NTIA SPECIAL PUBLICATION 01-44

ASSESSMENT OF ELECTROMAGNETIC SPECTRUM REALLOCATION

Response to Title X of the National Defense Authorization Act for Fiscal Year 2000

Special Publication

U.S. DEPARTMENT OF COMMERCE ● National Telecommunications and Information Administration

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Response to Title X of the National Defense Authorization Act for FY2000

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January 2001

ACKNOWLEDGEMENTS

The authors wish to thank the Federal agency representatives on the Interdepartment Radio Advisory Committee for reviewing, and providing vital comments and information used in this report. Specifically; we wish to thank the National Aeronautics and Space Administration and the Department of Commerce (National Oceanic and Atmospheric Administration) for their in-depth description of their respective current and future civil space program requirements, the Departments of Justice, Agriculture, Energy, Treasury, the Interior, and the Department of Defense for their detailed inputs on the impact of future spectrum reallocation on Federal agencies, and the Federal Communications Commission on their valuable contributions detailing the Commission's Spectrum Planning Program and the recent actions on reallocated spectrum.

We also wish to thank the many contributing NTIA employees in the completion of this report; especially, Richard Orsulak and Jeng Mao for their earlier draft description of the Federal public safety communications systems or programs, Steve Litts for electronically scanning the cover letter used in Appendix B, and William Hatch, Fred Wentland, Paul Roosa and Norbert Schroeder for providing quality suggestions and comments on the earlier versions of this report.

A special thanks to NTIA staff, Linda Smith and Cecilia Tucker for providing secretarial support, Joseph Camacho for his editorial assistance, and particularly, Joseph Gattuso and Kathy Smith for their in-depth review and invaluable comments on the final draft of this report.

EXECUTIVE SUMMARY

INTRODUCTION

On behalf of the Secretary of Commerce, the National Telecommunications and Information Administration (NTIA) has prepared this report to the President and the Congress as required by Title X of the National Defense Authorization Act for Fiscal Year 2000 (NDAA-2000). NDAA-2000 requires NTIA to convene an interagency review and assessment of certain spectrum reallocation issues in coordination with the Chairman of the Federal Communications Commission (FCC) and with Federal executive agencies via the Interdepartment Radio Advisory Committee (IRAC). The review includes: 1) Progress made in implementation of national spectrum planning; and 2) The spectrum reallocations made in accordance with the Omnibus Budget Reconciliation Act of 1993 (OBRA-93) and the Balanced Budget Act of 1997 (BBA-97), and the resulting implications to Federal executive agencies.

This report provides an assessment of electromagnetic spectrum reallocation from Federal to private-sector use in accordance with requirements of Title VI of OBRA-93 and Title III of BBA-97. The report, addressing progress in national spectrum planning, implications of past spectrum reallocation actions, and anticipated impact of future potential reallocations, was prepared in coordination with affected Federal agencies, and the FCC. As directed by NDAA-2000, the assessment focused particular attention on impacts of such reallocations on military capabilities, civil space programs, and Federal public safety systems.

GENERAL CONCLUSIONