar systems, the adoption of effective transmitter emission and receiver selectivity standards are essential to minimize interference to and from the Federal systems operating in this band;
- In order to protect essential radar operation, the Federal operations listed in TABLE 4-4 will be continued indefinitely.

**TABLE 4-4**

Sites at Which Federal Systems in the 3650-3700 MHz Band will be Retained Indefintely

| Location | Coordinates | Radius of Operation (km) |
|---|---|---|
| St. Inigoes, MD | 38°10'N 76°23'W | 80 |
| Pascagoula, MS | 30°22'N 88°29'W | 80 |
| Memphis, TN | 35°03'N 89°59'W | 80 |

**4400-4990 MHz.** As discussed in Section 2, comments from LQP, ALCATEL, and the FCC state that while the 4635-4660 and 4660-4685 MHz bands would be useful in providing some non-Federal services, NTIA should consider reallocating up to 150 MHz of additional spectrum adjacent to these band segments for MSS links, fixed microwave links, and new technologies, respectively. The FCC recommends that this adjacent spectrum should be for exclusive non-Federal use, while LQP offered to work with NTIA and the users of these adjacent bands to determine the feasibility and mechanisms for sharing. The FCC also urged NTIA to consider the potential for sharing the entire 4400-4990 MHz band with non-Federal services.

NTIA believes that the concerns expressed above and described fully in Section 2 have merit but fail to address the consequences in terms of the impact on incumbent Federal systems. NTIA selected the 4635-4660 and 4660-4685 MHz bands for reallocation to the private sector only after considerable analysis of existing Federal use of the entire 4400-4990 MHz band. NTIA's arguments against expansion of the proposed reallocation are based on the Preliminary Report findings which initially led to the selection of these specific bands. These findings are summarized below:

The 4400-4990 MHz band, in general, is one of the few bands allocated to the fixed and mobile services that are available to the military for tactical operations, in particular high-power tropospheric scatter operations. As such, the major users in this frequency range are the military services. The other significant users of the 4400-4990 MHz frequency range are DOE and Treasury.

Typical fixed uses include conventional point-to-point microwave, tactical radio relay and high-power tropospheric scatter systems. The latter systems use a transmitter power of up to 10 kilowatts and dual frequency operation for transmission over distances of 80 to 500 km. While most equipment is tunable over the full band, reallocation of any portion of this band increases spectrum congestion in the remaining portions and reduces flexibility for tactical training operations.

Mobile applications include control of remotely piloted vehicles (RPV), video and data telemetry links, target drone control links, and fleet defense systems. The tethered aerostat systems, at an altitude of approximately 15,000 feet above mean sea level, are an important part of drug interdiction efforts along the southern U.S. border.

The most significant and costly mobile applications are Navy systems required to support fleet defense operations. The operational LAMPS MK III system provides a full duplex wide-band link between helicopters and ships but does not use the frequencies between the ship-transmit and the air-transmit links (4660-4860 MHz). The system supports overall fleet defense and extensive training is required along coastal areas and shore installations to maintain operator proficiency. Navy adds that this system is also used to support drug interdiction efforts during peacetime. The total estimated investment in this system is nearly $270 million.[75]

Navy also uses portions of the 4400-4800 MHz band for their Integrated Target Control System (ITCS). The ITCS is a radio drone control system which integrates the functions of command, control, tracking, and telemetry. In the upper 4800-4990 MHz portion, a similar system (PIONEER) was designed to provide commands to a RPV via relay pods carried aboard an aircraft. The areas of operation for both the ITCS and the PIONEER are on major Navy test range centers. New developmental aeronautical systems are being developed in this band that operate throughout the 4400-4990 MHz band for immunity from jamming and improved reliability. The center portion of the band near 4700 MHz, specifically the 4635-4685 MHz band, is not expected to be used by these new wide-band systems.

The next-generation anti-air warfare and ship defense systems are at the advanced development stage for operation in the 4400-4990 MHz band. These high-priority systems are intended to achieve multi-service coordinated response to a variety of threats to the fleet. Wide bandwidth is essential for high data transmission, rapid response and resistance to jamming. Navy considers these systems as essential for coordinating anti-air weaponry within the fleet in an era of Navy downsizing. System coordination is important because budget pressures are increasing the requirements for fleet exercises at near-in coastal areas. Navy's estimated investment in this system to-date exceeds $500 million.[76]

There are military systems authorized to operate in the 4400-4990 MHz frequency range that typically have a tuning capability over the entire frequency range. These systems, which are normally fixed or transportable-fixed, have dual capability of line-of-sight operation at lower power or operationally selected to transmit at powers up to 10 kilowatts for tropospheric scatter modes over long distances.[a] These systems are primarily used for joint and tactical training exercises. The central portion of the band near 4700 MHz is lightly used for these troposcatter operations in order to accommodate the required frequency separation between two-way communication links.

One of the reasons these band segments were proposed for reallocation was to take advantage of the light spectrum usage between the transmit and receive frequencies of the uplink and downlink channels of the existing and next-generation Federal systems in this band.[b] Non-Federal use of spectrum outside the two specific bands proposed in the Preliminary Report would increase the risk of interference to the new user from these existing high-power systems, as well as from an electromagnetic environment

[a] Tropospheric scatter as a communications medium is only viable over a certain frequency range and works best over an even smaller range. New bands often mentioned as replacements for lost spectrum are in many cases unsuitable for tropo systems.

[b] The middle of the band is more lightly used because of the required transmit/receive frequency separation required by the systems in this band.

increasingly congested with systems displaced from the reallocated portion of the band. Air Force states that loss of frequencies for its tropospheric systems will significantly increase congestion, reduce flexibility, make co-sited operations more difficult to support, and increase the potential for interference.[77]

The critical nature and high cost of the Federal systems in this band and the increased risk of interference to new users as described above renders further reallocation of this band impractical. Therefore, NTIA reaffirms its choice made in the Preliminary Report for this band. Essential Federal operations at the locations listed in TABLE 4-5 will be continued and must be protected from interference for 15 years.

**TABLE 4-5**

Sites at Which Federal Airborne Operations in the 4635-4660 MHz Band will be Continued for 15 Years

| Location | Coordinates | Radius of Operation (km) |
|---|---|---|
| Pico Del Este, PR | 18°16'N 65°46'W | 80 |
| Dam Neck, VA | 36°46'N 75°57'W | 80 |
| St. Thomas, VI | 18°21'N 64°55'W | 80 |

## Proposed Alternatives to the Bands Identified in the Preliminary Report

**Spectrum Below 1 GHz.** In responding to the Preliminary Report, two commenters, APCO and Motorola, Inc., specifically addressed spectrum requirements below 1 GHz. APCO noted that, "While spectrum above 1 GHz will provide frequencies for future public safety communications (especially new technologies), spectrum below 1 GHz is needed now to alleviate current spectrum shortages facing public safety communications."[78] APCO further recognized, "there are a large number of Federal users on frequencies below 1 GHz, making reallocation extremely difficult."[79]

In addressing spectrum below 1 GHz, Motorola specifically commented on reallocating portions of the 225-400 MHz band, which is used by DOD for military fixed and mobile communications and by FAA to provide air traffic control services to military aircraft, to satisfy spectrum needs for wide-area land mobile systems. Motorola reiterated the view expressed in the Preliminary Report that this band offers very desirable propagation characteristics for land mobile use and reallocating a portion could offer substantial benefits to the public. Motorola urged either consideration of this band in the final spectrum reallocation plan or to consider it in a new inquiry outside the scope of Title VI.

The FCC Report also discussed the desirability of the 225-400 MHz band for "creation of wide area networks in the land mobile service."[80] Noting its on-going efforts in improving spectrum efficiency in use of non-Federal land mobile bands between 72 and 512 MHz, the FCC states that "Spectrum reallocated in the 225-400 MHz band could greatly facilitate our efforts by providing 'green space' in which to begin implementing spectrum efficient systems."[81] The FCC Report also noted the actions in Europe to address limited civilian use of portions of the 225-400 MHz band are among the issues being addressed nationally in preparation for the 1995 World Radiocommunication Conference. The FCC

Report specifically recommends an alternative spectrum reallocation plan including the 225-230 and 380-400 MHz band segments, possibly in the form of a joint Federal, state, and local government public safety network.

The Preliminary Report included a detailed assessment of spectrum below 1 GHz. Four bands, 138-144, 162-174, 220-222, and 406.1-420 MHz are the principal bands for supporting Federal land mobile communications. The Federal agencies will require continued access to these bands in order to, among other things, ensure national security; ensure safe travel within the National Airspace System; protect the U.S. borders from illegal entry; reestablish connectivity between disaster areas; protect the national forests and public lands; enforce Federal laws; maintain a preeminent position in space exploration; and ensure security of energy distribution networks. Much of these communications requirements directly support public-safety, at the national level.

The Preliminary Report noted that these bands are among the most heavily used by the Federal agencies. Within the 34 MHz of spectrum, the Federal agencies have over 60,000 land mobile frequency assignments. Reallocating a portion of this spectrum for non-Federal use would result in the loss of a portion of the over $4 billion invested in these systems and result in increased spectrum congestion in the remaining band segments. We continue to believe that because of the extremely high Federal investment in land mobile systems in these bands, the absence of alternative Federal bands, and their critical use in supporting communications for nearly all Federal missions, reallocation for non-Federal use is not a viable option.

Currently the Federal Government through, the Federal Wireless Policy Committee (FWPC), the Federal Wireless Users Forum (FWUF), the Federal Law Enforcement Wireless Users Group (FLEWUG), and the Federal Wireless Review Office (FWRO), are examining the entire range of Federal use of wireless services, including the land mobile radio services. These groups are working to ensure that the emerging wireless services satisfy Government functional requirements. It is also the responsibility of these groups to ensure that Federal users of wireless services can smoothly transition to more spectrum efficient, interoperable, and cost-effective digital technologies.

The 225-400 MHz band is allocated and used for military fixed and mobile communications, military mobile-satellite communications, aeronautical radionavigation functions, and radio astronomy observations. The Preliminary Report provided an overview of the Federal use of the band for fixed, mobile and satellite applications. DOD stated that the 225-400 MHz band is the single most critical spectrum resource of the military tactical forces. There are estimated to be over 75,000 Federal air-to-ground and ground-to-air radio equipments alone operating in this band. This does not include mobile-satellite equipments and backbone point-to-point capabilities, such as the Army's Mobile Subscriber Equipment (MSE) system. DOD reports that extensive peacetime training and alert exercises using these equipments are conducted at military bases throughout the United States to maintain combat readiness. DOD asserts that the military use of this frequency spectrum is predicated on the same technical reasons as the non-Federal users: low atmospheric and foliage penetration losses, availability of inexpensive components, and the ability to use short whip antennas for omni coverage by hand-held units.[82]

Navy states that by their very nature ships and aircraft are very crowded which results in considerable cosite problems that require all the frequency flexibility available to accommodate their requirements in this band. "Aboard ship the intermodulation products inevitably caused by exposure of metallic joints to salt spray combined with the requirement for dozens of UHF communications nets presents a major problem which has been the focus of major efforts for the past 30 years."[83] Navy further states that the need to take these effects into account while various forces shift their tactical relationships and missions on a real-time basis has required a major effort to develop spectrum management programs for task force commanders. Navy contends that any reduction in the 225-400 MHz band available for this spectrum management will have serious consequences in training and operational capability, particularly in joint exercises and operations, such as Desert Shield and Desert Storm.

Subsequent to release of the Preliminary Report, DOD provided further amplification on use of this band.[84] Reports from numerous military commands throughout the country expressed concern that loss of access to portions of this band would cause severe spectrum crowding in the remaining portions, leading to significantly increased training costs, degradation of command and control, and possible safety concerns. However, DOD stressed that the most serious factors affecting reallocation are the extensive use of radios having the HAVEQUICK II frequency hopping architecture, mobile-satellite communications, and backbone point-to-point transportable capabilities. Air Force further states that other uses of this spectrum include support of critical missile and Expendable Launch Vehicle (ELV) launch operations, test range telemetry, remote control of targets, communications supporting Air Defense Sectors, reliable training communications, and support of the President of the United States.

Air Force states that the HAVEQUICK family of radios is extensively deployed by the military services in a wide variety of fighter, tanker, close air support, reconnaissance, and bomber aircraft. Typical functions include approach/departure control at military airfields, air-to-air re-fueling operations, vectoring of fighter aircraft to engage hostile threats, and coordination between strike aircraft. Air Force reports that over 15,000 units are in their current inventory.

The HAVEQUICK II radios have the capability of frequency hopping across many individual frequencies over the 225-400 MHz band. Air Force states that this basic architecture is necessary to provide two fundamental aspects that enhance the electronic countermeasures (ECM) resistance of frequency hopping radios: a large number of channels and a wide spread in the bandwidth covered by those channels.[85] Air Force adds, "Interoperability between equipments is mandatory and frequency hopping radios must have the capability to hop on the same frequencies and under the control of a master clock."[86] To maintain the necessary interoperability, Air Force asserts that all of the HAVEQUICK radios would have to be returned for reprogramming. Based on the conversion of HQI to HQII, Air Force maintains that such reprogramming is very costly and time consuming.[87] Air Force indicates that to allow communications to continue while the modification is in progress, the modified radios must retain both the old and new capability until a specified change-over date. Existing radios without space for two sets of control software must be discarded. DOD expressed further concern over the loss of the anti-jam capability inherent to the HAVEQUICK II radios that would result from any loss of access to the full band. Reported costs from the various military commands that would result from reallocating any portion of the 225-400 MHz band total well over $1 billion.

The Air Force Satellite Communications System (AFSATCOM) and Milstar Satellite Communications System use the 225-400 MHz band, including the 380-400 MHz band segment, to provide survivable, jam-resistant communications for strategic and tactical military over the horizon requirements. Examples include communications to base from aircraft flying close to the ground to avoid hostile radar, over the ocean connectivity with cargo aircraft, extraction of personnel from areas far from friendly forces, and quick communications establishment with National authorities at the start of and during humanitarian missions. DOD reports that if reallocation of any portion of the 225-400 MHz band occurred, AFSATCOM and Milstar systems users would be subjected to interference from non-Federal users, severely reducing the usefulness of critical communications during certain missions. Air Force adds that the on-orbit and in storage satellites cannot be retuned and military missions must still be performed. In addition to unavoidable interference to non-Federal users, DOD investment in equipment estimated at over $1 billion would be jeopardized.

Army states that they are the primary user of line-of-sight multichannel radios in the 225-400 MHz band that are integrated as part of a theater wide network. Army uses these radios for terrestrial communications linking the functional areas of communications, command and control, intelligence, air defense, artillery fire support, aviation support, and logistical support. Army further states that this portion of the spectrum is critical to land force dominance.

From the preceeding discussion it can be seen that the 225-400 MHz band is crowded with many disparate kinds of military telecommunications systems. These systems are able to work in the same environment at the same time due to disciplined users operating in a hierarchical command structure, an acknowledgment by users that interference will occur, and a highly structured military spectrum management system. DOD believes that none of these conditions necessarily exist for non-Federal users. At the very least, military use of this spectrum indicates that sharing by dissimilar services is a possibility worth considering.

As directed by Congress, NTIA has initiated a strategic planning program to develop long-term spectrum planning. The first effort of the strategic planning program will identify the long-term spectrum requirements of both the Federal agencies and the non-Federal users. The long-range spectrum requirements identified below 1 GHz will be considered together with various spectrum management options, and as necssary, reallocation decisions will be made.

Furthermore, the FCC has been directed by Congress to identify the spectrum needs of the public-safety agencies, and to report its findings to Congress. In response to this Congressional mandate, on February 9, 1995, the FCC released the "Spectrum Needs through the Year 2010" report. NTIA, as well as, the Federal wireless working groups (e.g., FLEWUG, FWPC, and FWRO) will consider these spectrum needs in their long-term spectrum planning programs.

While recognizing the pressing need for additional spectrum below 1 GHz, we continue to affirm, as stated in the Preliminary Report, that planning of the 225-400 MHz military communications band cannot be effectively accomplished within the rigid time and spectrum-sharing constraints imposed by Title VI. The conventional spectrum management process provides the additional time and essential

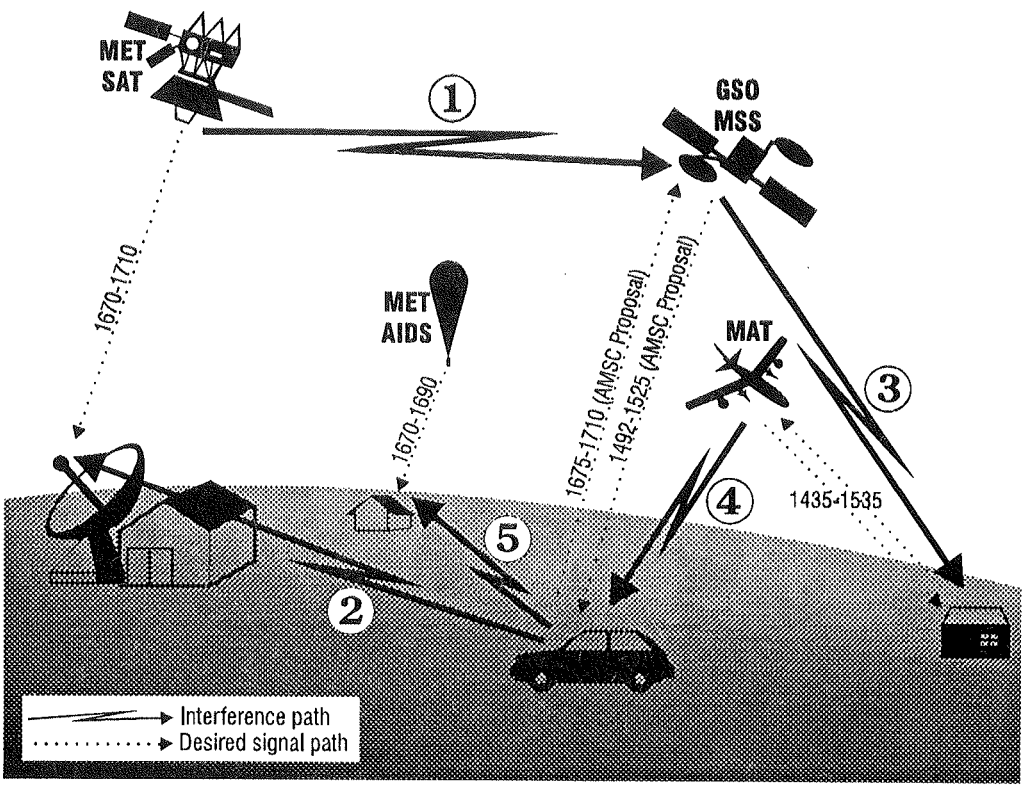
flexibility needed to explore the very complex issues involved, and to arrive at solutions that are mutually beneficial without adversely impacting Federal operations. As the first step in the process, NTIA is establishing a senior level forum to address the criticality of all or parts of the band for national defense, air traffic control of DOD aircraft, the non-Federal needs for spectrum below 1 GHz, and the NATO and European developments.[88]

**1492-1525 and 1675-1710 MHz.** In its comments on the Preliminary Report, AMSC proposed two alternative Federal bands (1492-1525 MHz for downlinks and 1675-1710 MHz for uplinks) that its analysis indicates can be shared immediately by domestic MSS systems and incumbent Federal users.[89] AMSC adds that these bands were allocated to MSS at the 1992 World Administrative Radio Conference (WARC-92) and, if allocated domestically, will help ensure the continued growth of this new service. In the FCC Report, the FCC agreed that potential MSS operations in these bands hold great promise to provide a wide variety of new communications services both domestically and internationally.[90] While the FCC recognizes the difficulties in reallocating these bands (as described in the Preliminary Report) they do not believe these problems fully preclude the possibility of shared Federal/non-Federal use.[91] The FCC points out, for example, that the 1492-1525 MHz band occupies less than 28% of the total spectrum currently allocated for the mobile aeronautical telemetry (MAT) service. The FCC recommends that NTIA more closely examine the possibility of reallocating these bands for non-Federal MSS use, at least on a mixed use basis. The FCC adds that discussions between NTIA and the FCC on MSS use of these bands are continuing.[92]

AMSC contends that a study included in its comments on the Preliminary Report shows how adjacent and co-channel sharing techniques could enable full protection of meteorological services from mobile earth station transmissions, and how power flux density limits and high satellite elevation angles could enable full protection of MAT services from MSS satellite transmissions.[93] The study likewise provides the means for full protection of the MSS links. Figure 4-2 gives an overview of the desired signal and potential interference paths between AMSC's proposed MSS links and systems in the meteorological satellite, meteorological aids (Radiosonde), and MAT services. Also included in Figure 4-2 is a summary of the interference mitigation techniques suggested in the AMSC study.

The AMSC study also shows that large separation distances are needed to protect mobile earth stations from co-channel MAT transmissions.[94] Consequently, off-tuning of MSS frequencies from MAT carrier freqencies is necessary.[95] AMSC stated that MSS downlinks can share the upper portion of the 1492-1525 MHz band interstitially if the incumbent MAT service applications are restricted to 1 MHz-channelized narrowband operation.[96] Specifically, AMSC states that this would require MAT system conformance with the standard and alternate channelizations specified for telemetry systems by the Range Commanders Council.[97]

A separate analysis of possible MSS interstitial sharing with Air Force radiosondes in the 1670-1690 MHz band suggested that this type of sharing would be very difficult to achieve.[98] For this reason AMSC considers MSS/meteorological sharing possible only in the 1690-1710 MHz segment of the proposed 1675-1710 MHz band.[99] Substantial distance separations are required for concurrent co-channel operation of mobile earth stations and meteorological receivers and AMSC claims that the




1. Interfering signal power levels in MSS channels because of METSAT transmissions are predicted to be 6 dB below the -169 dBw threshold and therefore can be readily accommodated in the MSS link power budget.

2. Improved efficiency and the planned reaccommodation of high data rate channels to other bands will open up 8.1 MHz and 15.55 MHz of the 1690-1710 band used by GOES and GOES-NEXT making adjacent channel sharing practical. Time sharing with METSAT fixed schedules and geographic sharing with known sites via GPS-equipped mobile unit reporting will also enhance compatibility.

3. Protection is achieved by limiting the number of MSS downlink channels and/or limiting their downlink Power Flux Density and/or clustering MSS channels at the boundaries of each standard 1MHz MAT channel. The high elevation angle of U.S. GSO MSS satellites also provides substantial antenna discrimination.

4. Clustering MSS channels at the boundaries of each standard 1MHz MAT channel protects mobile earth station receivers via increased frequency dependent rejection.

5. Time and geographic sharing techniques will help to avoid interference with radiosonde receivers.

**Figure 4-2.** Overview of desired signal and interference paths and interference mitigation techniques from AMSC's 1675-1710 and 1492-1525 MHz proposals.

locations of meteorological receivers are not known in most cases; thus, this sharing approach has very limited feasibility.[100] AMSC adds that implementation of an MSS allocation would be based on case-by-case coordination between the MSS operators and Federal incumbents.

The Federal agencies currently use the 1435-1525 MHz band to support aeronautical flight test telemetry at nine major military and NASA test ranges/centers and numerous smaller facilities. Aeronautical flight testing is expensive, technically sophisticated, and at times dangerous. A number of complex and organizationally independent functions must be successfully coordinated to complete a mission. Examples include: range safety, measurement support, and aeronautical telemetry. Because the successful scheduling of a mission relies on so many disparate factors, the availability of sufficient interference-free spectrum is essential. Loss of access to these bands to support flight test telemetering would have a significant operational impact and cost to the Federal Government.

The importance of these bands to DOD and to the aerospace industry was confirmed during the U.S. preparation for WARC-92. The U.S. position at that conference strongly supported the need for this spectrum for shared Federal and non-Federal aeronautical telemetry operations. At the recent 1993 World Radiocommunications Conference (WRC) in Geneva, the United States formally restated its intention to maintain the current allocations in the 1435-1525 MHz band.[101]

The current allocated uses for the 1435-1525 MHz band already provides considerable public benefit. The extensive airframe testing using telemetering equipment in this band has contributed to the U.S. leadership in the aerospace industry. Specific frequencies in this band are designated to support privately operated ELVs and are a key element in fostering the growth of this important new industry in the United States.

Outside of the United States, the 1435-1525 MHz band is used predominately for fixed microwave communications. However, recent international developments significantly affect these bands. At the WARC-92, the band 1452-1492 MHz was allocated worldwide, except in the United States, for the broadcasting-satellite (sound) service. At that conference, the United States chose to allocate the 2310-2360 MHz band for that purpose, thus giving up 50 MHz of spectrum that was previously available for flight test telemetry in the United States. Also at that conference, the band 1492-1525 MHz was allocated in Western Hemisphere nations, except for the United States, for the mobile-satellite service. Japan has also initiated a new land mobile development across the 1429-1525 MHz band for next-generation cellular and specialized mobile radio applications.[102]

The 1435-1525 MHz band is co-equally shared between Federal and non-Federal users and is designated for support of flight test telemetering for the military and aerospace industry. In recent years, the bands available to support these flight test telemetry operations have been reduced by over 30%. The cost and operational impact, to both Federal and non-Federal users, of any additional reallocation would appear to outweigh any positive public benefits. For this reason, the 1492-1525 MHz band is not considered for reallocation under Title VI.

Appropriate guidelines for protection of U.S. meteorological operations from foreign MSS systems are being developed in the ITU Radiocommunication Sector (ITU-R), and may ultimately produce workable approaches to sharing the 1670-1710 MHz band, but the work is not yet complete. This, in conjunction with the significant amount of coordination and conditions that AMSC studies have shown to be required for effective sharing of this band, indicates to NTIA that the meteorological and mobile satellite services are not yet ready to share the band. For these reasons the 1670-1710 MHz band is not included in the final plan.

**2400-2402 and 2417-2450 MHz.** The 2400-2402 and 2417-2450 MHz band segments are part of the larger 2390-2450 MHz band that is allocated for Federal radiolocation on a primary basis, and the amateur radio service on a secondary basis. In addition to these allocations, the 2400-2450 MHz portion is used by non-licensed devices and microwave ovens under the FCC Part 15 and 18 Rules, as well as Industrial, Scientific, and Medical (ISM) devices. In the Preliminary Report, NTIA identified 2390-2400 and 2402-2417 MHz for immediate reallocation. As stated earlier, the FCC has proposed that these bands be allocated to the fixed and mobile services. The FCC believes that this will permit flexible use of the bands, and enable licensees to offer a wide range of services.

The Preliminary Report excluded the 2400-2402 MHz band segment from reallocation, because these frequencies are of vital importance to spacecraft operations in the amateur-satellite service, for satellites in current use, as well as those under construction.[103] In general, the comments submitted by national and regional amateur organizations in response to the Preliminary Report supported NTIA's proposal. However, many commenters stated that the 2 MHz band segment may be too narrow to accommodate the anticipated increase in demand for amateur-satellite operations.[104]

As stated in the Preliminary Report, one of the most significant factors that had to be considered in the reallocation of spectrum in the 2400-2450 MHz band is the wide spread use of microwave ovens. Currently under the Part 18 Rules, microwave ovens can operate in the 2400-2500 MHz with no in-band emission constraints. Using extensive measurements of individual microwave ovens, in addition to open-air measurements in various urban/suburban locations, the Preliminary Report addressed the feasibility of spectrum sharing with microwave ovens. In general, these measurements indicated that the peak level of emissions at frequencies near 2400 MHz are much lower as compared to those at 2450 MHz.[105] Based in part on these measurements, the Preliminary Report concluded that effective spectrum sharing with microwave ovens is a function of the portion of the band being used, the type of service, and the type of modulation employed (i.e., spread spectrum).[106] Given the high level of ambient radio noise in the central part of the band, it was felt that the 2417-2450 MHz band segment could not be reallocated for a licensed service, hence it was not proposed for reallocation.

In 1985, the FCC authorized a new class of Part 15 devices using spread spectrum modulation for the 902-928, 2400-2483.5, and 5725-5875 MHz bands. As of June 1993, only four spread spectrum non-licensed devices were certified by the FCC in the 2400-2483.5 MHz band. This is in contrast to the over 120 non-licensed systems that were certified for use in the 902-928 MHz band. However, since the release of the Preliminary Report in February 1994, 13 companies have introduced wireless local area network (LAN) products that operate in the 2400 MHz band.[107] Fourteen non-licensed device

manufacturers also submitted comments in response to the Preliminary Report and the FCC NOI regarding the reallocation of the 2402-2417 MHz band segment (see TABLE 2-1 and TABLE 2-2). In general those commenters were opposed to the reallocation of this band segment to a licensed commercial application that is incompatible with the existing non-licensed devices. Non-licensed devices in this band use either frequency hopping or direct-sequence spread spectrum technology. Most of the non-licensed device manufacturers that submitted comments believe their ability to successfully share the 2400-2450 MHz band with microwave ovens can be directly attributed to the use of spread spectrum technology.[108] Several of the commenters stated that declining component cost and its world wide availability are two factors that make the 2400 MHz band attractive to non-licensed device manufacturers. Moreover, the IEEE has focused its initial standardization efforts on the 2400 MHz band, with the development of the IEEE 802.11 standard for wireless LANs. The European Telecommunication Standards Institute (ETSI) has already developed and approved a certification standard for wireless LANs operating in the 2400 MHz band. "As the IEEE 802.11 standardization work is compliant with the European regulations in the 2.4 GHz band, it is reasonable to assume that in the European market the IEEE standard will become the defacto functional standard — in addition to the ETSI type approval standard — because buyers want interoperable equipment."[109] The general consensus among the non-licensed device manufacturers is that the 2400-2450 MHz band should remain usable by spread spectrum Part 15 devices.

As discussed in Section 2, current amateur-satellite and amateur-television operations in the 2400-2450 MHz band are light compared to other bands, but usage is expected to increase in the next few years.[110] Appendix B examines the sharing options between the amateurs and possible commercial/public-safety applications. The amateurs currently share the 2400-2450 MHz band with Federal radiolocation operations and spread spectrum non-licensed devices. Based on the comments submitted by the amateur radio community and non-licensed device manufacturers this sharing arrangement has proven to be successful.

The general consensus among commercial commenters on the Preliminary Report and the FCC NOI is that microwave oven emissions and radio amateur operations will significantly limit the development of licensed commercial devices in any portion of the 2400-2450 MHz band.[111] As discussed in Section 2, several commenters indicate that with the exception of non-licensed devices, there is no previous experience of commercial sharing with the amateurs. Both Motorola and TIA stated in their comments that the manufacturers of non-licensed devices have made possible a host of useful products for consumers, business and public-safety agencies. Moreover, the commercial commenters question whether any additional benefits could be gained as a result of reallocating any portion of the 2400-2450 MHz band for a licensed service.[112]

As discussed in Section 2, the comments submitted by representatives of utilities expressed concern that the reallocation of any portion of the 2400-2450 MHz band segment for commercial use could be interpreted as a policy determination that this band should be allocated by the FCC for licensed radio services.[113] In their comments, UTC contends that many utilities currently employ spread spectrum equipment developed under the FCC's Part 15 rules for automatic meter reading, demand side management, and point-to-point communications to pipelines. UTC states that the 2400-2450 MHz

band is already used for important applications, and should not "... be dismissed as unnecessary or unimportant merely because they are non-licensed."[114] UTC also questions the commercial viability of any portion of the 2400-2450 MHz band for a new licensed service, given the significant projected use of this band for spread spectrum operations under the Part 15 rules. API's comments on the FCC NOI reiterated UTC's concern that non-licensed spread spectrum operation in the 2400-2450 MHz range should not be curtailed.

APCO is also concerned that the emissions generated by wide spread microwave oven use will prevent the commercial development of wide-area mobile systems in the 2400-2450 MHz band. However, APCO suggests that the FCC explore the possibility of allocating the 2400-2450 MHz band or portions of the band for private fixed service microwave operation in rural areas.[115] As discussed in Section 2, both APCO and COPE believe that this spectrum could be allocated for use by privately owned public-safety systems with technical parameters that are consistent with the existing Part 15 systems. COPE adds that many of the spread spectrum systems currently operating in the 2400 MHz band are primarily used by public-safety and industrial users.[116]

Another factor that had to be considered in identifying spectrum for reallocation is the impact to Federal agencies in terms of mission, cost, and potential reduction of services to the public. As stated in the Preliminary Report, the 2360-2450 MHz band has an estimated Federal investment cost of $33 million. The band is primarily used by the military for radar testing systems such as target scattering and enemy radar simulation, and telemetry systems. While it is recognized that spectrum used for military testing is vital for future research and development, the use of this spectrum is primarily limited to military test ranges. In their comments on the Preliminary Report, DOD emphasized that they need to have "...continued access to this spectrum at specific locations for limited periods of time."[117] The comments submitted by the amateur radio community, and the non-licensed device manufacturers indicate that they can effectively share the 2400-2450 MHz band with the current DOD research and development operations.

From the preceding discussion it can be seen that most of the parties submitting responses on the Preliminary Report and the FCC NOI agree that the 2400-2450 MHz band should not be used for a licensed commercial service. The majority of the commenters also believe that in order to use this band effectively, equipment manufacturers must use either frequency hopping or direct-sequence spread spectrum technology. Many non-licensed device manufacturers state that spread spectrum technology has been found useful particularly for error-free transmission in a noisy signal environment.[118] This resistance to unwanted signals makes spread spectrum technology the optimum choice for devices that are to operate in the same band as microwave ovens and ISM devices.

Many of the commenters also state that non-licensed spread spectrum devices have made possible a host of useful products for consumers, businesses and privately owned public-safety applications. Practical spread spectrum applications are becoming better understood and are destined to play a significant role in a world increasingly dependent on wireless technology. Non-licensed spread spectrum devices are also expected to be a key factor in the development of untethered operations as part of the National Information Infrastructure (NII) initiative.

Reallocating the 2400-2402 and 2417-2450 MHz band segments for non-Federal use would give the FCC the opportunity to develop a comprehensive plan for the 2400-2483.5 MHz band. The relatively small size of the 2400-2402 MHz band segment and its location between two exclusive non-Federal bands (2390-2400 and 2402-2417 MHz) will limit its usefulness for future military applications. However, the 2417-2450 MHz band segment is a contiguous block of spectrum that is large enough to accommodate both Federal and non-Federal users. These band segments when combined with the adjacent bands could be used to provide a permanent home for the next generation of non-licensed devices as well as provide some relief for the migration of 902-928 MHz systems. Reallocation of spectrum in the 2400 MHz frequency range provides a reasonable balance between the benefits to be gained by the public and the potential impact to the Federal agencies.

Taking the above factors into consideration, we are proposing that the the 2400-2402 MHz band segment be reallocated for exclusive non-Federal use begining in August 1995. This band segment can be combined with the two adjacent non-Federal bands to provide 27 MHz of contiguous spectrum for exclusive non-Federal use. We are also proposing that the 2417-2450 MHz band segment be reallocated for mixed Federal and non-Federal use beginning in August 1995. A mixed use reallocation will allow continued Federal use of the band on a secondary basis or Federal use of non-licensed devices, while providing the FCC greater flexibility in developing a comprehensive plan to address the needs of the amateur service and the non-licensed device industry.

**5000-5250 MHz.** In its comments on the Preliminary Report, LQP urged NTIA to evaluate the feasibility of making the 5000-5250 MHz band available for MSS feeder uplinks on a dedicated or shared basis with the current Federal users.[119] This band is currently allocated worldwide for aeronautical radionavigation, and footnote 796 of the ITU Radio Regulations states that " ... the Microwave Landing System (MLS) requirements take precedence over all other users in the band." In the United States MLS is a joint development of DOT, DOD, and NASA under the management of FAA. Its purpose is to provide a civil/military, Federal/non-Federal standardized approach and landing system with improved performance compared to existing landing systems. MLS operates in the 5000-5150 MHz band with an associated distance measuring equipment (DME) link in the 960-1215 MHz band.

In 1978, the International Civil Aviation Organization (ICAO) selected MLS as the international standard precision approach system, with implementation targeted at all international airports by early 1998. FAA originally planned to procure approximately 464 MLS systems through the year 2000, and an additional 786 after 1999. DOD also planned to procure up to 405 MLS systems through the FAA. However, in June 1994, FAA cancelled MLS research and development contracts supporting category II and III service because of severe budget constraints. The United States has continued to implement MLS for Category I service and has plans to install 26 such systems.[120] The Federal Radionavigation Plan (FRP) projects that MLS will be operational beyond the year 2025.[121] FAA has indicated that if MLS Category II and Category III service is required in the future in order to satisfy national and international requirements, then these systems will be procured on the open market.[122]

The FCC Report states that reallocation of the 5000-5250 MHz band, or a part of this band, could be useful for emerging non-Federal technologies.[123] The FCC cites LQP's MSS feeder uplink request and

recent European High Performance Local Area Network (HIPERLAN) proposals as evidence of the demand for non-Federal use of this spectrum. The FCC has also identified the 5000-5250 MHz band as a candidate band for Non-Geosynchronous-Orbit (NGSO) MSS feederlinks in its October 1994 Report and Order to amend its rules and policies pertaining to MSS.[124] The Report and Order cites Doc 4-5/TEMP/38(Rev 1)-E, which recognizes the critical safety aspects of MLS.[125] This study recommends that NGSO/MSS feederlink uplinks and MLS should use non-overlapping spectrum. The 5000-5250 MHz band is still being considered within various international fora.[126]

FAA believes that the implementation of MSS feederlinks in this band could very well result in severe constraints on the implementation of MLS and other future[a] aeronautical systems.[127] In an airspace system that requires internationally agreed-upon standards, operating practices, and protection, FAA insists it is crucial that the U.S. continues to support MLS into the future. In its comments to NTIA's Spectrum Requirements Study, FAA states that:

> "With the possibility that fewer MLS's will be installed, the FAA has begun investigating other applications for this spectrum to meet the needs of new aeronautical radionavigation systems and air traffic control concepts based on emerging technologies. Proposed uses of the band include weather radar, windshear radar, automatic dependent surveillance, GPS differential correction data link, and airport ground surveillance. The propagation characteristics of the 5000-5250 MHz band are ideally suited for these applications."[128]

In addition to the studies performed by LQP, and the ITU working group discussions, FAA has conducted a study of MSS and MLS sharing in this band. FAA's study found that the use of aeronautical radionavigation spectrum in the MLS band for MSS feederlink uplinks will result in an exclusion zone of approximately 320 kilometers around each MSS ground earth station (GES) within which MLS operations could be subject to harmful interference.[129] It is the position of FAA that the imposition of such large exclusion zones surrounding each MSS GES would cause an unacceptable restriction on the present and future expansion of MLS and other aeronautical systems in the United States.[130]

As discussed briefly above, there is currently a considerable amount of national and international debate over whether MSS feederlinks should be allowed to operate in the 5000-5250 MHz band on a shared basis. This debate is being conducted in ongoing FCC proceedings, ITU working group discussions, and WRC-95 planning sessions. In addition, extensive studies examining the issues surrounding this band are not yet complete. It is evident to NTIA from the previous discussion that there are sufficient fora, all involving public participation, for resolution of this debate outside of the Title VI spectrum reallocation process. NTIA therefore has not included the 5000-5250 MHz band in the final spectrum reallocation plan.

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[a] The FAA has submitted stage one spectrum support applications to the Spectrum Planning Subcommittee for the following additional aeronautical systems to operate in the 5000-5250 MHz band: Next Generation Weather Radar (NEXRAD), Airport Surface Detection Equipment (ASDE), Terminal Doppler Weather Radar (TDWR), Differential GPS (DGPS) Data Link, and an Automatic Dependent Surveillance (ADS) application. These applications are still under review by NTIA.

**5850-5925 MHz.** Several commenters with interest in satellite services noted that some of the proposed spectrum in the Preliminary Report, particularly the blocks above 3 GHz, would be useful for FSS operations. These entities urged, however, that additional spectrum for satellite service is required.[131] Furthermore, although Title VI requires that only spectrum below 5 GHz be considered toward fulfilling the 200 MHz minimum requirement, LQP recommends that NTIA consider spectrum above 5 GHz.[132]

The FCC Report also discusses reallocating spectrum above 5 GHz for non-Federal use, stating that "Options for spectrum reallocation need not be limited to bands below 5 GHz. Since the Reconciliation Act [Title VI] does not foreclose reallocation of spectrum in excess of 200 megahertz, NTIA and the FCC should also explore options available for sharing spectrum, thereby providing greater benefit to both Government and non-Government users and greatly expanding the efficient use of spectrum."[133] The FCC Report specifically recommends that the 5850-5925 MHz band be reallocated and paired with 3625-3700 MHz for non-Federal FSS, stating that "These bands are both currently allocated for use by the non-Government Fixed Satellite Service with one band allocated for use as an uplink and the other band allocated as a downlink. These bands might therefore be paired to provide usable spectrum for the Fixed Satellite Service."[134]

The 5850-5925 MHz band is currently allocated for primary use by the military for radiolocation operations. However, this band is also allocated for primary use for non-Federal FSS (Earth-to-space) as well as for secondary use by the amateur service. Footnote US245 limits the satellite activities in the United States to international inter-continental systems and such activities are subject to case-by-case EMC analysis.[135]

DOD indicates that they are performing advanced research in radiolocation in the 5255-5925 MHz band.[136] Air Force states that this band is used extensively, especially in Western and Southwestern test and training ranges. The primary system used is the Vega-Hurley Target Control System (HVTCS). Air Force further states that operations supported include operational training of a U.S. and NATO air defense system, research and development of this system for advanced compatibility development, missile and aircraft tracking radars performing skin tracking, tracking airborne transponders on missiles and aircraft, and full scale and subscale target drone control links. Air Force indicates that these systems cannot operate in other radiolocation bands since these bands are used by the very radars the HVTCS is supposed to test. Air Force stresses that "Positive continuous control of unmanned targets is mandatory to insure safety of test range personnel and the nearby public and this spectrum provides an excellent buffer between high-power radars and satellite uplink receivers."[137] Air Force maintains that this band is extremely important for test range instrumentation radars to track missiles and other targets, stating that "This band supports target control systems that are vital to maintain air defense and combat system readiness."[138] Moreover, Air Force opposes the reallocation of this band for non-Federal use in conjunction with the Title VI spectrum transfer, stating:

> "Title VI only covers reallocation of spectrum below 5 GHz. The Air Force feels that the inclusion of spectrum above 5 GHz in this reallocation would not be proper. In addition, any comments on the FCC's request for reallocation of the 5850-5925 MHz band should not be included in NTIA's final reallocation report. Any request to reallocate this band should be

initiated by the FCC through normal spectrum management channels where they may be considered outside of Title VI discussions."[139]

Navy also expressed concern that reallocation of this band may not be compatible with their shipboard radars when operating in coastal and inland waters. "The FCC proposal would increase instances of EMI to AN/SPS-10 and AN/SPS-67 radars, resulting in increased noise, decreased sensitivity, and reduced ability to detect surface craft and targets."[140] Navy adds that equipment re-tunability to adjacent Federal portions of the spectrum cannot be accomplished without magnetron modifications.

As discussed earlier, DOD, through ASD (C3I) and the efforts of the CSCI, have established a policy whereby DOD will implement to the extent possible commercial SATCOM capabilities. "To the extent operationally and fiscally practicable, DOD will augment its military SATCOM capability with both domestic and international commercial services."[141] In order to accomplish the goals established by the CSCI, DOD will require commercial fixed-satellite communications services. The policy established by the CSCI specifically requires that to the extent practical all new military transportable and deployable earth stations shall have access to the 6/4 GHz commercial frequency bands. In accordance with the CSCI policy, DOD is developing the LMST and the TROJAN SPIRIT II communications satellite terminals. As required by the CSCI, both of these satellite terminals access the 6/4 GHz commercial bands and can be configured to operate over military and commercial satellites.

Presently Federal agencies that operate earth stations in the 5850-7075 MHz band are on an unprotected, non-interference basis. With the background previously given on the CSCI and plans for a private satellite network, DOD is concerned over the secondary allocation status Federal earth stations would presently have as part of this network. To allow Federal FSS operations in the 5850-5925 MHz band, DOD has requested IRAC and NTIA support in pursuing with the FCC a means for Federal earth stations, as part of commercial satellite networks, to have a co-equal allocation status with respect to terrestrial non-Federal FSS stations. Federal earth station applicants would be required to comply with applicable parts (e.g., Parts 2 and 25) of the FCC rules and the operation of Federal satellites will not be permitted.

Although interested in developing FSS systems for operation in the 5850-5925 MHz band, DOD does not want to disrupt existing Federal operations. Air Force has stated that "Loss of this frequency band would be an impediment to range operations and would require an increase in time sharing."[142] Furthermore, Air Force strongly believes that any discussion concerning this band should be handled outside of the Title VI spectrum reallocation process.

Based on the preceding discussion, permitting Federal FSS operations in the 5850-5925 MHz band will give the private sector the opportunity to provide commercial services that are envisioned to meet the objectives established by the DOD's CSCI. This is seen as a benefit for DOD since they will be permitted access to commercial SATCOM services as directed by Congress. The private sector will also benefit since the commercial satellite industry will be the provider of the service. On the other hand DOD is strongly opposed to addressing Federal/non-Federal use of this band in conjunction with the sharing constraints specified by the Title VI spectrum reallocation process.

Taking the above factors into consideration, we are not including the 5850-5925 MHz band in the final spectrum reallocation plan. However, direct discussions between NTIA and the FCC regarding this band and larger issues involving Federal use of commercial FSS systems will continue.

## ENDNOTES

Requests for copies of references from Federal departments and agencies should be referred to the originating organization. Parts of the reference material may be exempt from public release.

1. See Comments filed in response to NAT'L TELECOMMUNICATIONS AND INFO. ADMIN. (NTIA), U.S. DEP'T OF COMMERCE, SPECIAL PUBLICATION 94-27, PRELIMINARY SPECTRUM REALLOCATION REPORT (Feb. 1994) [hereinafter NTIA PRELIMINARY REPORT]: Motorola, at 14 (May 11, 1994); Telecommunications Industry Assoc. (TIA), at 15 (May 11, 1994). [hereinafter all comments cited refer to NTIA PRELIMINARY REPORT, unless otherwise stated].
2. Institute for Telecommunication Sciences, U.S. Dep't of Commerce, *A Preliminary Look at Spectrum Requirements for the Fixed Services*, at 32-33 (May 1993).
3. *Id.*
4. REPORT FROM THE FEDERAL COMMUNICATIONS COMM'N, to Ronald H. Brown, Secretary, U.S. Dep't of Commerce, Regarding the NTIA PRELIMINARY REPORT, FCC 94-213, at 26 (Aug. 9, 1994) [hereinafter FCC REPORT].
5. NTIA PRELIMINARY REPORT, *supra* note 1, at 4-10.
6. Letter from Deborah R. Castleman, Deputy Assistant Secretary of Defense for Command, Control, and Communications, U.S. Dep't of Defense, to Richard Parlow, Assoc. Adm'r, Nat'l Telecommunications and Info. Admin., (Sept. 1, 1994) [hereinafter Joint DOD Response]; U.S. Dep't of Army Comments, at 2 (May 9, 1994); Dep't of Transportation (DOT) Comments, at 1 (June 1, 1994); U.S. Dep't of the Air Force Enclosure, at 13, A-9 (June 8, 1994).
7. Air Force Comments to the NTIA DRAFT FINAL REALLOCATION REPORT, (unpublished)(Dec. 6, 1994) [hereinafter NTIA DRAFT REALLOCATION REPORT], at 4 (Dec. 22, 1994) [hereinafter Air Force].
8. Joint DOD Response, *supra* note 6, at 3.
9. NTIA PRELIMINARY REPORT, *supra* note 1, at 4-11.
10. Joint DOD Response, *supra* note 6, at 6.
11. NTIA PRELIMINARY REPORT, *supra* note 1, at 4-12.
12. TIA Comments, *supra* note 1, at 15.
13. NTIA PRELIMINARY REPORT, *supra* note 1, at 2-5.
14. Comments filed in response to the *FCC Notice of Inquiry*, ET Docket No. 94-32, FCC 94-97, 59 Fed. Reg. 6005 (May 4, 1994) [hereinafter *FCC NOI*]: Pacific Bell and Nevada Bell, at 2 (June 15, 1994); Southwestern Bell, at 5 (June 15, 1994).
15. Nat'l Telecommunications and Info. Admin., U.S. Dep't of Commerce, *U.S. Spectrum Requirements: Projections and Trends*, at 129 (to be published in 1995).
16. FCC REPORT, *supra* note 4, at 14.
17. NTIA PRELIMINARY REPORT, *supra* note 1, at 4-27.
18. Aeronautical Systems Center, Dep't of the Air Force, *Potential Loss of Frequency Allocation - 1350-1400 MHz* (June 24, 1993).
19. FCC REPORT, *supra* note 4, at 15.
20. *Id.* at 31.
21. Meeting between NTIA and Nat'l Oceanic and Atmospheric Admin. (NOAA) on June 27, 1994.
22. Memorandum from D. James Baker, Under Secretary and Adm'r, NOAA, to Larry Irving, Assistant Secretary for Communications and Info., NTIA (Oct. 18, 1993).
23. NOAA Meeting, *supra* note 21.
24. *Id.*

## ENDNOTES

Requests for copies of references from Federal departments and agencies should be referred to the originating organization. Parts of the reference material may be exempt from public release.

25. NTIA PRELIMINARY REPORT, *supra* note 1, at 5-4.
26. Motorola Comments, *supra* note 1, at 11-12; TIA Comments, *supra* note 1, at 16.
27. TIA Comments, *supra* note 1, at 16.
28. FCC REPORT, *supra* note 4, at 15-16.
29. NTIA PRELIMINARY REPORT, *supra* note 1, at 4-30.
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93. AMSC Comments, *supra* note 89, Technical App. at 4-10.
94. *Id.* Annex 2, at 12.
95. *Id.*
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130. *Id.*

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139. *Id.*

140. Navy Comments to NTIA DRAFT FINAL REALLOCATION REPORT, *supra* note 61, at 5.

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## ENDNOTES

Requests for copies of references from Federal departments and agencies should be referred to the originating organization. Parts of the reference material may be exempt from public release.

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**TABLE 5-1**
Spectrum Reallocation Final Plan

| Bands Identified for Reallocation (MHz)[A] | Reallocation Status[B] | Reallocation Schedule |
|---|---|---|
| 1390 - 1400 | Exclusive | January 1999 |
| 1427 - 1432 | Exclusive | January 1999 |
| 1670 - 1675 | Mixed | January 1999 |
| 1710 - 1755 | Mixed | January 1999/2004[C] |
| 2300 - 2310 | Exclusive | August 1995 |
| 2390 - 2400 | Exclusive | Reallocation Complete |
| 2400 - 2402 | Exclusive | August 1995 |
| 2402 - 2417 | Exclusive | Reallocation Complete |
| 2417 - 2450 | Mixed | August 1995 |
| 3650 - 3700 | Mixed | January 1999 |
| 4635 - 4660 | Exclusive | January 1997 |
| 4660 - 4685 | Exclusive | Reallocation Complete |

A 225 - 400 Although not a part of this reallocation plan, ongoing discussions within the Federal Government regarding long range plans for the 225-400 MHz band will address non-Federal spectrum requirements, including the views expressed by the FCC in its upcoming report to Congress on the spectrum needs of public safety agencies.

3625 - 3650 Expanded non-Federal use of these bands
5850 - 5925 is being addressed jointly by NTIA and the FCC.

B Federal stations that will continue operation in certain bands are listed in Appendices E & F.

C Earlier availability date applies only to the 25 largest U.S. cities and is further subject to timely reimbursement of Federal costs, including reimbursement directly from the private sector. See Section 4 for details.

In reallocating these bands, several issues are of special importance: costs to Federal agencies, establishment of adequate receiver standards, adequate spectrum to which Federal agency operations can relocate, and implementation of appropriate Federal agency acquistion procedures so that the accelerated reallocation dates can be met. Title VI does not provide statutory authority for reimbursement of Federal agency costs associated with any reallocation of spectrum. However, the displaced Federal functions that result from spectrum reallocation must be preserved in other frequency bands at considerable cost to the Federal agencies. Reimbursement of Federal costs, including reimbursement directly from the private sector, will require Congressional legislation. Timely reimbursement is an essential element of the final plan for bands identified for accelerated reallocation.

Several bands identified for reallocation in the final plan are adjacent to bands that will continue to be used for high-power Federal systems, including megawatt radars. Numerous case histories exist where commercial or consumer radio systems received interference and failed to operate properly because of inadequate receiver filtering. In order to achieve the goals set by Title VI for development of new technologies, adoption of effective receiver standards, either regulatory or established by industry, is essential for bands identified in the final plan that are adjacent to high-power Federal systems.

### 1390-1400 MHz

This band is used by long-range air defense radars, air traffic control facilities, military test range telemetry links, tactical radio relays, and radio astronomy. The band has potential for new non-Federal fixed, mobile, and radiolocation communications technologies and applications. However, high-powered Federal Aviation Administration (FAA) and Department of Defense (DOD) radars must continue to operate in the lower adjacent-band, and important radio astronomy observations must continue within the band. Thus, reallocating this band for exclusive non-Federal use would require that: (1) airborne and space-to-Earth transmissions be prohibited to protect radio astronomy; (2) FAA and DOD install filters on their high-powered radar transmitters; and (3) probable re-engineering of the new ARSR-4 joint FAA/DOD long-range radar. In addition, adopting adequate regulatory or industry receiver standards for new non-Federal equipment in this band is essential to assure satisfactory performance of new non-Federal services in bands adjacent to Federal high-power radars. Reallocation of this band is scheduled in 1999 to permit satisfaction of these conditions and completion of Federal reaccommodation efforts. Federal operations at 17 sites will be continued for 14 years. (See TABLE 4-1 in the text for a list of the sites.)

### 1427-1432 MHz

This band is used by military tactical radio relay communications and military test range aeronautical telemetry and telecommand. The band has potential for new non-Federal fixed and mobile communications technologies and applications. In order to protect sensitive radio astronomy observations in the adjacent-band, reallocation for airborne or space-to-Earth communications should be avoided. Reallocation of this band for non-Federal use in 1999 is scheduled to permit the orderly phase-out of radio relay communications equipment, the procurement of replacement equipment, and the engineering of associated network systems. In addition, essential military airborne operations at 14 sites will be continued for 9 years. (See TABLE 4-2 in the text for a list of the sites.)

### 1670-1675 MHz

This band is used by meteorological equipment that will have to be redesigned or replaced. The band has potential for new non-Federal fixed or mobile communications. In order to protect sensitive radio astronomy observations in the adjacent-band, reallocation for airborne or space-to-Earth communications should be avoided. Reallocation of this band is scheduled in 1999 to permit design and procurement of replacement equipment for meteorological radiosonde systems. However, non-Federal use at a limited number of sites that are engineered to be fully compatible with all Federal operations could be given immediate consideration. Reallocation also requires continued protection of two important meteorological-satellite service earth stations.

### 1710-1755 MHz

This band is currently used extensively for Federal fixed point-to-point microwave communications, military tactical radio relay, and airborne telemetry systems. The band has potential for new non-Federal fixed and mobile communications services. Reallocation of this band is scheduled for 2004 to provide for the orderly phase-out of existing Federal systems, the design and procurement of replacement equipment, and associated systems engineering. However, recognizing the needs of non-Federal users for spectrum, especially in major urban areas, reallocation of the band in four years may be possible for the 25 largest U.S. cities (see Table 4-1 in the text for list of cities), provided that: (1) reimbursement is provided to the affected Federal agencies; (2) appropriate Federal Agency acquistion procedures are implemented in order to support relocation of Federal systems; and (3) suitable and sufficient radio spectrum is available for relocation. The reimbursement could be in the form of direct reimbursement of costs to the Federal agencies by non-Federal entities similar to the process established by the FCC in the adjacent 1850-1990 MHz band. New Congressional legislation would be necessary to effectuate such a process. Title VI requires that all microwave communication systems operated by Federal power agencies in this band continue operation and be protected from interference. Federal stations used for limited times during emergency and disaster response will also continue operation and be protected from interference. In addition, certain other Federal operations that provide safety-of-life and other critical functions, and are located outside of the largest 25 cities, will continue operation and will be protected from interference.

### 2300-2310 MHz, 2390-2400 MHz, and 2402-2417 MHz

These bands are used by the military for radar testing systems, such as target scattering and enemy radar simulators, and telemetry systems. The amateur service is also allocated in these bands on a secondary basis. NASA uses an adjacent band (2290-2300 MHz) for highly sensitive deep space communications and interplanetary research radar operations. The bands have potential for new non-Federal radiolocation and fixed and mobile communications technologies, and are located in close proximity to the 1850-2200 MHz band recently allocated by the FCC for personal communications services (PCS). Action on the 2390-2400 and 2402-2417 MHz bands was completed on August 9, 1994 to remove Federal operations in accordance with the immediate reallocation provisions of Title VI. Based on views expressed by the public, the reallocation date of the 2300-2310 MHz band is accelerated to August 1995 to provide the opportunity for effective pairing with the 2390-2400 MHz band. Reallocation of the 2300-2310 MHz band includes constraints necessary for the protection of NASA's Deep Space Network and Planetary Radar operations at Goldstone, California (See Section 4).

### 2400-2402 and 2417-2450 MHz

These band segments, which are part of the overall 2400-2450 MHz band, are allocated on a primary basis to the Federal Government and used to a limited extent by the military for radar testing systems such as target scattering and enemy radar simulators. The principal uses of these bands are industrial, scientific, and medical (ISM) devices, the amateur service, and non-licensed devices authorized under FCC Part 15 Rules. The Preliminary Report excluded the 2400-2402 MHz band segment from reallocation, because of its vital importance to amateur-satellite operations. However, comments to NTIA and the FCC from the amateur community argue that 2 MHz is too narrow to accommodate future amateur-satellite growth. The 2417-2450 MHz band segment was previously excluded from reallocation because of the high ambient radio noise levels from ISM devices, mostly microwave ovens. Additional comments to NTIA and the FCC from the Part 15 industry argue that the entire 2400-2483.5 MHz band should remain available for non-licensed use. Based on the public comments, we conclude that subdividing the 2400-2450 MHz band into three parts, as originally proposed, would not best meet the needs of the principal users of the band.

Reallocating the entire 2400-2450 MHz band would provide the FCC with the opportunity to develop a long-term regulatory framework and strategy that meets the needs of the amateur service and addresses the requirements of a robust and growing Part 15 industry. Under a mixed use reallocation, the Federal allocation would be reduced to secondary, with the limited remaining Federal presence posing no impact on non-Federal use. This action creates a sense of stability regarding future non-Federal use and provides the opportunity to have a significant amount of spectrum for long-term development of non-licensed technologies. Furthermore, this would provide significant opportunities for innovators and small companies to make contributions to the overall mix of products and services available to the American public. We therefore include the 2400-2402 and 2417-2450 MHz bands for reallocation beginning in August 1995. The 2 MHz in the first band is proposed for exclusive non-Federal use and the 33 MHz in the second band is proposed for mixed Federal and non-Federal use.

### 3650-3700 MHz

This band is used by Navy air traffic control radars on aircraft carriers; is allocated to a number of different radio services worldwide; and is designated as an expansion band for Federal ground-based radionavigation services which could not be accommodated in the 2700-2900 MHz band. Thus, the band could be used for new non-Federal technologies in the fixed, mobile (except aeronautical), fixed-satellite and radiolocation services. Reallocating this band in 1999 will allow sufficient time to re-engineer Navy radars for operation in coastal waters. In addition, adopting adequate regulatory or industry receiver standards for new non-Federal equipment in this band is essential to assure satisfactory performance of new non-Federal services in bands adjacent to Federal high-power radars. Essential military radar operations will be continued at three sites. (See TABLE 4-4 in the text for a list of the sites.)

### 4635-4660 and 4660-4685 MHz

These bands are used for military airborne telemetry and high-powered tropospheric scatter communications systems. These bands have potential for a variety of new non-Federal fixed, mobile, and fixed-satellite technologies and associated applications. Action on the 4660-4685 MHz band was completed

on August 9, 1994 to remove Federal operations in accordance with the immediate reallocation provisions of Title VI. However, reallocating the 4635-4660 MHz band in 1997 is necessary to re-design certain military telemetry systems. Furthermore, essential Federal airborne operations will be continued for 14 years in the 4635-4660 MHz band at three sites. (See TABLE 4-5 in the text for a list of the sites.)

## OVERVIEW OF FEDERAL IMPLEMENTATION COSTS

Every effort has been made to ensure that the bands identified in this report meet the Title VI selection criteria. However, the displaced Federal functions resulting from reallocation must, in most cases, be preserved in other frequency bands at considerable cost to the Federal Government. The Federal costs associated with the reallocation were addressed in the Preliminary Report only in general terms. Consequently, in releasing the Preliminary Report, the Secretary of Commerce issued requests to each affected Federal agency to provide cost estimates for reallocating the candidate bands. TABLE 5-2 summarizes the Federal reallocation costs based on the responses received from that request. The values represent estimated immediate and recurring costs over the 15-year period defined by Title VI.

## Table 5-2
Summary of Federal Reallocation Costs

| Federal Agency | Reallocation Approach | Estimated Reallocation Cost ($Million) |
|---|---|---|
| Agriculture | Replace 580 Forest Service fixed microwave links | 48 |
| Army | Change frequencies and realign 260 Corps of Engineers fixed microwave links<br>Increase training expenses for tactical radio relay systems | 33 |
| Commerce | Redesign and replace NOAA nationwide radiosonde network | 35-55 |
| Energy | Replace 30 fixed microwave links | 3-10[a] |
| Justice | Convert 560 FBI fixed microwave links to commercially available service<br>Replace 90 INS fixed microwave links<br>Change frequencies and realign 500 DEA transportable video links | 144 |
| Treasury | Replace Secret Service fixed microwave and air/ground video links | 1 |
| Interior | Change frequencies and realign or replace 135 fixed microwave links | 8-13 |
| Air Force | Redesign radar, telemetry and weapon control systems<br>Redesign integrated instrumentation systems | 60[b] |
| Transportation | Replace 150 FAA and Coast Guard fixed microwave links<br>Redesign software for 44 joint FAA/AF air traffic control radars (ARSR-4)<br>Add filters to older FAA air traffic control radars | 115[c] |
| Navy | Develop and possibly retrofit various weapon control systems | 30-113[d] |

[a] The higher range is required if an exception is not provided to other Federal agencies carrying DOE electrical power distribution information.

[b] Costs could increase by up to $123 million if unacceptable interference to or from non-Federal systems necessitates major hardware changes or replacement of Air Force telemetry and data link systems.

[c] Costs could increase by up to $500 million if unacceptable interference to or from non-Federal users necessitates major hardware changes or replacement of joint FAA/AF ARSR-4 radars.

[d] Costs could increase by up to $63 million if unacceptable interference to or from non-Federal users necessitates retrofit of Navy carrier landing system radars.

# APPENDIX A
# EXAMINATION OF TRANSITION OPTIONS AND COSTS FOR THE 1710-1755 MHZ BAND

## TRANSITION PLANS AND REALLOCATION COSTS

Title VI allows Federal Government and non-Federal sector mixed use in certain bands. It also excludes from reallocation the frequencies used by the Federal power agencies (FPAs). The 1710-1755 MHz band is being reallocated to the Federal Government and non-Federal sector for mixed use. As mandated in Title VI, frequencies designated for mixed use can be partially retained for use by the Federal Government. Further, the potential use of these frequencies by the Federal Government must be substantially less, as measured by geographic area, time, or by other means, than the potential use to be made by the non-Federal sector. Consequently, implementing the sharing criteria of the bill makes the Federal Government use of these frequencies less than primary, including those that support important and critical services to both the public and the Federal Government. To preclude or minimize anticipated disruptions to these existing services, it is necessary to implement some reallocation transition processes to reaccommodate these services.

This Appendix provides a broad examination of the feasible transition options, along with the NTIA estimates of associated costs, to implement the reallocation of the 1710-1755 MHz band. It also addresses an alternative reallocation option for Federal agencies that originally opted for a specific transition process which may not be totally feasible to implement. For example, some agencies have opted to retune to the remaining portion of the band (i.e., the 1755-1850 MHz band). However, in certain geographical areas, there could be insufficient spectrum to accommodate all the fixed microwave systems being relocated. In addition, there could be cases where the transmitter/receiver (T/R) frequency separation criteria of fixed microwave systems originally planned to be retuned to the 1755-1850 MHz band could not be met. In both cases, these fixed microwave systems might have to be reallocated to other bands. There could be also fixed microwave systems that are currently operating in the 1755-1850 MHz band that might have to be retuned within the 1755-1850 MHz band or relocated to other bands as a consequence of reallocating the 1710-1755 MHz band from the Federal Government to the non-Federal sector.

Another example is the case where bureaus or agencies have indicated their intention to relocate existing fixed microwave operations from the 1710-1755 MHz band to 7/8 GHz band. Moving to a higher band is more costly to implement because of the requirement for additional relay stations and the procurement of new systems. Because of dwindling budgets and complexity of the Federal budget process, the reallocation funding might be insufficient or not readily available to implement this option. Exacerbating the budget issue is the impact of advancing the reallocation date of the 1710-1775 MHz band from 2004 to 1999 in some major United States cities. Thus, the less costly transition option (retuning) or a combination of retuning and relocating could be a good option to implement. On this basis, various reallocation options were examined for fixed microwave systems in the 1710-1755 MHz band. These options are described below.

### Fixed Microwave Systems

Four reallocation options have been examined for the fixed microwave systems in the 1710-1755 MHz band. These reallocation options are: Option I - Retuning the existing fixed microwave systems in the 1710-1755 MHz band to the 1755-1850 MHz band; Option II - Relocating the existing fixed microwave systems in the 1710-1755 MHz band to the 7/8 GHz band; Option III- Converting the existing fixed

microwave systems in the 1710-1755 MHz band to commercial leased services; and Option IV - Retuning the narrowband fixed microwave systems in the 1710-1755 MHz band to the 1755-1850 MHz band, and relocating the wideband fixed microwave systems to the 7/8 GHz band. Specific transition plans and associated reallocation costs for each option are discussed in the subsequent paragraphs. The general transition plan stated in the next two paragraphs, however, applies to all the above options.

Use of frequencies authorized on or before February 10, 1994 to the FPAs and Federal agencies whose fixed microwave systems operate in conjunction with the FPAs for power generation and/or distribution will continue indefinitely. Further, continued operations on these frequencies will be protected from harmful interference by non-Federal users. Use of frequencies authorized to Federal agencies, where the majority of use carried out at these frequencies is in support of safety-of-life operations, will continue indefinitely. However, only those safety-of-life operations that are outside a 150 km radius of the 25 most populated United States cities are eligible for indefinite continued use (see TABLE 4-3 in Section 4 for the list of the 25 U.S. cities). The list of FPAs, Federal agencies and safety-of-life fixed microwave stations that are associated with these frequencies can be found in Appendix E.

In addition, operations of fixed microwave, tactical radio relay and mobile systems authorized as of February 10, 1994 to Federal agencies at the various locations and radius of operations shown in Appendix F are provided limited continued use, except in the 1710-1755 MHz band where Federal Government operations at the specified sites will continue indefinitely. Moreover, operations at these locations will be protected from harmful interference. However, other areas of operation for these systems will cease. Finally, fixed microwave stations where the areas of operation are isolated and geographically separated from urban communities need not be reallocated immediately. Further discussion on these stations is provided in the subsequent paragraphs. The remaining mobile and fixed operations may have to be reallocated by way of either one of the reallocation options described below.

**Option I: Retuning.** The approximately 1,700 fixed microwave systems in the 1710-1755 MHz band not exempted by Title VI for indefinite continued use may be retuned to the remaining portion of the band (i.e., the 1755-1850 MHz). Assuming that available frequencies exist and other criteria are met in the 1755-1850 MHz band to accommodate both displaced and incumbent systems, this option provides the least time and cost to implement. Generally, a microwave system in the 1710-1850 MHz band has a back-up or "hot-standby" unit, which means that there are two transmitters and two receivers at each fixed microwave station. There are, however, fixed microwave stations that have two-way "hot standby" units (e.g., those operated by the U.S. Geological Survey, Office of Earthquakes, Volcanoes, and Engineering of the DOI). In this case, the authorized intermediate fixed microwave site has four transmitters and four receivers.

A typical cost for retuning a fixed system in the 1710-1755 MHz band is $7,200 (i.e., $1,300 per unit and $2,000/site labor).[1] This cost is based on the agencies providing the basic labor. However, if the retuning is totally contracted to a commercial entity, the cost is $35,000 per site.[2] The FAA provided a value of $100,000 per site for in-band retuning cost for its fixed microwave systems.[3] Although, in general, retuning equipment involves modification of only a few components of the system (e.g., duplexers, modulators, crystals, etc.), there are other costs associated with retuning. While a system is being retuned at the manufacturer's laboratory, a "switchover" system is needed to fulfill the function

of the system being retuned so that critical operations are not disrupted. The "switchover" system must be procured by the affected agency. Other costs that may be involved in retuning are logistical in nature. For example, the costs to contract technical assistance to augment limited staff personnel and hire transportation during site visits. Several Federal agencies included these logistical costs in their estimated reallocation costs.

The estimated number of equipment and reallocation costs for each major user in the 1710-1755 MHz band are presented in TABLE A-1. Whenever an agency did not provide the number of its fixed microwave sites, the number of fixed microwave assignments in the Government Master File (GMF) for the 1710-1755 MHz frequency range was used as the number of fixed microwave sites. Note that some fixed microwave stations operated by the Army, DOI, USCG and FAA, and all of the FPAs fixed microwave stations are exempted from reallocation and, thus, reallocation costs are projected accordingly for these entities. Also, note that DOJ's retuning cost only accounts for the 90 INS fixed microwave sites since FBI started converting their 427 fixed microwave stations to commercial leased services about 3 years ago.

**Option II: Reallocation to the 7/8 GHz Band.** Fixed microwave stations in the 1710-1755 MHz band that are not exempted by Title VI for indefinite continued use may be reallocated to the 7/8 GHz band. Given the current congestion in the remaining portion of the 1710-1850 MHz band, particularly in certain areas of the United States, this option is worth considering. However, it is expensive because reallocating to a higher band will necessitate additional intermediate relay stations. This involves but not limited to the following: site engineering to determine viable locations of additional relay stations; procurement of new systems and land; and construction of relay stations. An estimated 25% of existing fixed microwave stations will require additional relay stations.[4] In addition to this requirement, the old stations need to be refurbished to operate in the higher frequency bands.

Another aspect of the reallocation process to other bands is consideration of the depreciation costs incurred for the existing equipment. Theoretically, if the reallocation will take place in the year 2004, equipment procured on or after 1983 will incur a depreciation cost. On the other hand, equipment procured before 1983 will be totally depreciated and, therefore, has no residual investment cost. In this report, the estimated residual investment cost (values after the equipment incurred depreciation) is calculated by taking the ratio of the remaining useful life to the total useful life of a piece of equipment and multiplying by the investment or procurement cost of the equipment. Federally owned fixed microwave systems in the 1710-1850 MHz band have a useful life of 15 to 20 years.[5,6] Since the task of identifying the specific procurement date of all relevant pieces of equipment in the Federal Government inventory would be extremely burdensome, an average procurement date for each Federal agency was determined and used to established the average remaining life of the equipment. The average remaining life of existing pieces of equipment was established for the years 1999 and 2004 since the 1710-1755 MHz band will be reallocated for Federal and non-Federal mixed use in the years 1999 and 2004. TABLE A- 2 shows the estimated costs per major user of the 1710-1755 MHz band for the different reallocation requirements to the 7/8 GHz band.

## TABLE A-1

1710-1755 MHz In-Band Reallocation Costs Analysis for Fixed Microwave Systems[a]

| Agency (See Key) | Estimated# of Sites[b] | Estimated # of Equipment[c] | Retuning Costs [(XX)[d]/(YY)[e]] (Millions) | Added Costs (Millions)[f] |
|---|---|---|---|---|
| A | 532* | 2128 | 3.8 / 18.6 | 0.4 |
| AF | 65 | 260 | 0.5 / 2.3 | 0.06 |
| Ar/ACE | 259 | 1036 | 1.9 / 23.0* | 0.2 |
| CG | 41[g] | 164 | 0.3 / 1.4 | 0.04 |
| DOE | 30* | 120 | 0.2 / 1.1 | 0.03 |
| FAA | 85[g] | 340 | 0.6 / 8.5[h] | 0.08 |
| FPA[i] | 314 | 1256 | not applicable | not applicable |
| DOI | 97 | 516[j] | 0.9 / 8.0* | 0.09 |
| DOJ | 517* | 2068 | 0.7 / 3.2[k] | 0.08[i] |
| N | 54 | 216 | 0.4 / 2.0 | 0.05 |
| T | 10[g] | 40 | 0.07 / 0.4 | 0.02 |
| **TOTAL** | 2,004 | 8,114 | 9.4 / 68.5 | 1.1 |

**Key:** **A** - Agriculture **DOE** - Energy **DOJ** - Justice **AF** - Air Force
**FAA** - Federal Aviation Administration **FPA** - Federal Power Agency **N** - Navy **T** - Treasury
**Ar/ACE** - Army/Army Corps of Engineers **CG** - Coast Guard **DOI** - Interior * - Agency input

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[a] The cost provided by an agency was used when appropriate. The computed retuning costs are based on the assumption that all affected fixed microwave systems will be retuned, unless otherwise stated.

[b] If data is unavailable, the total number of the agency's fixed microwave frequency assignments in the 1710-1755 MHz band was used to determine the number of fixed sites.

[c] It is assumed that fixed microwave stations include a "hot-standby" unit (i.e., two transmitters and two receivers). However, there are fixed microwave stations that have two-way "hot standby" units (e.g.,those operated by the U.S. Geological Survey, Office of Earthquakes, Volcanoes, and Engineering of the DOI).

[d] A cost of $7,200 per site or $1,300 per unit and $2,000 per site for labor was used to estimate the retuning cost, assuming that basic labor will be provided by the agency.

[e] A cost of $35,000 per site was used to estimate the retuning cost, assuming that labor will be contracted to commercial institution.

[f] Includes cost of $9,000 to purchase a set of "hot-switchover" units for changeout while retuning is taking place and site visits for $800.00 per site.

[g] Fixed microwave stations supporting safety-of-life operations that are outside a 150 km radius of the 25 most populated U.S. cities are exempted from reallocation. Thus, they are not included in the count.

[h] FAA provided a value of $100,000 per site for in-band retuning cost.

[i] FPA includes the Tennessee Valley Authority, the Bonneville Power Admin., the Western Area Power Admin., the Southwestern Power Admin., the Southeastern Power Admin., and the Alaska Power Admin. FPA assignments are exempted from reallocation.

[j] It is assumed that one-third of the DOI's fixed sites uses two-way "hot standby" units (see footnote number c).

[k] Projected cost is for the 90 INS fixed microwave sites only. The 427 FBI fixed microwave sites are currently being converted to leased commercial services.

## Table A-2

1710-1755 MHz Out-of-Band Estimated Reallocation Costs Analysis for Fixed Microwave Systems[a]

| Agency (See Key) | # of Sites[b] | Equipment Avg. Remaining Life (years) | | Estimated Residual Costs (Millions)[c] | | Replacement & New Station Costs (Millions)[d] | Added Costs (Millions)[e] |
|---|---|---|---|---|---|---|---|
| | | 5-Yr Plan 1999 | 10-Yr Plan 2004 | 5-yr Plan 1999 | 10-yr Plan 2004 | | |
| A | 532* | 5 | 0.00 | 13.3 | 0.00 | 48.1* | 24.4 |
| AF | 65 | 8 | 3 | 2.6 | 1.0 | 7.3 | 3.0 |
| Ar/ACE | 259 | 10 | 5 | 13.0 | 6.5 | 230* | 11.9 |
| CG | 41[f] | 4 | 0.00 | 0.8 | 0.00 | 10.6* | 2.3* |
| DOE | 30* | 7 | 2 | 1.1 | 0.3 | 2.4* | 1.4 |
| FAA | 85[f] | 11 | 6 | 4.7 | 2.6 | 96* | 3.9 |
| FPA[g] | 314 | 7 | 2 | 0.00 | 0.00 | 0.00 | 0.00 |
| DOI | 97 | 11 | 6 | 5.3 | 2.9 | 13* | 4.5 |
| DOJ | 517* | 8 | 3 | 3.6[h] | 1.4[h] | 10.3[h] | 4.1[h] |
| N | 54 | 10 | 5 | 2.7 | 1.4 | 6.2 | 2.5 |
| T | 10[f] | 8 | 3 | 0.4 | 0.2 | 1.3 | 0.5 |
| **TOTAL** | 2,004 | Avg=8 | Avg=3 | 47.5 | 16.3 | 419.2 | 58.1 |

**Key:** **A** - Agriculture **DOE** - Energy **DOJ** - Justice **AF** - Air Force
**FAA** - Federal Aviation Administration **FPA** - Federal Power Agency **N** - Navy **T** - Treasury
**Ar/ACE** - Army/Army Corps of Engineers **CG** - Coast Guard **DOI** - Interior * - Agency input

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[a] It is assumed that the reallocation band is the 7/8 GHz band.

[b] If data is unavailable, the number of fixed microwave frequency assignments in the 1710-1755 MHz band was used to determine the number of fixed microwave sites.

[c] The operational life of Federal Government fixed microwave systems in this band is 20 years. The estimated residual investment cost analysis is based on a $100,000/site investment.

[d] If data is unavailable, a value of $250,000 per new site development and $50,000 per site conversion to 7/8 GHz band was used to compute the replacement and new station costs. Also, it is assumed that 25% of existing stations need new relay stations.

[e] Includes cost of $9,000 to purchase a set of "hot-switchover" units for changeout while relocation is taking place and site visits for $800.00 per site. It also includes a 15-year recurring operational and maintenance cost (i.e., $3,000 per site per year).

[f] Fixed microwave stations supporting safety-of-life operations that are outside a 150 km radius of the 25 most populated U.S. cities are exempted from reallocation.

[g] FPA includes the Tennessee Valley Authority, the Bonneville Power Admin., the Western Area Power Admin., the Southwestern Power Admin., the Southeastern Power Admin. and the Alaska Power Admin. FPA assignments are exempted from reallocation.

[h] Projected cost is for the 90 INS fixed microwave sites only. The 427 FBI fixed microwave sites are currently being converted to leased commercial services.

As before, whenever an agency did not provide the number of its fixed microwave sites, the number of fixed microwave assignments in the GMF was used as the number of fixed microwave sites. This GMF data was also used to determine the number of new relay stations. Values of $250,000[7,8] and $50,000[9] were used to compute the costs for new relay and refurbishing of old stations, respectively. The $250,000 per new site includes costs for land acquisition, facility construction and equipment procurement. For the residual investment costs, the values are directly proportional to the remaining life of the equipment (i.e., the more recently bought equipment has the least depreciation cost and, therefore, has more residual investment cost value), as can be seen for the 5-year and 10-year plans in TABLE A- 2. For the 5-year Plan (1999), the average remaining life of Federal equipment ranges from 4 to 11 years, with USCG having the lower range and both FAA and DOI having the upper range. An annual recurring cost of $3,000 per site per year,[10] which includes maintenance and operational costs, is used to calculate the added cost for each major user of the band.

**Option III: Employing Leased Commercial Services.** This option is the most expensive of all the options examined. For example, DOJ/FBI provided a conversion cost estimate of over $121 million for its off-the-shelf fixed microwave systems, which support land mobile radio-communications operations, if converted to leased commercial services. This value includes the following: personnel costs (e.g., temporary hiring of engineers to design and implement the system changes); material and supply costs (e.g., installation/optimization services and miscellaneous hardware for installing wireline equipment and adapting radio equipment to wireline operations); and other attributable costs like installation of wirelines to sites without existing wireline service, procuring wirelines to remaining lines, removal of existing microwave equipment and returning radio sites to acceptable condition. DOJ indicated that FBI is currently pursuing this option and had started implementing the conversion process 3 years ago.

Leasing commercial services is not a practical option for the majority of the Federal agencies to adopt. The majority of fixed operations by the Federal agencies in the 1710-1755 MHz band require high reliability and cannot afford even the slightest down time. In addition, numerous Federal Government fixed microwave sites are in rural areas where commercial services are not and will not be available for a long time. As such, the majority of the Federal agencies did not provide costs data for employing leased commercial services.

Because of insufficient data to evaluate the other agencies' total cost for this option, the estimated values shown in TABLE A-3 are based on the recurring leased line costs of $27,630 per site per year.[11] Other costs, such as design and implementation, personnel, material and supply costs cannot be quantified for each of the major users. However, additional costs are calculated for each agency. These costs include a $5,000 per site removal of existing microwave equipment and returning radio sites to acceptable condition. The costs also include a $6,900 per site procurement and installation of wirelines[12] and $800 per site visits.[13]

**Option IV: Retuning and Relocating.** This option involves two reallocation processes: first, retuning the fixed narrowband systems (i.e., $\leq$5 MHz emission bandwidth) operating in the 1710-1755 MHz band to the 1755-1850 MHz band; and second, relocating the wideband systems (i.e., >5 MHz emission bandwidth) operating in the 1710-1755 MHz band to the 7/8 GHz band. As stated earlier, the congestion in the 1755-1850 MHz band makes this option more attractive. In addition, this option will

TABLE A-3

Costs Analysis for Fixed Microwave Systems in the 1710-1755 MHz Band Employing Leased Commercial Services[a]

| Agency (See Key) | # of Sites[b] | Estimated Recurring Leased Line Costs (Millions)[c] | | | Procure and Install Wirelines (Millions)[d] | Added Costs (Millions)[e] |
|---|---|---|---|---|---|---|
| | | 5 Years | 10 Years | 15 Years | | |
| A | 532* | 73.5 | 147.0 | 220.5 | 3.7 | 3.1 |
| AF | 65 | 9.0 | 18.0 | 27.0 | 0.5 | 0.4 |
| Ar/ACE | 259 | 35.6 | 71.2 | 106.8 | 1.8 | 1.5 |
| CG | 41[f] | 5.7 | 11.4 | 17.1 | 0.3 | 0.3 |
| DOE | 30* | 4.2 | 8.4 | 12.6 | 0.2 | 0.2 |
| FAA | 85[f] | 11.7 | 23.4 | 35.1 | 0.6 | 0.5 |
| FPA | 314[g] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DOI | 97 | 13.4 | 26.8 | 40.2 | 0.7 | 0.6 |
| DOJ[h] | 517* | 59.0 | 118.0 | 177.0* | 3.0* | 2.5 |
| N | 54 | 7.5 | 15.0 | 22.5 | 0.4 | 0.3 |
| T | 10[f] | 1.4 | 2.8 | 4.2 | 0.07 | 0.07 |
| **TOTAL** | 2,004 | 221 | 442 | 663 | 11.3 | 9.5 |

**Key:** **A** - Agriculture; **FAA** - Federal Aviation Administration; **Ar/ACE** - Army/Army Corps of Engineers; **DOE** - Energy; **FPA** - Federal Power Agency; **CG** - Coast Guard; **DOJ** - Justice; **N** - Navy; **DOI** - Interior; **AF** - Air Force; **T** - Treasury; * - Agency input

[a] The calculated values reflect only the conversion of existing fixed microwave stations that are operating in the 1710-1755 MHz frequency range to leased commercial services.

[b] If data is unavailable, the number of fixed microwave assignments in the 1710-1755 MHz frequency range was used to determine the number of fixed microwave sites.

[c] The calculated values were based on a recurring cost of $27,630 per site annually to leased commercial wirelines.

[d] The calculated values were based on a $6,900 per site for procurement and installation of wirelines to existing fixed microwave sites.

[e] The calculated values were based on: (1) $5,000 per site for removal of existing microwave equipment and restoring sites to acceptable conditions; (2) site visits at $800 per site; (3) $9,000 to procure a set of "hot-switchover" unit to fulfill the system's function while conversion is taking place.

[f] Fixed microwave stations supporting safety-of-life operations that are outside a 150 km radius of the 25 most populated U.S. cities are exempted from reallocation.

[g] FPA includes the Tennessee Valley Authority, the Bonneville Power Admin., the Western Area Power Admin., the Southwestern Power Admin., the Southeastern Power Admin. and the Alaska Power Admin.. FPA assignments are exempted from reallocation.

[h] The FBI started converting its 427 fixed microwave sites in 1991. The INS 90 fixed microwave sites will not be converted to leased commercial services.

easily accommodate the T/R frequency separation requirement that is inherent in existing 1710-1850 MHz fixed microwave systems.

The approximately 700 fixed microwave wideband systems in the 1710-1755 MHz band have a T/R frequency separation greater than 40 MHz and as wide as 110 MHz. Because of this operational characteristic, the fixed stations supporting wideband operations in the 1710-1755 MHz band, and possibly including those in the 1755-1850 MHz band, may have to be reallocated to the 7/8 GHz band. It is possible, however, for these wideband systems to either remain or retune elsewhere in the band. The process may require employing better filters, special duplexers and/or high performance antennas to reduce the T/R frequency separation to within 40 MHz or less. However, a manufacturer of these systems has indicated that modifying these components might not be cost effective. Thus, reallocating the wideband systems to the 7/8 GHz band is a more practical and economical solution. This is in agreement with the recommendation provided by USDA.[14]

A typical narrowband system in the 1710-1755 MHz band generally has a T/R frequency separation of 40 MHz or less. There are approximately 1,100 fixed microwave stations supporting narrowband systems in the 1710-1755 MHz band that are not exempted from reallocation. Some narrowband systems in the 1755-1850 MHz band may also have to be reallocated because of the "domino effect." This is particularly the case when one or more hops of a link that is made-up of numerous hops fall in either the 1710-1755 MHz or 1755-1850 MHz frequency range. For the purposes of this report, however, it is assumed that all the links of the fixed microwave stations in the 1710-1755 MHz band are contained in this band segment.

Although there may be other options that could be undertaken for the narrowband systems (e.g., retuning to the 2200-2290 MHz, 932-935/941-944 MHz, or 1700-1710 MHz band), especially those with T/R frequency separation of much less than 10 MHz, the cost estimates considered for this report deal only with the wideband systems operating in the 1710-1755 MHz band being relocated to the 7/8 GHz band and the narrowband systems in the 1710-1755 MHz band being retuned to the upper portion of the band (i.e., 1755-1850 MHz). The process used in computing the costs is a combination of options I and II. The retuning cost per site, however, is based on commercial contract (i.e., $35,000 per site). As before, the reallocation costs for agencies whose fixed microwave systems are exempted for reallocation are adjusted accordingly, as noted in TABLE A-4.

## Mobile Systems

The mobile systems in the 1710-1755 MHz band will be retuned to the upper portion of the 1710-1850 MHz band (i.e., the 1755-1850 MHz). The estimated reallocation cost, shown in TABLE A-5, is based on the following assumptions: (1) base/repeater station supports an average of 25 mobiles/portables;[15] (2) the cost to retune a mobile/portable is $350;[16] (3) the cost to retune a base/repeater is $3,300;[17] (4) an assignment for the station classes FB, FLE, and FLEC may represent a base/repeater station; and (5) an assignment for the station classes MOEC, ML, MLP, MO, MOD and MLD may represent mobiles/portables. However, note that the estimated reallocation costs in TABLE A-5 do not include costs assessment on aeronautical or flight telemetering and aeronautical mobile systems. The number of these systems in an authorized frequency assignment is very difficult to quantify.

## TABLE A-4

1710-1755 MHz In-Band and Out-of-Band Reallocation Costs Analysis for Fixed Microwave Systems[a]

| Agency (See Key) | # of Sites[b] | Wideband Stations | Narrowband Stations | Wideband Stations Relocation Costs ( 7/8 GHz) (Millions)[c] | Narrowband Stations Retuning Costs (1755-1850 MHz) (Millions)[d] | Total Reallocation Costs (Millions) |
|---|---|---|---|---|---|---|
| A | 532* | 5 | 527 | 0.8 | 18.9 | 19.7 |
| AF | 65 | 12 | 53 | 2.1 | 2.0 | 4.1 |
| Ar/ACE | 259 | 72 | 187 | 12.2 | 6.8 | 19 |
| CG | 41[e] | 3 | 38 | 0.60 | 1.30 | 1.90 |
| DOE | 30* | 21 | 9 | 3.5 | 0.3 | 3.8 |
| FAA | 85[e] | 0.00 | 85 | 0.00 | 8.5[f] | 8.5 |
| FPA | 314[g] | 142 | 172 | 0.00 | 0.00 | 0.00 |
| I | 97 | 7 | 90 | 1.3 | 3.3 | 4.6 |
| J[h] | 517* | 428 | 89 | 0.4 | 3.2 | 3.6 |
| N | 54 | 13 | 41 | 2.1 | 1.4 | 3.5 |
| T | 10[e] | 4 | 6 | 0.7 | 0.2 | 0.9 |
| **TOTAL** | 2,004 | 707 | 1,297 | 23.7 | 45.9 | 69.6 |

**Key:** **A** - Agriculture; **FAA** - Federal Aviation Administration; **Ar/ACE** -Army/Army Corps of Engineer; **DOE** - Energy; **FPA** - Federal Power Agency; **CG** - Coast Guard; **DOJ** - Justice; **N** - Navy; **DOI** - Interior; **AF** - Air Force; **T** - Treasury; * - Agency input

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[a] The cost data provided by an agency was used whenever appropriate, otherwise the retuning and relocation costs were calculated as before (see Tables A-1 and A-2, respectively).

[b] If data is unavailable, the number of fixed microwave frequency assignments in the GMF for the 1710-1755 MHz frequency range was used to determine the number of fixed microwave sites.

[c] The calculated values include the following: (1) $250,000 per additional relay station and $50,000 per site refurbishment; (2) 15-yr. recurring cost (i.e., $3,000 per site per yr.); (3) site visits at $800 per site; and (4) $9,000 to procure a set of "hot-switchover" units to fulfill the system's function while relocation is taking place.

[d] It is assumed that retuning of systems will be contracted to commercial entities. The calculated values include the following: (1) $800 for site visits (i.e., two visits at $400 per site visit) and (2) $9,000 to procure a set of "switchover" units to fulfill the system's function while retuning is taking place.

[e] Fixed microwave systems supporting safety-of-life operations (i.e., only those outside the 150 km radius of the 25 most populated U.S. cities) are exempted from reallocation.

[f] FAA provided a value of $100,000 per site for in-band retuning cost for its fixed microwave systems.

[g] FPA includes the Tennessee Valley Authority, the Bonneville Power Admin., the Western Area Power Admin., the Southwestern Power Admin., the Southeastern Power Admin. and the Alaska Power Admin.. FPA assignments are exempted from reallocation.

[h] Only the INS 90 fixed microwave stations are considered for the costs analysis. All but one support narrowband operations. The FBI 427 fixed microwave systems are currently being converted to leased commercial services.

**TABLE A-5**

Estimated Retuning Costs for Mobile Systems in the 1710-1755 MHz Band[a]

| Station Classes | Number of Federal Government Agency Mobile Assignments | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Air Force | Army | Energy | Navy | NASA | Treasury | Transportation | Total |
| FB/ML | | | | 1 | | | | 1 |
| FLE | | 7 | | | | | | 7 |
| FLEC | | 1 | | | | | | 1 |
| FLEC/MOEC | | | | | | | 1 | 1 |
| MA | | 1 | 2 | 1 | | 1 | | 5 |
| MAD | 1 | | | | | | | 1 |
| ML | | 2 | 6 | 10 | | | | 18 |
| ML/MLP | | 1 | | | | | | 1 |
| MLD | 1 | | 2 | | | | | 3 |
| MO | | | | 17 | | | | 17 |
| MOEA | 1 | 2 | | 23 | 2 | | | 28 |
| MOEB | 2 | 1 | | 13 | 2 | 1 | | 19 |
| MOD | | | 1 | | | | | 1 |
| **Retuning Cost** | 9K | 53K | 79K | 248K | NA* | NA* | 12K | 401K |

*NA = Not applicable

## Special Areas of Operation

As mentioned earlier, there are cases where a fixed microwave station operates in an isolated area and is geographically separated from a metropolitan area. Stations serving in this capacity are allowed for continued use, on non-interference basis, until their areas of operation become urbanized and a potential threat of EMI exists between these stations and other communications systems that will be introduced in the locality. Such stations are usually employed by USDA, DOI and ACE for backbone microwave communications systems supporting various Federal Government requirements such as: disaster control within national parks and forests; management, maintenance and distribution of water and electric power to isolated remote areas; and control of land mobile radios supporting law enforcement. Currently, there are approximately one thousand stations in this category in the 1710-1755 MHz band.

[a] The estimated cost per agency is based on the following assumptions: (1) an assignment for the station classes FB, FLE, and FLEC represents a base/repeater station; (2) an assignment for the station classes MOEC, ML, MLP, MO, MOD and MLD represents 25 portables/mobiles; (3) the cost to retune a mobile/portable is $350, and (4) the cost to retune a base/repeater station is $3,300. The estimated cost per agency, however, does not include cost assessment on the agency's aeronautical or flight telemetering and aeronautical mobile systems.

## ENDNOTES

Requests for copies of references from Federal departments and agencies should be referred to the originating organization. Parts of the reference material may be exempt from public release.

1. U.S. Dep't of the Interior (DOI) Comments, at 3 (May 4, 1994), filed in response to NAT'L TELECOMMUNICATIONS AND INFO. ADMIN. (NTIA), U.S. DEP'T OF COMMERCE, SPECIAL PUBLICATION 94-27, PRELIMINARY SPECTRUM REALLOCATION REPORT, (Feb. 1994) [hereinafter NTIA PRELIMINARY REPORT and all comments cited refer to this report, unless otherwise stated].
2. U.S. Dep't of the Army Memorandum for Director, Command, Control, Communications and Intelligence, Assistant Secretary of Defense, at 1 (Dec. 30, 1993).
3. Fax from D. Willis (FAA/Spectrum Planning and Int'l Division) to E. Cerezo (NTIA/OSM), Subject: Corrections to the FAA Comments to the NTIA DRAFT FINAL SPECTRUM REALLOCATION REPORT, at 6 (Jan. 25, 1995).
4. DOI Comments, *supra* note1, at 14.
5. U.S. Dep't of Justice (DOJ) Comments, at 3-4 (May 31, 1994).
6. U.S. Dep't of Agriculture (USDA) Comments, at 2 (May 11, 1994).
7. NTIA, U.S. Dep't of Commerce, NTIA Report 92-285, *Federal Spectrum Usage of the 1710-1850 MHz and 2200-2290 MHz Bands,* at 5-5 (March 1992).
8. Senkowski, R.M., et al., UTAM Plan for Financing and Managing 2 GHz Microwave Relocation, at 27 ( Aug.1, 1994)
9. DOI Comments, *supra* note 1, at 14.
10. *Id.* at 19.
11. DOJ Comments, *supra* note 5, at 3.
12. *Id.*
13. DOI Comments, *supra* note 1, at 22.
14. USDA Comments, *supra* note 6, at 5.
15. DOI Comments, *supra* note 1, at 8.
16. DOJ Comments, *supra* note 5, at 6.
17. DOI Comments, *supra* note 1, at 3.

# APPENDIX B
# AMATEUR SHARING STUDY

## INTRODUCTION

The preliminary reallocation plan identified the 2300-2310, 2390-2400, and 2402-2417 MHz bands as part of the 200 MHz to be reallocated to the FCC for non-Federal use. These bands are allocated to the amateur and amateur-satellite services on a secondary basis. Based on the public comments, subdividing the 2400-2450 MHz band into three parts, as proposed in the Preliminary Report, would not meet the needs of the principal users of the band. However, reallocating the entire 2400-2450 MHz band would give the FCC greater flexibility in developing a comprehensive plan to address the spectrum needs of the amateurs as well as the other users of the band. Therefore, the 2400-2402 and 2417-2450 MHz band segments will be included in the final reallocation plan for mixed Federal and non-Federal use.

Though NTIA's proposed reallocation to the FCC for non-Federal use does not in itself deny these frequencies to the amateur radio services, the amateur radio community believes these actions set the stage for the amateur services having limited access in the reallocated bands. Title VI requires that the Secretary of Commerce determine the extent to which, in general, the private sector can share the frequencies to be reallocated with the incumbent amateur radio licensees.[1] This requirement presupposes that NTIA knows the specific types of potential commercial and public-safety applications intended by the FCC for the reallocated spectrum, or at least the range of possible uses. Until candidate radio services are selected or at least identified, it is difficult for NTIA to conduct the mandatory sharing study required by Congress in Title VI. The only practical means for the Secretary to discharge NTIA's statutory obligation is to conduct a general sharing study based on information about present and near-term future amateur uses of the segments proposed for reallocation, and a range of possible commercial and public-safety applications.

## AMATEUR BAND USAGE

The 2300-2450 MHz band comprises part of the spectrum known in the amateur community as the 13 cm band. The amateur allocation at 13 cm is currently split into two parts: 2300-2310 MHz and 2390-2450 MHz. A band plan outlining the structure of amateur spectrum uses and needs for the 2300-2450 MHz band is given in Figure B-1.[2] As indicated in the Figure B-1, the amateur radio community intends to develop the 2300-2450 MHz band for the following uses: weak-signal experimentation, narrowband and wideband point-to-point linking, satellite activities, and amateur television transmission.

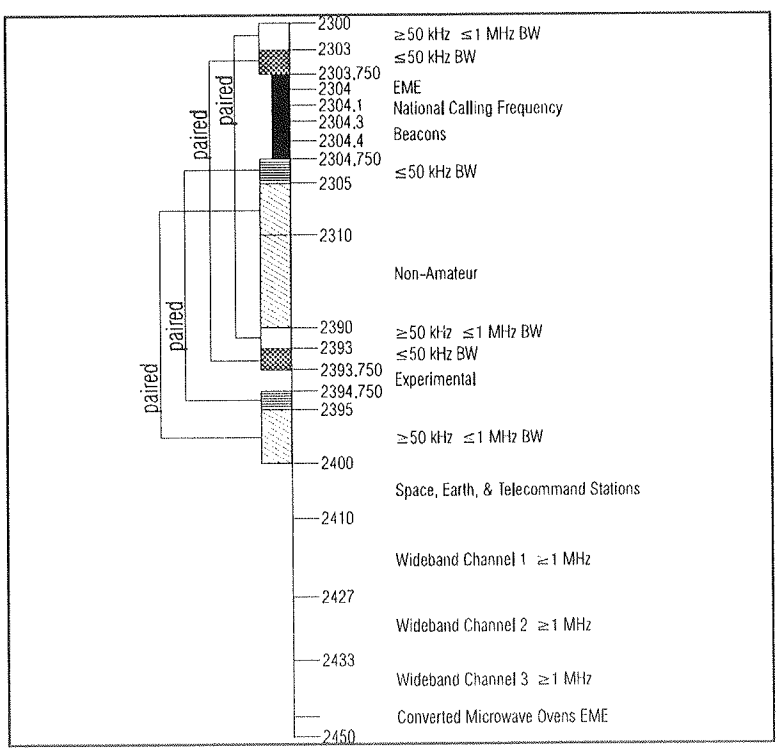


**Figure B-1.** 2300-2450 MHz Amateur Band Plan.

## SHARING WITH AMATEUR OPERATIONS

The amateur radio service has successfully co-existed with Federal fixed, mobile and radiolocation services (i.e., radar) for nearly fifty years.[3] As indicated in many of the public comments on the Preliminary Report and the FCC NOI, this sharing arrangement has been successful for both Federal and amateur spectrum users. This success is primarily due to the fact that much of the Federal spectrum usage is located away from populated areas, minimizing potential interference as well as the amateur's ability to utilize the guard bands placed between different types of Federal services.[4] In addition to the Federal Government, the amateur radio service shares the 2400-2450 MHz segment with non-licensed devices and Industrial, Scientific, and Medical (ISM) devices. Recently, amateurs have indicated that there are practical problems sharing spectrum with commercial services that have a relatively high transmitter power, a high number of stations in heavily populated areas, and/or high duty cycle.[5] The following paragraphs will examine in general the sharing possibilities for each of the four amateur radio operations that could be potentially impacted by the spectrum reallocation.

### Weak-Signal Operations

Currently most amateur weak-signal operations take place at or near 2304 MHz. The comments submitted by representatives of the amateur radio service on the Preliminary Report indicate that the spectrum from 2448-2450 MHz is also of interest to amateurs involved in weak-signal operations.[6] Amateurs are engaged primarily in employing weak-signal techniques for extended range communications.[a] Weak-signal stations typically employ sensitive narrow bandwidth receivers (3 kHz or less), high transmitter power, and highly directional antennas. Most of the time the highly directional antennas are pointed well above the horizon.[7] Based on these operational constraints the amateurs indicate that weak-signal stations could co-exist with certain commercial or public-safety terrestrial operations. The receivers used in weak-signal communications are sensitive and cannot operate in a high-noise environment; therefore, sharing with a high-power, high-density commercial application is considered impractical.[8] Commercial satellite applications are also likely to conflict with typical weak-signal operations. The amateurs feel that satellite uplinks would be a problem since as a satellite transponder travels over the horizon, it could be easily saturated by the high-power signal emitted from a weak-signal transmitter.[9] Satellite downlinks are also seen as potential problems because of the sensitivity of the weak-signal receivers

### Television Operations

As shown in Figure B-1, amateur television (ATV) will occupy three channels: 2410-2427, 2427-2433, and 2433-2450 MHz. The concern expressed by the amateur community is that a loss of spectrum at the lower portion of the 2400 MHz band would force other displaced amateur operations into the ATV channels.[10] With ATV likely to evolve to a digitally compressed format, it will have a better chance to co-exist in a high interference environment.[11] In addition, the rapidly expanding use of digital compression at reasonable costs may lessen the need of 40 MHz for ATV operations. However, the amateur commenters feel that if the spectrum is reallocated for commercial applications with a high duty

[a] Amateur weak-signal stations communicate by many propagation methods such as tropospheric ducting and scatter; low atmospheric inversion ducting; refraction and reflection off natural objects (i.e., mountains); and EME (moonbounce), to name a few.

cycle, the band would be rendered virtually unusable for ATV.[12] Currently ATV operates in the presence of ISM and spread spectrum non-licensed devices. Most ATV operations are expected to occur in residential areas, or proximate to residential areas, with current uses primarily in metropolitan areas near cities and suburbs. The simplest type of commercial use to accommodate in these allocations would be licensed terrestrial point-to-point stations, or services not routinely located proximate to residential areas. Commercial or public-safety applications with low duty cycles would be more likely to avoid interference to and from ATV operations in the same band, and digital operation would be preferred over analog technologies. Wide bandwidth and spread spectrum uses are particularly suitable to sharing with ATV operations.[13]

## Point-to-Point Operations

Point-to-point amateur operations involve paired frequencies with spacing from 40 MHz to 150 MHz. This is accomplished by using portions of the 2300-2310 MHz and the 2390-2400 MHz bands. Two bands are required because transmission and reception from one site simultaneously normally involves using different frequencies to increase isolation between the transmitter and receiver. Amateur point-to-point applications use high-performance receivers to ensure good path reliability. These receivers are protected by filters sufficient to reject their own transmitter operating on the same antenna. These filters are more than sufficient to reject near-band or out-of-band interference of any normal magnitude.[14] The amateur fixed point-to-point services may effectively use the same spectrum as low-power spread spectrum or medium bandwidth digital commercial devices intended for localized uses.[15] Several public-safety commenters to the FCC suggested that the 2390-2400 MHz band would be particularly suitable for the advanced private mobile communications technologies described in the COPE Petition, including private fixed service microwave operations at remote site locations.[16] Electronic Toll and Traffic Management (ETTM) systems could possibly share with amateur point-to-point operations. ETTM systems are low-power, low duty cycle devices employing directional antennas.[17] In general these systems will be used on highways away from residential areas where interference problems could be handled on a case-by-case basis. The amateurs also feel that high-power wide-area operations should be restricted in favor of more localized commercial and public-safety applications.[18]

## Satellite Operations

Amateur-satellite downlink operations are planned for the 2400-2410 MHz portion of the 2300-2450 MHz band as shown in Figure B-1. However, all current and near future amateur-satellite usage can be accommodated in the 2400-2402 MHz band segment. TABLE B-1 gives a list of the amateur-satellite operations in the 2400 MHz band.[19] The amateur-satellite community is planning to increase its use of 2400-2402 MHz to include uplinks on the next generation of satellites. Amateur-satellite operations employ a relatively weak signal and often use high-power

**TABLE B-1**
Amateur-Satellite Usage in the 2400 MHz Band

| Amateur-Satellite | Band (MHz) |
|---|---|
| AMSAT-OSCAR 13 | 2400.711-2400.747 & 2400.650 |
| UOSAT-OSCAR 11 | 2401.5 |
| PACSAT (AO-16) | 2401.1 |
| Dove (DO-17) | 2401.22 |
| Phase 3D | 2400.500-2400.900 & 2400.100-2400.500 |

terrestrial transmitters. This poses interference potential to adjacent operations and those operations pose potential interference to the terrestrial satellite receivers (most commonly through excessive sideband noise). The amateurs feel that any adjacent operations should be limited to an assigned occupied bandwidth of 50 to 100 kHz to minimize sideband noise. The amateurs contend that this bandwidth limitation for commercial and public-safety systems will also encourage the use of filtering on the adjacent systems receivers which will aid in protecting them from high-power satellite (terrestrial) transmitters.[20] In evaluating the feasibility of frequency sharing with the amateur-satellite service, it is important to realize two distinct types of satellites are employed in this service. One is the high-altitude, elliptical orbit type of satellite. The other, more numerous type is the low-earth-orbit (LEO) satellite, generally in circular orbits below 1000 kilometers in altitude. During approximately half the time in which an amateur LEO satellite is within range of an earth station, it is less than 10 degrees above the horizon. Thus, unlike commercial services using geostationary spacecraft, the elevation angle of amateur earth stations is unlikely to provide much, if any, relief from interference from and to terrestrial services.[21] Spread spectrum local area networks can effectively share with amateur-satellite operations, because satellite receivers are generally not collocated with those type of devices.[22] The amateur-satellite community as a whole is concerned about sharing spectrum with high-density mobile commercial services. The general consensus among amateur commenters is that it would be far less difficult to share with point-to-point microwave links since the chances of interference would be relatively slight and could be dealt with on a case-by-case basis.[23] Several public-safety organizations suggested that spectrum in the 2400-2450 MHz band could be used for private fixed microwave service operations in remote locations.[24] The amateurs also indicate that low-power, low duty cycle ETTM systems using directional antennas can also share with amateur-satellite operations.

## SUMMARY

The importance of the 2300-2450 MHz band to the amateur radio service is principally in the near future. The sharing opportunities between amateurs and commercial services depend largely on the development of a sharing plan which will permit the orderly growth of the amateur users of the bands while at the same time supporting commercial and public-safety applications. The fundamental ability of the amateurs to continue operations in the reallocated bands is dependent largely on the characteristics of the commercial and public-safety applications that are to be added to the bands. TABLE B-2 provides an overview of the potential impact to current and future amateur operations and possible sharing options between the amateur service and commercial and public-safety applications.

## TABLE B-2

Overview of Potential Impact to Amateur Operations and Sharing Options

| Amateur Operation | Potential Impact | Sharing Options |
|---|---|---|
| **Weak-Signal** | | |
| 2304 MHz | Potentially impacted by spectrum reallocation; Protecting 0.5 MHz around 2304 MHz would eliminate impact. | Federal Government; Non-licensed device (Part 15) applications; Certain commercial terrestrial and public-safety applications. |
| 2450 MHz | Not impacted by spectrum reallocation.[a] | |
| **Amateur TV** | | |
| Current analog | 1 of 3 channels potentially impacted; Conversion of one ATV channel from FM to AM would minimize impact. | Federal Government; Industrial, scientific, and medical (ISM) applications; Part 15 applications. |
| Future digital | Expected minimal impact; at least 11 compressed video channels, each 3 MHz wide, will be available. | Federal Government; ISM applications; Part 15 applications; Commercial spread spectrum applications; Commercial or public-safety applications; Low duty cycle applications. |
| **Point-to-Point** | | |
| Current narrowband | Potentially impacted by spectrum reallocation. | Federal Government; ISM applications; Part 15 applications. |
| Future wideband | 30% of available band potentially impacted. | Federal Government; ISM applications; Part 15 applications; Commercial and public-safety point-to-point applications; Low-power commercial or public-safety spread spectrum applications; Electronic Toll and Traffic Management (ETTM) systems. |
| **Satellite** | | |
| Current generation | Not impacted by spectrum reallocation.[a] | Federal Government; ISM; Part 15 applications; Spread spectrum Local Area Networks; Commercial point-to-point applications; Public-safety microwave operations in rural areas; ETTM systems. |
| Next generation | Not impacted by spectrum reallocation.[a] | |
| Long-term | Expansion beyond 2 MHz potentially impacted. | |

[a] This assumes that the FCC will take amateur usage of the band into consideration when identifying additional services to be placed in this spectrum.

## ENDNOTES

Requests for copies of references from Federal departments and agencies should be referred to the originating organization. Parts of the reference material may be exempt from public release.

1. 47 U.S.C. § 923(c)(3)(C) (Supp. V 1993).
2. Southern California Repeater and Remote Base Assoc. (SCRRBA) Comments, at 10 (May 10, 1994), filed in response to NAT'L TELECOMMUNICATIONS AND INFO. ADMIN. (NTIA), U.S. DEP'T OF COMMERCE, SPECIAL PUBLICATION 94-27, PRELIMINARY SPECTRUM REALLOCATION REPORT (Feb. 1994) [hereinafter NTIA PRELIMINARY REPORT and all comments cited refer to this report, unless otherwise stated].
3. SCRRBA Comments, *supra* note 2, at 7.
4. *Id.*; American Radio Relay League Comments, at 8 (Nov. 6, 1992), filed in response to NTIA Notice of Inquiry in ET Docket No 92053-2132, 57 Fed. Reg. 25,010 (June 12, 1992) [hereinafter *NTIA NOI*]; Northern Amateur Relay Council of California Comments, at 3 (June 15, 1994), filed in response to FCC Notice of Inquiry ET Docket No 94-32, FCC 94-97, 59 Fed. Reg. 6005 (May 4, 1994) [hereinafter *FCC NOI*].
5. SCRRBA Comments, *supra* note 2, at 7; Radio Amateur Satellite Corp. (AMSAT) Comments, at 4 (June 8, 1994), filed in response to *FCC NOI*, *supra* note 4.
6. San Bernardino Microwave Society Inc. Comments, at 3 (May 2, 1994).
7. Southern California Repeater and Remote Base Assoc. (SCRRBA) Comments, at 13 (June 15, 1994), filed in response to *FCC NOI*, *supra* note 4.
8. AMSAT Comments, *supra* note 5, at 4.
9. SCRRBA Comments, *supra* note 7, at 14.
10. Northern Amateur Relay Council of California Comments, at 2 (June 13, 1994), filed in response to *FCC NOI*, *supra* note 4.
11. Northern Amateur Relay Council of California Comments, *supra* note 10, at 2.
12. SCRRBA Comments, *supra* note 7, at 4.
13. American Radio Relay League Comments, at 14 (June 15, 1994), filed in response to *FCC NOI*, *supra* note 4.
14. SCRRBA Comments, *supra* note 7, at 14.
15. *Id.* at 11.
16. Coalition of Private Users of Emerging Multimedia Technologies (COPE) Comments, at 5 (June 15, 1994), filed in response to *FCC NOI*, *supra* note 4.
17. Florida Dep't of Transportation Comments, at 1 (May 10, 1994).
18. SCRRBA Comments, *supra* note 7, at 10.
19. AMSAT Comments, *supra* note 5, at 5.
20. SCRRBA Comments, *supra* note 7, at 10.
21. Radio Amateur Satellite Corp. (AMSAT) Reply Comments, at 7 (June 30, 1994), filed in response to *FCC NOI*, *supra* note 4.
22. AT&T Corp. Comments, at 2 (June 15, 1994), filed in response to *FCC NOI*, *supra* note 4.
23. AMSAT Comments, *supra* note 5, at 4.
24. COPE Comments, *supra* note 16, at 5.

# APPENDIX C
# SHARING CRITERIA FOR THE 1670-1675 MHZ BAND

## INTRODUCTION

As discussed elsewhere in this report, the 1670-1675 MHz band will become available for mixed use in 1999 subject to the continued operation of meteorological satellite (METSAT) downlinks. NTIA has decided to permit immediate mixed use on a more restricted basis: all Government operations must be protected until the spectrum transfer in 1999. These operations include METSAT downlinks received at Wallops Island, Virginia and Fairbanks, Alaska, and radiosonde transmissions received at a large number of locations throughout the United States and its possessions (US&P). The National Weather Service (NWS) provided the following sharing criteria for compatibility with radiosondes and ground receivers in the 1670-1675 MHz band.

## PROTECTION FOR RADIOSONDES

The largest user of radiosondes within the US&P is NWS, which considers the following sharing criteria adequate to protect its operations. The reader should be aware that radiosondes are also operated by a number of other Federal organizations, such as DOD, DOE, NASA, and NSF. These operations are at times and places unrelated to NWS, and their protection criteria may differ. Accordingly, it will be necessary for non-Federal users of the band also to coordinate with these agencies prior to licensing. In addition, radiosondes are operated by various non-Federal entities, such as universities and state and local governments.

For compatibility with NWS, the power density in the 1670-1675 MHz range from all sources and from all azimuths at each NWS ground-based receiver site must not exceed the following limits:

> Power density in a 1.3 MHz bandwidth shall not exceed -150 dBW/meter$^2$ more than 0.24% of the time, nor -135 dBW/meter$^2$ more than 0.03% of the time. These power densities correspond to field strengths of 0.67 microvolts/meter and 3.5 microvolts/meter respectively. These levels are applicable during the hours of 2300-0200 Universal Time (UT) and 1100-1400 UT every day. During periods of abnormal weather and special research programs, protection must be provided at additional times. These special events can last 3 or more hours and may cover one or more launch sites. During current or anticipated regional level severe weather conditions when the accuracy of weather forecasts, warnings or alerts could affect safety-of-life and property for communities, means must be provided by the non-Federal user(s) to shut down their transmitters within 10 minutes of being notified and prior to radiosonde release. The non-Federal transmitters shall remain off until the end of the radiosonde flight(s). NOAA agencies such as the National Severe Storms Laboratory and the Hurricane Research Division require these specialized radiosonde flights for severe weather and hurricane forecasting.

## PROTECTION FOR METSAT RECEIVERS

Wallops Island, Virginia, is the location of the Command and Data Acquisition (CDA) station used to control NOAA's Geostationary (GOES) satellites. For GOES-7, the currently operational spacecraft, the receiver thermal noise level is -145 dBW into a 20 MHz bandwidth centered on 1681.6 MHz.

In the new generation of GOES satellites, called GOES I through M, the received signal will occupy the band centered on 1676 MHz with a 5.0 MHz bandwidth. The noise level is not currently known. The

first of these satellites, the former GOES-I, now called GOES-8, is currently in its operational demonstration phase. Should tests be completed successfully, it will replace Meteosat-3 around February, 1995. GOES-7 will eventually be replaced by GOES-9 around early 1996. In an emergency (e.g., failure of an operational satellite), GOES-7 may be recalled to operational status at any time up to the end of its useful life, estimated to be about two years.

The criterion for adequate protection of the CDA stations at Wallops Island and Fairbanks is as follows:

- The cumulative interference at the receiver input in any 1 kHz band can be no higher than 10 dB below the receiver thermal noise power in that band, for 99.99 percent of the time during any one-month period.

- The cumulative interference at the receiver input in any 1-Hz band can be no higher than the receiver thermal noise power in that band, for 99.99 percent of the time during any one month period.

For purposes of coordination, the receiver noise temperature in the band 1670-1675 MHz is assumed to be 50 Kelvins. Therefore the thermal noise power at the receiver input is -182 dBW in 1 kHz, and -212 dBW in 1 Hz. The receive antenna gain is assumed to be 49 dBi, and the antenna is pointed at the geosynchronous arc between 75 W and 135 W longitude.

Appendix 28 of the ITU Radio Regulations is customarily used to develop coordination contours for satellite stations. However, this Appendix contains no coordination criteria for METSAT ground stations — they are currently under development — and makes certain assumptions regarding the number and characteristics of the terrestrial stations with which the satellite ground stations must share the band. In the present case, there is no way to predict the use of the band by non-Federal users. It will therefore be necessary to coordinate all proposed ground systems, regardless of type or location. Moreover, the use of airborne or satellite transmitters in this band must be avoided.

# APPENDIX D
# TECHNICAL ISSUES REGARDING THE 1761-1842 MHZ BAND SEGMENT

## INTRODUCTION

Expanding the reallocation of the 1710-1755 MHz band to include the 1755-1760 MHz and 1845-1850 MHz band segments is addressed for several reasons. The general consensus among the public-safety organizations responding to the Preliminary Report and the FCC NOI is that the 1710-1755 MHz band is the only band identified for reallocation below 3 GHz that is feasible to support the development of the wide-area emerging technology systems specified in the Coalition of Emerging Multimedia Technologies (COPE) Petition for Rule Making. Thirty-seven commenters on the FCC NOI supported the recommendations made in the COPE petition. Commercial entities believe that the reallocation of a larger portion of the band would greatly enhance their ability to provide new and advanced telecommunications technologies to benefit the needs of the public. In the FCC Report, the FCC supports the reallocation of a larger portion of the 1710-1850 MHz band and specifically recommends that the 1755-1760 MHz and 1845-1850 MHz band segments be reallocated for public-safety and commercial applications. The FCC report states that reallocation of the 1755-1760 MHz band segment would provide a contiguous 50-MHz block of spectrum located in a band for which equipment could be quickly developed. Moreover, the 1845-1850 MHz band segment is immediately adjacent to spectrum currently allocated for PCS and could serve as an adjunct to this service.[1]

The NTIA Preliminary Report discussed the 1710-1850 MHz band as four separate band segments: 1710-1755, 1755-1761, 1761-1842, and 1842-1850 MHz. The 1710-1755 MHz band segment was proposed for reallocation to the private sector on a mixed use basis. The 1761-1842 MHz band segment was excluded from reallocation because it is used by Air Force to operate the Space-Ground Link Subsystem (SGLS). The SGLS has 20 discrete factory preset uplink frequencies throughout the 1761-1842 MHz band segment that provide tracking, telemetry, and control for all military satellites.[2] Over 90 satellites, both geostationary and non-geostationary, are supported by SGLS. In addition to the five fixed SGLS site locations, DOD has transportable SGLS-compatible earth stations that are used to provide additional coverage for launch and on-orbit operations.[3]

In addition to SGLS, DOD also uses this band segment for Air Combat Training Systems (ACTS) such as, Air Force's Air Combat Maneuvering Instrumentation (ACMI) and Navy's Air Combat Maneuvering Range (ACMR) and Tactical Aircrew Combat Training System (TACTS). The ACMI, ACMR, and TACTS all employ factory preset frequencies in 1761-1842 MHz that are used to transmit information to and from training aircraft. Training support systems such as these are key elements in the military's efforts to provide realistic simulation and pilot training in a peacetime environment.[4] As stated in Section 4, NTIA reaffirms its decision not to include the 1761-1842 MHz band segment in the reallocated spectrum.

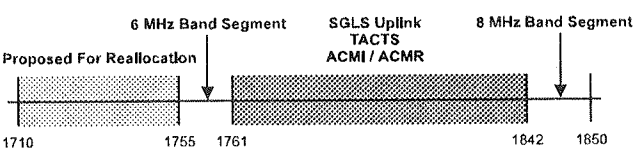


**Figure D-1.** 1710-1850 MHz Band Breakdown .

As shown in Figure D-1, two band segments remain for consideration: 1755-1761 MHz (6 MHz) and 1842-1850 MHz (8 MHz). The Preliminary Report states that a guard band must exist around the 1761-1842 MHz band segment to provide adequate interference protection for both Federal satellite

command and control and combat training systems; and PCS (or other adjacent-band users).[5] The question remains as to how wide the guard band should be to protect Federal and non-Federal operations. Transmitter and receiver characteristics (power, antenna gain, emission spectrum, and receiver selectivity) as well as projected PCS transmitter and receiver characteristics will be used to estimate the guard band requirements around the 1761-1842 MHz band segment.

## FIXED MICROWAVE SYSTEMS IN THE 1755-1850 MHZ BAND

Since fixed microwave systems currently operate in the 1710-1850 MHz band with SGLS uplink transmitters it is reasonable to characterize the impact of this existing radio service. From the Government Master File it can be found that in each 5 MHz band segment from 1755-1850 MHz there are an average 492 fixed assignments with typical parameters given in TABLE D-1.

**TABLE D-1**
Characteristics of Fixed Microwave Systems in 1755-1850 MHz Band

| | |
|---|---|
| **Transmitter Bandwidth** | 1-8 MHz |
| **Transmitter Power** | 3 Watts |
| **Antenna Gain** | 28 dBi |

### Interference from Fixed Microwave Transmitters to Low-Orbiting SGLS Satellite Receivers

In this analysis a 1.8 meter parabolic antenna with a mainbeam gain of 28 dBi and a beamwidth of 8 degrees will be used to represent the fixed microwave transmitter in the 1755-1850 MHz band. Since an omnidirectional antenna is assumed for the SGLS satellite receiver, coupling will depend on the mainbeam and sidelobe characteristics of the fixed microwave antenna.

If the fixed microwave transmitters are randomly distributed regarding geographic position as well as azimuth pointing angle, then the number of mainbeam couplings that can occur will be the number of emitters contained in the annular ring of the SGLS low-orbiting satellite footprint where it can be viewed at elevation angles between 0 and 4 degrees. The percent of the area that the annular ring occupies, of the entire footprint, times the number of fixed transmitters, will give the number of mainbeam couplings that can occur. The area of the annular ring and the area of the SGLS low-orbiting satellite footprint are calculated as follows:

$$A_{annulus} = 2\pi R^2(\cos\theta_1 - \cos\theta)$$

$$A_{footprint} = 2\pi R^2(\cos\theta)$$

where

$$\theta = 90 - \sin^{-1}(R/(R+H)) \quad \text{(0 degree elevation)}$$

$$\theta_1 = 90 - 4 - \sin^{-1}((R/(R+H))\cos 4) \quad \text{(4 degree elevation)}$$

R is the radius of the earth, and H is the satellite altitude.

The ratio of the area of the annular ring and the satellite footprint is calculated as follows:

$$A_{annulus}/A_{footprint} = (\cos\theta_1 - \cos\theta)/\cos\theta$$

From the above calculation, two percent of the 492 transmitters can intersect the SGLS low-orbiting satellite with their mainbeam. Because of the random azimuth pointing angles, only

$$(8 \text{ degrees}/360 \text{ degrees})\,(.02)\,(492) = .21$$

will be likely to do so. Therefore, the probability of intersecting the SGLS low-orbiting satellite receiver with a single fixed microwave transmitter antenna mainbeam is low; the probability of multiple intersections is very low. Consequently, for analysis purposes, a single mainbeam coupling will be considered.

In the mainbeam case the elevation angle is near zero degrees, and the slant range to the satellite (250 km orbit) is 1,979 km. For the remaining 491 fixed microwave transmitters, coupling will be in the sidelobe region of the fixed microwave antenna pattern. If the representative elevation angle to the satellite from these transmitters is 45 degrees, the slant range is 415 km. The total interference power density at the SGLS low-orbiting satellite receiver is calculated by

$$I_o = SPD + G_T + 10\log(n) - L_{FS} - G_R$$

where

$I_o$ is the interference power density at the SGLS low-orbit satellite receiver (dBW/Hz);
SPD is the fixed microwave power spectral density (dBW/Hz);
$G_T$ is the fixed microwave transmitter antenna gain (dBi);
n is the number of fixed microwave transmitters;
$L_{FS}$ is the free space path loss (dB);
$G_R$ is the SGLS receiver antenna gain (dBi).

For a 5 MHz emission bandwidth, the spectral power density is -62.2 dBW/Hz. Using the parameters in TABLE D-1 and the previous calculations, the interference power density at the SGLS low-orbit satellite receiver from fixed microwave transmitters is

$$I_o = -185 \text{ dBW/Hz}$$

It should be noted that a Monte Carlo simulation of the interference to low-orbiting satellites in the 2025-2110 MHz band from fixed microwave emissions reaches a very similar estimate of the interference power density.[6]

## Interference from Fixed Microwave Transmitters to Geostationary SGLS Satellite Receivers

Elevation angles to the SGLS geostationary satellites from fixed microwave transmitters range from 15 to 45 degrees. Using the sidelobe pattern for fixed microwave antennas, the gain in the direction of the SGLS geostationary satellite receiver for this range of elevation angles is

$$G(\theta) = 52 - 10\log(D/\lambda) - 25\log(\theta)$$

where

$G(\theta)$ is the off-axis antenna gain (dBi);
$\theta$ is the fixed microwave elevation angle (degrees);
D is the diameter of the fixed microwave antenna (m);
$\lambda$ is the wavelength (m).

Using an antenna diameter of 1.8 meters and a frequency of 1755 MHz, the off-axis antenna gains for elevation angles of 15 and 45 degrees are:

$$G(15) = 12.3 \text{ dB}$$
$$G(45) = .4 \text{ dB}$$

The slant range to a geostationary SGLS satellite at elevation angles of 15 and 45 degrees is 40,277 km and 37,627 km respectively. These slant ranges correspond to a free space path loss of approximately 189 dB. For analysis purposes it is assumed that half of the 492 fixed microwave transmitters are at each extreme of elevation angle to the SGLS geostationary satellite. Using the equation stated earlier, the interference power density at the SGLS geostationay satellite receiver from fixed microwave transmitters is given below:

$$I_o = -215 \text{ dBW/Hz}$$

### Impact to SGLS Satellite Receiver from Fixed Microwave Transmitters

Since fixed microwave systems operated by the FPAs and certain safety-of-life stations will continue to operate indefinitely in the 1755-1850 MHz band segment, their contribution must be included in the total interference power density calculation for the SGLS satellite receivers. From the preceding discussion the interference levels from the existing fixed microwave transmitters are: -185 dBW/Hz (low-orbiting satellites) and -215 dBW/Hz (geostationary satellites). When interference from the proposed terrestrial mobile service are on this order, the total interference power density at the SGLS satellite receiver will be increased by 3 dB to take into account the existing interference from fixed microwave transmitters.[7]

## TERRESTRIAL MOBILE SERVICES

The mobile telecommunications service industry continues to change as technologies continue to evolve. Because of the volatility, it is difficult to predict what the industry will look like in 5, 10, or 15 years. Different proponents have different perspectives on the future of mobile services, and how the

pieces will fit together is not clear. Among the fastest-growing segments of the mobile telecommunications industry are terrestrially-based radio systems serving mobile users in cars (mobile) and on foot (personal). Although clear service definitions and specifications have not yet been developed, the Future Public Land Mobile Telecommunications System (FPLMTS) is currently conceived as a terrestrially-based system located throughout a region to provide an array of voice, data, and video services to mobile users.[8] These characteristics will also be true for Personal Communications Services (PCS), to be allocated in the 1850-1990 MHz band. Estimated characteristics for these terrestrially based mobile and personal stations are given in TABLE D-2.[9]

**TABLE D-2**
Estimated Parameters For Terrestrial Mobile And Personal Stations

| | Base and Mobile Stations | Personal Stations |
|---|---|---|
| **Transmitter** | | |
| **Transmitter e.i.r.p.** | 10 W *base* 1 W *mobile* | 3 mW *indoor* 20 mW *outdoor* |
| **Bandwidth per Channel** | 25 kHz | 50 kHz |
| **Traffic Density** | 582 E/km$^2$ | 25000 E/km$^2$ |
| **Assumed Bandwidth** | 140 MHz | 140 MHz |
| **Estimated e.i.r.p. Density** | -104 dBW/m$^2$/Hz | -123 dBW/m$^2$/Hz |
| **Receiver** | | |
| **Interference Threshold** | -117 dBm *indoor stations*<br>-119 dBm *outdoor stations* | |

The parameters shown in TABLE D-2 were taken from ITU-R Rec. 687-1. The e.i.r.p. densities given in TABLE D-2 represent a worst-case scenario insofar as they correspond to a mature system in an urban environment operating at its peak traffic load. The e.i.r.p densities for rural areas will be much less than those given in TABLE D-2. The e.i.r.p. densities are derived from the number of terminals per km$^2$ area and the power for each category of station (e.g., mobile or personal).

To facilitate sharing, an allocation of 10% of the total interference budget to external interference sources is used. ITU-R Rec. 687-1 specifies a level of -117 dBm for indoor personal stations and a level of -119 dBm for outdoor personal stations.[10] These values are shown in TABLE D-2 and represent maximum permissible interference levels that can be received by personal stations without significantly degrading the quality of the service provided. ITU-R Rec. 687-1 did not specify an interference threshold for the base stations.

### INTERFERENCE TO SGLS SATELLITE RECEIVERS FROM TERRESTRIAL MOBILE SERVICES

Interference to the SGLS satellite receiver will be assessed in terms of carrier-to-interference (C/I) ratio. The C/I ratio represents the number of dB by which the power level of the desired signal "C" at the input of the SGLS receiver exceeds the power level of the undesired signal "I" at the same point in the

receiver. The C/I ratios calculated in this analysis will not include the effects of signal processing performed by the SGLS receivers.

### SGLS Parameters Used in the Analysis

The nominal SGLS transmitter, receiver, and antenna characteristics used in this analysis are given in TABLE D-3.[11]

**TABLE D-3**
Nominal SGLS Characteristics

| | |
|---|---|
| **Earth Station Transmitter** | |
| **Frequency** | 1763.721 - 1839.795 MHz |
| **Output Power** | Fixed SGLS Stations: 2 - 7 kW<br>Transportable SGLS Stations: 250W - 1 kW |
| **Bandwidth** | 4 MHz with subcarriers |
| **Antenna Gain**<br>**Mainbeam**<br>**Sidelobe** | <br>41 dBi<br>23 dBi |
| **Satellite Receiver** | |
| **Selectivity**<br>**-3 dB**<br>**-20 dB**<br>**-60 dB** | <br>3.9 MHz<br>7.1 MHz<br>14.2 MHz |
| **Antenna Gain** | 0 dBi |

The sidelobe antenna gain given in TABLE D-3 is calculated based on the procedures specified in the International Telecommunication Union (ITU) Radio Regulations Appendix 29 for an elevation angle of 3 degrees.

### C/I Analysis for SGLS Low-Orbiting Satellite Receivers

The amount of interference received by a low-orbiting satellite is a function of the altitude of the satellite, the area over which the terrestrial mobile stations are deployed, their radiation characteristics, their population density and other factors.[12] Ignoring the effects of atmospheric refraction, the total area on the Earth visible from a satellite is given by:

$$A_0 = 2\pi (r_e)^2 (\beta - 1)/\beta \qquad \text{and} \qquad \beta = 1 + h/r_e$$

where

$r_e$ is the radius of the Earth (6378 km);
h is the altitude of the satellite.

For example, the total area visible from a low-orbiting satellite at an altitude of 250 km is $9.6 \times 10^6$ km$^2$.

The mobile and personal stations are assumed to be uniformly distributed over the field-of-view of the satellite. The amount of interference power received at the satellite due to stations within a spherical area bounded by $\delta_1$ and $\delta_2$ elevation angles is proportional to the e.i.r.p., station density, the spherical area, the transmitter antenna gain, the square of the range to the satellite, and the gain of the satellite receiving antenna.[13] The ratio of the station distribution to the total visibility area is given by:

$$A/A_0 = (\beta/(\beta\text{-}1))(\cos\theta_2\text{-}\cos\theta_1) \quad \text{and} \quad \theta_i = \cos^{-1}(\beta^{-1}\cos\delta_i)\text{-}\delta_i$$

The range to the satellite $R_s$ is given by

$$R_s = r_e\beta(\sin\theta_i/\cos\delta_i)$$

Using the above equations it was determined that approximately 14% of the total-visibility interference will be caused by terrestrial stations located between 0 and 5 degrees elevation angle and radiating isotropically ($\alpha$). The area of the spherical region bounded by elevation angles between 0 and 5 degrees is 44% of the total visibility area (A).[14] These values will be used to calculate the aggregate interference power density.

The aggregate interference power density at the output of the satellite receiving antenna caused by the emissions from the terrestrial mobile and portable stations operating in the field-of-view of a low-orbiting satellite is given by[15]

$$I_o = \rho + 10\text{Log}A + 10\text{Log}(\lambda^2/4\pi) + G_R - 10\text{Log}\alpha - 10\text{Log}(4\pi) - 20\text{Log}R_s - FDR - L$$

where

$I_o$ is the total interference power density from a given spherical area (dBW/Hz);
$\rho$ is the aggregate e.i.r.p. density (dBW/m$^2$/Hz);
A is the field of view within the range of elevation angles (0 to 5 degrees);
$\lambda$ is the wavelength (m);
$G_R$ is the antenna gain of the satellite receiving antenna (dBi);
$\alpha$ is the fraction of the total-visibility interference contributed by mobile and portable stations operating within the range of elevation angles (e.g., 0 to 5 degrees);
$R_s$ is the range to the satellite (km);
FDR is the frequency dependent rejection (dB);
L is the building penetration, shadow loss, and urban/rural loss (dB).

A document used in the development of ITU-R Rec. 687-1 specifies that building penetration loss, shadowing loss, the relative deployment of urban systems compared to suburban and rural systems, and the relative maturity of the systems will reduce the total interference power density by 20 to 40 dB.[16] A conservative value of 20 dB will be used in this analysis.

The FDR value used in the calculation of the interference power density is the attenuation of an undesired signal power by the SGLS receiver because of on-tune and off-frequency rejection. The on-

tune rejection occurs because of the limited bandwidth of a receiver with respect to the undesired terrestrial emission bandwidth. The off-frequency rejection is the rejection provided by detuning of the SGLS receiver with respect to the terrestrial transmitters. From the SGLS receiver selectivity given in TABLE D-3, a value of 23 dB corresponding to a 3.7 MHz frequency separation for the lower SGLS channel (1763.721 MHz) and approximately 40 dB corresponding to a 5 MHz frequency separation on the upper SGLS channel (1839.795 MHz) will be used in this analysis.

Using the parameters given above and a satellite altitude of 250 km, the aggregate interference power density resulting from personal and mobile terrestrial stations to a SGLS low-orbiting satellite receiver is given in TABLE D-4.

**TABLE D-4**

Aggregate Interference Power Density From Terrestrial Stations to SGLS Low-orbiting Satellite Receivers

| SGLS Channel | Mobile Stations $I_o$ (dBW/Hz) | Personal Stations $I_o$ (dBW/Hz) |
|---|---|---|
| **Lower** | -171 | -190 |
| **Upper** | -188 | -207 |

It should be noted that the values of FDR used in the calculation of $I_o$ represents a worst-case scenario insofar that it locates all of the mobile and personal stations in the first adjacent channel (minimum frequency separation) from the SGLS receiver. In a more realistic scenario, these stations will be distributed across the entire band, which will result in further reduction of the interference levels at the SGLS receiver. The FDR is one of the parameters in the determination of $I_o$ that is not already determined and is significant in determining compatibility.

The carrier power density at the SGLS receiver is given by:

$$C_o = P_T + G_T + G_R - 10\,\mathrm{Log}(BW) - L_{FS}$$

where

$C_o$ is the carrier power density at the SGLS receiver (dBW/Hz);
$P_T$ is the SGLS earth station transmitter power (dBm);
$G_T$ is the SGLS earth station transmitter antenna gain (dBi);
$G_R$ is the SGLS satellite receiver antenna gain (dBi);
BW is the SGLS earth station transmitter bandwidth (Hz);
$L_{FS}$ is the free-space path loss (dB).

To compute the carrier power density at the SGLS receiver, a transmitter power of 2 kW will be used for fixed SGLS stations and a value of 250 W will be used for transportable SGLS stations. In addition, during approximately half of the time low-orbiting satellites are within range of the earth station at elevation angles of less than 10 degrees above the horizon. To compute the range, an elevation angle

of between 0 and 5 degrees will be used, resulting in a range of 1720 km. This value will be used to compute the free-space path loss.

Using the equation above and the parameters in TABLE D-2, the carrier power density at the SGLS low-orbiting satellite receiver for fixed and transportable SGLS stations is given below:

$$C_o = -155 \text{ dBW/Hz} \qquad \text{(fixed SGLS stations)}$$

$$C_o = -165 \text{ dBW/Hz} \qquad \text{(transportable SGLS stations)}$$

The C/I ratios can now be evaluated for the fixed and transportable SGLS station receivers as follows:

$$C/I = C_o - I_o$$

The calculated C/I ratios for the upper and lower channels of fixed and transportable SGLS station receivers are given in TABLE D-5.

**TABLE D-5**

Calculated C/I Ratios for Fixed and Transportable SGLS Station Receivers

| SGLS Channel | Mobile Stations C/I (dB) | Personal Stations C/I (dB) |
|---|---|---|
| **Lower** | | |
| **Fixed SGLS Station** | 16 | 35 |
| **Transportable SGLS Station** | 6 | 25 |
| **Upper** | | |
| **Fixed SGLS Station** | 33 | 52 |
| **Transportable SGLS Station** | 23 | 42 |

## C/I Analysis For SGLS Geostationary Satellite Receivers

As in the case of low-orbiting satellites the amount of interference received by a geostationary satellite receiver is a function of the altitude of the satellite, the area over which the terrestrial mobile stations are deployed, their radiation characteristics, the area visible by the satellite and the density of the mobile and portable stations. The total area on the Earth visible from a geostationary satellite excluding atmospheric effects is $2.2 \times 10^8$ km$^2$.

As stated earlier, the terrestrial mobile and personal stations are uniformly distributed over the field-of-view of the satellite. Using the previous equations, and a satellite altitude of 36,000 km, it was determined that approximately 0.57% of the total-visibility interference will be caused by terrestrial stations located between 0 and 1 degrees elevation angles and radiating isotropically. The area of the spherical region bounded by the elevation angles between 0 and 1 degrees is 2% of the total visibility

area.[17] The aggregate interference power density at the output of the SGLS geostationary satellite receiver caused by the emissions from mobile and personal stations is then given in TABLE D-6.

**TABLE D-6**
Aggregate Interference Power Density From Terrestrial Stations to SGLS Geostationary Satellite Receivers

| SGLS Channel | Mobile Stations $I_o$ (dBW/Hz) | Personal Stations $I_o$ (dBW/Hz) |
|---|---|---|
| Lower | -184 | -204 |
| Upper | -201 | -221 |

Using the equation stated earlier and the parameters in TABLE D-3, the carrier power density at the SGLS geostationary satellite receiver for fixed and transportable SGLS stations is given below:

$C_o$ = -180 dBW/Hz (fixed SGLS stations)

$C_o$ = -190 dBW/Hz (transportable SGLS stations)

The calculated C/I ratios for the upper and lower channels of fixed and transportable SGLS stations are given in TABLE D-7.

**TABLE D-7**
Calculated C/I Ratios For Fixed And Transportable SGLS Stations

| SGLS Channel | Mobile Stations C/I (dB) | Personal Stations C/I (dB) |
|---|---|---|
| **Lower** | | |
| **Fixed SGLS Station** | 4 | 24 |
| **Transportable SGLS Station** | -6 | 14 |
| **Upper** | | |
| **Fixed SGLS Station** | 21 | 41 |
| **Transportable SGLS Station** | 11 | 31 |

## Protection Margin For SGLS Satellite Receivers

In general the C/I threshold levels required for acceptable performance will vary with the modulation specifications. The input C/I thresholds are determined from the output performance requirements on the baseband information extracted (e.g., telephony pW0p, video SNR, digital BER), by including the receiver processing gain as a function of the modulation parameters. ITU-R Rec. 363-3 specifies a C/I protection ratio of 20 dB for spacecraft receivers. An overview of the calculated C/I values is given in TABLE D-8.

TABLE D-8
Overview of Calculated C/I Values

| | Lower Channel | Upper Channel |
|---|---|---|
| **Low-Orbiting SGLS Satellites** | | |
| **Fixed** | 16 dB | 33 dB |
| **Transportable** | 6 dB | 23 dB |
| **Geostationary SGLS Satellites** | | |
| **Fixed** | 4 dB | 21 dB |
| **Transportable** | -6 dB | 11 dB |

The C/I values shown in TABLE D-8 are based on a 5 MHz guard band. Given this guard band constraint, the calculated C/I values for the lower SGLS channel are below the established threshold. Hence, reallocation of the 1755-1760 MHz band segment is not possible without degrading the SGLS uplink transmissions.

The calculated C/I values for the upper SGLS channel for low-orbiting satellites exceed the threshold of 20 dB. However, for geostationary SGLS satellites, the calculated C/I for the upper channel of transportable SGLS earth stations is below the established threshold. Hence, reallocation of the 1845-1850 MHz band segment with a 5 MHz guard band would degrade uplink transmissions of transportable SGLS earth stations.

It should be noted that the actual C/I values may be greater than those shown in TABLE D-8 when factors such as receiver signal processing are taken into consideration.

### Interference to SGLS Satellite Receivers from Aeronautical and Satellite Uplinks

Air Force indicates that aeronautical and satellite uplink transmissions in the 1845-1850 MHz band segment will have a high probability of causing interference to low-orbiting and geostationary SGLS satellite receivers. If such interference occurs during critical maneuvers, it could cause satellite contact losses, resulting in auto-track breaks, telemetry stream interference, and probable commanding errors.[18] Air Force urges that aeronautical and Earth-to-space links should be avoided in the 1845-1850 MHz band segment.

## INTERFERENCE TO TERRESTRIAL MOBILE SERVICE FROM SGLS EARTH STATIONS

The interference impact on terrestrial mobile and personal stations from SGLS earth stations will be assessed under interference-limited conditions.[19] An interference-limited condition exists when the

signal-to-noise ratio at the victim receiver is somewhat greater than the minimum required value, so that the interference level might be allowed to exceed the receiver noise. The maximum permissible interference levels that can be received by personal stations without significantly degrading the quality of the service provided are given in TABLE D-2.

The interference level at a mobile service receiver from SGLS earth station transmissions can be determined using the following equation:

$$I = P_I + G_I + G_R - L_{req} - FDR$$

where

I is the interference power at the terrestrial receiver (dBm);
$P_I$ is the SGLS earth station transmitter power (dBm);
$G_I$ is the SGLS earth station transmitter antenna gain in the direction of the terrestrial mobile receiver (dBi);
$G_R$ is the antenna gain of the terrestrial mobile receiver (dBi);
$L_{req}$ is the propagation loss required to preclude interference to the terrestrial receivers (dB);
FDR is the frequency dependent rejection (dB).

To compute the interference level at a mobile service receiver, a transmitter power of 7 kW will be used for fixed SGLS earth stations and a value of 1 kW will be used for transportable SGLS earth stations. The term $G_I$ is a function of the antenna elevation of the earth station. For the purpose of this analysis $G_I$ will be calculated using both the mainbeam and sidelobe antenna gains shown in TABLE D-3. The mainbeam gain represents the worst-case condition and will result in the maximum required distance separation to preclude interference to mobile and personal terrestrial receivers. The sidelobe antenna gain was calculated using an earth station elevation angle of 3 degrees and procedures specified in Appendix 29 of the ITU Radio Regulations.[20]

As stated earlier, the FDR term used in the interference calculation is the summation of two terms. The first term takes into account the rejection provided by specific detuning of the terrestrial receivers with respect to the SGLS earth station transmitters. As shown in TABLE D-3, the SGLS earth station uplink transmission bandwidth is 4 MHz with subcarriers.[21] The subcarriers extend beyond 1845 MHz, and cannot be filtered without impacting vital satellite command and control functions. A value of 30 dB will be used in this analysis for the off-frequency rejection based on a 5 MHz guard band. The second term is the power attenuation provided by the terrestrial receiver to the SGLS earth station uplink transmission when the terrestrial receiver bandwidth is narrower than the SGLS uplink transmission bandwidth. Although the channel bandwidth is 4 MHz, the SGLS uplink transmission is not always spread over the entire channel. Air Force states that the worst-case for producing possible interference is a 1 kHz transmission modulating each of the subcarriers.[22] Since a large portion of the signal energy is often concentrated within 1 to 2 kHz on one or more subcarriers, there is no attenuation resulting from the bandwidth mismatch.

Using the above equation and the parameters specified in TABLE D-3, the path loss required for terrestrial receiver protection is given in TABLE D-9.

**TABLE D-9**

Required Path Loss to Preclude Interference to Terrestrial Stations

| SGLS Station | Indoor Station $L_{req}$ (dB) | Outdoor Station $L_{req}$ (dB) |
|---|---|---|
| **Fixed** | | |
| **Mainbeam Gain** | 196 | 198 |
| **SidelobeGain** | 178 | 180 |
| **Transportable** | | |
| **Mainbeam Gain** | 188 | 190 |
| **Sidelobe Gain** | 170 | 172 |

The values shown in TABLE D-9 represent the path loss that is required to protect the indoor and outdoor personal stations from interference resulting from fixed and transportable SGLS earth station transmissions. In order to determine the required distance separation, the Egli propagation model for ground-to-ground propagation shown below will be used.[23]

$$L_{req} = 48 + 20\,\mathrm{Log}F + 40\mathrm{Log}D_{sep} + (10\text{-}10\mathrm{Log}h_1) + (10\text{-}10\mathrm{Log}h_2)$$

where

$D_{sep}$ is the required distance separation (km);
$h_1$ is the height of the personal or mobile receiver antenna (m);
$h_2$ is the height of the SGLS earth station transmitter antenna (m);
F is the frequency (MHz).

Antenna heights of 1 meter (terrestrial) and 15 meters (SGLS earth station) will be used to determine the required distance separation. Using the above equation, the required distance separations necessary to preclude interference between SGLS earth stations and terrestrial receivers are given in TABLE D-10.

**TABLE D-10**

Required Distance Separations to Preclude Interference Between SGLS Earth Stations And Terrestrial Receivers

| SGLS Station | Indoor Station $D_{sep}$ (km) | Outdoor Station $D_{sep}$ (km) |
|---|---|---|
| **Fixed** | | |
| **Mainbeam Gain** | 73 | 82 |
| **Sidelobe Gain** | 26 | 29 |
| **Transportable** | | |
| **Mainbeam Gain** | 46 | 52 |
| **Sidelobe Gain** | 16 | 18 |

Provided that the calculated distance separations given in TABLE D-10 can be maintained, the impact on terrestrial stations from fixed SGLS earth station transmitters is expected to be manageable. However, the transportable SGLS earth stations present a more difficult problem, since their exact locations are not always known, hence making coordination difficult.

### Interference to Aeronautical and Satellite Receivers from SGLS Earth Stations

Air Force indicates that the 1845-1850 MHz band segment may be authorized for either aeronautical or satellite operations. As a result, aeronautical and satellite receivers may experience interference when operating within the mainbeam of the SGLS earth station uplink transmitter. Air Force believes that the lack of non-Federal receiver standards coupled with the high-power transmissions of the adjacent band SGLS earth stations would most likely cause numerous interference problems to aeronautical and satellite receivers.[24] Therefore, Air Force urges that aeronautical and space-to-Earth links should be avoided in the 1845-1850 MHz band segment.

## INTERFERENCE TO ACTS AIRBORNE RECEIVERS FROM MOBILE SERVICE STATIONS

This section assesses aggregate interference from terrestrial mobile and personal stations into the ACTS receiver. The personal and mobile stations are assumed to be uniformly distributed over the earth's surface, and have the same emission levels and frequency. The aircraft is assumed to have an isotropic antenna pattern (unit gain) over the visibility region determined by the aircraft altitude. The aggregate interference is derived by modeling the emitter distribution and deriving their power-sum level into the victim receiver under free-space propagation conditions.

The ACTS airborne receivers are most susceptible to interference in the Frequency Shift Key (FSK) demodulation stage. This FSK detection, which is accomplished by mark and space filters, uses a selectable FSK data rate of 62 kHz or 198 kHz. It is assumed that the mark and space filter bandwidths are equal to the data rate.[25]

### ACTS Interference Threshold

The acceptable level of noise-like interference signals at the ACTS receiver is defined by the signal-to-interference (S/I) ratio threshold of 15 dB in the detection filter bandwidth. This threshold is sufficient to ensure an acceptable $10^{-5}$ bit error probability.[26]

### ACTS Parameters Used in the Analysis

The nominal ACTS transmitter, receiver, and antenna parameters used in this analysis are given in TABLE D-11.[27]

### Aggregate Interference at ACTS Aircraft Receivers

The net interference power at the ACTS receiver can be determined using the following equation:

$$I = P_R + G_R - FDR - L$$

TABLE D-11
Nominal ACTS Characteristics

| ACTS Ground Station Transmitter | |
|---|---|
| Frequency | 1840 MHz |
| Output Power | 5 W |
| Bandwidth | 600 kHz |
| Antenna Gain | 0 dBi |
| **ACTS Airborne Station Receiver** | |
| Selectivity<br>-3 dB<br>-60 dB | <br>1.2 MHz<br>12 MHz |
| Antenna Gain | 0 dBi |

where

I is the interference power at the ACTS receiver (dBm);
$P_R$ is the aggregate interference power into the receiver antenna under free-space propagation (dBm);
$G_R$ is the ACTS airborne receiver antenna gain (dBi);
FDR is the frequency dependent rejection (dB);
L is the building penetration, shadow loss, and urban/rural field-of-view loss (dB).

The aggregate interference power $P_R$ can be derived from a computer program (PDOME), developed by NTIA for this purpose.[28] PDOME computes the power-sum aggregate interference at an airborne receiver by modeling the emitter distribution and integrating their collective effect under free-space propagation. The user specifies the aircraft altitude, the emitter density, the emission level and the emission frequency. Using these values, PDOME determines the number of emitters in the field-of-view of the aircraft and computes the aggregate power-sum into the aircraft receiver.

Using PDOME and the parameters for the mobile and personal stations given in TABLE D-2, the aggregate received power levels into an aircraft receiver at 30,000 feet were determined to be

$$P_R = -16.3 \text{ dBm (mobile stations)}$$

$$P_R = -27.3 \text{ dBm (personal stations)}$$

The FDR value used in the calculation of the interference power is the attenuation of an undesired signal power by the ACTS receiver because of off-frequency rejection. The off-frequency rejection is the rejection provided by detuning of the ACTS receiver with respect to the terrestrial transmitters. A value of 62 dB corresponding to a 7 MHz frequency separation for the lower ACTS channel

(1768 MHz) and 56 dB corresponding to a 5 MHz frequency separation on the upper ACTS channel (1840 MHz) will be used in this analysis. The other values used in the calculation of I were defined earlier.

Using the above results, the net interference power at the ACTS receiver from the terrestrial station emitters is given in TABLE D-12.

**TABLE D-12**
Net Interference Power at The ACTS Receiver From Terrestrial Stations

| ACTS Channel | Mobile Station I (dB) | Personal Station I (dB) |
|---|---|---|
| Lower | -98 | -109 |
| Upper | -92 | -103 |

The values of FDR used in the calculation of I represents a worst-case scenario insofar that it locates all of the mobile and personal stations in the first adjacent channel (minimum frequency separation) from the ACTS receiver. In a more realistic scenario, the terrestrial stations will be distributed across the entire band, which will result in further reduction of interference levels at the ACTS receiver.

The minimum desired signal level in the detection filter of the ACTS receiver is given by:

$$S = P_T + G_T + G_R - L_{FS}$$

where

S is the minimum desired signal in the detection filter of the ACTS receiver (dBm);
$P_T$ is the ACTS ground station transmitter power (dBm);
$G_T$ is the ACTS ground station transmitter antenna gain (dBi);
$G_R$ is the ACTS airborne station receiver antenna gain (dBi);
$L_{FS}$ is the free-space propagation loss between the ACTS ground and airborne stations at a maximum altitude of 30,000 feet (dB).

Using the equation above, the minimum desired signal level in the detection filter of the ACTS receiver is given below:

$$S = -80 \text{ dBm}$$

The S/I ratios can now be evaluated for the personal and mobile terrestrial stations as follows:

$$S/I = S - I$$

The calculated S/I ratios for the lower and upper channels of the ACTS receiver are given in TABLE D-13.

TABLE D-13
Calculated S/I Ratios for ACTS Receivers

| ACTS Channel | Mobile Station S/I (dB) | Personal Station S/I (dB) |
|---|---|---|
| Lower | 18 | 29 |
| Upper | 12 | 23 |

The calculated S/I ratios for the lower ACTS receiver channels exceed the protection threshold. However, the calculated S/I for the upper channel is below the protection threshold of 15 dB. Hence, reallocation of the 1845-1850 MHz band segment will degrade the ACT uplink transmission.

## INTERFERENCE TO TERRESTRIAL STATIONS FROM ACTS GROUND STATION TRANSMITTERS

As stated earlier it will be assumed that the personal and mobile systems are interference-limited. To facilitate sharing, an allocation of 10% of the total interference budget to external interference sources is used. ITU-R Rec. 687-1 specifies a level of -117 dBm for indoor personal stations and -119 dBm for outdoor personal stations. These values represent maximum permissible interference power levels that can be received by personal stations without significantly degrading the quality of the service provided.

The interference power at a victim receiver can be determined using the following equation:

$$I = P_I + G_I + G_R - L_{req} - FDR$$

where

I is the interference power at the terrestrial receiver (dBm);
$P_I$ is the ACTS ground station transmitter power (dBm);
$G_I$ is the ACTS ground station transmitter antenna gain in the direction of the terrestrial receiver (dBi);
$G_R$ is the antenna gain of the terrestrial receiver (dBi);
$L_{req}$ is the propagation loss required to preclude interference to the terrestrial receivers (dB);
FDR is the frequency dependent rejection (dB).

As stated earlier, the FDR term used in the interference calculation is the summation of two components. The first term takes into account the rejection provided by specific detuning of the terrestrial receivers with respect to the ACTS ground station transmitters. A conservative value of 50 dB will be used in this analysis, based on the assumption that the adjacent channel selectivity characteristics of the mobile and portable receivers will be similar to the current Federal land mobile receivers.[29] The second term is the power attenuation provided by the terrestrial receiver to the ACTS ground station transmitter signal when the terrestrial receiver bandwidth is narrower than the ACTS emission bandwidth. As shown in TABLE D-11, the ACTS ground station transmitter bandwidth is

600 kHz. The bandwidth of terrestrial personal stations is 50 kHz as given in TABLE D-2. This bandwidth mismatch between the terrestrial receivers and the ACTS uplink transmitter will reduce the interfering signal by an additional 11 dB.

Using the above parameters, the required path loss to preclude interference can be determined and is given below:

$L_{req}$ = 93 dB (indoor personal stations)

$L_{req}$ = 95 dB (outdoor personal stations)

The values shown above represent the path loss required to protect the indoor and outdoor personal stations from the interference resulting from ACTS ground station transmitters. As stated earlier, the Egli propagation model was used to determine that the required distance separation to preclude interference is less than 1 km. Provided that the calculated distance separation can be maintained, the impact on terrestrial mobile and personal stations from ACTS ground station transmitters is expected to be manageable.

## CONCLUSIONS

Based on a 5 MHz guard band, the calculated C/I values for the lower SGLS channel are below the established threshold. Therefore, reallocation of the 1755-1760 MHz band segment for terrestrial mobile and personal stations is not possible without degradation of the SGLS uplink transmission.

Reallocation of the 1845-1850 MHz band segment for terrestrial mobile and personal stations with a 5 MHz guard band will degrade uplink transmissions of transportable SGLS earth stations.

A maximum distance separation of 82 km between fixed SGLS earth stations and terrestrial mobile personal stations is needed to preclude interference. Provided the calculated distance separations can be maintained, the impact on terrestrial mobile and personal stations from fixed SGLS earth stations is expected to be manageable.

A maximum distance separation of 52 km between transportable SGLS earth stations and terrestrial mobile and personal stations is needed to preclude interference. However, because of the highly mobile nature of the proposed terrestrial service and the unknown location of the transportable SGLS earth stations, these distance separartions may be difficult to maintain.

Reallocation of the 1845-1850 MHz band segment for terrestrial mobile and personal stations with a 5 MHz guard band will degrade uplink ACTS transmissions.

To reduce the impact to and from Federal satellite command and control and combat training systems operating in the 1761-1842 MHz band segment, reallocation of the 1845-1850 MHz band segment for aeronautical or satellite links must be avoided.

## ENDNOTES

Requests for copies of references from Federal departments and agencies should be referred to the originating organization. Parts of the reference material may be exempt from public release.

1. REPORT FROM THE FEDERAL COMMUNICATIONS COMM'N,to Ronald H. Brown, Secretary, U.S. Dep't of Commerce, Regarding the NTIA PRELIMINARY REPORT, FCC 94-213, at 27 (Aug. 9, 1994)[hereinafter FCC REPORT].
2. NAT'L TELECOMMUNICATIONS AND INFO. ADMIN. (NTIA), U.S. DEP'T OF COMMERCE, SPECIAL PUBLICATION 94-27, PRELIMINARY REPORT, at 4-30. (Feb. 1994) [hereinafter NTIA PRELIMINARY REPORT and all comments cited refer to this report, unless otherwise stated].
3. NTIA, U.S. Dep't of Commerce, NTIA Report 92-285, *Federal Spectrum Usage of the 1710-1850 and 2200-2290 MHz Bands*, at 5-10 (March 1992).
4. NTIA PRELIMINARY REPORT, *supra* note 2, at 2-27.
5. *Id.* at 4-30.
6. Int'l Telecommunication Union Radiocommunication Sector (ITU-R) Document, U.S. Working Party (USWP) 7B/4, at 1 (Aug. 12, 1994).
7. Memorandum from the U.S. Dep't of the Air Force, to Chairman of IRAC, Subject: Comments on Draft Final Reallocation Report Executive Summary and App. D., at 2 (Jan. 6, 1995).
8. The 1992 World Administrative Radio Conference: Technology and Policy Implications, at 77 (May 1993).
9. Int'l Radio Consultative Comm. (CCIR) Recommendation 687-1, *Future Public Land Mobile Telecommunication System (FPLMTS)*, Annex 1, at 16 (Sept. 22, 1992).
10. *Id.*
11. NTIA, U.S. Dep't of Commerce, NTIA Report 80-47, *Spectrum Resource Assessment in the 1710-1850 MHz Band*, at 55 (Sept. 1980); Spectrum Planning Subcommittee (SPS) Submission SPS-9082, Loral Model CXS-800 SGLS Transponder; Int'l Telecommunications Union Radio Regulations, Appendix 29, Annex III, at AP29-14 (1990 Edition).
12. Document U.S. Study Group (USSG) 8A/39 (Rev.1), *Criteria for Sharing Between the Mobile Services and Space Research, Space Operations and Earth Exploration-Satellite Service Space Stations in the 2025-2110 MHz and 2200-2290 MHz Bands*, at 6 (Nov. 12, 1991) [ hereinafter USSG Sharing Study].
13. *Id.* at 7.
14. *Id.* at 9.
15. *Id.* at 11.
16. *Id.* at 12-13.
17. *Id.* at 16.
18. B. B. Pottorff and N. A. Willett, Allied Signal Bendix Field Engineering Corp., *Analysis of the Air Force Satellite Control Network Spectrum Usage in the 1760-1850 MHz and 2200-2300 MHz Bands*, at 31 (June 11, 1991).
19. CCIR, *supra* note 9, at 17.
20. *Id.* at 8 30.
21. Air Force Memorandum, *supra* note 7, at 2.
22. *Id.* at 5.
23. W. G. Duff, Don White Consultants, Inc., MOBILE COMMUNICATIONS, at 24 (1976).
24. Memorandum from the Dep't of the Air Force, to Chairman of IRAC, Subject: Air Force Comments on Title VI of the Omnibus Budget Reconciliation Act (OBRA) of 1993, at 2-3 (Jan. 5, 1995).

## ENDNOTES

Requests for copies of references from Federal departments and agencies should be referred to the originating organization. Parts of the reference material may be exempt from public release.

25. Electromagnetic Compatibility Analysis Center, *Electromagnetic Compatibility (EMC) Analysis of the Proposed Fallon NAS TACTS Expansion*, ECAC-CR-87-098, at 3-10 (Oct. 1987); Electromagnetic Compatibility Analysis Center, *EMC Analysis of the Proposed Cherry Point MCAS TACTS and the Dare County Expansion,* ECAC-CR-86-066, at 3-8 (June 1986); Electromagnetic Compatibility Analysis Center, *EMC of Air Combat Maneuvering Instrumentation (ACMI) System at Nellis Range*, ESD-TR-75-020, at 48 (Oct. 1975).
26. EMC Analysis of the Proposed Fallon NAS TACTS Expansion, *supra* note 25, at 3-8.
27. *Id.*; Spectrum Planning Subcommittee (SPS) Submission SPS-10045, Technical Data Information of the TACTS ACMI Aircraft Instrumentation Subsystem (AIS) Pods, at 2 (Aug. 31, 1994).
28. NTIA, U.S. Dep't of Commerce, NTIA-TM-89-139, *Single and Aggregate Emission Level Models for Interference Analysis*, at 4-1 (March 1989).
29. NTIA *Manual of Regulations and Procedures for Federal Radio Frequency Management*, at § 5.6, 5-27-5-28 (June 6, 1994).

# APPENDIX E
# FEDERAL GOVERNMENT FIXED MICROWAVE STATIONS IN THE 1710-1755 MHZ BAND EXEMPTED FROM REALLOCATION

## INTRODUCTION

This Appendix contains a list of the Federal Government fixed microwave stations in the 1710-1755 MHZ band that are exempted from reallocation. These stations were authorized as of February 10, 1994, to operate in this band. In particular, this Appendix contains a list of the fixed microwave stations used by the FPAs and fixed microwave stations where the majority of communications carried on at these stations involve safety-of-life operations. In addition, certain fixed microwave stations belonging to Federal agencies where operation in these stations supports FPA in the generation and distribution of electric power energy are also exempted from reallocation.

## EXEMPTED FEDERAL POWER AGENCIES FIXED MICROWAVE STATIONS[a]

Under Title VI requirements, any frequency assigned to, or any frequency assignment used by, a FPA may not be reallocated to non-Federal sector use. In addition, frequencies assigned to any FPA may only be eligible for reallocation on a mixed use basis for Federal Government and non-Federal sector use. The Federal power agencies' operations conducted on frequencies that were reallocated for mixed use must be protected from harmful interference by the non-Federal sector users. However, in order for these operations to be afforded the proper protection, the locations as well as key technical parameters associated with these operations must be provided to the public.

It was mentioned in the Preliminary Report that a list of stations used by the FPAs in the 1710-1755 MHz band is forthcoming and to be provided in the final spectrum reallocation report. In addition, numerous commenters to the Preliminary Report have pointed out that the absence of such a list makes it difficult to assess the usefulness of the band for non-Federal sector operation. As a follow-up to the Preliminary Report and due to the need to respond to public concerns, the list of FPAs fixed microwave stations, including those fixed microwave stations belonging to Federal agencies that support the FPAs, operating in the 1710-1755 MHz band is provided in this Appendix.

The geographical representation of the location of these stations is shown in Figure E-1. A circle, triangle, or square marker indicates the location of one or more fixed microwave stations. TABLE E-1 contains the technical parameters associated with each station. The parameters include, but are not limited to, frequency, emission bandwidth, power output, and antenna height and gain.

## EXEMPTED SAFETY-OF-LIFE FIXED MICROWAVE STATIONS

The House Energy and Commerce Committee Report on Title VI provides a discussion on aviation-related communications safety. The Committee Report stated, "The Committee believes that the implementation of this legislation will not result in the degradation of this or other safety-related service." Because the House Committee Report is a part of the legislative history of Title VI, NTIA seeks to implement the Committee's views to the extent they are consistent with the actual language of the statute.

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[a] Title VI defines Federal power agencies as the Tennessee Valley Authority, the Bonneville Power Administration, the Western Area Power Administration, the Southwestern Power Administration, the Southeastern Power Administration, and the Alaska Power Administration.

# APPENDIX E EXEMPTED FEDERAL GOVERNMENT MICROWAVE STATIONS

Originally, NTIA exempted from reallocation Federal Government fixed microwave stations supporting safety-of-life operations that were authorized as of February 10, 1994 to operate in the 1710-1755 MHz band. In its Preliminary Report, NTIA also indicated that a list of these stations will be provided in this final spectrum reallocation report. Commenters to the Preliminary Report, however, questioned the indefinite continued use and protection to be afforded to these stations. NTIA re-examined the actual language of Title VI and, based on this, is modifying its original recommendation that all safety-of-life operations will be protected. Clearly, safety-of-life operations are not included in Title VI's specific exemption that is applicable to the FPA. However, there are other provisions in Title VI that appropriately address safety-related issues and which require NTIA to consider public safety concerns during the spectrum reallocation process.

Since spectrum is in great demand by non-Federal users in the urban areas, NTIA only provides protection to safety-related fixed microwave stations operating in the 1710-1755 MHz band that are outside a 150 km radius of the 25 most populated cities in the United States. A list of these cities is found in Section 4, TABLE 4-3. The geographical representation of the location of these stations is shown in Figure E-2. As before, a circle, triangle or square marker represents one or more fixed microwave stations supporting safety-related operations. The key technical parameters associated with these stations are provided in TABLE E-2.

Electronic access to these lists is available to the public via the set of Internet servers operated by NTIA. Detailed instructions for gaining access to these servers can be obtained i) by connecting through a modem to (202) 482-1199, ii) by connecting through the Internet to http://gopher.ntia.doc.gov, or iii) by connecting through the Internet to http://www.ntia.doc.gov.

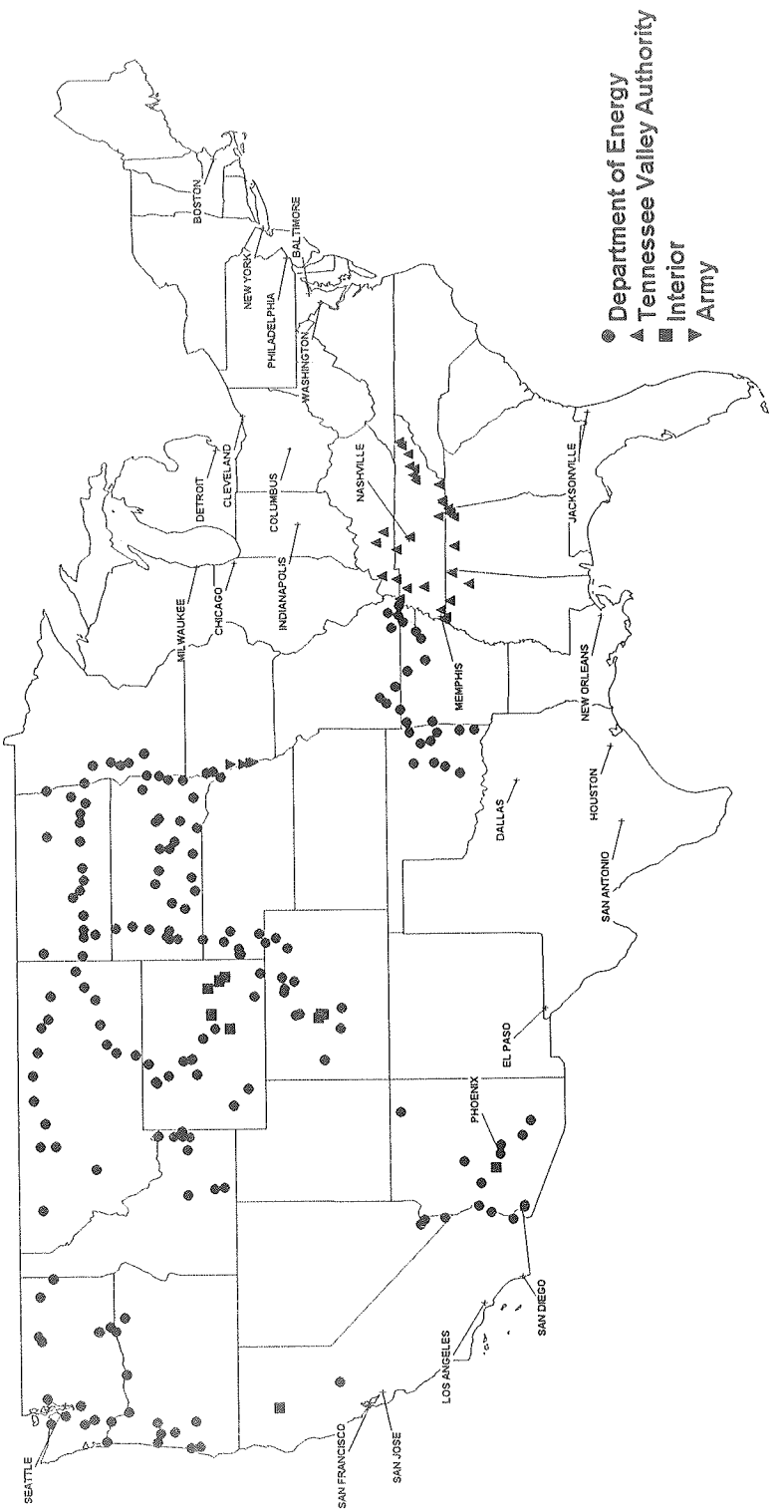



Figure E-1. Geographic distribution of Federal power agencies fixed microwave stations in the 1710-1755 MHz band exempted from reallocation.

## TABLE E-1

Technical Parameters of Federal Power Agencies Fixed Microwave Stations in the 1710-1755 MHz Band Exempted From Reallocation

```
FREQ: M1710.000000 SER:DOE 786136 BUR:B    STC:FX     EMS:    10M00F9W   PWR:    W5.00000 NOM:C,LEN778F2

      TX LOCATION:    WA   ADDY SUBSTATION          482128N1175055W      TX ANT DATA: 30GPARABOLIC 00504H0015T
      RX LOCATION(S): WA   GRANITE MOUNTAIN        482707N1180331W      RX ANT DATA: 24GPARABOLIC 01297H0009T
-------------------------------------------------------------------------------------------------------------
FREQ: M1710.500000 SER:TVA 920502 BUR:TVA  STC:FX     EMS:   800K00F8W   PWR:    W1.00000 NOM:

      TX LOCATION:    TN   HICKMAN                 363018N0891526W      TX ANT DATA: 33GPARABOLIC 00505H0190T
      RX LOCATION(S): TN   UNION CITY              362443N0890205W      RX ANT DATA: 33GPARABOLIC 00310H0190T
-------------------------------------------------------------------------------------------------------------
FREQ: M1711.000000 SER:DOE 944911 BUR:B    STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,WMX12012-2A23DD2D12

      TX LOCATION:    WA   GREEN MOUNTAIN           473342N1224826W      TX ANT DATA: 33GPARABOLIC 00515H0046T
      RX LOCATION(S): WA   BLYN                     480058N1225534W      RX ANT DATA: 33GPARABOLIC 00634H0025T
-------------------------------------------------------------------------------------------------------------
FREQ: M1711.000000 SER:DOE 839568 BUR:M    STC:FX     EMS:     1M90F9WJF PWR:    W2.00000 NOM:C,GRA6018-3A/72

      TX LOCATION:    AZ   NEWMAN PEAK              324308N1112358W      TX ANT DATA: 30GPARABOLIC 01374H0006T
      RX LOCATION(S): AZ   MARICOPA                325737N1115943W      RX ANT DATA: 30GPARABOLIC 00378H0006T
                      AZ   CASA GRANDE             325309N1114628W                   30GPARABOLIC 00421H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1711.000000 SER:DOE 839509 BUR:M    STC:FX     EMS:     1M00F9WJ  PWR:    W1.00000 NOM:C,MOTK16RBF1200

      TX LOCATION:    AZ   WELLTON MOHAWK          324000N1141555W      TX ANT DATA: 28GPARABOLIC 00205H0006T
      RX LOCATION(S): AZ   TELEGRAPH PASS          324012N1142006W      RX ANT DATA: 28GPARABOLIC 00541H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1711.000000 SER:DOE 859480 BUR:M    STC:FX     EMS:     1M80F9WWF PWR:    W2.00000 NOM:C,MOTK16RBF1200

      TX LOCATION:    CA   BLACK MOUNTAIN           330314N1144944W      TX ANT DATA: 28GPARABOLIC 00634H0009T
      RX LOCATION(S): CA   GOLDFIELD               330245N1145256W      RX ANT DATA: 28GPARABOLIC 00263H0009T
-------------------------------------------------------------------------------------------------------------
FREQ: M1711.000000 SER:DOE 829635 BUR:M    STC:FX     EMS:     2M00F9WWF PWR:    W1.00000 NOM:C,MOTK16RBF2200

      TX LOCATION:    CA   BLACK POINT             334500N1143121W      TX ANT DATA: 30GPARABOLIC 00707H0012T
      RX LOCATION(S): CA   BLYTHE                  333640N1144047W      RX ANT DATA: 30GPARABOLIC 00102H0012T
-------------------------------------------------------------------------------------------------------------
FREQ: M1711.000000 SER:I   921391 BUR:RGP  STC:FX     EMS:     1M60F9W   PWR:    W1.50000 NOM:C,MOTK16RBF2200

      TX LOCATION:    WY   GLENDO                  422802N1045718W      TX ANT DATA: 30GPARABOLIC 01378H0015T
      RX LOCATION(S): WY   GLENDO                  422818N1045655W      RX ANT DATA: 00GREFLECTOR 01501H0005T
                      WY   PINE RIDGE              422055N1050150W                   28GPARABOLIC 01603H0012T
-------------------------------------------------------------------------------------------------------------
FREQ: M1712.500000 SER:I   921392 BUR:RGP  STC:FX     EMS:     1M60F9W   PWR:    W3.00000 NOM:C,MOTK16RBF200

      TX LOCATION:    WY   CASPER MTN              424425N1062134W      TX ANT DATA: 32GPARABOLIC 02438H0023T
      RX LOCATION(S): WY   PATHFINDER L            422832N1064751W      RX ANT DATA: 00GREFLECTOR 01884H0005T
                      WY   FREMONT                 422836N1064742W                   32GPARABOLIC 01682H0018T
-------------------------------------------------------------------------------------------------------------
FREQ: M1713.000000 SER:DOE 916477 BUR:M    STC:FX     EMS:     5M00F9WWF PWR:    W1.00000 NOM:C,WMXTWO 2000

      TX LOCATION:    AZ   LOLAMAI POINT           363913N1102304W      TX ANT DATA: 30GPARABOLIC 02388H0017T
      RX LOCATION(S): AZ   LONGHOUSE VALLEY SUBSTAT 363618N1103050W    RX ANT DATA: 30GPARABOLIC 02056H0016T
-------------------------------------------------------------------------------------------------------------
FREQ: M1713.500000 SER:I   940713 BUR:RGP  STC:FX     EMS:     5M00F9W   PWR:    W1.00000 NOM:C,MOTK16RBF2200

      TX LOCATION:    CO   HAGERMAN PASS           391533N1062849W      TX ANT DATA: 29GPARABOLIC 03684H0012T
      RX LOCATION(S): CO   GRANITE                 390509N1061604W      RX ANT DATA: 29GPARABOLIC 03076H0016T
-------------------------------------------------------------------------------------------------------------
FREQ: M1714.000000 SER:DOE 839561 BUR:M    STC:FX     EMS:     1M90F9WJF PWR:    W2.00000 NOM:C,GRA6018-3A/72

      TX LOCATION:    AZ   ROGERS SUB              332528N1114759W      TX ANT DATA: 30GPARABOLIC 00381H0015T
      RX LOCATION(S): AZ   THOMPSON PEAK           333839N1114841W      RX ANT DATA: 30GPARABOLIC 01214H0006T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1715.000000 SER:DOE 876614 BUR:B    STC:FX     EMS:    10M00F9WJ  PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:    ID   IONA BUTTE               433243N1115314W      TX ANT DATA: 28GPARABOLIC 01680H0006T
      RX LOCATION(S): ID   GOSHEN SUBSTATION        431834N1120624W      RX ANT DATA: 28GPARABOLIC 01399H0021T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 924924 BUR:B    STC:FX     EMS:     5M00F9W   PWR:    W5.00000 NOM:C,WMX12012-2A23DD2D12

      TX LOCATION:    MT   ROCKY RIDGE              463056N1124019W      TX ANT DATA: 24GPARABOLIC 01802H0005T
      RX LOCATION(S): MT   ANACONDA SUBSTATION      460600N1125230W      RX ANT DATA: 28GPARABOLIC 01576H0005T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 896453 BUR:B    STC:FX     EMS:    10M00F9W   PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    OR   ROUNDUP SUBSTATION       453815N1184445W      TX ANT DATA: 28GPARABOLIC 00432H0006T
      RX LOCATION(S): OR   CABBAGE HILL             453525N1183455W      RX ANT DATA: 28GPARABOLIC 01052H0008T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 786125 BUR:B    STC:FX     EMS:     3M50F9WJF PWR:    W5.00000 NOM:C,LEN779F1

      TX LOCATION:    WA   ASHE SUBSTATION          462845N1192004W      TX ANT DATA: 28GPARABOLIC 00134H0030T
      RX LOCATION(S): WA   WASH PWR SYS NUC PLANT D 462830N1191907W      RX ANT DATA: 28GPARABOLIC 00134H0030T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 786126 BUR:B    STC:FX     EMS:     3M50F9W   PWR:    W5.00000 NOM:C,LEN79F1

      TX LOCATION:    WA   ASHE SUBSTATION          462835N1192001W      TX ANT DATA: 28GPARABOLIC 00134H0030T
      RX LOCATION(S): WA   WASH PWR NUC PLANT A     462801N1191853W      RX ANT DATA: 28GPARABOLIC 00134H0030T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 889656 BUR:M    STC:FX     EMS:     5M00F9WJF PWR:    W1.00000 NOM:C,MOTR2000

      TX LOCATION:    AZ   PRESCOTT                343606N1122702W      TX ANT DATA: 31GPARABOLIC 01573H0008T
      RX LOCATION(S): AZ   MINGUS                  344201N1120703W      RX ANT DATA: 31GPARABOLIC 02379H0012T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 859504 BUR:M    STC:FX     EMS:     5M00F9WWF PWR:    W1.00000 NOM:C,COLMIR-2

      TX LOCATION:    CO   LANDSEND                 390520N1081323W      TX ANT DATA: 31GPARABOLIC 03044H0009T
      RX LOCATION(S): CO   ISLAND LAKE              390246N1080109W      RX ANT DATA: 31GPARABOLIC 03288H0034T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 869431 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MN   BARRETT                  455420N0955415W      TX ANT DATA: 30GPARABOLIC 00378H0050T
      RX LOCATION(S): MN   MORRIS                   453928N0955539W      RX ANT DATA: 30GPARABOLIC 00360H0059T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 889407 BUR:M    STC:FX     EMS:     6M40F9WJF PWR:    W5.00000 NOM:C,COLMIR-2A

      TX LOCATION:    MT   CONRAD BUTTE             481730N1114213W      TX ANT DATA: 31GPARABOLIC 01116H0012T
      RX LOCATION(S): MT   SHELBY 2 SUB             482758N1115141W      RX ANT DATA: 31GPARABOLIC 01042H0009T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 849669 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   CUSTER                   460728N1073008W      TX ANT DATA: 31GPARABOLIC 00876H0009T
      RX LOCATION(S): MT   HYSHAM                   460347N1071414W      RX ANT DATA: 31GPARABOLIC 01133H0037T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 926578 BUR:M    STC:FX     EMS:    10M00F9WWF PWR:    W1.00000 NOM:C,WMXTWO-2000

      TX LOCATION:    MT   HAVRE                    483029N1094802W      TX ANT DATA: 26GPARABOLIC 00803H0030T
      RX LOCATION(S): MT   HAVRE MAINTENANCE        483159N1094442W      RX ANT DATA: 26GPARABOLIC 00793H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 849660 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   KELLY CREEK              462934N1054031W      TX ANT DATA: 31GPARABOLIC 00834H0058T
      RX LOCATION(S): MT   MILES CITY               462429N1054734W      RX ANT DATA: 31GPARABOLIC 00737H0052T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1715.000000 SER:DOE 849715 BUR:M    STC:FX     EMS:      7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     MT   VIDA                    475536N1053025W      TX ANT DATA: 31GPARABOLIC 00791H0044T
      RX LOCATION(S): MT   FORT PECK REPEATER      480147N1061847W      RX ANT DATA: 31GPARABOLIC 00814H0024T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 890495 BUR:M    STC:FX     EMS:      7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2A

      TX LOCATION:     ND   CROWN BUTTE             465658N1010818W      TX ANT DATA: 31GPARABOLIC 00707H0005T
      RX LOCATION(S): ND   MANDAN                  465120N1005533W      RX ANT DATA: 31GPARABOLIC 00600H0018T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 849741 BUR:M    STC:FX     EMS:      7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     ND   CUSTER LOOKOUT           465055N1021012W      TX ANT DATA: 31GPARABOLIC 00824H0006T
      RX LOCATION(S): ND   LEFOR                    464108N1023657W      RX ANT DATA: 31GPARABOLIC 00863H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 849756 BUR:M    STC:FX     EMS:      7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     ND   DRISCOLL                465206N1001344W      TX ANT DATA: 31GPARABOLIC 00619H0017T
      RX LOCATION(S): ND   TAPPEN                  465804N0993655W      RX ANT DATA: 31GPARABOLIC 00604H0067T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 890477 BUR:M    STC:FX     EMS:      7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     ND   HUNTER                  471141N0971807W      TX ANT DATA: 31GPARABOLIC 00328H0090T
      RX LOCATION(S): ND   FARGO                   464959N0965653W      RX ANT DATA: 31GPARABOLIC 00277H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 906572 BUR:M    STC:FX     EMS:      7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     ND   SENTINEL BUTTE           465241N1035015W      TX ANT DATA: 31GPARABOLIC 01033H0040T
      RX LOCATION(S): MT   BELLE PRAIRIE           470658N1042830W      RX ANT DATA: 31GPARABOLIC 00838H0079T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 849767 BUR:M    STC:FX     EMS:      7M30F9WWF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:     ND   VALLEY CITY             465434N0975836W      TX ANT DATA: 31GPARABOLIC 00424H0009T
      RX LOCATION(S): ND   PEAK                    465423N0975327W      RX ANT DATA: 31GPARABOLIC 00460H0009T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 899901 BUR:M    STC:FX     EMS:      7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     NE   JONES CREEK             422034N0963307W      TX ANT DATA: 30GPARABOLIC 00427H0027T
      RX LOCATION(S): IA   SIOUX CITY              423144N0961623W      RX ANT DATA: 30GPARABOLIC 00427H0038T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 859553 BUR:M    STC:FX     EMS:      7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     SD   ELKTON                  442108N0962754W      TX ANT DATA: 30GPARABOLIC 00596H0059T
      RX LOCATION(S): SD   BROOKINGS               442143N0964713W      RX ANT DATA: 30GPARABOLIC 00517H0014T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 859558 BUR:M    STC:FX     EMS:      7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     SD   GARY                    444350N0962739W      TX ANT DATA: 30GPARABOLIC 00521H0041T
      RX LOCATION(S): SD   TORONTO                 443658N0964213W      RX ANT DATA: 30GPARABOLIC 00602H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 859514 BUR:M    STC:FX     EMS:      7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     SD   HIGHMORE                442109N0992734W      TX ANT DATA: 30GPARABOLIC 00666H0090T
      RX LOCATION(S): SD   SNAKE BUTTE             442531N1002129W      RX ANT DATA: 30GPARABOLIC 00585H0050T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 916699 BUR:M    STC:FX     EMS:      1M60F9WWF PWR:    W1.00000 NOM:C,WMX1-2000

      TX LOCATION:     SD   HURON OFFICE            442143N0981304W      TX ANT DATA: 20GPARABOLIC 00391H0012T
      RX LOCATION(S): SD   HURON SHOP              442209N0981238W      RX ANT DATA: 20GPARABOLIC 00388H0012T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1715.000000 SER:DOE 916685 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   IRON SHELL              431347N1011148W      TX ANT DATA: 30GPARABOLIC 01000H0027T
      RX LOCATION(S): SD   OKREEK                 431844N1002557W      RX ANT DATA: 30GPARABOLIC 00828H0094T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 859525 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   LAKE ANDES              430855N0983728W      TX ANT DATA: 30GPARABOLIC 00590H0059T
      RX LOCATION(S): SD   TRIPP                  431137N0980303W      RX ANT DATA: 30GPARABOLIC 00570H0035T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 859545 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   SIOUX FALLS             433429N0963901W      TX ANT DATA: 30GPARABOLIC 00464H0058T
      RX LOCATION(S): SD   COLMAN                 435638N0964606W      RX ANT DATA: 30GPARABOLIC 00521H0046T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 889436 BUR:M    STC:FX     EMS:    10M00F9WJF PWR:    W5.00000 NOM:C,COLMIR-2A

      TX LOCATION:    SD   WAYSIDE SUB             425955N1031241W      TX ANT DATA: 31GPARABOLIC 01097H0023T
      RX LOCATION(S): NE   CHADRON RPT            423806N1030610W      RX ANT DATA: 31GPARABOLIC 01380H0056T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 799255 BUR:W    STC:FX     EMS:     3M50F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    MO   HERCULES                364017N0925240W      TX ANT DATA: 28GPARABOLIC 00425H0046T
      RX LOCATION(S): AR   BULL SHOALS            362147N0923554W      RX ANT DATA: 28GPARABOLIC 00338H0046T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 859202 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W1.00000 NOM:C,RIEMIR-2

      TX LOCATION:    OK   BROKEN BOW POWERHOUSE  340824N0944104W      TX ANT DATA: 29GPARABOLIC 00189H0012T
      RX LOCATION(S): OK   BROKEN BOW             340910N0944127W      RX ANT DATA: 29GPARABOLIC 00214H0076T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 849270 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    OK   FORT GIBSON             355205N0951322W      TX ANT DATA: 31GPARABOLIC 00256H0075T
      RX LOCATION(S): OK   MOODYS                 360735N0945315W      RX ANT DATA: 29GPARABOLIC 00366H0072T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 849299 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    OK   KANSAS                 361356N0944713W      TX ANT DATA: 29GPARABOLIC 00366H0049T
      RX LOCATION(S): AR   DECATUR                361816N0942205W      RX ANT DATA: 29GPARABOLIC 00440H0066T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 849332 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    OK   KIAMICHI MOUNTAIN      343648N0944139W      TX ANT DATA: 29GPARABOLIC 00675H0037T
      RX LOCATION(S): AR   POTEAU MOUNTAIN        345746N0942227W      RX ANT DATA: 29GPARABOLIC 00675H0037T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:DOE 849267 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    OK   LAMAR                  350509N0961023W      TX ANT DATA: 29GPARABOLIC 00305H0057T
      RX LOCATION(S): OK   WELEETKA               352106N0960726W      RX ANT DATA: 29GPARABOLIC 00274H0075T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:TVA 842920 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W2.00000 NOM:C,FECSS2000W

      TX LOCATION:    AL   BROWNS FERRY           344213N0870706W      TX ANT DATA: 33GPARABOLIC 00172H0052T
      RX LOCATION(S): AL   TRINITY                3436XXN08703XXW      RX ANT DATA: 33GPARABOLIC 00184H0026T
-------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:TVA 870163 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,COLMW-218

      TX LOCATION:    AL   FABIUS                 344839N0854702W      TX ANT DATA: 28GPARABOLIC 00447H0038T
      RX LOCATION(S): AL   GOOSE POND             343538N0860334W      RX ANT DATA: 33GPARABOLIC 00183H0040T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1715.000000 SER:TVA 842932 BUR:TVA  STC:FX     EMS:      1M00F9W   PWR:     W4.50000 NOM:C,MOTMR200,MTH4D20-0

      TX LOCATION:     KY   CALVERT                  370323N0882102W      TX ANT DATA: 29GPARABOLIC 00106H0026T
      RX LOCATION(S): KY   MARSHALL                 370137N0882338W      RX ANT DATA: 29GPARABOLIC 00109H0061T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:TVA 843246 BUR:TVA  STC:FX     EMS:      8M00F9W   PWR:     W5.00000 NOM:C,COLMW-218

      TX LOCATION:     KY   LYNN GROVE               363550N0882811W      TX ANT DATA: 32GPARABOLIC 00169H0091T
      RX LOCATION(S): KY   MAYFIELD                 364153N0883347W      RX ANT DATA: 30GPARABOLIC 00163H0027T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:TVA 843032 BUR:TVA  STC:FX     EMS:      8M00F9W   PWR:     W5.00000 NOM:C,MOT MS-228

      TX LOCATION:     KY   PARADISE                 371519N0865844W      TX ANT DATA: 33GPARABOLIC 00129H0160T
      RX LOCATION(S): KY   BOWLING GREEN            370019N0863123W      RX ANT DATA: 33GPARABOLIC 00240H0079T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:TVA 842614 BUR:TVA  STC:FX     EMS:      8M00F9W   PWR:     W4.00000 NOM:C,MOTMR-200

      TX LOCATION:     TN   CHATTANOOGA              350540N0851346W      TX ANT DATA: 32GPARABOLIC 00226H0032T
      RX LOCATION(S): TN   RACCOON MOUNTAIN         350321N0852306W      RX ANT DATA: 28GPARABOLIC 00505H0024T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:TVA 843031 BUR:TVA  STC:FX     EMS:      8M00F9W   PWR:     W5.00000 NOM:C,COLMS-228

      TX LOCATION:     TN   NASHVILLE                360921N0864445W      TX ANT DATA: 28GPARABOLIC 00128H0078T
      RX LOCATION(S): TN   HOLLIS CHAPEL            362921N0863140W      RX ANT DATA: 33GPARABOLIC 00290H0101T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:TVA 833295 BUR:TVA  STC:FX     EMS:      8M00F9W   PWR:     W5.00000 NOM:C,COLMS228

      TX LOCATION:     TN   PHIPPS BEND              362739N0824835W      TX ANT DATA: 33GPARABOLIC 00360H0049T
      RX LOCATION(S): TN   CHURCH HILL              363505N0824312W      RX ANT DATA: 31GPARABOLIC 00559H0063T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:TVA 843216 BUR:TVA  STC:FX     EMS:      1M00F9W   PWR:     W4.50000 NOM:C,MOTMR-200,MTN4D20-1

      TX LOCATION:     TN   ROANE                    355640N0842323W      TX ANT DATA: 29GPARABOLIC 00236H0039T
      RX LOCATION(S): TN   OAK RIDGE                355627N0842424W      RX ANT DATA: 29GPARABOLIC 00233H0011T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:TVA 843269 BUR:TVA  STC:FX     EMS:      8M00F9W   PWR:     W5.00000 NOM:C,MOTMR200

      TX LOCATION:     TN   VOLUNTEER                360716N0834854W      TX ANT DATA: 32GPARABOLIC 00333H0105T
      RX LOCATION(S): TN   SHARPE RIDGE             355928N0835744W      RX ANT DATA: 28GPARABOLIC 00407H0046T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1716.000000 SER:DOE 839573 BUR:M    STC:FX     EMS:      1M90F9WJF PWR:     W2.00000 NOM:C,GRA6018-3A/72

      TX LOCATION:     AZ   NEWMANPK                 324308N1112358W      TX ANT DATA: 28GPARABOLIC 01374H0006T
      RX LOCATION(S): AZ   PICACHO                  323618N1113417W      RX ANT DATA: 30GPARABOLIC 00506H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1716.000000 SER:I   921393 BUR:RGP  STC:FX     EMS:      1M60F9W   PWR:     W1.50000 NOM:C,MOTK16RBF2200

      TX LOCATION:     WY   GUERNSEY                 421726N1044543W      TX ANT DATA: 32GPARABOLIC 01325H0015T
      RX LOCATION(S): WY   GUERNSEY                 421733N1044535W      RX ANT DATA: 00GREFLECTOR 01347H0005T
                       WY   PINE RIDGE               422055N1050150W                   32GPARABOLIC 01603H0009T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1716.500000 SER:I   940714 BUR:RGP  STC:FX     EMS:      5M00F9W   PWR:     W1.00000 NOM:C,MOTK16RBF2200

      TX LOCATION:     CO   HAGERMAN PASS             391533N1062849W      TX ANT DATA: 33GPARABOLIC 03684H0012T
      RX LOCATION(S): CO   SUNLIGHT PEAK            392539N1072253W      RX ANT DATA: 29GPARABOLIC 03219H0027T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1717.000000 SER:DOE 926910 BUR:M    STC:FX     EMS:      7M30F9WWF PWR:      W.20000 NOM:C,COLMIR2A

      TX LOCATION:     WY   COPPER MOUNTAIN SUB      432238N1080830W      TX ANT DATA: 28GPARABOLIC 01460H0006T
      RX LOCATION(S): WY   BOYSEN PEAK              432728N1081135W      RX ANT DATA: 28GPARABOLIC 02307H0006T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1719.000000 SER:DOE 839578 BUR:M    STC:FX     EMS:     1M90F9WJF PWR:    W2.00000 NOM:C,GRA6018-3A/72

      TX LOCATION:    AZ   NEWMANPK                 324308N1112358W      TX ANT DATA: 28GPARABOLIC 01374H0012T
      RX LOCATION(S): AZ   ORACLE                   323603N1105853W      RX ANT DATA: 32GPARABOLIC 01102H0018T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1719.500000 SER:I   940733 BUR:RGP  STC:FX     EMS:     5M00F9W   PWR:    W1.00000 NOM:C,MOTK16RBF2200

      TX LOCATION:    CO   MT ELBERT                390539N1062106W      TX ANT DATA: 25GPARABOLIC 02818H0006T
      RX LOCATION(S): CO   GRANITE                  390509N1061604W      RX ANT DATA: 25GPARABOLIC 03076H0012T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1720.000000 SER:AR  867018 BUR:CE   STC:FX     EMS:     5M00F9W   PWR:    W1.00000 NOM:C,//MOTK36HBF1400$ANDP

      TX LOCATION:    NE   OMAHA                    412206N0955752W      TX ANT DATA: 30GPARABOLIC 00372H0027T
      RX LOCATION(S): IA   MODALE                   413616N0960200W      RX ANT DATA: 30GPARABOLIC 00306H0030T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1720.000000 SER:DOE 899899 BUR:M    STC:FX     EMS:     1M60D7WWT PWR:    W1.00000 NOM:C,COLMDR5302

      TX LOCATION:    AZ   MOUNT LEMMON             322634N1104716W      TX ANT DATA: 30GPARABOLIC 02791H0020T
      RX LOCATION(S): AZ   DEL BAC                  320805N1105913W      RX ANT DATA: 30GPARABOLIC 00757H0011T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1720.000000 SER:DOE 916756 BUR:M    STC:FX     EMS:    10M00F9WWF PWR:    W5.00000 NOM:C,WMXONE 2000

      TX LOCATION:    MT   DUTTON                   474800N1114224W      TX ANT DATA: 31GPARABOLIC 01244H0006T
      RX LOCATION(S): MT   KNEE HILL                480058N1112103W      RX ANT DATA: 31GPARABOLIC 01175H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1720.000000 SER:DOE 916675 BUR:M    STC:FX     EMS:    10M00F9WWF PWR:    W5.00000 NOM:C,WMX1-2000

      TX LOCATION:    MT   GOVERNMENT HILL          480806N1104516W      TX ANT DATA: 31GPARABOLIC 01052H0008T
      RX LOCATION(S): MT   TYLER                    480858N1101717W      RX ANT DATA: 31GPARABOLIC 00933H0010T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1720.000000 SER:DOE 916681 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   COLOME                   431707N0994040W      TX ANT DATA: 30GPARABOLIC 00719H0061T
      RX LOCATION(S): SD   BIJOU HILLS              433152N0990518W      RX ANT DATA: 30GPARABOLIC 00600H0061T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1720.000000 SER:TVA 843313 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,COLMS228

      TX LOCATION:    MS   LAMAR                    345301N0892206W      TX ANT DATA: 32GPARABOLIC 00198H0090T
      RX LOCATION(S): MS   GRAHAM                   343433N0884736W      RX ANT DATA: 32GPARABOLIC 00213H0120T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1720.000000 SER:TVA 843316 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,COLMS228

      TX LOCATION:    MS   TUPELO                   341521N0884146W      TX ANT DATA: 32GPARABOLIC 00079H0072T
      RX LOCATION(S): MS   VANVLEET                 340038N0885441W      RX ANT DATA: 32GPARABOLIC 00140H0114T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1721.000000 SER:I   921394 BUR:RGP  STC:FX     EMS:     1M60F9W   PWR:    W1.50000 NOM:C,MOTK16RBF2200

      TX LOCATION:    WY   CASPER MTN               424411N1061829W      TX ANT DATA: 32GPARABOLIC 02463H0061T
      RX LOCATION(S): WY   SYBRANT                  425117N1051429W      RX ANT DATA: 32GPARABOLIC 01637H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1721.000000 SER:I   921395 BUR:RGP  STC:FX     EMS:     1M60F9W   PWR:    W1.50000 NOM:C,MOTK16RBF2200

      TX LOCATION:    WY   SAND DRAW                422823N1045313W      TX ANT DATA: 15GPARABOLIC 01597H0009T
      RX LOCATION(S): WY   PINE RIDGE               422055N1050150W      RX ANT DATA: 32GPARABOLIC 01603H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1721.000000 SER:TVA 872797 BUR:TVA  STC:FX     EMS:     5M00F9W   PWR:    W5.00000 NOM:C,RIEMDR-1402

      TX LOCATION:    TN   SEWANEE                  351310N0855314W      TX ANT DATA: 31GPARABOLIC 00621H0050T
      RX LOCATION(S): TN   FRANKLIN                 352008N0860700W      RX ANT DATA: 32GPARABOLIC 00308H0040T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1725.000000 SER:DOE 876618 BUR:B    STC:FX     EMS:    10M00F9WJ  PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:     ID   ALBION BUTTE              422141N1132717W      TX ANT DATA: 28GPARABOLIC 02167H0009T
      RX LOCATION(S): ID   BURLEY MAINTENANCE        423212N1134829W      RX ANT DATA: 28GPARABOLIC 01268H0009T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 876613 BUR:B    STC:FX     EMS:    10M00F9WJ  PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:     ID   IONA BUTTE                433243N1115314W      TX ANT DATA: 28GPARABOLIC 01680H0006T
      RX LOCATION(S): ID   BIRCH CREEK               433208N1113547W      RX ANT DATA: 28GPARABOLIC 02015H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 924903 BUR:B    STC:FX     EMS:    800K00F9W  PWR:    W1.00000 NOM:

      TX LOCATION:     ID   MINIDOKA                  424035N1132939W      TX ANT DATA: 30GPARABOLIC 00390H0003T
      RX LOCATION(S): ID   ALBION BUTTE              422142N1132717W      RX ANT DATA: 30GPARABOLIC 00661H0004T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 925165 BUR:B    STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,WMX12013-2A23DD2D12

      TX LOCATION:     ID   TARGHEE SUBSTATION        434320N1110655W      TX ANT DATA: 33GPARABOLIC 01857H0043T
      RX LOCATION(S): ID   ASHTON HILL               441031N1112547W      RX ANT DATA: 31GPARABOLIC 01971H0030T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 787231 BUR:B    STC:FX     EMS:    10M00F9W   PWR:    W5.00000 NOM:C,LEN779F1

      TX LOCATION:     OR   BLUE RIDGE               431504N1240642W      TX ANT DATA: 28GPARABOLIC 00366H0009T
      RX LOCATION(S): OR   LENEVE                    431237N1241815W      RX ANT DATA: 28GPARABOLIC 00173H0031T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 924905 BUR:B    STC:FX     EMS:    800K00F9W  PWR:    W1.00000 NOM:

      TX LOCATION:     OR   CELILO DC CONVERTER      453544N1210650W      TX ANT DATA: 28GPARABOLIC 00069H0002T
      RX LOCATION(S): OR   CHENOWETH SUBSTATION      453807N1211209W      RX ANT DATA: 28GPARABOLIC 00046H0002T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 787255 BUR:B    STC:FX     EMS:    10M00F9W   PWR:    W5.00000 NOM:C,LEN779F1

      TX LOCATION:     OR   LAKESIDE                 433200N1241026W      TX ANT DATA: 30GPARABOLIC 00227H0006T
      RX LOCATION(S): OR   GOODWIN PEAK              435541N1235325W      RX ANT DATA: 28GPARABOLIC 00554H0012T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 944925 BUR:B    STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,WMX12012-2A23DD2D12

      TX LOCATION:     OR   MARYS PEAK               443016N1233305W      TX ANT DATA: 30GPARABOLIC 01249H0010T
      RX LOCATION(S): OR   PROSPECT HILL             445118N1230714W      RX ANT DATA: 28GPARABOLIC 00345H0018T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 787227 BUR:B    STC:FX     EMS:    10M00F9W   PWR:    W5.00000 NOM:C,LEN779F1

      TX LOCATION:     OR   NOTI                     440303N1233005W      TX ANT DATA: 28GPARABOLIC 00557H0016T
      RX LOCATION(S): OR   COBURG                    440657N1230215W      RX ANT DATA: 28GPARABOLIC 00362H0024T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 786590 BUR:B    STC:FX     EMS:     3M50F9W   PWR:    W5.00000 NOM:C,LEN70F3

      TX LOCATION:     OR   PORTLAND                 453148N1223916W      TX ANT DATA: 25GPARABOLIC 00038H0042T
      RX LOCATION(S): OR   PORTLAND PGE              453059N1224021W      RX ANT DATA: 25GPARABOLIC 00015H0051T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 846435 BUR:B    STC:FX     EMS:    10M00F9W   PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     OR   SCOTT MOUNTAIN           432217N1230348W      TX ANT DATA: 31GPARABOLIC 01291H0009T
      RX LOCATION(S): OR   KENYON MOUNTAIN           430009N1234640W      RX ANT DATA: 28GPARABOLIC 01002H0023T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 826273 BUR:B    STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,LEN70F3

      TX LOCATION:     WA   CAPITOL PEAK              465829N1230816W      TX ANT DATA: 28GPARABOLIC 00036H0030T
      RX LOCATION(S): WA   COSMOPOLIS SUBSTATION     465658N1234555W      RX ANT DATA: 28GPARABOLIC 00810H0012T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1725.000000 SER:DOE 786274 BUR:B    STC:FX     EMS:     3M50F9W   PWR:    W5.00000 NOM:C,COLMW228

      TX LOCATION:    WA   KENNEWICK               460615N1190751W      TX ANT DATA: 28GPARABOLIC 00664H0005T
      RX LOCATION(S): WA   SUNNYSIDE               462909N1195929W      RX ANT DATA: 25GPARABOLIC 00941H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 839466 BUR:M    STC:FX     EMS:     4M60F9WJF PWR:    W1.00000 NOM:C,FECLR2-2000

      TX LOCATION:    CA   SOUTH FORK MOUNTAIN      403930N1223123W      TX ANT DATA: 28GPARABOLIC 01057H0015T
      RX LOCATION(S): CA   KESWICK                  403642N1222635W      RX ANT DATA: 28GPARABOLIC 00198H0018T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 869427 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MN   ERHARD                   462847N0960148W      TX ANT DATA: 30GPARABOLIC 00485H0020T
      RX LOCATION(S): MN   DALTON                   461028N0955609W      RX ANT DATA: 30GPARABOLIC 00424H0020T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 859562 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MN   GRANITE FALLS            444936N0953307W      TX ANT DATA: 30GPARABOLIC 00312H0059T
      RX LOCATION(S): MN   LAC QUI PARLE            445754N0955557W      RX ANT DATA: 30GPARABOLIC 00322H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 849727 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   OFALLON                  465024N1050748W      TX ANT DATA: 31GPARABOLIC 00668H0011T
      RX LOCATION(S): MT   FALLON                   465539N1051003W      RX ANT DATA: 31GPARABOLIC 00882H0046T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 849671 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   PINE RIDGE               454947N1075036W      TX ANT DATA: 31GPARABOLIC 01219H0018T
      RX LOCATION(S): MT   HYSHAM                   460347N1071414W      RX ANT DATA: 31GPARABOLIC 01133H0018T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 849716 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   VIDA                     475536N1053025W      TX ANT DATA: 31GPARABOLIC 00791H0052T
      RX LOCATION(S): MT   LINDSAY RIDGE            471809N1051753W      RX ANT DATA: 31GPARABOLIC 01004H0018T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 849769 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   BUFFALO                  464356N0973248W      TX ANT DATA: 31GPARABOLIC 00369H0018T
      RX LOCATION(S): ND   PEAK                     465423N0975327W      RX ANT DATA: 31GPARABOLIC 00460H0009T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 849760 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   CLEVELAND                465604N0990710W      TX ANT DATA: 31GPARABOLIC 00593H0037T
      RX LOCATION(S): ND   JAMESTOWN                465237N0984106W      RX ANT DATA: 31GPARABOLIC 00450H0018T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 849750 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   CROWN BUTTE              465658N1010818W      TX ANT DATA: 31GPARABOLIC 00707H0014T
      RX LOCATION(S): ND   BISMARCK                 465015N1004114W      RX ANT DATA: 31GPARABOLIC 00567H0008T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 890363 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   GRANDFORKS               475850N0970352W      TX ANT DATA: 31GPARABOLIC 00253H0047T
      RX LOCATION(S): ND   MAYVILLE                 474005N0971928W      RX ANT DATA: 31GPARABOLIC 00308H0090T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 849732 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   SENTINEL BUTTE           465241N1035015W      TX ANT DATA: 31GPARABOLIC 01033H0005T
      RX LOCATION(S): ND   FRYBURG                  465326N1031955W      RX ANT DATA: 31GPARABOLIC 00870H0017T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1725.000000 SER:DOE 859520 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   BIG BEND NATIONAL PARK   440158N0992644W      TX ANT DATA: 30GPARABOLIC 00448H0009T
      RX LOCATION(S): SD   FORT THOMPSON            440753N0992614W      RX ANT DATA: 30GPARABOLIC 00530H0014T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 859550 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   ELKTON                   442108N0962754W      TX ANT DATA: 30GPARABOLIC 00596H0059T
      RX LOCATION(S): SD   COLMAN                   435638N0964606W      RX ANT DATA: 30GPARABOLIC 00521H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 916338 BUR:M    STC:FX     EMS:     1M60F9WWF PWR:    W1.00000 NOM:C,WESTRN1-2000

      TX LOCATION:    SD   ELLSWORTH                440915N1030515W      TX ANT DATA: 30GPARABOLIC 00983H0034T
      RX LOCATION(S): SD   NEW UNDERWOOD            440424N1024940W      RX ANT DATA: 30GPARABOLIC 00882H0034T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 859573 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   HURONSUB                 442817N0982026W      TX ANT DATA: 30GPARABOLIC 00398H0035T
      RX LOCATION(S): SD   WESSINGTON SPRINGS       440142N0983640W      RX ANT DATA: 30GPARABOLIC 00597H0051T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 859527 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   LAKE ANDES               430855N0983728W      TX ANT DATA: 30GPARABOLIC 00590H0059T
      RX LOCATION(S): SD   FORT RANDALL             430343N0983314W      RX ANT DATA: 30GPARABOLIC 00387H0041T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 839551 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   LODGE POLE               454808N1024407W      TX ANT DATA: 30GPARABOLIC 00910H0005T
      RX LOCATION(S): ND   ROCKY RIDGE              460355N1023710W      RX ANT DATA: 30GPARABOLIC 00893H0029T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 916689 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   POTATO CREEK             433250N1015638W      TX ANT DATA: 30GPARABOLIC 00945H0030T
      RX LOCATION(S): SD   MARTIN                   431331N1014220W      RX ANT DATA: 30GPARABOLIC 00993H0061T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 859544 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   SIOUX FALLS              433429N0963901W      TX ANT DATA: 30GPARABOLIC 00464H0058T
      RX LOCATION(S): SD   MOE                      431013N0963835W      RX ANT DATA: 30GPARABOLIC 00469H0035T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 859532 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   TURKEY RIDGE             431454N0972239W      TX ANT DATA: 30GPARABOLIC 00529H0041T
      RX LOCATION(S): SD   TRIPP                    431137N0980303W      RX ANT DATA: 30GPARABOLIC 00570H0035T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 859566 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   WATERTOWN                445303N0970230W      TX ANT DATA: 30GPARABOLIC 00553H0084T
      RX LOCATION(S): SD   TORONTO                  443658N0964213W      RX ANT DATA: 30GPARABOLIC 00602H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 859479 BUR:M    STC:FX     EMS:     5M00F9WWF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:    WY   FONTENELLE DAM           420137N1100348W      TX ANT DATA: 28GPARABOLIC 01955H0015T
      RX LOCATION(S): WY   FONTENELLE               415910N1100336W      RX ANT DATA: 28GPARABOLIC 01996H0024T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 839475 BUR:M    STC:FX     EMS:     5M00F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    WY   GREEN RIVER              413310N1092335W      TX ANT DATA: 33GPARABOLIC 02240H0023T
      RX LOCATION(S): UT   GRIZZLY RIDGE           404419N1092859W      RX ANT DATA: 33GPARABOLIC 02783H0021T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1725.000000 SER:DOE 936052 BUR:W    STC:FX     EMS:     4M70F9W   PWR:    W3.00000 NOM:C,MOTSTARPT

      TX LOCATION:    AR   PIGGOTT                362350N0901302W      TX ANT DATA: 03GPARABOLIC 00509H0160T
      RX LOCATION(S): MO   POPLAR BLUFF           364730N0902534W      RX ANT DATA: 03GPARABOLIC 00460H0135T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 799256 BUR:W    STC:FX     EMS:     3M50F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    MO   SPRINGFIELD             370939N0932023W      TX ANT DATA: 28GPARABOLIC 00384H0061T
      RX LOCATION(S): MO   SELMORE                 365647N0931212W      RX ANT DATA: 28GPARABOLIC 00422H0045T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 849277 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W2.50000 NOM:C,RIEMIR-2

      TX LOCATION:    MO   SUGAR CAMP              363142N0935000W      TX ANT DATA: 29GPARABOLIC 00489H0030T
      RX LOCATION(S): AR   HUMPHREY MOUNTAIN      362446N0935716W      RX ANT DATA: 29GPARABOLIC 00518H0036T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 849284 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    OK   FORT GIBSON              355205N0951322W      TX ANT DATA: 31GPARABOLIC 00256H0075T
      RX LOCATION(S): OK   BALD HILL               354620N0954915W      RX ANT DATA: 31GPARABOLIC 00280H0042T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:DOE 849329 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    OK   SHORT MOUNTAIN           352002N0944635W      TX ANT DATA: 29GPARABOLIC 00227H0030T
      RX LOCATION(S): AR   POTEAU MOUNTAIN         345746N0942227W      RX ANT DATA: 29GPARABOLIC 00814H0037T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:I   921917 BUR:RGP  STC:FX     EMS:     1M60F9W   PWR:    W2.00000 NOM:C,MOTK16RBF2200

      TX LOCATION:    WY   CASPER MTN              424422N1062134W      TX ANT DATA: 32GPARABOLIC 02438H0009T
      RX LOCATION(S): WY   SEMINOE PEAK           420840N1065454W      RX ANT DATA: 32GPARABOLIC 02237H0005T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:TVA 870164 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,COLHW-228

      TX LOCATION:    AL   FABIUS                  344839N0854702W      TX ANT DATA: 28GPARABOLIC 00447H0038T
      RX LOCATION(S): AL   WIDOWS CREEK            345302N0854524W      RX ANT DATA: 28GPARABOLIC 00191H0009T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:TVA 843111 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,MOTMR200

      TX LOCATION:    GA   STEPHENSVILLE           345335N0853417W      TX ANT DATA: 32GPARABOLIC 00506H0084T
      RX LOCATION(S): AL   LAMBERT CHAPEL          344239N0855311W      RX ANT DATA: 30GPARABOLIC 00445H0038T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:TVA 872809 BUR:TVA  STC:FX     EMS:    10M00F9W   PWR:    W5.00000 NOM:C,RIEMDR-1802

      TX LOCATION:    TN   ALLEN                   350430N0900855W      TX ANT DATA: 31GPARABOLIC 00073H0055T
      RX LOCATION(S): TN   FREEPORT                350000N0900219W      RX ANT DATA: 31GPARABOLIC 00091H0099T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:TVA 872805 BUR:TVA  STC:FX     EMS:    10M00F9W   PWR:    W5.00000 NOM:C,RIEMDR-1802

      TX LOCATION:    TN   CORDOVA                 351030N0894445W      TX ANT DATA: 34GPARABOLIC 00094H0069T
      RX LOCATION(S): TN   NEWCASTLE               351208N0891035W      RX ANT DATA: 34GPARABOLIC 00189H0148T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:TVA 843423 BUR:TVA  STC:FX     EMS:    10M00F9W   PWR:    W5.00000 NOM:C,COLMS228

      TX LOCATION:    TN   MONTGOMERY              363534N0871510W      TX ANT DATA: 33GPARABOLIC 00162H0066T
      RX LOCATION(S): TN   VANLEER                 361427N0872648W      RX ANT DATA: 31GPARABOLIC 00262H0090T
-------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:TVA 870530 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,MOTMR200

      TX LOCATION:    TN   MORRISTOWN              361042N0831739W      TX ANT DATA: 30GPARABOLIC 00514H0047T
      RX LOCATION(S): TN   GREENTOP                354848N0834011W      RX ANT DATA: 30GPARABOLIC 00920H0021T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1725.000000 SER:TVA 843257 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,COLMW-218

      TX LOCATION:     TN   WEAKLEY                  361629N0884959W      TX ANT DATA: 28GPARABOLIC 00114H0061T
      RX LOCATION(S): TN   MARTIN                    361849N0885044W      RX ANT DATA: 28GPARABOLIC 00119H0024T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1726.000000 SER:DOE 839501 BUR:M    STC:FX     EMS:     2M00F9WJF PWR:    W1.00000 NOM:C,MOTK16RBF1200

      TX LOCATION:     AZ   NEWMANPK                  324308N1112358W      TX ANT DATA: 33GPARABOLIC 01374H0006T
      RX LOCATION(S): AZ   COOLIDGE                  330032N1113133W      RX ANT DATA: 33GPARABOLIC 00427H0030T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1726.000000 SER:DOE 890441 BUR:M    STC:FX     EMS:     6M40F9WJF PWR:    W5.00000 NOM:C,LEN79F1

      TX LOCATION:     AZ   PETE SMITH PEAK           340410N1132108W      TX ANT DATA: 30GPARABOLIC 01524H0012T
      RX LOCATION(S): CA   METAL MOUNTAIN            341833N1140951W      RX ANT DATA: 30GPARABOLIC 00518H0009T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1726.000000 SER:DOE 926641 BUR:M    STC:FX     EMS:   800K00F8E   PWR:    W1.00000 NOM:C,WMX-2000

      TX LOCATION:     CA   HEAD GATE                 340940N1141640W      TX ANT DATA: 30GPARABOLIC 00130H0008T
      RX LOCATION(S): CA   METAL MOUNTAIN            341832N1140951W      RX ANT DATA: 30GPARABOLIC 00524H0019T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1727.000000 SER:DOE 869442 BUR:M    STC:FX     EMS:    10M00F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     CO   ERIE                      400159N1045845W      TX ANT DATA: 31GPARABOLIC 01585H0017T
      RX LOCATION(S): CO   BALD MTN                  402121N1051547W      RX ANT DATA: 31GPARABOLIC 02164H0012T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1727.000000 SER:DOE 906366 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:     CO   PANORAMA PEAK             402158N1052511W      TX ANT DATA: 30GPARABOLIC 02630H0015T
      RX LOCATION(S): CO   ESTES PARK                402237N1053032W      RX ANT DATA: 30GPARABOLIC 02284H0015T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1727.000000 SER:DOE 849436 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     CO   PEETZ TABLE               405737N1032226W      TX ANT DATA: 28GPARABOLIC 01451H0040T
      RX LOCATION(S): NE   KIMBALL                   410857N1033732W      RX ANT DATA: 28GPARABOLIC 01463H0040T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1727.000000 SER:DOE 849444 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     NE   CARTER CANYON             414534N1035001W      TX ANT DATA: 28GPARABOLIC 01494H0030T
      RX LOCATION(S): NE   STEGALL REPEATER          414850N1035108W      RX ANT DATA: 28GPARABOLIC 01402H0008T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1727.000000 SER:DOE 869453 BUR:M    STC:FX     EMS:     2M00F9WWF PWR:    W1.00000 NOM:C,MOTK16RBF1200

      TX LOCATION:     NE   SIDNEY                    410949N1025922W      TX ANT DATA: 28GPARABOLIC 01298H0030T
      RX LOCATION(S): NE   BASIN                     411132N1030257W      RX ANT DATA: 28GPARABOLIC 01326H0030T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1727.000000 SER:DOE 849447 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W1.00000 NOM:C,LEN700F1

      TX LOCATION:     NE   STEGALL REPEATER          414850N1035108W      TX ANT DATA: 28GPARABOLIC 01402H0008T
      RX LOCATION(S): NE   STEGALL                   414927N1035638W      RX ANT DATA: 28GPARABOLIC 01295H0014T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1727.000000 SER:DOE 889671 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     WY   RADERVILLE RADIO SITE    430037N1071845W      TX ANT DATA: 32GPARABOLIC 01926H0018T
      RX LOCATION(S): WY   HORSE HEAVEN              424250N1070045W      RX ANT DATA: 32GPARABOLIC 02259H0018T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1727.000000 SER:DOE 829695 BUR:M    STC:FX     EMS:     2M00F9WWF PWR:    W1.00000 NOM:C,MOTK16RBF1200

      TX LOCATION:     WY   THERMOPOLIS              433855N1081333W      TX ANT DATA: 28GPARABOLIC 01359H0011T
      RX LOCATION(S): WY   BOYSEN PEAK               432728N1081135W      RX ANT DATA: 28GPARABOLIC 02303H0006T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1728.000000 SER:DOE 889435 BUR:M    STC:FX     EMS:    10M00F9WJF PWR:    W5.00000 NOM:C,COLMIR-2A

      TX LOCATION:    SD   WAYSIDE SUB              425955N1031241W      TX ANT DATA: 31GPARABOLIC 01097H0038T
      RX LOCATION(S): SD   BATTLE MTN              432627N1032708W      RX ANT DATA: 31GPARABOLIC 01335H0041T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1729.000000 SER:DOE 839571 BUR:M    STC:FX     EMS:     1M90F9WJF PWR:    W2.00000 NOM:C,GRA6018-3A/72

      TX LOCATION:    AZ   NEWMANPK                 324308N1112358W      TX ANT DATA: 28GPARABOLIC 01374H0006T
      RX LOCATION(S): AZ   ELOY                     324405N1113359W      RX ANT DATA: 28GPARABOLIC 00481H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:DOE 786350 BUR:B    STC:FX     EMS:     8M00F9W   PWR:    W1.00000 NOM:C,NEABSF89N2B600-6D1

      TX LOCATION:    WA   MURRAY SUBSTATION        480919N1220500W      TX ANT DATA: 32GPARABOLIC 00158H0008T
      RX LOCATION(S): WA   KING LAKE                474857N1215521W      RX ANT DATA: 32GPARABOLIC 00490H0028T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:DOE 916922 BUR:M    STC:FX     EMS:     5M00F8EWF PWR:    W1.00000 NOM:C,WMXTWO-2000

      TX LOCATION:    CO   NORTH GUNNISON           383337N1065524W      TX ANT DATA: 29GPARABOLIC 02359H0006T
      RX LOCATION(S): CO   BIG MESA                 382603N1070115W      RX ANT DATA: 29GPARABOLIC 02666H0037T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:DOE 869657 BUR:M    STC:FX     EMS:     6M40F9WJF PWR:    W1.00000 NOM:C,COLMIR-2

      TX LOCATION:    MT   MALTA REPEATER           482140N1074938W      TX ANT DATA: 25GPARABOLIC 00689H0006T
      RX LOCATION(S): MT   MALTA SUBSTATION        482058N1075003W      RX ANT DATA: 25GPARABOLIC 00713H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:DOE 926743 BUR:M    STC:FX     EMS:    10M00F9WWF PWR:    W5.00000 NOM:C,WMXTWO-2000

      TX LOCATION:    ND   DEVILS LAKE REPEATER    475901N0985608W      TX ANT DATA: 31GPARABOLIC 00522H0059T
      RX LOCATION(S): ND   CARRINGTON REPEATER     472047N0991715W      RX ANT DATA: 31GPARABOLIC 00651H0059T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:DOE 916692 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   COLOME                   431707N0994040W      TX ANT DATA: 30GPARABOLIC 00719H0061T
      RX LOCATION(S): SD   GREGORY                  431246N0992551W      RX ANT DATA: 30GPARABOLIC 00664H0023T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:I   940720 BUR:RGP  STC:FX     EMS:   660K00F9W   PWR:    W1.00000 NOM:C,MOTK16RBF1200SP

      TX LOCATION:    CO   MALTA                    391118N1061926W      TX ANT DATA: 25GPARABOLIC 02880H0006T
      RX LOCATION(S): CO   GRANITE                  390509N1061604W      RX ANT DATA: 25GPARABOLIC 03076H0012T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:I   921396 BUR:RGP  STC:FX     EMS:     1M60F9W   PWR:    W3.00000 NOM:C,MOTK16RBF200

      TX LOCATION:    WY   CASPER MTN               424425N1062134W      TX ANT DATA: 32GPARABOLIC 02438H0026T
      RX LOCATION(S): WY   ALCOVA                   423242N1064306W      RX ANT DATA: 00GREFLECTOR 01707H0005T
                      WY   ALCOVA                   423253N1064300W                   32GPARABOLIC 01625H0018T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:I   921919 BUR:RGP  STC:FX     EMS:     1M60F9W   PWR:    W2.00000 NOM:C,MOTK16RBF2200

      TX LOCATION:    WY   SEMINOE PEAK            420840N1065454W      TX ANT DATA: 28GPARABOLIC 02237H0008T
      RX LOCATION(S): WY   SEMINOE                  420933N1065434W      RX ANT DATA: 00GREFLECTOR 01957H0005T
                      WY   SEMINOE                  420922N1065428W                   28GPARABOLIC 01920H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:I   921397 BUR:RGP  STC:FX     EMS:     1M60F9W   PWR:    W1.50000 NOM:C,MOTK16RBF2200

      TX LOCATION:    WY   SYBRANT                  425117N1051429W      TX ANT DATA: 30GPARABOLIC 01637H0021T
      RX LOCATION(S): WY   SAND DRAW                422823N1045313W      RX ANT DATA: 15GPARABOLIC 01597H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1731.000000 SER:TVA 920506 BUR:TVA  STC:FX     EMS:   800K00F8W   PWR:    W1.00000 NOM:

      TX LOCATION:    TN   WEAKLEY                  361629N0884959W      TX ANT DATA: 33GPARABOLIC 00375H0215T
      RX LOCATION(S): TN   UNION CITY               362443N0890205W      RX ANT DATA: 33GPARABOLIC 00310H0190T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1733.000000 SER:DOE 916697 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   MISSION                 431934N1003914W      TX ANT DATA: 30GPARABOLIC 00805H0012T
      RX LOCATION(S): SD   OKREEK                  431844N1002557W      RX ANT DATA: 30GPARABOLIC 00828H0094T
-------------------------------------------------------------------------------------------------------------
FREQ: M1733.000000 SER:I   892140 BUR:RLC  STC:FX     EMS:   800K00F9W   PWR:    W3.00000 NOM:C,FECFAS2000

      TX LOCATION:    AZ   HASSAYAMPA              333529N1124302W      TX ANT DATA: 28GPARABOLIC 00427H0003T
      RX LOCATION(S): AZ   WHITE TANK MTN          333405N1123440W      RX ANT DATA: 28GPARABOLIC 01244H0008T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:AR  867017 BUR:CE   STC:FX     EMS:     5M00F9W   PWR:    W1.00000 NOM:C,//MOTK36HBF1400$ANDP

      TX LOCATION:    NE   OMAHA                   411540N0955615W      TX ANT DATA: 30GPARABOLIC 00316H0027T
      RX LOCATION(S): NE   OMAHA                   412206N0955752W      RX ANT DATA: 30GPARABOLIC 00372H0009T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 925158 BUR:B    STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,WMX12013-2A23DD2D12

      TX LOCATION:    ID   IONA BUTTE              433243N1115314W      TX ANT DATA: 33GPARABOLIC 01399H0006T
      RX LOCATION(S): ID   ASHTON HILL             441031N1112547W      RX ANT DATA: 31GPARABOLIC 01971H0022T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 796474 BUR:B    STC:FX     EMS:    10M00F9WJF PWR:    W5.00000 NOM:C,LEN779F1

      TX LOCATION:    OR   LAKESIDE                433200N1241026W      TX ANT DATA: 28GPARABOLIC 00227H0006T
      RX LOCATION(S): OR   NORTH BEND MAINTENANCE  433008N1241250W      RX ANT DATA: 28GPARABOLIC 00024H0015T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 944921 BUR:B    STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,WMX12012-2A23DD2D12

      TX LOCATION:    OR   TOLEDO SUB              443718N1235521W      TX ANT DATA: 28GPARABOLIC 00010H0030T
      RX LOCATION(S): OR   BURPEE                  443655N1235433W      RX ANT DATA: 28GPARABOLIC 00169H0040T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 925063 BUR:B    STC:FX     EMS:     1M60F9W   PWR:    W2.00000 NOM:C,WMX12013-2A23DD2D12

      TX LOCATION:    WA   ALLSTON SUBSTATION      460631N1230159W      TX ANT DATA: 28GPARABOLIC 00231H0031T
      RX LOCATION(S): WA   LONGVIEW MAINTENANCE    460858N1225910W      RX ANT DATA: 28GPARABOLIC 00004H0012T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 786127 BUR:B    STC:FX     EMS:     3M50F9WJF PWR:    W5.00000 NOM:C,LEN779F1

      TX LOCATION:    WA   ASHE SUBSTATION         462845N1192004W      TX ANT DATA: 28GPARABOLIC 00134H0030T
      RX LOCATION(S): WA   WASH PWR SYS NUC PLANT B 462816N1191958W      RX ANT DATA: 28GPARABOLIC 00134H0078T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 924918 BUR:B    STC:FX     EMS:   800K00F9W   PWR:    W5.00000 NOM:C,WMX12013-1A03BB1B12

      TX LOCATION:    WA   EAST OMAK SUBSTATION    482544N1192956W      TX ANT DATA: 28GPARABOLIC 00319H0006T
      RX LOCATION(S): WA   FOX MOUNTAIN            481937N1194216W      RX ANT DATA: 28GPARABOLIC 00905H0008T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 924916 BUR:B    STC:FX     EMS:   800K00F9W   PWR:    W5.00000 NOM:C,WMX12013-1A03BB1B12

      TX LOCATION:    WA   FOX MOUNTAIN            481937N1194216W      TX ANT DATA: 30GPARABOLIC 00905H0008T
      RX LOCATION(S): WA   FOSTER CREEK            475833N1193648W      RX ANT DATA: 30GPARABOLIC 00695H0015T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 839463 BUR:M    STC:FX     EMS:     4M60F9WJF PWR:    W1.00000 NOM:C,FECLR2-2000

      TX LOCATION:    CA   ELVERTA                 384249N1212859W      TX ANT DATA: 28GPARABOLIC 00012H0079T
      RX LOCATION(S): CA   SACRAMENTO              383608N1212350W      RX ANT DATA: 28GPARABOLIC 00012H0027T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 859705 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    CO   STERLING                403752N1031119W      TX ANT DATA: 28GPARABOLIC 01195H0026T
      RX LOCATION(S): CO   MERINO                  403003N1032340W      RX ANT DATA: 28GPARABOLIC 01298H0024T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1735.000000 SER:DOE 859581 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    CO   WELD                    402538N1044827W      TX ANT DATA: 30GPARABOLIC 01462H0021T
      RX LOCATION(S): CO   POUDRE                 403615N1050359W      RX ANT DATA: 30GPARABOLIC 01513H0018T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 859564 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MN   HOLLOWAY                452001N0955443W      TX ANT DATA: 30GPARABOLIC 00347H0059T
      RX LOCATION(S): MN   LAC QUI PARLE           445754N0955557W      RX ANT DATA: 30GPARABOLIC 00322H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 869412 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MN   MOORHEAD                464604N0964453W      TX ANT DATA: 30GPARABOLIC 00279H0037T
      RX LOCATION(S): MN   ROLAG                   464208N0961322W      RX ANT DATA: 30GPARABOLIC 00463H0011T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 859753 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   BELLE PRAIRIE           470658N1042830W      TX ANT DATA: 31GPARABOLIC 00837H0082T
      RX LOCATION(S): MT   DAWSON COUNTY           470621N1044610W      RX ANT DATA: 31GPARABOLIC 00664H0034T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 889409 BUR:M    STC:FX     EMS:     6M40F9WJF PWR:    W5.00000 NOM:C,COLMIR-2A

      TX LOCATION:    MT   CONRAD BUTTE            481730N1114213W      TX ANT DATA: 31GPARABOLIC 01116H0006T
      RX LOCATION(S): MT   KNEE HILL               480058N1112103W      RX ANT DATA: 31GPARABOLIC 01004H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 916672 BUR:M    STC:FX     EMS:    10M00F9WWF PWR:    W5.00000 NOM:C,WMX1-2000

      TX LOCATION:    MT   HAVRE                   483030N1094805W      TX ANT DATA: 31GPARABOLIC 00803H0051T
      RX LOCATION(S): MT   TYLER                   480858N1101717W      RX ANT DATA: 31GPARABOLIC 00933H0038T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 926580 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W1.00000 NOM:C,COLMIR2A

      TX LOCATION:    MT   VIDA                   475536N1053025W      TX ANT DATA: 31GPARABOLIC 00792H0030T
      RX LOCATION(S): MT   WOLF POINT              480524N1054246W      RX ANT DATA: 31GPARABOLIC 00631H0012T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 849753 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   BISMARCK SUB            464845N1004346W      TX ANT DATA: 31GPARABOLIC 00506H0018T
      RX LOCATION(S): ND   BISMARCK                465015N1004114W      RX ANT DATA: 31GPARABOLIC 00567H0015T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 849739 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   DICKINSON                465020N1024455W      TX ANT DATA: 31GPARABOLIC 00765H0012T
      RX LOCATION(S): ND   LEFOR                   464108N1023657W      RX ANT DATA: 31GPARABOLIC 00863H0012T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 899910 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2A

      TX LOCATION:    ND   WILLISTON SUBSTATION     480829N1034355W      TX ANT DATA: 31GPARABOLIC 00637H0043T
      RX LOCATION(S): MT   FOX CREEK               474239N1042121W      RX ANT DATA: 31GPARABOLIC 00800H0081T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 859584 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    NE   ALLIANCE                420612N1025411W      TX ANT DATA: 30GPARABOLIC 01213H0023T
      RX LOCATION(S): NE   MORRILL                 415933N1031929W      RX ANT DATA: 30GPARABOLIC 01362H0020T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 839413 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    NE   CARTER CANYON           414534N1035001W      TX ANT DATA: 33GPARABOLIC 01494H0012T
      RX LOCATION(S): NE   PLATTE REPEATER        414922N1033622W      RX ANT DATA: 33GPARABOLIC 01201H0005T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1735.000000 SER:DOE 839415 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,LEN700F1

      TX LOCATION:    NE   PLATTE REPEATER          414922N1033622W      TX ANT DATA: 28GPARABOLIC 01201H0005T
      RX LOCATION(S): NE   GERING OFFICE           414950N1033939W      RX ANT DATA: 31GPARABOLIC 01192H0017T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 849440 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    NE   SAINT MARYS              421803N1031828W      TX ANT DATA: 28GPARABOLIC 01372H0023T
      RX LOCATION(S): NE   CHADRON HILL            423806N1033732W      RX ANT DATA: 28GPARABOLIC 01380H0020T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 859539 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   BRUNSVL                  424828N0962135W      TX ANT DATA: 30GPARABOLIC 00444H0041T
      RX LOCATION(S): IA   SIOUXCY                  423144N0961623W      RX ANT DATA: 30GPARABOLIC 00427H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 859551 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   ELKTON                   442108N0962754W      TX ANT DATA: 30GPARABOLIC 00596H0059T
      RX LOCATION(S): SD   TORONTO                  443658N0964213W      RX ANT DATA: 30GPARABOLIC 00602H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 859570 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   HURONSUB                 442817N0982026W      TX ANT DATA: 30GPARABOLIC 00398H0035T
      RX LOCATION(S): SD   CLARK                    444820N0974554W      RX ANT DATA: 30GPARABOLIC 00570H0096T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 859578 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   MOUNT VERNON            434115N0981931W      TX ANT DATA: 30GPARABOLIC 00438H0021T
      RX LOCATION(S): SD   WESSINGTON SPRINGS      440142N0983640W      RX ANT DATA: 30GPARABOLIC 00597H0051T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 889522 BUR:M    STC:FX     EMS:    10M00F9WJF PWR:    W5.00000 NOM:C,COLMIR-2A

      TX LOCATION:    SD   PIERRE SUBSTATION       442246N1002143W      TX ANT DATA: 31GPARABOLIC 00483H0008T
      RX LOCATION(S): SD   SNAKE BUTTE             442531N1002129W      RX ANT DATA: 31GPARABOLIC 00585H0023T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 916690 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   POTATO CREEK            433250N1015638W      TX ANT DATA: 30GPARABOLIC 00945H0030T
      RX LOCATION(S): SD   WALL                     435338N1021350W      RX ANT DATA: 30GPARABOLIC 00930H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 839445 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   RAPID CITY SUB          440453N1031115W      TX ANT DATA: 31GPARABOLIC 00983H0011T
      RX LOCATION(S): SD   RAPID CITY REPEATER     440657N1031437W      RX ANT DATA: 31GPARABOLIC 01201H0011T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 859535 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   TURKEY RIDGE            431454N0972239W      TX ANT DATA: 30GPARABOLIC 00529H0041T
      RX LOCATION(S): SD   GAVINS POINT            425032N0972903W      RX ANT DATA: 30GPARABOLIC 00416H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 906365 BUR:M    STC:FX     EMS:     2M00F9WWF PWR:    W1.00000 NOM:C,MOTK16RBF 1200

      TX LOCATION:    WY   BOYSEN PLANT            432505N1081037W      TX ANT DATA: 28GPARABOLIC 01408H0015T
      RX LOCATION(S): WY   BOYSEN PEAK             432728N1081135W      RX ANT DATA: 28GPARABOLIC 02300H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 889679 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    WY   CODY                     443238N1090336W      TX ANT DATA: 31GPARABOLIC 01518H0032T
      RX LOCATION(S): WY   MCCULLOUGH              443358N1085143W      RX ANT DATA: 31GPARABOLIC 01878H0012T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1735.000000 SER:DOE 849263 BUR:W    STC:FX     EMS:     4M70F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    AR   ALMOND                354157N0914727W      TX ANT DATA: 29GPARABOLIC 00364H0055T
      RX LOCATION(S): AR   SULPHUR ROCK          354623N0912946W      RX ANT DATA: 29GPARABOLIC 00165H0042T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 849264 BUR:W    STC:FX     EMS:     4M70F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    AR   BETHEL                355919N0903711W      TX ANT DATA: 29GPARABOLIC 00152H0072T
      RX LOCATION(S): AR   JONESBORO             355057N0904320W      RX ANT DATA: 29GPARABOLIC 00088H0060T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 849265 BUR:W    STC:FX     EMS:     4M70F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    AR   PIGGOTT               362352N0901301W      TX ANT DATA: 29GPARABOLIC 00155H0043T
      RX LOCATION(S): MO   MALDEN                363231N0895741W      RX ANT DATA: 29GPARABOLIC 00085H0037T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 916061 BUR:W    STC:FX     EMS:     4M70F9W   PWR:    W8.00000 NOM:C,WESTERN TWO-2000

      TX LOCATION:    AR   PIGGOTT               362352N0901301W      TX ANT DATA: 28GPARABOLIC 00155H0046T
      RX LOCATION(S): MO   KENNETT               361714N0900303W      RX ANT DATA: 28GPARABOLIC 00079H0038T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 849268 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W1.00000 NOM:C,RIEMIR-2

      TX LOCATION:    MO   CRANE                 365809N0933448W      TX ANT DATA: 29GPARABOLIC 00428H0043T
      RX LOCATION(S): MO   AURORA                365714N0934303W      RX ANT DATA: 29GPARABOLIC 00439H0041T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 916063 BUR:W    STC:FX     EMS:     4M70F9W   PWR:    W8.00000 NOM:C,WESTERN TWO-2000

      TX LOCATION:    MO   GREEN FOREST           364606N0902748W      TX ANT DATA: 24GPARABOLIC 00141H0030T
      RX LOCATION(S): MO   POPLAR BLUFF           364730N0902534W      RX ANT DATA: 28GPARABOLIC 00129H0037T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 849269 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W2.50000 NOM:C,RIEMIR-2

      TX LOCATION:    MO   SUGAR CAMP             363142N0935000W      TX ANT DATA: 29GPARABOLIC 00489H0042T
      RX LOCATION(S): MO   JENKINS               364503N0934544W      RX ANT DATA: 29GPARABOLIC 00459H0060T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 849271 BUR:W    STC:FX     EMS:     6M20F9W   PWR:     W.13000 NOM:C,RIEMIR-2

      TX LOCATION:    OK   GORE SUBSTATION        353308N0950817W      TX ANT DATA: 29GPARABOLIC 00168H0007T
      RX LOCATION(S): OK   GORE                   353512N0950636W      RX ANT DATA: 29GPARABOLIC 00293H0024T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 849293 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    OK   KANSAS                 361356N0944713W      TX ANT DATA: 29GPARABOLIC 00366H0038T
      RX LOCATION(S): OK   MOODYS                 360735N0945315W      RX ANT DATA: 29GPARABOLIC 00366H0037T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 849280 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    OK   REDFORK                360700N0960230W      TX ANT DATA: 29GPARABOLIC 00286H0045T
      RX LOCATION(S): OK   BALD HILL              354620N0954915W      RX ANT DATA: 29GPARABOLIC 00286H0042T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:DOE 849273 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    OK   TUPELO                 343705N0962720W      TX ANT DATA: 29GPARABOLIC 00230H0037T
      RX LOCATION(S): OK   ALLEN                  345330N0962523W      RX ANT DATA: 29GPARABOLIC 00277H0078T
-------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:TVA 843026 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,MOT MS-228

      TX LOCATION:    KY   BOWLING GREEN          370019N0863123W      TX ANT DATA: 33GPARABOLIC 00240H0079T
      RX LOCATION(S): TN   HOLLIS CHAPEL          362921N0863140W      RX ANT DATA: 33GPARABOLIC 00290H0101T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1735.000000 SER:TVA 841308 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,COLMS228

      TX LOCATION:     TN   CHATTANOOGA              350540N0851346W      TX ANT DATA: 28GPARABOLIC 00226H0035T
      RX LOCATION(S): TN   RACCOON MOUNTAIN         350300N0852232W      RX ANT DATA: 00GREFLECTOR 00418H0009T
                      TN   CHATTANOOGA              350236N0851841W                   33GPARABOLIC 00206H0046T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:TVA 870529 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,MOTMR200

      TX LOCATION:     TN   JOHN SEVIER              362237N0825747W      TX ANT DATA: 28GPARABOLIC 00335H0040T
      RX LOCATION(S): TN   BUNKER HILL              362654N0825633W      RX ANT DATA: 28GPARABOLIC 00536H0029T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:TVA 843266 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,MOTMR200

      TX LOCATION:     TN   KNOXVILLE                355758N0835513W      TX ANT DATA: 28GPARABOLIC 00292H0058T
      RX LOCATION(S): TN   SHARPE RIDGE             355928N0835744W      RX ANT DATA: 28GPARABOLIC 00407H0012T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1736.000000 SER:DOE 829645 BUR:M    STC:FX     EMS:     6M40F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     CA   BLACK POINT               334500N1143121W      TX ANT DATA: 32GPARABOLIC 00707H0012T
      RX LOCATION(S): CA   METAL MOUNTAIN           341832N1140951W      RX ANT DATA: 32GPARABOLIC 00518H0018T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1738.000000 SER:DOE 829647 BUR:M    STC:FX     EMS:    10M00F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     NV   CHRISTMAS TREE PASS       351508N1144449W      TX ANT DATA: 32GPARABOLIC 01478H0012T
      RX LOCATION(S): NV   OPAL                      354202N1145310W      RX ANT DATA: 32GPARABOLIC 01442H0005T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:DOE 786137 BUR:B    STC:FX     EMS:     10M00F9W   PWR:    W5.00000 NOM:C,LEN778F2

      TX LOCATION:     WA   MOUNT SPOKANE             475520N1170646W      TX ANT DATA: 28GPARABOLIC 01786H0006T
      RX LOCATION(S): WA   GRANITE MOUNTAIN         482707N1180331W      RX ANT DATA: 30GPARABOLIC 01297H0009T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:DOE 890361 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     ND   BELFIELD SUBSTATION       465028N1030411W      TX ANT DATA: 31GPARABOLIC 00813H0012T
      RX LOCATION(S): ND   FRYBURG                   465326N1031955W      RX ANT DATA: 31GPARABOLIC 00870H0017T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:DOE 829634 BUR:M    STC:FX     EMS:     2M00F9WWF PWR:     W.10000 NOM:C,MOTK16RBF2200

      TX LOCATION:     NV   BASIC                     360228N1145954W      TX ANT DATA: 28GPARABOLIC 00617H0006T
      RX LOCATION(S): NV   RED MOUNTAIN             355944N1145145W      RX ANT DATA: 28GPARABOLIC 01114H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:DOE 916693 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     SD   COLOME                    431707N0994040W      TX ANT DATA: 30GPARABOLIC 00719H0061T
      RX LOCATION(S): SD   WINNER                    432127N0995050W      RX ANT DATA: 30GPARABOLIC 00630H0009T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:DOE 889432 BUR:M    STC:FX     EMS:    10M00F9WJF PWR:    W5.00000 NOM:C,COLMIR-2A

      TX LOCATION:     SD   HERMOSA                   434827N1031110W      TX ANT DATA: 31GPARABOLIC 01067H0059T
      RX LOCATION(S): SD   BATTLE MTN                432627N1032708W      RX ANT DATA: 31GPARABOLIC 01335H0059T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:TVA 843314 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,COLMS228

      TX LOCATION:     MS   LAMAR                     345301N0892206W      TX ANT DATA: 30GPARABOLIC 00198H0090T
      RX LOCATION(S): MS   HOLLY SPRINGS            344542N0892604W      RX ANT DATA: 28GPARABOLIC 00183H0024T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:TVA 843321 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,COLMS228

      TX LOCATION:     MS   WOODALL MOUNTAIN         344717N0881430W      TX ANT DATA: 32GPARABOLIC 00238H0056T
      RX LOCATION(S): MS   GRAHAM                    343433N0884736W      RX ANT DATA: 32GPARABOLIC 00213H0120T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1740.000000 SER:TVA 872807 BUR:TVA  STC:FX     EMS:     10M00F9W   PWR:     W5.00000 NOM:C,RIEMDR-1802

      TX LOCATION:     TN   FREEPORT                  350000N0900219W      TX ANT DATA: 33GPARABOLIC 00091H0099T
      RX LOCATION(S): TN   CORDOVA                    351030N0894445W      RX ANT DATA: 31GPARABOLIC 00094H0084T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:TVA 930911 BUR:TVA  STC:FX     EMS:     10M00F9W   PWR:     W5.00000 NOM:C,RIEMDR-1802

      TX LOCATION:     TN   JACKSON                   354222N0884721W      TX ANT DATA: 28GPARABOLIC 00140H0048T
      RX LOCATION(S): TN   NORTON HILL                353146N0884637W      RX ANT DATA: 33GPARABOLIC 00169H0084T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:TVA 870096 BUR:TVA  STC:FX     EMS:      3M50F9W   PWR:     W2.00000 NOM:C,AVKDR2C-01

      TX LOCATION:     TN   OAK RIDGE                 360106N0841033W      TX ANT DATA: 41GPARABOLIC 00317H0030T
      RX LOCATION(S): TN   BULL RUN                   360113N0840911W      RX ANT DATA: 41GPARABOLIC 00245H0011T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:TVA 870179 BUR:TVA  STC:FX     EMS:      8M00F9W   PWR:     W1.00000 NOM:C,COLMIR2

      TX LOCATION:     TN   OSWALD DOME               351131N0843331W      TX ANT DATA: 33GPARABOLIC 00918H0044T
      RX LOCATION(S): TN   E CLEVELAND                351105N0844916W      RX ANT DATA: 33GPARABOLIC 00259H0075T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1742.000000 SER:DOE 944927 BUR:B    STC:FX     EMS:      1M60F9W   PWR:     W1.00000 NOM:C,WMX12013-2A23DD2D12

      TX LOCATION:     OR   ALBANY SUB                443718N1230730W      TX ANT DATA: 28GPARABOLIC 00066H0020T
      RX LOCATION(S): OR   PROSPECT HILL              445118N1230714W      RX ANT DATA: 28GPARABOLIC 00345H0034T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1744.000000 SER:DOE 869402 BUR:M    STC:FX     EMS:      6M30F9WWF PWR:     W5.00000 NOM:C,MOTMR200

      TX LOCATION:     AZ   NEWMANPK                  324308N1112358W      TX ANT DATA: 33GPARABOLIC 01374H0006T
      RX LOCATION(S): AZ   THOMPSON PEAK              333839N1114841W      RX ANT DATA: 33GPARABOLIC 01214H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:AR  867020 BUR:CE   STC:FX     EMS:      5M00F9W   PWR:     W1.00000 NOM:C,//MOTK36HBF1400$

      TX LOCATION:     IA   ONAWA                     420048N0960100W      TX ANT DATA: 30GPARABOLIC 00319H0030T
      RX LOCATION(S): IA   SIOUX CITY                 423042N0961953W      RX ANT DATA: 30GPARABOLIC 00402H0030T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 924902 BUR:B    STC:FX     EMS:    800K00F9W   PWR:     W1.00000 NOM:

      TX LOCATION:     ID   HEYBURN SUBSTATION         433341N1134453W      TX ANT DATA: 30GPARABOLIC 00386H0003T
      RX LOCATION(S): ID   ALBION BUTTE               422142N1132717W      RX ANT DATA: 30GPARABOLIC 00661H0004T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 925156 BUR:B    STC:FX     EMS:      1M60F9W   PWR:     W1.00000 NOM:C,WMX12013-2A23DD2D12

      TX LOCATION:     ID   MACKS INN SUBSTATION       442932N1111843W      TX ANT DATA: 31GPARABOLIC 01951H0046T
      RX LOCATION(S): ID   ASHTON HILL                441031N1112547W      RX ANT DATA: 29GPARABOLIC 01971H0022T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 876616 BUR:B    STC:FX     EMS:     10M00F9WJ  PWR:     W1.00000 NOM:C,COLMIR2

      TX LOCATION:     ID   RELAY RIDGE                434224N1112035W      TX ANT DATA: 28GPARABOLIC 02694H0012T
      RX LOCATION(S): ID   DRUMMOND SUSTATION         435934N1112017W      RX ANT DATA: 28GPARABOLIC 01732H0018T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 876610 BUR:B    STC:FX     EMS:     10M00F9WJ  PWR:     W1.00000 NOM:C,COLMIR2

      TX LOCATION:     ID   SWAN VALLEY                432813N1112207W      TX ANT DATA: 28GPARABOLIC 01769H0006T
      RX LOCATION(S): ID   BIRCH CREEK                433208N1113547W      RX ANT DATA: 28GPARABOLIC 02015H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 787230 BUR:B    STC:FX     EMS:     10M00F9WJF PWR:     W5.00000 NOM:C,LEN779F1

      TX LOCATION:     OR   BLUE RIDGE                431504N1240642W      TX ANT DATA: 28GPARABOLIC 00366H0009T
      RX LOCATION(S): OR   FAIRVIEW SUBSTATION        431249N1240426W      RX ANT DATA: 28GPARABOLIC 00039H0006T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1745.000000 SER:DOE 787256 BUR:B    STC:FX     EMS:     10M00F9W   PWR:     W5.00000 NOM:C,LEN779F1

      TX LOCATION:     OR   LAKESIDE                 433200N1241026W      TX ANT DATA: 28GPARABOLIC 00227H0006T
      RX LOCATION(S): OR   LENEVE                    431237N1241815W      RX ANT DATA: 28GPARABOLIC 00173H0024T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 934924 BUR:B    STC:FX     EMS:      1M60F9W   PWR:     W1.00000 NOM:C,WMX12012-2A23DD2D12

      TX LOCATION:     OR   MCNARY SUBSTATION        455530N1191846W      TX ANT DATA: 31GPARABOLIC 00094H0012T
      RX LOCATION(S): WA   HORSE HEAVEN SUBSTATION  455602N1193759W      RX ANT DATA: 33GPARABOLIC 00147H0015T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 787287 BUR:B    STC:FX     EMS:     10M00F9W   PWR:     W5.00000 NOM:C,LEN779F1

      TX LOCATION:     OR   NOTI                     440303N1233005W      TX ANT DATA: 28GPARABOLIC 00557H0016T
      RX LOCATION(S): OR   GOODWIN PEAK              435541N1235325W      RX ANT DATA: 28GPARABOLIC 00554H0016T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 846434 BUR:B    STC:FX     EMS:     10M00F9W   PWR:     W5.00000 NOM:C,COLMIR2

      TX LOCATION:     OR   SCOTT MOUNTAIN           432217N1230348W      TX ANT DATA: 33GPARABOLIC 01291H0030T
      RX LOCATION(S): OR   COBURG                    440657N1230215W      RX ANT DATA: 28GPARABOLIC 00362H0030T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 944914 BUR:B    STC:FX     EMS:      1M60F9W   PWR:     W1.00000 NOM:C,WMX12012-2A23DD2D12

      TX LOCATION:     WA   HAPPY VALLEY SUBSTATION  480234N1230613W      TX ANT DATA: 28GPARABOLIC 00213H0020T
      RX LOCATION(S): WA   BLYN                      480058N1225534W      RX ANT DATA: 28GPARABOLIC 00634H0020T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 905204 BUR:B    STC:FX     EMS:     10M00F9W   PWR:     W5.00000 NOM:

      TX LOCATION:     WA   KENNEWICK                460615N1190751W      TX ANT DATA: 28GPARABOLIC 00664H0030T
      RX LOCATION(S): WA   WALLA WALLA SUBSTATION   460407N1182419W      RX ANT DATA: 28GPARABOLIC 00233H0034T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 925059 BUR:B    STC:FX     EMS:      1M60F9W   PWR:     W2.00000 NOM:C,WMX12012-2A23DD2D12

      TX LOCATION:     WA   MEGLER                   461558N1235234W      TX ANT DATA: 28GPARABOLIC 00333H0037T
      RX LOCATION(S): WA   CLATSOP SUBSTATION       460833N1235022W      RX ANT DATA: 28GPARABOLIC 00033H0015T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 924920 BUR:B    STC:FX     EMS:      5M00F9W   PWR:     W5.00000 NOM:C,WMX22012-4K23JJ3J23

      TX LOCATION:     WA   MOUNT SPOKANE            475520N1170646W      TX ANT DATA: 28GPARABOLIC 01786H0006T
      RX LOCATION(S): WA   GRANITE MOUNTAIN         482707N1180331W      RX ANT DATA: 30GPARABOLIC 01297H0009T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 869439 BUR:M    STC:FX     EMS:     10M00F9WJF PWR:     W5.00000 NOM:C,COLMIR2

      TX LOCATION:     CO   BALD MTN                 402121N1051547W      TX ANT DATA: 31GPARABOLIC 02164H0009T
      RX LOCATION(S): CO   POLE HILL                412158N1051952W      RX ANT DATA: 28GPARABOLIC 02012H0005T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 829701 BUR:M    STC:FX     EMS:      2M00F9WWF PWR:     W1.00000 NOM:C,MOTK16RBF1200

      TX LOCATION:     CO   GREEN MOUNTAIN           395245N1062000W      TX ANT DATA: 30GPARABOLIC 02408H0015T
      RX LOCATION(S): CO   GREEN MOUNTAIN REPEATER 395228N1061952W      RX ANT DATA: 00GPARABOLIC 02448H0008T
                       CO   BLUE RIDGE MOUNTAIN     395541N1061608W                   30GPARABOLIC 03311H0015T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 926301 BUR:M    STC:FX     EMS:      7M30F9WJF PWR:     W5.00000 NOM:C,COLMIR2

      TX LOCATION:     CO   KREMMLING SUBSTATION     400024N1062155W      TX ANT DATA: 29GPARABOLIC 02256H0017T
      RX LOCATION(S): CO   KREMMLING REPEATER       400030N1062134W      RX ANT DATA: 00GPARABOLIC 02353H0005T
                       CO   GROUSE MOUNTAIN         400806N1061019W                   29GPARABOLIC 03005H0012T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 916923 BUR:M    STC:FX     EMS:      5M00F8EWF PWR:     W1.00000 NOM:C,WMXTWO-2000

      TX LOCATION:     CO   NORTH GUNNISON           383337N1065524W      TX ANT DATA: 29GPARABOLIC 02359H0006T
      RX LOCATION(S): CO   SKITO                    383252N1062711W      RX ANT DATA: 29GPARABOLIC 02366H0006T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1745.000000 SER:DOE 849438 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    CO   PEETZ TABLE              405737N1032226W      TX ANT DATA: 28GPARABOLIC 01451H0058T
      RX LOCATION(S): NE   SIDNEY                  410949N1025922W      RX ANT DATA: 28GPARABOLIC 01298H0058T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 859580 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    CO   WELD                    402538N1044827W      TX ANT DATA: 30GPARABOLIC 01462H0014T
      RX LOCATION(S): CO   AULT                    403615N1044845W      RX ANT DATA: 30GPARABOLIC 01561H0015T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 869426 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MN   ERHARD                  462847N0960148W      TX ANT DATA: 30GPARABOLIC 00485H0030T
      RX LOCATION(S): MN   ROLLAG                  464201N0961300W      RX ANT DATA: 30GPARABOLIC 00463H0024T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 869444 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MN   MORRIS SUB              453505N0960058W      TX ANT DATA: 30GPARABOLIC 00340H0017T
      RX LOCATION(S): MN   MORRIS RPTR             453928N0955539W      RX ANT DATA: 30GPARABOLIC 00360H0046T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 899907 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2A

      TX LOCATION:    MT   BELLE PRAIRE           470658N1042830W      TX ANT DATA: 31GPARABOLIC 00838H0079T
      RX LOCATION(S): MT   FOX CREEK              474239N1042121W      RX ANT DATA: 31GPARABOLIC 00800H0081T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 849666 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   FORSYTH                462044N1064157W      TX ANT DATA: 31GPARABOLIC 00920H0058T
      RX LOCATION(S): MT   HYSHAM                 460347N1071414W      RX ANT DATA: 31GPARABOLIC 01133H0043T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 839421 BUR:M    STC:FX     EMS:     6M40F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   HARLEM                  483144N1084730W      TX ANT DATA: 31GPARABOLIC 00719H0038T
      RX LOCATION(S): MT   DODSON                  481852N1081713W      RX ANT DATA: 31GPARABOLIC 00815H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 849729 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   KELLY CREEK             462934N1054031W      TX ANT DATA: 31GPARABOLIC 00834H0035T
      RX LOCATION(S): MT   FALLON                  465539N1051003W      RX ANT DATA: 31GPARABOLIC 00882H0030T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 839428 BUR:M    STC:FX     EMS:     6M40F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   RICHARDSON COULEE      481333N1064748W      TX ANT DATA: 31GPARABOLIC 00657H0044T
      RX LOCATION(S): MT   HINSDALE               483511N1070528W      RX ANT DATA: 31GPARABOLIC 00828H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 849759 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   CLEVELAND               465604N0990710W      TX ANT DATA: 31GPARABOLIC 00593H0037T
      RX LOCATION(S): ND   TAPPEN                  465804N0993655W      RX ANT DATA: 31GPARABOLIC 00604H0067T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 849742 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   CUSTER LOOKOUT          465055N1021012W      TX ANT DATA: 31GPARABOLIC 00824H0006T
      RX LOCATION(S): ND   HAILSTONE BUTTE         465447N1014029W      RX ANT DATA: 31GPARABOLIC 00753H0005T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 839556 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   EAST RAINY BUTTE        462737N1025840W      TX ANT DATA: 30GPARABOLIC 01006H0021T
      RX LOCATION(S): ND   ROCKY RIDGE            460355N1023710W      RX ANT DATA: 30GPARABOLIC 00893H0029T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1745.000000 SER:DOE 849764 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   ECKELSON              465520N0982107W      TX ANT DATA: 31GPARABOLIC 00459H0082T
      RX LOCATION(S): ND   PEAK                  465423N0975327W      RX ANT DATA: 31GPARABOLIC 00460H0023T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 890478 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   HUNTER                471141N0971807W      TX ANT DATA: 31GPARABOLIC 00328H0084T
      RX LOCATION(S): ND   MAYVILLE              474005N0971928W      RX ANT DATA: 31GPARABOLIC 00308H0090T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 829712 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,LEN79F1

      TX LOCATION:    NE   CARTER CANYON          414534N1035001W      TX ANT DATA: 30GPARABOLIC 01494H0044T
      RX LOCATION(S): WY   ROUND TOP             412636N1042035W      RX ANT DATA: 30GPARABOLIC 01701H0043T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 889439 BUR:M    STC:FX     EMS:    10M00F9WJF PWR:    W5.00000 NOM:C,COLMIR-2A

      TX LOCATION:    SD   FLANDREAU SUBSTATION   440307N0963812W      TX ANT DATA: 31GPARABOLIC 00498H0014T
      RX LOCATION(S): SD   COLMAN SUBSTATION      435638N0964606W      RX ANT DATA: 31GPARABOLIC 00518H0056T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 859559 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   GARY                  444350N0962739W      TX ANT DATA: 30GPARABOLIC 00521H0041T
      RX LOCATION(S): MN   LAC QUI PARLE         445754N0955557W      RX ANT DATA: 30GPARABOLIC 00322H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 839439 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   HIGHLAND              451525N1023913W      TX ANT DATA: 31GPARABOLIC 00900H0005T
      RX LOCATION(S): SD   MAURINE               450028N1023531W      RX ANT DATA: 31GPARABOLIC 00876H0029T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 859515 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   HIGHMORE              442109N0992734W      TX ANT DATA: 30GPARABOLIC 00666H0018T
      RX LOCATION(S): SD   FORT THOMPSON         440753N0992614W      RX ANT DATA: 30GPARABOLIC 00530H0014T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 839584 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   HOPEWELL              443007N1005438W      TX ANT DATA: 31GPARABOLIC 00673H0059T
      RX LOCATION(S): SD   EAGLE BUTTE           445924N1011650W      RX ANT DATA: 31GPARABOLIC 00744H0041T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 859524 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   LAKE ANDES            430855N0983728W      TX ANT DATA: 30GPARABOLIC 00590H0059T
      RX LOCATION(S): SD   BIJOU HILLS           433152N0990518W      RX ANT DATA: 30GPARABOLIC 00600H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 839448 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   NEW UNDERWOOD         440424N1024940W      TX ANT DATA: 31GPARABOLIC 00882H0040T
      RX LOCATION(S): SD   RAPID CITY REPEATER   440657N1031437W      RX ANT DATA: 31GPARABOLIC 01201H0023T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 839541 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   PHILIP JUNCTION       435810N1014228W      TX ANT DATA: 30GPARABOLIC 00780H0029T
      RX LOCATION(S): SD   MIDLAND               441033N1010857W      RX ANT DATA: 30GPARABOLIC 00706H0058T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 859576 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   PUKWANA              435150N0991004W      TX ANT DATA: 30GPARABOLIC 00553H0035T
      RX LOCATION(S): SD   WESSINGTON SPRINGS    440142N0983640W      RX ANT DATA: 30GPARABOLIC 00597H0051T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1745.000000 SER:DOE 859533 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   TURKEY RIDGE              431454N0972239W      TX ANT DATA: 30GPARABOLIC 00529H0041T
      RX LOCATION(S): SD   MOE                       431013N0963835W      RX ANT DATA: 30GPARABOLIC 00469H0035T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 859567 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   WATERTOWN                 445303N0970230W      TX ANT DATA: 30GPARABOLIC 00553H0084T
      RX LOCATION(S): SD   CLARK                     444820N0974554W      RX ANT DATA: 30GPARABOLIC 00570H0096T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 839476 BUR:M    STC:FX     EMS:     5M00F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    WY   GREEN RIVER               413310N1092335W      TX ANT DATA: 31GPARABOLIC 02240H0027T
      RX LOCATION(S): WY   FONTENELLE               415910N1100336W      RX ANT DATA: 31GPARABOLIC 01996H0066T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 859590 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:    WY   LOVELL SUBSTATION         444733N1082015W      TX ANT DATA: 28GPARABOLIC 01212H0008T
      RX LOCATION(S): WY   LITTLE SHEEP MOUNTAIN     444743N1081535W      RX ANT DATA: 28GPARABOLIC 01572H0008T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 889682 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    WY   MEETEETSE                 440827N1084918W      TX ANT DATA: 31GPARABOLIC 02042H0012T
      RX LOCATION(S): WY   MCCULLOUGH                443358N1085143W      RX ANT DATA: 31GPARABOLIC 01878H0009T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 829691 BUR:M    STC:FX     EMS:     2M00F9WWF PWR:    W1.00000 NOM:C,MOTK16RBF1200

      TX LOCATION:    WY   PILOT BUTTE               431308N1084710W      TX ANT DATA: 30GPARABOLIC 01669H0035T
      RX LOCATION(S): WY   BOYSEN PEAK               432728N1081135W      RX ANT DATA: 30GPARABOLIC 02303H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 809554 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,LEN79F1

      TX LOCATION:    WY   RADERVILLE RADIO SITE     430037N1071845W      TX ANT DATA: 32GPARABOLIC 01899H0030T
      RX LOCATION(S): WY   CASPER MOUNTAIN           424410N1061827W      RX ANT DATA: 32GPARABOLIC 02463H0017T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 889674 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    WY   SPENCE                    423730N1065500W      TX ANT DATA: 32GPARABOLIC 01871H0018T
      RX LOCATION(S): WY   HORSE HEAVEN              424250N1070045W      RX ANT DATA: 32GPARABOLIC 02259H0018T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 849274 BUR:W    STC:FX     EMS:     4M70F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    AR   ALMOND                    354157N0914727W      TX ANT DATA: 29GPARABOLIC 00364H0055T
      RX LOCATION(S): AR   MELBOURNE                 360036N0915901W      RX ANT DATA: 29GPARABOLIC 00305H0048T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 849276 BUR:W    STC:FX     EMS:     4M70F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    AR   PIGGOTT                   362352N0901301W      TX ANT DATA: 31GPARABOLIC 00155H0081T
      RX LOCATION(S): AR   PARAGOULD                 360451N0902920W      RX ANT DATA: 29GPARABOLIC 00098H0044T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 849305 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    AR   VAN BUREN                 352828N0942002W      TX ANT DATA: 29GPARABOLIC 00168H0045T
      RX LOCATION(S): AR   POTEAU MOUNTAIN           345746N0942227W      RX ANT DATA: 31GPARABOLIC 00814H0037T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 849275 BUR:W    STC:FX     EMS:     4M70F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    AR   WINESBURG                 354904N0905403W      TX ANT DATA: 29GPARABOLIC 00076H0066T
      RX LOCATION(S): AR   JONESBORO                 355057N0904320W      RX ANT DATA: 29GPARABOLIC 00088H0037T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1745.000000 SER:DOE 849282 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:     MO   CRANE                    365809N0933448W      TX ANT DATA: 29GPARABOLIC 00428H0087T
      RX LOCATION(S): MO   SPRINGFIELD              370939N0932023W      RX ANT DATA: 29GPARABOLIC 00381H0061T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 916059 BUR:W    STC:FX     EMS:     4M70F9W   PWR:    W8.00000 NOM:C,WESTERN TWO-2000

      TX LOCATION:     MO   MALDEN                   363231N0895741W      TX ANT DATA: 31GPARABOLIC 00084H0046T
      RX LOCATION(S): MO   NEW MADRID POWER PLANT   363106N0893356W      RX ANT DATA: 31GPARABOLIC 00088H0087T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 849278 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:     OK   FORT GIBSON              355205N0951322W      TX ANT DATA: 29GPARABOLIC 00256H0075T
      RX LOCATION(S): OK   GORE                     353512N0950636W      RX ANT DATA: 29GPARABOLIC 00293H0075T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 849281 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:     OK   HENRYETTA                352654N0960056W      TX ANT DATA: 29GPARABOLIC 00288H0030T
      RX LOCATION(S): OK   WELEETKA                 352106N0960726W      RX ANT DATA: 29GPARABOLIC 00274H0030T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 849333 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:     OK   KIAMICHI MOUNTAIN        343648N0944139W      TX ANT DATA: 31GPARABOLIC 00675H0076T
      RX LOCATION(S): OK   BROKEN BOW               340910N0944127W      RX ANT DATA: 31GPARABOLIC 00206H0061T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:DOE 849279 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:     OK   SHORT MOUNTAIN           352002N0944635W      TX ANT DATA: 29GPARABOLIC 00227H0015T
      RX LOCATION(S): OK   R S KERR DAM             352041N0944632W      RX ANT DATA: 29GPARABOLIC 00158H0015T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:I   863621 BUR:RMP  STC:FX     EMS:     3M50F9W   PWR:    W5.00000 NOM:C,FECFM2000

      TX LOCATION:     CA   SO FORK MTN             403930N1223123W      TX ANT DATA: 31GPARABOLIC 01057H0015T
      RX LOCATION(S): CA   GRAPEVINE PASS          392106N1222719W      RX ANT DATA: 31GPARABOLIC 00689H0015T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:TVA 843106 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,MOTMR200

      TX LOCATION:     AL   BELLEFONTE              344230N0855537W      TX ANT DATA: 28GPARABOLIC 00189H0030T
      RX LOCATION(S): AL   LAMBERT CHAPEL          344239N0855311W      RX ANT DATA: 28GPARABOLIC 00445H0030T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:TVA 870533 BUR:TVA  STC:FX     EMS:     8M00F9W   PWR:    W5.00000 NOM:C,MOTMR200

      TX LOCATION:     TN   VOLUNTEER               360716N0834854W      TX ANT DATA: 30GPARABOLIC 00333H0099T
      RX LOCATION(S): TN   GREENTOP                354848N0834011W      RX ANT DATA: 30GPARABOLIC 00920H0021T
-------------------------------------------------------------------------------------------------------------
FREQ: M1748.000000 SER:DOE 839512 BUR:M    STC:FX     EMS:     6M40F9WJF PWR:    W5.00000 NOM:C,MOTMR200

      TX LOCATION:     AZ   TELEGRAPH PASS           324012N1142006W      TX ANT DATA: 28GPARABOLIC 00541H0009T
      RX LOCATION(S): AZ   GILA                     324105N1142809W      RX ANT DATA: 28GPARABOLIC 00061H0024T
-------------------------------------------------------------------------------------------------------------
FREQ: M1748.000000 SER:DOE 859706 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:     CO   BEAVER CREEK             401518N1033553W      TX ANT DATA: 28GPARABOLIC 01300H0012T
      RX LOCATION(S): CO   MERINO                   403003N1032340W      RX ANT DATA: 28GPARABOLIC 01298H0048T
-------------------------------------------------------------------------------------------------------------
FREQ: M1750.000000 SER:DOE 849658 BUR:M    STC:FX     EMS:   800K00F9WJF PWR:    W2.00000 NOM:C,GRA6018-1A/12

      TX LOCATION:     AZ   NEWMAN PEAK             324308N1112358W      TX ANT DATA: 33GPARABOLIC 01374H0006T
      RX LOCATION(S): AZ   TUCSON                   321509N1105928W      RX ANT DATA: 33GPARABOLIC 00707H0006T
                       AZ   NOGALES                 320310N1105128W                   33GPARABOLIC 00864H0006T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1750.000000 SER:DOE 899522 BUR:M    STC:FX     EMS:     6M40F9WJF PWR:    W5.00000 NOM:C,MOTMR200

      TX LOCATION:    AZ   PHOENIX                 332633N1120859W      TX ANT DATA: 30GPARABOLIC 00331H0021T
      RX LOCATION(S): AZ   WHITE TANKS MTN         333432N1123440W      RX ANT DATA: 30GPARABOLIC 01231H0005T
-------------------------------------------------------------------------------------------------------------
FREQ: M1750.000000 SER:DOE 916676 BUR:M    STC:FX     EMS:    10M00F9WWF PWR:    W5.00000 NOM:C,WMX1-2000

      TX LOCATION:    MT   GOVERNMENT HILL          480806N1104516W      TX ANT DATA: 31GPARABOLIC 01052H0035T
      RX LOCATION(S): MT   KNEE HILL               480058N1112103W      RX ANT DATA: 31GPARABOLIC 01175H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1751.000000 SER:DOE 936304 BUR:M    STC:FX     EMS:     1M60F8E   PWR:    W1.00000 NOM:C,WMX1-2000

      TX LOCATION:    CO   SALIDA                  383115N1060501W      TX ANT DATA: 06GCOLLINEAR 02298H0015T
      RX LOCATION(S): CO   PONCHA                  383034N1060527W      RX ANT DATA: 30GPARABOLIC 02309H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1754.000000 SER:DOE 944907 BUR:B    STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,WMX12012-2A23DD2D12

      TX LOCATION:    WA   S TACOMA SWITCH STATION  470534N1222213W      TX ANT DATA: 28GPARABOLIC 00121H0030T
      RX LOCATION(S): WA   TACOMA                  471104N1222221W      RX ANT DATA: 28GPARABOLIC 00131H0030T
-------------------------------------------------------------------------------------------------------------
FREQ: M1754.000000 SER:DOE 809627 BUR:M    STC:FX     EMS:     6M40F9WWF PWR:    W5.00000 NOM:C,COLMIR-2

      TX LOCATION:    CA   BLACK MOUNTAIN           330308N1144939W      TX ANT DATA: 30GPARABOLIC 00632H0009T
      RX LOCATION(S): AZ   GILA                    324105N1142809W      RX ANT DATA: 33GPARABOLIC 00061H0005T
-------------------------------------------------------------------------------------------------------------
FREQ: M1754.000000 SER:DOE 869435 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   YELLOWTAIL               451129N1075710W      TX ANT DATA: 34GPARABOLIC 01189H0053T
      RX LOCATION(S): MT   E PRYOR MTN             451020N1082030W      RX ANT DATA: 00GPARABOLIC 02646H0017T
                      WY   LITTLE SHEEP MTN        444743N1081535W                   34GPARABOLIC 01572H0003T
-------------------------------------------------------------------------------------------------------------
FREQ: M1754.000000 SER:DOE 839411 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    NE   CARTER CANYON           414534N1035001W      TX ANT DATA: 31GPARABOLIC 01494H0030T
      RX LOCATION(S): NE   MORRIL                  415933N1031929W      RX ANT DATA: 31GPARABOLIC 01362H0030T
-------------------------------------------------------------------------------------------------------------
FREQ: M1754.000000 SER:DOE 829708 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,LEN79F1

      TX LOCATION:    WY   ARCHER                  410838N1043842W      TX ANT DATA: 28GPARABOLIC 01821H0006T
      RX LOCATION(S): WY   SPEER                   410252N1045324W      RX ANT DATA: 28GPARABOLIC 01949H0008T
-------------------------------------------------------------------------------------------------------------
FREQ: M1754.000000 SER:DOE 890359 BUR:M    STC:FX     EMS:    10M00F9WWF PWR:    W5.00000 NOM:C,COLMIR2A

      TX LOCATION:    WY   HEART MOUNTAIN          443046N1090743W      TX ANT DATA: 31GPARABOLIC 01554H0004T
      RX LOCATION(S): WY   MCCULLOUGH PEAK         443358N1085143W      RX ANT DATA: 31GPARABOLIC 01878H0011T
-------------------------------------------------------------------------------------------------------------
FREQ: M1754.000000 SER:DOE 809550 BUR:M    STC:FX     EMS:     2M00F9WWF PWR:    W1.00000 NOM:C,MOTK16RBF1200

      TX LOCATION:    WY   LARAMIE SUBSTATION      412008N1053516W      TX ANT DATA: 28GPARABOLIC 02204H0008T
      RX LOCATION(S): WY   SHERMAN HILL            411358N1052636W      RX ANT DATA: 28GPARABOLIC 02694H0012T
-------------------------------------------------------------------------------------------------------------
FREQ: M1754.000000 SER:DOE 809564 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,LEN79F1

      TX LOCATION:    WY   MEETEETSE               440827N1084918W      TX ANT DATA: 32GPARABOLIC 02050H0015T
      RX LOCATION(S): WY   BOYSEN PEAK             432728N1081135W      RX ANT DATA: 32GPARABOLIC 02303H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:AR  867019 BUR:CE   STC:FX     EMS:     5M00F9W   PWR:    W1.00000 NOM:C,//MOTK36HBF1400$

      TX LOCATION:    IA   MODALE                  413616N0960200W      TX ANT DATA: 30GPARABOLIC 00306H0027T
      RX LOCATION(S): IA   ONAWA                   420048N0960100W      RX ANT DATA: 30GPARABOLIC 00319H0027T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1755.000000 SER:DOE 925161 BUR:B    STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,WMX12013-2A23DD2D12

      TX LOCATION:    ID   DRUMMOND SUBSTATION      435934N1112017W      TX ANT DATA: 29GPARABOLIC 01727H0018T
      RX LOCATION(S): ID   ASHTON HILL              441031N1112547W      RX ANT DATA: 29GPARABOLIC 01971H0022T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 935041 BUR:B    STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,WMX12012-2A23DD2D12

      TX LOCATION:    MT   FLATHEAD SUBSTATION      481442N1141839W      TX ANT DATA: 28GPARABOLIC 00918H0010T
      RX LOCATION(S): MT   BLACKTAIL PEAK           480048N1142156W      RX ANT DATA: 28GPARABOLIC 02036H0007T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 924921 BUR:B    STC:FX     EMS:     5M00F9W   PWR:    W5.00000 NOM:C,WMX22012-4K23JJ3J23

      TX LOCATION:    WA   ADDY SUBSTATION          482128N1175055W      TX ANT DATA: 30GPARABOLIC 00504H0015T
      RX LOCATION(S): WA   GRANITE MOUNTAIN         482707N1180331W      RX ANT DATA: 24GPARABOLIC 01297H0009T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 925066 BUR:B    STC:FX     EMS:   800K00F9W   PWR:    W2.00000 NOM:C,WMX12012-1A230B1B12

      TX LOCATION:    WA   CHEHALIS                 463940N1225656W      TX ANT DATA: 31GPARABOLIC 00195H0044T
      RX LOCATION(S): WA   SILVERCREEK SUBSTATION   463123N1223528W      RX ANT DATA: 31GPARABOLIC 00201H0046T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 925062 BUR:B    STC:FX     EMS:     1M60F9W   PWR:    W2.00000 NOM:C,WMX12012-2A23DD2D12

      TX LOCATION:    WA   MEGLER                   461558N1235234W      TX ANT DATA: 28GPARABOLIC 00333H0023T
      RX LOCATION(S): WA   NASELLE                 462517N1234735W      RX ANT DATA: 28GPARABOLIC 00582H0052T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 786128 BUR:B    STC:FX     EMS:     3M50F9W   PWR:    W5.00000 NOM:C,LEN779F1

      TX LOCATION:    WA   WASH PUB PWR NUC PLANT A 462801N1191853W      TX ANT DATA: 28GPARABOLIC 00134H0030T
      RX LOCATION(S): WA   WASH PUB PWR NUC PLANT B 462816N1191958W      RX ANT DATA: 28GPARABOLIC 00134H0078T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 859505 BUR:M    STC:FX     EMS:     5M00F9WWF PWR:    W1.00000 NOM:C,COLMIR-2

      TX LOCATION:    CO   LANDSEND                 390520N1081323W      TX ANT DATA: 31GPARABOLIC 03044H0008T
      RX LOCATION(S): CO   LOWER MOLINA            391148N1080259W      RX ANT DATA: 31GPARABOLIC 01674H0017T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 869430 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MN   BARRETT                  455420N0955415W      TX ANT DATA: 30GPARABOLIC 00378H0053T
      RX LOCATION(S): MN   DALTON                   461028N0955609W      RX ANT DATA: 30GPARABOLIC 00424H0053T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 849719 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   BELLE PRAIRE            470658N1042830W      TX ANT DATA: 31GPARABOLIC 00837H0018T
      RX LOCATION(S): MT   LINDSAY RIDGE           471809N1051753W      RX ANT DATA: 31GPARABOLIC 01004H0018T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 889411 BUR:M    STC:FX     EMS:     6M40F9WJF PWR:    W5.00000 NOM:C,COLMIR-2A

      TX LOCATION:    MT   CONRAD BUTTE            481730N1114213W      TX ANT DATA: 31GPARABOLIC 01116H0012T
      RX LOCATION(S): MT   CONRAD BUTTE SUB        480745N1115611W      RX ANT DATA: 31GPARABOLIC 01109H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 839432 BUR:M    STC:FX     EMS:     6M40F9WJF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   FORT PECK OFFICE        480035N1062640W      TX ANT DATA: 31GPARABOLIC 00649H0014T
      RX LOCATION(S): MT   FORT PECK               480147N1061847W      RX ANT DATA: 31GPARABOLIC 00814H0017T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 839420 BUR:M    STC:FX     EMS:     6M40F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   HARLEM                  483144N1084730W      TX ANT DATA: 31GPARABOLIC 00719H0034T
      RX LOCATION(S): MT   CHINOOK                 483933N1091917W      RX ANT DATA: 31GPARABOLIC 00836H0059T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1755.000000 SER:DOE 849662 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   KELLY CREEK              462934N1054031W      TX ANT DATA: 31GPARABOLIC 00834H0047T
      RX LOCATION(S): MT   HATHAWAY                461640N1060906W      RX ANT DATA: 31GPARABOLIC 00836H0023T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 839425 BUR:M    STC:FX     EMS:     6M40F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    MT   MALTA                   482140N1074938W      TX ANT DATA: 31GPARABOLIC 00689H0052T
      RX LOCATION(S): MT   HINSDALE                483511N1070528W      RX ANT DATA: 31GPARABOLIC 00828H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 849770 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   BUFFALO                  464356N0973248W      TX ANT DATA: 31GPARABOLIC 00369H0053T
      RX LOCATION(S): ND   FARGO                    484959N0965653W      RX ANT DATA: 31GPARABOLIC 00274H0059T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 849745 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   CAHOON                   471056N1012553W      TX ANT DATA: 31GPARABOLIC 00701H0030T
      RX LOCATION(S): ND   HAILSTONE BUTTE          465447N1014029W      RX ANT DATA: 31GPARABOLIC 00753H0005T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 849755 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   DRISCOLL                 465206N1001344W      TX ANT DATA: 31GPARABOLIC 00619H0017T
      RX LOCATION(S): ND   BISMARCK                 465015N1004114W      RX ANT DATA: 31GPARABOLIC 00567H0015T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 849735 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   EAST RAINY BUTTE         462737N1025840W      TX ANT DATA: 31GPARABOLIC 01006H0021T
      RX LOCATION(S): ND   FRYBURG                  465326N1031955W      RX ANT DATA: 31GPARABOLIC 00870H0017T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 849763 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    ND   ECKELSON                 465520N0982107W      TX ANT DATA: 31GPARABOLIC 00459H0082T
      RX LOCATION(S): ND   JAMESTOWN                465237N0984106W      RX ANT DATA: 31GPARABOLIC 00450H0018T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 899898 BUR:M    STC:FX     EMS:    10M00F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    NV   MEAD                     355541N1144957W      TX ANT DATA: 30GPARABOLIC 00627H0008T
      RX LOCATION(S): NV   OPAL                     354202N1145310W      RX ANT DATA: 30GPARABOLIC 01442H0003T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 859538 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   BRUNSVL                  424828N0962135W      TX ANT DATA: 30GPARABOLIC 00444H0041T
      RX LOCATION(S): SD   MOE                      431013N0963835W      RX ANT DATA: 30GPARABOLIC 00469H0035T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 916682 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   COLOME                   431707N0994040W      TX ANT DATA: 30GPARABOLIC 00719H0061T
      RX LOCATION(S): SD   OKREEK                   431844N1002557W      RX ANT DATA: 30GPARABOLIC 00828H0094T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 859555 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   ELKTON                   442108N0962754W      TX ANT DATA: 30GPARABOLIC 00596H0041T
      RX LOCATION(S): SD   WHITE                    442309N0963215W      RX ANT DATA: 30GPARABOLIC 00546H0005T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 839443 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   FAIRPOINT                444235N1024703W      TX ANT DATA: 31GPARABOLIC 00945H0029T
      RX LOCATION(S): SD   RAPID CITY REPEATER      440657N1031437W      RX ANT DATA: 31GPARABOLIC 01201H0023T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1755.000000 SER:DOE 839583 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   HIGHLAND                 451525N1023913W      TX ANT DATA: 30GPARABOLIC 00900H0005T
      RX LOCATION(S): SD   BISON                    453032N1023834W      RX ANT DATA: 30GPARABOLIC 00885H0029T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 839544 BUR:M    STC:FX     EMS:     7M30F9WJF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   HOPEWELL                 443007N1005438W      TX ANT DATA: 30GPARABOLIC 00673H0040T
      RX LOCATION(S): SD   MIDLAND                  441033N1010857W      RX ANT DATA: 30GPARABOLIC 00706H0040T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 859571 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   HURONSUB                 442817N0982026W      TX ANT DATA: 30GPARABOLIC 00398H0035T
      RX LOCATION(S): SD   HURON                    442143N0981304W      RX ANT DATA: 30GPARABOLIC 00390H0020T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 859529 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   LAKE ANDES               430855N0983728W      TX ANT DATA: 30GPARABOLIC 00590H0041T
      RX LOCATION(S): SD   ARMOUR                   431526N0981937W      RX ANT DATA: 30GPARABOLIC 00444H0014T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 859518 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W5.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   PUKWANA                  435150N0991004W      TX ANT DATA: 30GPARABOLIC 00553H0035T
      RX LOCATION(S): SD   FORT THOMPSON            440753N0992614W      RX ANT DATA: 30GPARABOLIC 00530H0014T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 859547 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   SIOUX FALLS              433429N0963901W      TX ANT DATA: 30GPARABOLIC 00464H0040T
      RX LOCATION(S): SD   SIOX FALLS SUB           433554N0963859W      RX ANT DATA: 30GPARABOLIC 00415H0011T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 859542 BUR:M    STC:FX     EMS:     7M30F9WWF PWR:    W1.00000 NOM:C,COLMIR2

      TX LOCATION:    SD   SIOXCYSB                 423603N0961820W      TX ANT DATA: 30GPARABOLIC 00354H0011T
      RX LOCATION(S): IA   SIOUXCY                  423144N0961623W      RX ANT DATA: 30GPARABOLIC 00427H0038T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 849292 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    AR   DECATUR                  361816N0942205W      TX ANT DATA: 29GPARABOLIC 00440H0066T
      RX LOCATION(S): AR   HUMPHREY MOUNTAIN        362446N0935716W      RX ANT DATA: 29GPARABOLIC 00518H0036T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 799257 BUR:W    STC:FX     EMS:     3M50F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    AR   NORFORK                  361556N0921449W      TX ANT DATA: 28GPARABOLIC 00250H0075T
      RX LOCATION(S): AR   BULL SHOALS              362147N0923554W      RX ANT DATA: 28GPARABOLIC 00338H0045T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 799258 BUR:W    STC:FX     EMS:     3M50F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    MO   HERCULES                 364017N0925240W      TX ANT DATA: 28GPARABOLIC 00425H0045T
      RX LOCATION(S): MO   SELMORE                  365647N0931212W      RX ANT DATA: 28GPARABOLIC 00422H0045T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 849290 BUR:W    STC:FX     EMS:     4M70F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:    MO   IDALIA                   365218N0895116W      TX ANT DATA: 29GPARABOLIC 00141H0060T
      RX LOCATION(S): MO   MALDEN                   363231N0895741W      RX ANT DATA: 29GPARABOLIC 00085H0037T
-------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 916072 BUR:W    STC:FX     EMS:     6M20F9W   PWR:    W8.00000 NOM:C,WMX2-2000

      TX LOCATION:    MO   NEW MADRID POWER PLANT  363106N0893356W      TX ANT DATA: 25GPARABOLIC 00088H0044T
      RX LOCATION(S): MO   NEW MADRID               363438N0893413W      RX ANT DATA: 25GPARABOLIC 00091H0030T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-1 *(Continued)*

```
FREQ: M1755.000000 SER:DOE 849286 BUR:W    STC:FX     EMS:      6M20F9W   PWR:     W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:     OK   LAMAR                    350509N0961023W      TX ANT DATA: 29GPARABOLIC 00305H0057T
      RX LOCATION(S): OK   ALLEN                    345330N0962523W      RX ANT DATA: 29GPARABOLIC 00277H0078T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:DOE 849285 BUR:W    STC:FX     EMS:      6M20F9W   PWR:     W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:     OK   REDFORK                   360700N0960230W      TX ANT DATA: 29GPARABOLIC 00286H0015T
      RX LOCATION(S): OK   KEYSTONE                 360900N0961508W      RX ANT DATA: 25GPARABOLIC 00235H0010T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:TVA 842921 BUR:TVA  STC:FX     EMS:      8M00F9W   PWR:     W2.00000 NOM:C,FECSS2000W

      TX LOCATION:     AL   BROWNS FERRY             344213N0870706W      TX ANT DATA: 33GPARABOLIC 00172H0052T
      RX LOCATION(S): AL   TRINITY                  343637N0870304W      RX ANT DATA: 33GPARABOLIC 00184H0026T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:TVA 843110 BUR:TVA  STC:FX     EMS:      8M00F9W   PWR:     W5.00000 NOM:C,MOTMR200

      TX LOCATION:     AL   WIDOWS CREEK             345302N0854524W      TX ANT DATA: 32GPARABOLIC 00191H0041T
      RX LOCATION(S): AL   LAMBERT CHAPEL           344239N0855311W      RX ANT DATA: 32GPARABOLIC 00445H0030T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:TVA 843027 BUR:TVA  STC:FX     EMS:      8M00F9W   PWR:     W5.00000 NOM:C,MOT MS-228

      TX LOCATION:     KY   BOWLING GREEN            370019N0863123W      TX ANT DATA: 33GPARABOLIC 00240H0079T
      RX LOCATION(S): KY   PARADISE                 371519N0865844W      RX ANT DATA: 33GPARABOLIC 00129H0160T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:TVA 843210 BUR:TVA  STC:FX     EMS:      8M00F9W   PWR:     W4.00000 NOM:C,MOTMR-200

      TX LOCATION:     TN   MOCCASIN                 350347N0852000W      TX ANT DATA: 28GPARABOLIC 00201H0024T
      RX LOCATION(S): TN   RACCOON MOUNTAIN         350321N0852306W      RX ANT DATA: 28GPARABOLIC 00505H0021T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:TVA 870183 BUR:TVA  STC:FX     EMS:      8M00F9W   PWR:     W1.00000 NOM:C,COLMIR2

      TX LOCATION:     TN   OSWALD DOME              351131N0843331W      TX ANT DATA: 33GPARABOLIC 00918H0044T
      RX LOCATION(S): TN   HIWASSEE DAM             350900N0841029W      RX ANT DATA: 33GPARABOLIC 00515H0047T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:TVA 870532 BUR:TVA  STC:FX     EMS:      8M00F9W   PWR:     W5.00000 NOM:C,MOTMR200

      TX LOCATION:     TN   PHIPPS BEND              362739N0824835W      TX ANT DATA: 30GPARABOLIC 00360H0043T
      RX LOCATION(S): TN   BUNKER HILL              362654N0825633W      RX ANT DATA: 30GPARABOLIC 00536H0029T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1755.000000 SER:TVA 843217 BUR:TVA  STC:FX     EMS:      1M00F9W   PWR:     W4.50000 NOM:C,MOTMR-200,MTN4D20-1

      TX LOCATION:     TN   ROANE                    355640N0842323W      TX ANT DATA: 29GPARABOLIC 00236H0036T
      RX LOCATION(S): TN   OAK RIDGE                355627N0842424W      RX ANT DATA: 29GPARABOLIC 00233H0014T
-------------------------------------------------------------------------------------------------------------------
```

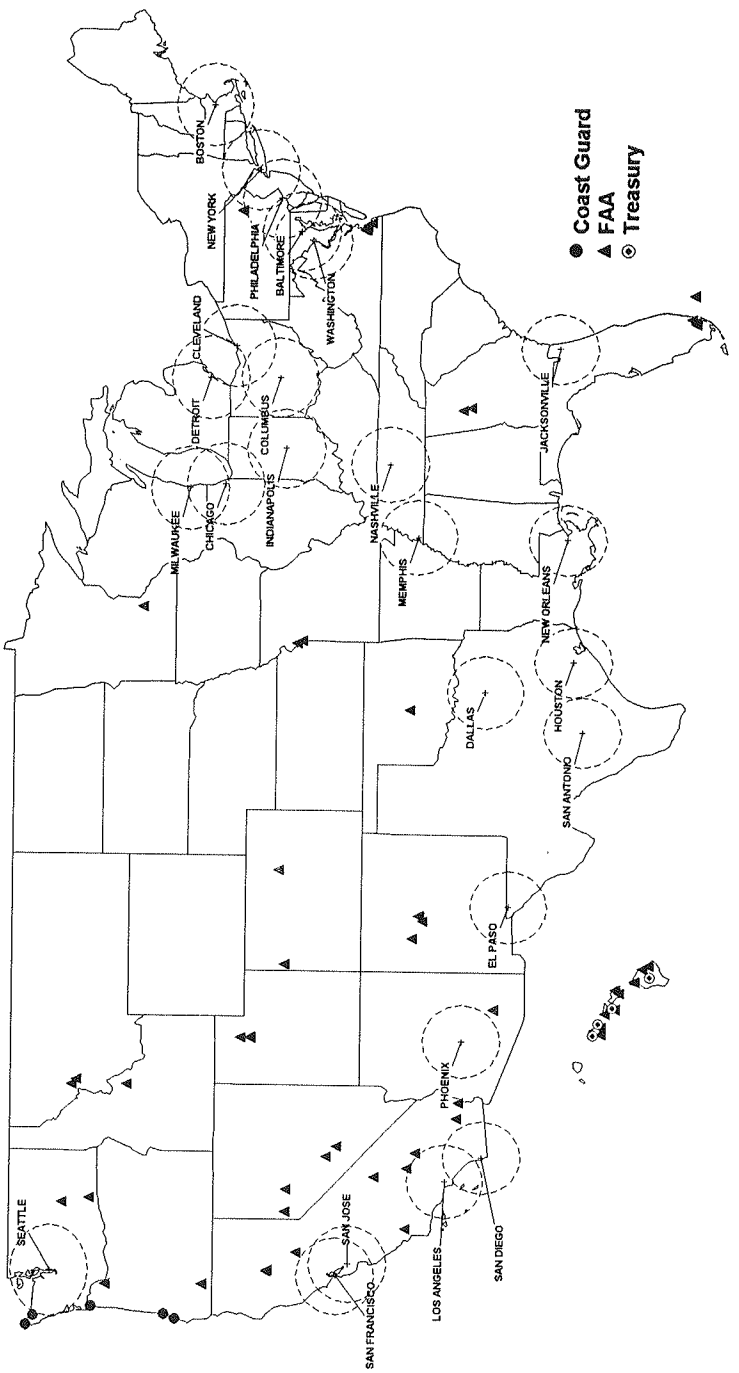



Figure E-2. Geographic distribution of safety-of-life fixed microwave stations in the 1710-1755 MHz band exempted from reallocation.

## TABLE E-2

Safety-of-Life Fixed Microwave Stations in the 1710-1755 MHz Band Exempted From Reallocation

```
FREQ: M1710.000000 SER:FAA 932863 BUR:     STC:FX     EMS:     1M60D7W   PWR:    W1.25000 NOM:C,COLMDR5302

      TX LOCATION:    CA   PASO ROBLES              352342N1202112W      TX ANT DATA: 28GPARABOLIC 00484H0006T
      RX LOCATION(S): CA   SAN LUIS OBISPO         351930N1203620W      RX ANT DATA: 28GPARABOLIC 00791H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1710.400000 SER:FAA 853074 BUR:SO   STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,MOT K16RBF220

      TX LOCATION:    VI   CROWN MOUNTAIN           182117N0645820W      TX ANT DATA: 34GGRID       00471H0029T
      RX LOCATION(S): PR   PICO DEL ESTE           181608N0654552W      RX ANT DATA: 34GGRID       01036H0008T
-------------------------------------------------------------------------------------------------------------
FREQ: M1710.400000 SER:FAA 853083 BUR:SO   STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,MOT K16RBF220

      TX LOCATION:    VI   SAINT CROIX              174404N0644203W      TX ANT DATA: 28GGRID       00260H0003T
      RX LOCATION(S): VI   SAINT CROIX              174202N0644822W      RX ANT DATA: 25GGRID       00019H0018T
-------------------------------------------------------------------------------------------------------------
FREQ: M1710.500000 SER:FAA 860113 BUR:SO   STC:FX     EMS:   800K00F9W   PWR:   W10.00000 NOM:C,MOT K16RBF2100$

      TX LOCATION:    BAH  BIMINI                  254234N0791632W      TX ANT DATA: 29GGRID       00002H0006T
      RX LOCATION(S): BAH  BIMINI                  254216N0791739W      RX ANT DATA: 29GGRID       00002H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1710.500000 SER:FAA 850690 BUR:SO   STC:FX     EMS:   800K00F9W   PWR:    W.10000 NOM:C,MOT K16RBF2100$

      TX LOCATION:    FL   TAMIAMI                  253831N0803029W      TX ANT DATA: 29GGRID       00003H0043T
      RX LOCATION(S): FL   TAMIAMI                  253854N0802535W      RX ANT DATA: 29GGRID       00003H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1711.000000 SER:CG  753885 BUR:17   STC:FX     EMS:   300K00F8W   PWR:    W1.50000 NOM:C,CDN8020

      TX LOCATION:    AK   GRAVINA ISLAND           5522XXN13148XXW      TX ANT DATA: 26GOPNGRDPRBL00750H0005T
      RX LOCATION(S): AK   KETCHIKAN                5521XXN13140XXW      RX ANT DATA: 26GDISH       00018H0018T
-------------------------------------------------------------------------------------------------------------
FREQ: M1711.000000 SER:CG  753882 BUR:17   STC:FX     EMS:   300K00F8W   PWR:    W1.50000 NOM:C,CDN8020

      TX LOCATION:    AK   LENA POINT               5823XXN13446XXW      TX ANT DATA: 25GOPNGRDPRBL00125H0018T
      RX LOCATION(S): AK   ROBERT BARRON PEAK       5814XXN13450XXW      RX ANT DATA: 25GDISH       01564H0005T
-------------------------------------------------------------------------------------------------------------
FREQ: M1711.000000 SER:CG  753884 BUR:17   STC:FX     EMS:   300K00F8W   PWR:    W1.50000 NOM:C,CDN8020

      TX LOCATION:    AK   ZAREMBO ISLAND           5621XXN13252XXW      TX ANT DATA: 28GOPNGRDPRBL01463H0005T
      RX LOCATION(S): AK   DUNCAN CANAL             5645XXN13310XXW      RX ANT DATA: 25GOPNGRDPRBL00792H0005T
-------------------------------------------------------------------------------------------------------------
FREQ: M1711.000000 SER:FAA 830657 BUR:AL   STC:FX     EMS:     1M98F9W   PWR:    W1.00000 NOM:C,MOTK16RBF

      TX LOCATION:    AK   ANCHORAGE                611301N1495031W      TX ANT DATA: 25GPARABOLIC 00040H0018T
      RX LOCATION(S): AK   ANCHORAGE                611346N1494651W      RX ANT DATA: 25GPARABOLIC 00061H0027T
-------------------------------------------------------------------------------------------------------------
FREQ: M1711.000000 SER:FAA 941081 BUR:     STC:FX     EMS:     1M60D7W   PWR:    W1.25000 NOM:C,COLMDR5302

      TX LOCATION:    CA   BEALE AFB               390748N1212736W      TX ANT DATA: 28GPARABOLIC 00041H0006T
      RX LOCATION(S): CA   MCCLELLAN AFB           384008N1212353W      RX ANT DATA: 28GPARABOLIC 00032H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1711.000000 SER:FAA 931010 BUR:SW   STC:FX     EMS:   800K00F9W   PWR:    W1.00000 NOM:C,MOT K16RBF-P87

      TX LOCATION:    NM   ALBUQUERQUE              350004N1063613W      TX ANT DATA: 25GPARABOLIC 01631H0012T
      RX LOCATION(S): NM   ALBUQUERQUE              350256N1063621W      RX ANT DATA: 25GPARABOLIC 01631H0027T
-------------------------------------------------------------------------------------------------------------
FREQ: M1711.000000 SER:T   880216 BUR:C    STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,MOT,STARPOINT

      TX LOCATION:    HI   LANAI                   205036N1565402W      TX ANT DATA: 30GOPNGRDPRBL00686H0006T
      RX LOCATION(S): HI   HALEAKALA              204238N1561541W      RX ANT DATA: 32GPARABOLIC 03051H0006T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-2 *(Continued)*

```
FREQ: M1712.000000 SER:FAA 910783 BUR:SO   STC:FX     EMS:     3M20D7W   PWR:    W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     FL   MIAMI                    254736N0801757W      TX ANT DATA: 28GPARABOLIC 00003H0048T
      RX LOCATION(S): FL   MIAMI                    254930N0801908W      RX ANT DATA: 28GPARABOLIC 00005H0038T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1712.000000 SER:FAA 941150 BUR:EA   STC:FX     EMS:     3M20F7W   PWR:    W1.00000 NOM:C,COLMDR5302

      TX LOCATION:     PA   WILKES BARRE              412010N0754344W      TX ANT DATA: 31GPARABOLIC 00287H0014T
      RX LOCATION(S): PA   WILKES BARRE              411742N0754212W      RX ANT DATA: 31GPARABOLIC 00503H0023T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1712.000000 SER:FAA 932377 BUR:EA   STC:FX     EMS:     3M20F7W   PWR:    W1.00000 NOM:C,COLMDR530

      TX LOCATION:     VA   NEWPORT NEWS              370755N0763003W      TX ANT DATA: 28GPARABOLIC 00011H0012T
      RX LOCATION(S): VA   NEWPORT NEWS              370421N0762949W      RX ANT DATA: 28GPARABOLIC 00011H0091T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1712.100000 SER:FAA 850760 BUR:NM   STC:FX     EMS:     3M20D7W   PWR:    W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     UT   SALT LAKE CITY           404625N1115732W      TX ANT DATA: 28GPARABOLIC 01286H0011T
      RX LOCATION(S): UT   SALT LAKE CITY           404605N1115803W      RX ANT DATA: 28GPARABOLIC 01286H0003T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1713.000000 SER:FAA 941010 BUR:     STC:FX     EMS:     1M60D7W   PWR:    W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     CA   VELVET PEAK              350336N1170051W      TX ANT DATA: 28GPARABOLIC 01282H0006T
      RX LOCATION(S): CA   BARSTOW                  345053N1170232W      RX ANT DATA: 28GPARABOLIC 00940H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1713.000000 SER:FAA 941133 BUR:EA   STC:FX     EMS:     3M20F7W   PWR:    W1.00000 NOM:C,COLMDR5302

      TX LOCATION:     VA   HAMPTON                  370218N0761847W      TX ANT DATA: 31GPARABOLIC 00006H0061T
      RX LOCATION(S): VA   LANGLEY AFB              370514N0762149W      RX ANT DATA: 31GPARABOLIC 00003H0008T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:CG  830084 BUR:13   STC:FX     EMS:     5M00F9W   PWR:    W5.00000 NOM:C,RIEMIR-2

      TX LOCATION:     OR   WINCHESTER HILL          433923N1241111W      TX ANT DATA: 31GPARABOLIC 00122H0038T
      RX LOCATION(S): OR   GOODWIN PEAK             435541N1235326W      RX ANT DATA: 31GPARABOLIC 00564H0011T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:CG  890939 BUR:07   STC:FX     EMS:     2M00F8W   PWR:    W5.00000 NOM:C,MOTMR200

      TX LOCATION:     PR   EL YUNKEE               181846N0654734W      TX ANT DATA: 31GPARABOLIC 01036H0036T
      RX LOCATION(S): VI   CROWN MOUNTAIN          182132N0645822W      RX ANT DATA: 31GPARABOLIC 00472H0024T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:FAA 871040 BUR:NM   STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,MOTK16RBC

      TX LOCATION:     CO   DOUGLAS PASS             393819N1084546W      TX ANT DATA: 31GPARABOLIC 02743H0006T
      RX LOCATION(S): CO   GRAND MESA               390523N1081332W      RX ANT DATA: 31GPARABOLIC 03030H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1715.000000 SER:FAA 921437 BUR:EA   STC:FX     EMS:   800K00F9W   PWR:    W2.00000 NOM:C,GRA 6018-3A

      TX LOCATION:     PA   PITTSBURGH               402939N0801417W      TX ANT DATA: 25GPARABOLIC 00365H0047T
      RX LOCATION(S): PA   PITTSBURGH               402823N0801547W      RX ANT DATA: 25GPARABOLIC 00365H0023T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1716.000000 SER:FAA 932566 BUR:     STC:FX     EMS:     3M20D7W   PWR:    W1.00000 NOM:C,COLMDR-5102

      TX LOCATION:     HI   MOLOKAI                  210758N1571048W      TX ANT DATA: 28GPARABOLIC 00415H0006T
      RX LOCATION(S): HI   MAUNA KAPU               212350N1580605W      RX ANT DATA: 28GPARABOLIC 00771H0015T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1716.500000 SER:FAA 805311 BUR:WP   STC:FX     EMS:     1M60F9W   PWR:    W5.00000 NOM:C,TERTCM-6

      TX LOCATION:     HI   HALEAKALA               204220N1561553W      TX ANT DATA: 35GPARABOLIC 02972H0006T
      RX LOCATION(S): HI   DIAMOND HEAD             211556N1574805W      RX ANT DATA: 35GPARABOLIC 00145H0009T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-2 *(Continued)*

```
FREQ: M1716.500000 SER:FAA 931439 BUR:WP   STC:FX     EMS:     3M20D7W   PWR:    W1.00000 NOM:C,COL MDR-5102

      TX LOCATION:    HI   HILO                  194305N1550341W      TX ANT DATA: 29GPARABOLIC 00009H0015T
      RX LOCATION(S): HI   HILO                  194258N1550251W      RX ANT DATA: 29GPARABOLIC 00009H0024T
-------------------------------------------------------------------------------------------------------------
FREQ: M1717.000000 SER:FAA 890279 BUR:AL   STC:FX     EMS:     3M70F9W   PWR:    W1.00000 NOM:C,MOT,STARPOINT

      TX LOCATION:    AK   ANCHORAGE             611255N1495305W      TX ANT DATA: 40GPARABOLIC 00030H0024T
      RX LOCATION(S): AK   SITE SUMMIT           611530N1493143W      RX ANT DATA: 40GPARABOLIC 01196H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1717.000000 SER:FAA 932209 BUR:WP   STC:FX     EMS:     3M20D7W   PWR:    W1.00000 NOM:C,COLMDR5302

      TX LOCATION:    NV   TONOPAH               374715N1164515W      TX ANT DATA: 28GPARABOLIC 01707H0015T
      RX LOCATION(S): NV   TONOPAH               380830N1171201W      RX ANT DATA: 28GPARABOLIC 02164H0011T
-------------------------------------------------------------------------------------------------------------
FREQ: M1718.000000 SER:CG  900734 BUR:07   STC:FX     EMS:     2M00F8W   PWR:    W5.00000 NOM:C,MOTMR200

      TX LOCATION:    PR   EL YUNKEE             181846N0654734W      TX ANT DATA: 31GPARABOLIC 01036H0036T
      RX LOCATION(S): VI   CROWN MOUNTAIN        182132N0645822W      RX ANT DATA: 31GPARABOLIC 00472H0024T
-------------------------------------------------------------------------------------------------------------
FREQ: M1718.500000 SER:FAA 921543 BUR:NM   STC:FX     EMS:     2M00F9W   PWR:    W1.00000 NOM:C,MOTK16RBF

      TX LOCATION:    MT   MILLER PEAK           464524N1135331W      TX ANT DATA: 41GPARABOLIC 02128H0021T
      RX LOCATION(S): MT   MISSOULA              465507N1140500W      RX ANT DATA: 37GPARABOLIC 00976H0014T
-------------------------------------------------------------------------------------------------------------
FREQ: M1719.000000 SER:FAA 932860 BUR:     STC:FX     EMS:     1M60D7W   PWR:    W1.25000 NOM:C,COLMDR5302

      TX LOCATION:    AZ   MOUNT LEMMON          322430N1104000W      TX ANT DATA: 28GPARABOLIC 02606H0006T
      RX LOCATION(S): AZ   DAVIS MONTHAN         321012N1105233W      RX ANT DATA: 28GPARABOLIC 00823H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1719.000000 SER:FAA 941025 BUR:     STC:FX     EMS:     1M60D7W   PWR:    W1.25000 NOM:C,COLMDR5302

      TX LOCATION:    CA   CHUCKWALLA            333918N1152712W      TX ANT DATA: 28GPARABOLIC 01148H0006T
      RX LOCATION(S): CA   TWENTYNINE PALMS      340006N1155233W      RX ANT DATA: 28GPARABOLIC 01402H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1719.000000 SER:FAA 921402 BUR:NM   STC:FX     EMS:     2M00F9W   PWR:    W1.00000 NOM:C,MOTKO6RBF

      TX LOCATION:    OR   MEDFORD               422202N1225234W      TX ANT DATA: 37GPARABOLIC 00406H0008T
      RX LOCATION(S): OR   JOHNS PEAK            422112N1225937W      RX ANT DATA: 37GPARABOLIC 00886H0014T
-------------------------------------------------------------------------------------------------------------
FREQ: M1719.000000 SER:FAA 901797 BUR:NM   STC:FX     EMS:     2M00F9W   PWR:    W1.00000 NOM:C,MOTKO6RBF

      TX LOCATION:    OR   SCAPPOOSE             454155N1225530W      TX ANT DATA: 29GPARABOLIC 00490H0024T
      RX LOCATION(S): OR   PORTLAND              453521N1223536W      RX ANT DATA: 29GPARABOLIC 00008H0041T
-------------------------------------------------------------------------------------------------------------
FREQ: M1719.000000 SER:T   880222 BUR:C    STC:FX     EMS:     5M00F9W   PWR:    W4.00000 NOM:C,MOT,MR200

      TX LOCATION:    HI   MAUNA KAPU            212406N1580601W      TX ANT DATA: 12GOPNGRDPRBL00841H0021T
      RX LOCATION(S): HI   WAHIAWA               213105N1580001W      RX ANT DATA: 12GOPNGRDPRBL00457H0009T
-------------------------------------------------------------------------------------------------------------
FREQ: M1719.000000 SER:T   880212 BUR:C    STC:FX     EMS:     5M00F9W   PWR:    W2.60000 NOM:C,MOT,STARPOINT 2000

      TX LOCATION:    HI   MAUNA LOA             193519N1552710W      TX ANT DATA: 34GPARABOLIC 02487H0011T
      RX LOCATION(S): HI   HALEAKALA            204238N1561541W      RX ANT DATA: 34GPARABOLIC 03051H0013T
-------------------------------------------------------------------------------------------------------------
FREQ: M1720.000000 SER:CG  860435 BUR:13   STC:FX     EMS:     5M00F9W   PWR:    W2.00000 NOM:C,GRA 6018-3A

      TX LOCATION:    OR   ASTORIA               460918N1235256W      TX ANT DATA: 31GPARABOLIC 00003H0012T
      RX LOCATION(S): WA   NASELLE RIDGE         462518N1234751W      RX ANT DATA: 31GPARABOLIC 00594H0015T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-2 *(Continued)*

```
FREQ: M1720.000000 SER:CG  792160 BUR:13   STC:FX     EMS:     1M60F9W   PWR:    W3.20000 NOM:C,FECTR1900PN

      TX LOCATION:    WA   BAHOKUS                  482223N1244027W      TX ANT DATA: 33GPARABOLIC 00430H0005T
      RX LOCATION(S): WA   MOUNT ELLIS              480747N1241815W      RX ANT DATA: 33GPARABOLIC 00704H0008T
-------------------------------------------------------------------------------------------------------------
FREQ: M1720.000000 SER:FAA 860755 BUR:CE   STC:FX     EMS:     3M50F9W   PWR:    W1.00000 NOM:C,GRANGER 6018-3A

      TX LOCATION:    MO   KANSAS CITY              391751N0944256W      TX ANT DATA: 30GPARABOLIC 00302H0065T
      RX LOCATION(S): MO   PARKVILLE                391134N0943813W      RX ANT DATA: 28GPARABOLIC 00288H0067T
-------------------------------------------------------------------------------------------------------------
FREQ: M1720.000000 SER:FAA 922510 BUR:CE   STC:FX     EMS:     3M50F9W   PWR:    W1.00000 NOM:C,GRANGER 6018-3A

      TX LOCATION:    MO   KANSAS CITY              391751N0944256W      TX ANT DATA: 30GPARABOLIC 00302H0065T
      RX LOCATION(S): MO   PARKVILLE                391134N0943813W      RX ANT DATA: 28GPARABOLIC 00288H0067T
-------------------------------------------------------------------------------------------------------------
FREQ: M1720.000000 SER:FAA 932639 BUR:NM   STC:FX     EMS:     3M20D7W   PWR:    W1.25000 NOM:C,COLMDR5302

      TX LOCATION:    MT   MISSOULA                 465506N1140602W      TX ANT DATA: 28GPARABOLIC 00973H0005T
      RX LOCATION(S): MT   MISSOULA                 465507N1140500W      RX ANT DATA: 28GPARABOLIC 00976H0014T
-------------------------------------------------------------------------------------------------------------
FREQ: M1720.000000 SER:FAA 932372 BUR:EA   STC:FX     EMS:     3M20F7W   PWR:    W1.00000 NOM:C,COLMDR5302

      TX LOCATION:    VA   HAMPTON                  370218N0761847W      TX ANT DATA: 28GPARABOLIC 00006H0116T
      RX LOCATION(S): VA   NORFOLK                  365344N0761137W      RX ANT DATA: 28GPARABOLIC 00008H0030T
-------------------------------------------------------------------------------------------------------------
FREQ: M1721.000000 SER:FAA 850682 BUR:SO   STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,MOT STARPOINT$

      TX LOCATION:    GA   HAMPTON                  332250N0841800W      TX ANT DATA: 25GPARABOLIC 00094H0046T
      RX LOCATION(S): GA   ATLANTA                  333928N0842533W      RX ANT DATA: 25GPARABOLIC 00313H0046T
-------------------------------------------------------------------------------------------------------------
FREQ: M1722.000000 SER:CG  764502 BUR:17   STC:FX     EMS:   800K00F8W   PWR:    W1.50000 NOM:C,CCC8020

      TX LOCATION:    AK   CAPE HINCHINBROOK         6015XXN14639XXW      TX ANT DATA: 25GDISH      00051H0012T
      RX LOCATION(S): AK   NAKED I                  603849N1472036W      RX ANT DATA: 25GDISH      00370H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1722.000000 SER:FAA 931444 BUR:WP   STC:FX     EMS:     3M20D7W   PWR:    W1.00000 NOM:C,COL MDE-5102

      TX LOCATION:    HI   UPOLU POINT              201202N1555036W      TX ANT DATA: 29GPARABOLIC 00536H0006T
      RX LOCATION(S): HI   HALEAKALA                204220N1561553W      RX ANT DATA: 29GPARABOLIC 02972H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1722.000000 SER:FAA 932099 BUR:NM   STC:FX     EMS:     3M20D7W   PWR:    W1.25000 NOM:C,COLMDR5302

      TX LOCATION:    UT   SALT LAKE CITY           404709N1115831W      TX ANT DATA: 28GPARABOLIC 01288H0037T
      RX LOCATION(S): UT   SALT LAKE CITY           404838N1115800W      RX ANT DATA: 28GPARABOLIC 01280H0009T
-------------------------------------------------------------------------------------------------------------
FREQ: M1722.500000 SER:FAA 931457 BUR:WP   STC:FX     EMS:     3M20D7W   PWR:    W1.00000 NOM:C,COL MDR-5102

      TX LOCATION:    HI   DIAMOND HEAD             211556N1574805W      TX ANT DATA: 29GPARABOLIC 00145H0006T
      RX LOCATION(S): HI   MOUNT KAALA              213028N1580831W      RX ANT DATA: 29GPARABOLIC 01233H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1722.500000 SER:FAA 794832 BUR:WP   STC:FX     EMS:   800K00F9W   PWR:    W2.00000 NOM:C,WMI 200

      TX LOCATION:    HI   MAUNA KAPU              212350N1580605W      TX ANT DATA: 25GPARABOLIC 00771H0018T
      RX LOCATION(S): HI   DIAMOND HEAD            211556N1574815W      RX ANT DATA: 25GPARABOLIC 00145H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1722.500000 SER:FAA 794833 BUR:WP   STC:FX     EMS:   800K00F9W   PWR:    W4.00000 NOM:C,WMI 200

      TX LOCATION:    HI   NINOLE                  195437N1551122W      TX ANT DATA: 33GPARABOLIC 00468H0018T
      RX LOCATION(S): HI   HILO                    194302N1550126W      RX ANT DATA: 33GPARABOLIC 00011H0023T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-2 *(Continued)*

```
FREQ: M1722.500000 SER:FAA 931442 BUR:WP   STC:FX     EMS:     3M20D7W   PWR:     W1.00000 NOM:C,COL MDR-5102

      TX LOCATION:     HI   NINOLE                    195437N1551122W       TX ANT DATA: 29GPARABOLIC 00468H0018T
      RX LOCATION(S): HI   HILO                      194302N1550126W       RX ANT DATA: 29GPARABOLIC 00011H0023T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1723.000000 SER:FAA 841482 BUR:AL   STC:FX     EMS:     2M00F9W   PWR:      W.10000 NOM:C,MOT K06RBF2100

      TX LOCATION:     AK   ANCHORAGE                 610958N1500108W       TX ANT DATA: 24GPARABOLIC 00043H0006T
      RX LOCATION(S): AK   ANCHORAGE                 611036N1495859W       RX ANT DATA: 24GPARABOLIC 00028H0048T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:CG  840406 BUR:07   STC:FX     EMS:     1M60F9W   PWR:     W1.00000 NOM:C,MOTK16RBF

      TX LOCATION:     PR   SAN JUAN                  182746N0660701W       TX ANT DATA: 25GPARABLCDSH00003H0009T
      RX LOCATION(S): PR   EL YUNQUE                 181836N0654730W       RX ANT DATA: 25GPARABLCDSH01036H0015T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:FAA 922066 BUR:SO   STC:FX     EMS:     3M20D7W   PWR:     W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     FL   TAMIAMI                   253854N0802557W       TX ANT DATA: 28GPARABOLIC 00002H0026T
      RX LOCATION(S): FL   MIAMI                     254736N0801757W       RX ANT DATA: 28GPARABOLIC 00003H0048T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:FAA 902105 BUR:SW   STC:FX     EMS:     1M60F9W   PWR:     W1.00000 NOM:C,WEST MUX ONE-2000

      TX LOCATION:     NM   ISLETA                    345342N1064854W       TX ANT DATA: 28GPARABOLIC 01657H0012T
      RX LOCATION(S): NM   ALBUQUERQUE               350208N1063717W       RX ANT DATA: 28GPARABOLIC 01618H0018T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1725.000000 SER:FAA 932548 BUR:EA   STC:FX     EMS:     3M20F7W   PWR:     W1.00000 NOM:C,COLMDR5302

      TX LOCATION:     VA   NORFOLK                   365340N0761206W       TX ANT DATA: 31GPARABOLIC 00008H0012T
      RX LOCATION(S): VA   NORFOLK                   365345N0761133W       RX ANT DATA: 31GPARABOLIC 00008H0023T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1726.000000 SER:FAA 932867 BUR:     STC:FX     EMS:     1M60D7W   PWR:     W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     CA   BLYTHE                    333546N1144537W       TX ANT DATA: 28GPARABOLIC 00011H0006T
      RX LOCATION(S): CA   MCCOY                     333823N1144740W       RX ANT DATA: 28GPARABOLIC 00405H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1726.000000 SER:FAA 910253 BUR:NM   STC:FX     EMS:     3M20D7W   PWR:     W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     UT   SALT LAKE CITY            404605N1115803W       TX ANT DATA: 28GPARABOLIC 01287H0011T
      RX LOCATION(S): UT   SALT LAKE CITY            404817N1115831W       RX ANT DATA: 28GPARABOLIC 01287H0011T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1728.000000 SER:FAA 880870 BUR:NM   STC:FX     EMS:     1M60F9W   PWR:     W1.00000 NOM:C,MOTK88RB

      TX LOCATION:     WA   PASCO                     461537N1190658W       TX ANT DATA: 29GPARABOLIC 00121H0017T
      RX LOCATION(S): WA   WALLULA                   460135N1185156W       RX ANT DATA: 29GPARABOLIC 00538H0005T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1729.000000 SER:CG  764493 BUR:17   STC:FX     EMS:   800K00F8W   PWR:     W1.50000 NOM:C,CCC8020

      TX LOCATION:     AK   VALDEZ                    6108XXN14621XXW       TX ANT DATA: 25GDISH       00010H0010T
      RX LOCATION(S): AK   MOUNT THOMAS              610306N14644XXW       RX ANT DATA: 25GDISH       00884H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1729.000000 SER:T   900200 BUR:C    STC:FX     EMS:     5M00F9W   PWR:     W1.00000 NOM:C,MOT,STARPOINT

      TX LOCATION:     HI   SAND ISLAND               211832N1573231W       TX ANT DATA: 24GOPNGRDPRBL00001H0018T
      RX LOCATION(S): HI   MAUNA KAPU               212406N1580601W       RX ANT DATA: 24GOPNGRDPRBL00841H0021T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:FAA 830658 BUR:AL   STC:FX     EMS:     1M98F9W   PWR:     W1.00000 NOM:C,MOTK16RBF

      TX LOCATION:     AK   ANCHORAGE                 611346N1494651W       TX ANT DATA: 25GPARABOLIC 00061H0027T
      RX LOCATION(S): AK   ANCHORAGE                 611036N1495859W       RX ANT DATA: 25GPARABOLIC 00028H0037T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-2 *(Continued)*

```
FREQ: M1730.000000 SER:FAA 871733 BUR:AL   STC:FX     EMS:   800K00F9W   PWR:    W1.00000 NOM:C,MOT16RBF$ANAP4-17C

      TX LOCATION:    AK   KENAI                    603409N1511428W      TX ANT DATA: 25GPARABOLIC 00026H0015T
      RX LOCATION(S): AK   KENAI                    603656N1511659W      RX ANT DATA: 25GPARABOLIC 00032H0017T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:FAA 931361 BUR:     STC:FX     EMS:    3M20D7W   PWR:    W1.00000 NOM:C,COLMDR-5102

      TX LOCATION:    HI   MOLOKAI                   210758N1571048W      TX ANT DATA: 29GPARABOLIC 00415H0006T
      RX LOCATION(S): HI   HALEAKALA                204220N1561553W      RX ANT DATA: 29GPARABOLIC 02972H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:FAA 814797 BUR:NM   STC:FX     EMS:   800K00F9W   PWR:    W1.00000 NOM:C,MOTK16RBF2200

      TX LOCATION:    ID   SALMON                    450114N1140455W      TX ANT DATA: 29GPARABOLIC 02827H0005T
      RX LOCATION(S): ID   SALMON                    451010N1135313W      RX ANT DATA: 29GPARABOLIC 01207H0009T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:FAA 922578 BUR:GL   STC:FX     EMS:    3M20D7W   PWR:    W1.25000 NOM:C,ALCATEL MDR5302

      TX LOCATION:    MN   FARMINGTON                443813N0930905W      TX ANT DATA: 29GPARABOLIC 00276H0058T
      RX LOCATION(S): MN   APPLE VALLEY              444510N0931338W      RX ANT DATA: 29GPARABOLIC 00340H0008T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:FAA 915382 BUR:     STC:FX     EMS:    3M50B7D   PWR:    W5.00000 NOM:C,COLMDR-5102

      TX LOCATION:    NV   TONOPAH                   380829N1171202W      TX ANT DATA: 33GPARABOLIC 02164H0011T
      RX LOCATION(S): NV   TONOPAH TEST RANGE        374712N1164522W      RX ANT DATA: 33GPARABOLIC 01707H0015T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:FAA 941024 BUR:     STC:FX     EMS:    1M60D7W   PWR:    W1.25000 NOM:C,COLMDR5302

      TX LOCATION:    NV   VISTA                     393149N1193914W      TX ANT DATA: 28GPARABOLIC 01782H0006T
      RX LOCATION(S): NV   RENO                      392939N1194559W      RX ANT DATA: 28GPARABOLIC 02531H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1730.000000 SER:FAA 922732 BUR:WP   STC:FX     EMS:   800K00F9W   PWR:    W1.00000 NOM:C,ROCKWLHSB

      TX LOCATION:    SMA  TAFUNA                   142010S1704421W      TX ANT DATA: 29GPARABOLIC 00009H0009T
      RX LOCATION(S): SMA  MOUNT OLOTELE            141922S1704544W      RX ANT DATA: 29GPARABOLIC 00493H0009T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1733.000000 SER:FAA 932558 BUR:SW   STC:FX     EMS:    3M20D7W   PWR:    W1.00000 NOM:C,COLMDR5302

      TX LOCATION:    NM   ALBUQUERQUE               350256N1063621W      TX ANT DATA: 28GPARABOLIC 01631H0027T
      RX LOCATION(S): NM   ALBUQUERQUE               351023N1063401W      RX ANT DATA: 28GPARABOLIC 01631H0012T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1733.000000 SER:FAA 850756 BUR:NM   STC:FX     EMS:    3M20D7W   PWR:    W1.25000 NOM:C,COLMDR5302

      TX LOCATION:    UT   HILL                     410801N1115815W      TX ANT DATA: 28GPARABOLIC 01459H0010T
      RX LOCATION(S): UT   SALT LAKE CITY           410159N1115019W      RX ANT DATA: 28GPARABOLIC 02900H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1734.000000 SER:FAA 932864 BUR:     STC:FX     EMS:    1M60D7W   PWR:    W1.25000 NOM:C,COLMDR5302

      TX LOCATION:    CA   COTTONWOOD                362755N1180405W      TX ANT DATA: 28GPARABOLIC 01842H0006T
      RX LOCATION(S): CA   KEELER                    363301N1174806W      RX ANT DATA: 28GPARABOLIC 02815H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1734.000000 SER:FAA 860758 BUR:CE   STC:FX     EMS:    3M50F9W   PWR:    W1.00000 NOM:C,GRANGER 6018-3A

      TX LOCATION:    MO   KANSAS CITY              390724N0943553W      TX ANT DATA: 30GPARABOLIC 00227H0031T
      RX LOCATION(S): MO   PARKVILLE                 391134N0943813W      RX ANT DATA: 28GPARABOLIC 00288H0067T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1734.000000 SER:FAA 922511 BUR:CE   STC:FX     EMS:    3M50F9W   PWR:    W1.00000 NOM:C,GRANGER 6018-3A

      TX LOCATION:    MO   KANSAS CITY              390724N0943553W      TX ANT DATA: 30GPARABOLIC 00227H0031T
      RX LOCATION(S): MO   PARKVILLE                 391134N0943813W      RX ANT DATA: 28GPARABOLIC 00288H0067T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-2 *(Continued)*

```
FREQ: M1734.400000 SER:FAA 853076 BUR:SO   STC:FX     EMS:      1M60F9W   PWR:      W.10000 NOM:C,MOT K16RBF220

      TX LOCATION:     VI   SAINT THOMAS              182050N0650134W      TX ANT DATA: 25GGRID       00181H0006T
      RX LOCATION(S): VI   SAINT THOMAS              182122N0650132W      RX ANT DATA: 25GGRID       00197H0005T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1734.800000 SER:FAA 853071 BUR:SO   STC:FX     EMS:      1M60F9W   PWR:     W1.00000 NOM:C,MOT K16RBF220

      TX LOCATION:     PR   EL YUNQUE                 181838N0654729W      TX ANT DATA: 25GGRID       01030H0006T
      RX LOCATION(S): PR   PICO DEL ESTE             181608N0654552W      RX ANT DATA: 25GGRID       00316H0002T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:CG  742256 BUR:14   STC:FX     EMS:    800K00F8W   PWR:     W4.00000 NOM:C,MOTMR200

      TX LOCATION:     HI   MAUNA KAPU                212406N1580601W      TX ANT DATA: 12GOPNGRDPRBL00823H0021T
      RX LOCATION(S): HI   WAHIAWA                   213105N1580001W      RX ANT DATA: 12GOPNGRDPRBL00457H0009T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:FAA 881828 BUR:WP   STC:FX     EMS:      5M00F9W   PWR:     W5.00000 NOM:C,TER-TCM 602

      TX LOCATION:     CA   RAND MOUNTAIN             352019N1174101W      TX ANT DATA: 29GPARABOLIC 01437H0008T
      RX LOCATION(S): CA   BORON                     350456N1173456W      RX ANT DATA: 29GPARABOLIC 00916H0018T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:T   880210 BUR:C    STC:FX     EMS:      5M00F9W   PWR:     W2.60000 NOM:C,MOT,STARPOINT 2000

      TX LOCATION:     HI   MAUNA KAPU                212406N1580601W      TX ANT DATA: 35GOPNGRDPRBL00841H0018T
      RX LOCATION(S): HI   HALEAKALA                 204238N1561541W      RX ANT DATA: 34GPARABOLIC 03051H0018T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:T   880214 BUR:C    STC:FX     EMS:      5M00F9W   PWR:     W2.60000 NOM:C,MOT,STARPOINT 2000

      TX LOCATION:     HI   MAUNA LOA                 193519N1552710W      TX ANT DATA: 28GOPNGRDPRBL02487H0012T
      RX LOCATION(S): HI   HILO                      194351N1550326W      RX ANT DATA: 30GPARABOLIC 00003H0012T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1735.000000 SER:T   880220 BUR:C    STC:FX     EMS:      5M00F9W   PWR:     W1.00000 NOM:C,MOT,STARPOINT

      TX LOCATION:     HI   NORTH SHORE               213257N1581149W      TX ANT DATA: 28GPARABOLIC 00631H0006T
      RX LOCATION(S): HI   WAHIAWA                   213127N1575958W      RX ANT DATA: 28GPARABOLIC 00366H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1737.000000 SER:FAA 850685 BUR:SO   STC:FX     EMS:      1M60F9W   PWR:     W1.00000 NOM:C,MOT STARPOINT

      TX LOCATION:     GA   ATLANTA                   334100N0842533W      TX ANT DATA: 25GPARABOLIC 00313H0046T
      RX LOCATION(S): GA   ATLANTA                   333928N0842533W      RX ANT DATA: 25GPARABOLIC 00313H0046T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1737.500000 SER:FAA 931448 BUR:WP   STC:FX     EMS:      3M20D7W   PWR:     W1.00000 NOM:C,COL MDR-5102

      TX LOCATION:     HI   DIAMOND HEAD              211556N1574815W      TX ANT DATA: 29GPARABOLIC 00145H0005T
      RX LOCATION(S): HI   WAIMANALO                 211829N1574050W      RX ANT DATA: 29GPARABOLIC 00393H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1737.500000 SER:FAA 890570 BUR:WP   STC:FX     EMS:      3M20D7W   PWR:     W1.00000 NOM:C,COLMDR-5102

      TX LOCATION:     HI   PUUNIANIAU               204619N1561420W      TX ANT DATA: 29GPARABOLIC 02012H0018T
      RX LOCATION(S): HI   HALEAKALA RTR             204220N1561553W      RX ANT DATA: 29GPARABOLIC 02972H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1739.000000 SER:FAA 932707 BUR:     STC:FX     EMS:      1M60D7W   PWR:     W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     CA   RED BLUFF                 400620N1221406W      TX ANT DATA: 28GPARABOLIC 00098H0006T
      RX LOCATION(S): CA   CORNING                   400846N1221812W      RX ANT DATA: 28GPARABOLIC 00092H0006T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:CG  920411 BUR:13   STC:FX     EMS:      3M00F9W   PWR:     W1.00000 NOM:C,MOT MR200

      TX LOCATION:     OR   SEVEN DEVILS             431644N1242208W      TX ANT DATA: 28GPARABOLIC 00064H0015T
      RX LOCATION(S): OR   CAPE BLANCO               425002N1243308W      RX ANT DATA: 28GPARABOLIC 00057H0017T
-------------------------------------------------------------------------------------------------------------------
```

## TABLE E-2 *(Continued)*

```
FREQ: M1740.000000 SER:CG  743632 BUR:07   STC:FX     EMS:     6M00F9W   PWR:     W4.00000 NOM:C,MOTMR200

      TX LOCATION:     PR   CERRO DE PUNTO          1810XXN06635XXW      TX ANT DATA: 25GOPNGRDPRBL01338H0030T
      RX LOCATION(S): PR   MONTE DEL ESTADO        1809XXN06700XXW      RX ANT DATA: 25GOPNGRDPRBL00753H0030T
-------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:CG  792164 BUR:13   STC:FX     EMS:     1M60F9W   PWR:     W3.20000 NOM:C,FECTR1900PN

      TX LOCATION:     WA   MOUNT ELLIS             480747N1241815W      TX ANT DATA: 31GPARABOLIC 00704H0005T
      RX LOCATION(S): WA   STRIPED PEAK            480903N1234010W      RX ANT DATA: 33GPARABOLIC 00323H0008T
-------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:FAA 941017 BUR:     STC:FX     EMS:     1M60D7W   PWR:     W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     CA   RED BLUFF               400846N1221812W      TX ANT DATA: 28GPARABOLIC 00143H0006T
      RX LOCATION(S): CA   CORNING                 395038N1221151W      RX ANT DATA: 28GPARABOLIC 00092H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:FAA 932700 BUR:     STC:FX     EMS:     1M60D7W   PWR:     W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     NV   FALLON                  393013N1184012W      TX ANT DATA: 28GPARABOLIC 01198H0006T
      RX LOCATION(S): NV   EAGLE RIDGE             392911N1191903W      RX ANT DATA: 28GPARABOLIC 01478H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:FAA 820053 BUR:SW   STC:FX     EMS:   800K00F9W   PWR:     W1.00000 NOM:C,MOT K16RBF-P87

      TX LOCATION:     OK   OKLAHOMA CITY           352353N0973601W      TX ANT DATA: 25GPARABOLIC 00393H0018T
      RX LOCATION(S): OK   OKLAHOMA CITY           352238N0973605W      RX ANT DATA: 25GPARABOLIC 00393H0018T
-------------------------------------------------------------------------------------------------------------
FREQ: M1740.000000 SER:FAA 932677 BUR:NM   STC:FX     EMS:     3M20D7W   PWR:     W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     UT   SALT LAKE CITY          404710N1115707W      TX ANT DATA: 28GPARABOLIC 01286H0015T
      RX LOCATION(S): UT   SALT LAKE CITY          404625N1115732W      RX ANT DATA: 28GPARABOLIC 01286H0011T
-------------------------------------------------------------------------------------------------------------
FREQ: M1743.000000 SER:FAA 941083 BUR:     STC:FX     EMS:     1M60D7W   PWR:     W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     NV   TONOPAH DOE             380829N1171159W      TX ANT DATA: 28GPARABOLIC 02117H0006T
      RX LOCATION(S): NV   TONOPAH ATCBI2          380624N1164519W      RX ANT DATA: 28GPAROBOLIC 02117H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1743.000000 SER:FAA 941091 BUR:     STC:FX     EMS:     1M60D7W   PWR:     W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     NV   TONOPAH DOE             380829N1171159W      TX ANT DATA: 28GPARABOLIC 02117H0006T
      RX LOCATION(S): NV   TONOPAH ATCBI1          374712N1164519W      RX ANT DATA: 28GPAROBOLIC 02117H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:FAA 931017 BUR:NM   STC:FX     EMS:   800K00F9W   PWR:     W1.00000 NOM:C,COLMDR5302

      TX LOCATION:     CO   DENVER                  395145N1044023W      TX ANT DATA: 24GPARABOLIC 01635H0087T
      RX LOCATION(S): CO   PLATTEVILLE             401348N1044305W      RX ANT DATA: 24GPARABOLIC 01544H0021T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:FAA 922069 BUR:SO   STC:FX     EMS:     3M20D7W   PWR:     W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     FL   TAMIAMI                253849N0803019W      TX ANT DATA: 28GPARABOLIC 00003H0018T
      RX LOCATION(S): FL   TAMIAMI                253854N0802557W      RX ANT DATA: 28GPARABOLIC 00002H0026T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:FAA 932680 BUR:NM   STC:FX     EMS:     3M20D7W   PWR:     W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     UT   HILL                   410801N1115815W      TX ANT DATA: 28GPARABOLIC 01459H0010T
      RX LOCATION(S): UT   HILL                   410717N1115640W      RX ANT DATA: 28GPARABOLIC 01475H0008T
-------------------------------------------------------------------------------------------------------------
FREQ: M1745.000000 SER:FAA 932098 BUR:NM   STC:FX     EMS:     3M00D7W   PWR:     W1.25000 NOM:C,COLMDR5302

      TX LOCATION:     UT   SALT LAKE CITY          404709N1115831W      TX ANT DATA: 28GPARABOLIC 01288H0037T
      RX LOCATION(S): UT   SALT LAKE CITY          404817N1115831W      RX ANT DATA: 28GPARABOLIC 01286H0009T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-2 *(Continued)*

```
FREQ: M1746.000000 SER:FAA 921404 BUR:NM   STC:FX     EMS:     2M00F9W   PWR:    W1.00000 NOM:C,MOTKO6RBF

      TX LOCATION:    OR   MEDFORD                  422202N1225234W      TX ANT DATA: 37GPARABOLIC 00406H0008T
      RX LOCATION(S): OR   MEDFORD                  422305N1225151W      RX ANT DATA: 37GPARABOLIC 00400H0018T
-------------------------------------------------------------------------------------------------------------
FREQ: M1746.000000 SER:FAA 901798 BUR:NM   STC:FX     EMS:     2M00F9W   PWR:    W1.00000 NOM:C,MOTKO6RBF

      TX LOCATION:    OR   SCAPPOOSE                454155N1225530W      TX ANT DATA: 29GPARABOLIC 00490H0015T
      RX LOCATION(S): OR   NEWBERG                  451822N1225338W      RX ANT DATA: 29GPARABOLIC 00370H0021T
-------------------------------------------------------------------------------------------------------------
FREQ: M1746.400000 SER:FAA 853069 BUR:SO   STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,MOT K16RBF220

      TX LOCATION:    PR   CERRO DE PUNTO             181020N0663528W      TX ANT DATA: 28GGRID       01327H0015T
      RX LOCATION(S): PR   PONCE                     175933N0663110W      RX ANT DATA: 30GGRID       00005H0004T
-------------------------------------------------------------------------------------------------------------
FREQ: M1746.400000 SER:FAA 853063 BUR:SO   STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,MOT K16RBF220

      TX LOCATION:    PR   LASMESAS                  181113N0670659W      TX ANT DATA: 25GGRID       00397H0023T
      RX LOCATION(S): PR   MAYAGUEZ                  181612N0670854W      RX ANT DATA: 25GGRID       00009H0020T
-------------------------------------------------------------------------------------------------------------
FREQ: M1746.400000 SER:FAA 853081 BUR:SO   STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,MOT K16RBF220

      TX LOCATION:    VI   CROWN MOUNTAIN            182117N0645820W      TX ANT DATA: 34GGRID       00471H0029T
      RX LOCATION(S): VI   SAINT CROIX               174404N0644203W      RX ANT DATA: 34GGRID       00260H0004T
-------------------------------------------------------------------------------------------------------------
FREQ: M1747.500000 SER:FAA 810709 BUR:WP   STC:FX     EMS:     1M60F9W   PWR:    W5.00000 NOM:C,TERTCM-6

      TX LOCATION:    HI   HALEAKALA                 204220N1561553W      TX ANT DATA: 35GPARABOLIC 02972H0006T
      RX LOCATION(S): HI   DIAMOND HEAD              211556N1574805W      RX ANT DATA: 35GPARABOLIC 00145H0009T
-------------------------------------------------------------------------------------------------------------
FREQ: M1747.500000 SER:FAA 931450 BUR:WP   STC:FX     EMS:     3M20D7W   PWR:    W1.00000 NOM:C,COL MDR-5102

      TX LOCATION:    HI   LANAI                     204553N1565808W      TX ANT DATA: 29GPARABOLIC 00381H0006T
      RX LOCATION(S): HI   HALEAKALA                 204220N1561553W      RX ANT DATA: 29GPARABOLIC 02972H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1747.500000 SER:FAA 931454 BUR:WP   STC:FX     EMS:     3M20D7W   PWR:    W1.00000 NOM:C,COL MDR-5102

      TX LOCATION:    HI   MAUNA KAPU               212350N1580605W      TX ANT DATA: 29GPARABOLIC 00771H0006T
      RX LOCATION(S): HI   MOUNT KAALA              213028N1580831W      RX ANT DATA: 29GPARABOLIC 01233H0006T
-------------------------------------------------------------------------------------------------------------
FREQ: M1750.000000 SER:FAA 820084 BUR:SW   STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,MOT K16RBF-P87

      TX LOCATION:    NM   LA MOSCA PEAK             351510N1073548W      TX ANT DATA: 33GPARABOLIC 03335H0006T
      RX LOCATION(S): NM   ALBUQUERQUE               350254N1063715W      RX ANT DATA: 33GPARABOLIC 01620H0015T
-------------------------------------------------------------------------------------------------------------
FREQ: M1750.000000 SER:FAA 861959 BUR:SO   STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,MOT K16RBF220

      TX LOCATION:    PR   MAYAGUEZ                  181612N0670054W      TX ANT DATA: 30GGRID       00009H0020T
      RX LOCATION(S): PR   MONTE DEL ESTADO         180859N0665919W      RX ANT DATA: 28GGRID       00870H0015T
-------------------------------------------------------------------------------------------------------------
FREQ: M1750.000000 SER:FAA 881481 BUR:NM   STC:FX     EMS:     1M60F9W   PWR:    W1.00000 NOM:C,MOTK88RB

      TX LOCATION:    WA   MOSES LAKE                471157N1191909W      TX ANT DATA: 24GPARABOLIC 00357H0012T
      RX LOCATION(S): WA   MOSES LAKE                471123N1191925W      RX ANT DATA: 24GPARABOLIC 00366H0024T
-------------------------------------------------------------------------------------------------------------
FREQ: M1752.000000 SER:FAA 915008 BUR:SO   STC:FX     EMS:     1M60F9W   PWR:    W2.00000 NOM:C,MOTOROLA STARPOINT

      TX LOCATION:    PR   SAN JUAN                  182707N0655929W      TX ANT DATA: 24GPARABOLIC 00003H0015T
      RX LOCATION(S): PR   SAN JUAN                  182614N0655907W      RX ANT DATA: 24GPARABOLIC 00003H0015T
-------------------------------------------------------------------------------------------------------------
```

## TABLE E-2 *(Continued)*

```
FREQ: M1752.000000 SER:FAA 921401 BUR:WP   STC:FX     EMS:    800K00F9W   PWR:     W1.00000 NOM:C,ROCKWLHSB

      TX LOCATION:     SMA  TAFUNA                    142010S1704421W      TX ANT DATA: 29GPARABOLIC 00009H0009T
      RX LOCATION(S): SMA  MOUNT OLOTELE              141922S1704544W      RX ANT DATA: 29GPARABOLIC 00493H0009T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1753.000000 SER:CG  891032 BUR:07   STC:FX     EMS:     2M00F8W   PWR:     W5.00000 NOM:C,MOTMR200

      TX LOCATION:     VI   BLUE MOUNTAIN             174520N0644755W      TX ANT DATA: 31GPARABOLIC 00307H0020T
      RX LOCATION(S): VI   CROWN MOUNTAIN            182132N0645822W      RX ANT DATA: 31GPARABOLIC 00472H0021T
-------------------------------------------------------------------------------------------------------------------
FREQ: M1754.000000 SER:FAA 932378 BUR:EA   STC:FX     EMS:     3M20F7W   PWR:     W1.00000 NOM:C,COLMDR5302

      TX LOCATION:     VA   NEWPORT NEWS              370421N0762949W      TX ANT DATA: 28GPARABOLIC 00011H0091T
      RX LOCATION(S): VA   NEWPORT NEWS              370755N0763003W      RX ANT DATA: 28GPARABOLIC 00011H0012T
-------------------------------------------------------------------------------------------------------------------
```

# APPENDIX F
# PROTECTED FEDERAL GOVERNMENT SITES

The Federal Government, specifically DOD, operates and maintains extensive networks of radar, tactical radio relay, fixed microwave and aeronautical mobile systems across the entire radio spectrum. These systems are fundamental to the Federal Government in meeting their varying, essential communications requirements. Four specific frequency bands, the 1390-1400 MHz, 1427-1432 MHz, 1710-1755 MHz and 4635-4660 MHz, that will be reallocated for non-Federal use, provide for some of these essential communications requirements. Essential Federal operations in these bands are normally concentrated on a few sites across the United States. Protection to these sites is vital to minimize the impact that may be caused by non-Federal sector users to these essential and other Federal Government operations. As such, protection is afforded to sites across the United States at which essential operations are being conducted by the Federal Government in each of the four bands.

In particular, to protect essential operations in the 1390-1400 MHz band, high-valued Federal radar systems at the sites listed in Figure F-1 will continue to operate for nine more years. This will provide ample time for the affected agency to re-engineer existing channeling arrangements and possibly redesign, procure and install system replacements.

In the 1427-1432 MHz band, the Federal systems at the sites listed in Figure F-2 will continue to operate for 14 more years. This is appropriate considering the remaining useful life of Federal Government fixed microwave systems that have been purchased and contracted for. It also provides ample time necessary to redesign, procure and install replacement telemetry equipments.

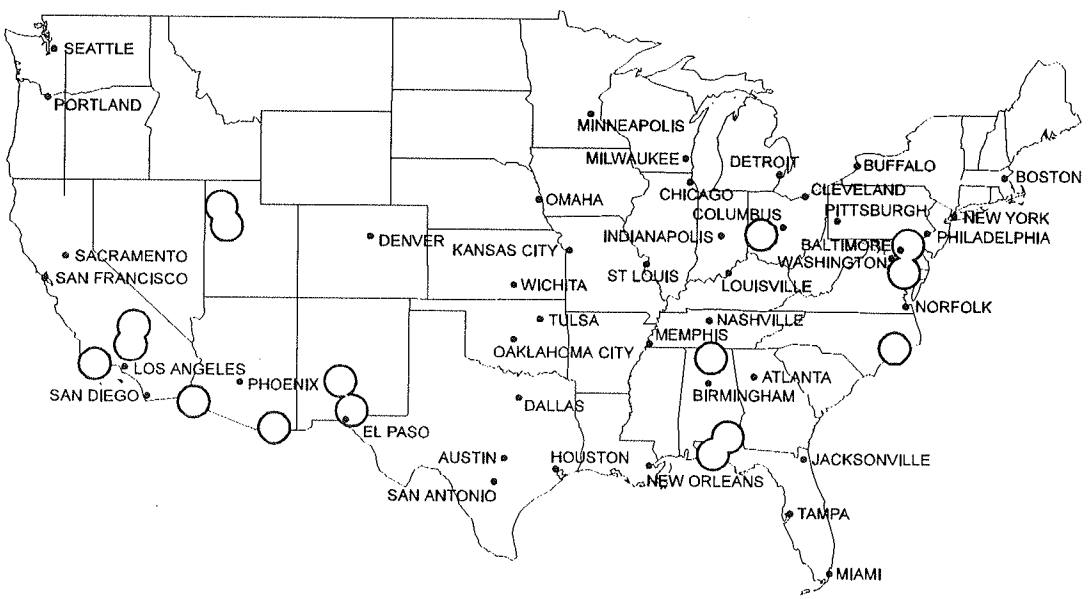
For the 1710-1755 MHz band, a more stringent requirement is imposed to protect essential operations at sites listed in Figure F-3. Fixed microwave, tactical radio relay and aeronautical mobile stations authorized as of February 10, 1994 to Federal agencies at these sites will be retained indefinitely. Moreover, Federal Government operations conducted on these stations must be protected from harmful interference.

To provide sufficient time to re-engineer assignments on existing tactical and tropospheric scatter microwave equipment in the 4635-4660 MHz band, a minimum delay of three years in reallocating this band is necessary. However, essential Federal airborne operations at the locations listed in TABLE F-1 will be continued and must be protected from interference for 14 years.

## TABLE F-1

Sites at Which Federal Airborne Operations in the 4635-4660 MHz Band Will Continue for 14 Years

| Location | Coordinates | Radius of Operation (km) |
|---|---|---|
| Pico Del Este, Pr | 18° 16' N 65° 46' W | 80 |
| Dam Neck, VA | 36° 46' N 75° 57' W | 80 |
| St. Thomas, VI | 18° 21' N 64° 55' W | 80 |

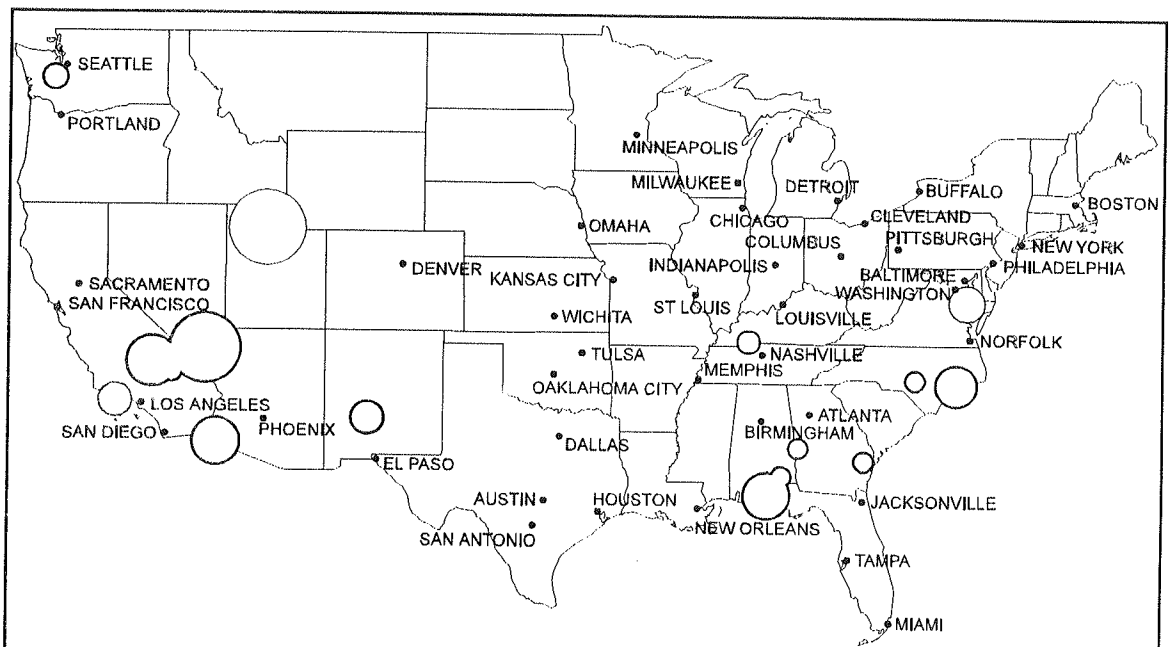



| Location | Coordinates | Radius of Operation (km) |
|---|---|---|
| Eglin AFB, FL | 30°28'N 86°31'W | 80 |
| Dugway Proving Grounds, UT | 40°11'N 112°53'W | 80 |
| China Lake, CA | 35°41'N 117°41'W | 80 |
| Edwards AFB, CA | 34°54'N 117°53'W | 80 |
| Ft. Huachuca, Az | 31°33'N 110°18'W | 80 |
| Cherry Point, NC | 34°57'N 76°56'W | 80 |
| Patuxent River, MD | 38°17'N 76°25'W | 80 |
| Aberdeen Proving Ground, MD | 39°29'N 76°08'W | 80 |
| Wright Patterson AFB, OH | 39°50'N 84°03'W | 80 |
| Ft. Greely, AK | 63°47'N 145°52'W | 80 |
| Ft. Rucker, AL | 31°13'N 85°49'W | 80 |
| Redstone, AL | 34°35'N 86°35'W | 80 |
| Utah Test Range, UT | 40°57'N 113°05'W | 80 |
| White Sands Missile Rng, NM | 32°10'N 106°21'W | 80 |
| Holloman AFB, NM | 33°29'N 106°50'W | 80 |
| Yuma, AZ | 32°29'N 114°20'W | 80 |
| Pacific Missile Range, CA | 34°07'N 119°30'W | 80 |

**Figure F-1.** Sites at which Federal operations in the 1390-1400 MHz band will be continued for 14 years.


| Location | Coordinates | Radius of Operation (km) |
|---|---|---|
| Patuxent River, MD | 38°17'N 76°24'W | 70 |
| NAS Oceana, VA | 36°49'N 76°02'W | 100 |
| MCAS Cherry Point, NC | 34°54'N 76°52'W | 100 |
| Beaufort MCAS, SC | 32°26'N 80°40'W | 160 |
| NAS Cecil Field, FL | 30°13'N 81°52'W | 160 |
| NAS Whidbey Is., WA | 48°19'N 122°24'W | 70 |
| Yakima Firing Ctr AAF, WA | 46°40'N 120°15'W | 70 |
| Mountain Home AFB, ID | 43°01'N 115°50'W | 160 |
| NAS Fallon, NV | 39°24'N 118°43'W | 100 |
| Nellis AFB, NV | 36°14'N 115°02'W | 100 |
| NAS Lemore, CA | 36°18'N 119°47'W | 120 |
| MCAS Twenty Nine Palms, CA | 34°15'N 116°03'W | 80 |
| China Lake, CA | 35°29'N 117°16'W | 80 |
| Yuma MCAS, AZ | 32°39'N 114°35'W | 160 |

**Figure F-2.** Sites at which Federal operations in the 1427-1432 MHz band will be continued for nine years.




| Location | Coordinates | Radius of Operation (km) |
|---|---|---|
| China Lake, CA | 35°41'N 117°41'W | 120 |
| Eglin AFB, FL | 30°29'N 86°31'W | 120 |
| Yuma, AZ | 32°29'N 114°29'W | 120 |
| Cherry Point, NC | 34°58'N 76°56'W | 100 |
| Pacific Missile Test Range, CA | 34°07'N 119°30'W | 80 |
| Nellis AFB, NV | 36°14'N 115°02'W | 160 |
| Hill AFB, UT | 41°08'N 115°58'W | 160 |
| Patuxent River, MD | 38°17'N 76°25'W | 80 |
| Holloman AFB, NM | 33°29'N 106°50'W | 80 |
| Ft. Irwin, CA | 35°16'N 116°41'W | 50 |
| Ft. Rucker, AL | 31°13'N 85°49'W | 50 |
| Ft. Bragg, NC | 35°09'N 79°01'W | 50 |
| Ft. Campbell, Ky | 36°41'N 87°28'W | 50 |
| Ft. Lewis, WA | 47°05'N 122°36'W | 50 |
| Ft. Benning, GA | 32°22'N 84°56'W | 50 |
| Ft. Stewart, NC | 31°52'N 81°37'W | 50 |

**Figure F-3.** Sites at which operations of Federal fixed microwave, tactical radio relay and aeronautical mobile stations in the 1710-1755 MHz band will be retained indefinitely.



* U.S. GOVERNMENT PRINTING OFFICE: 1995-386-551/23002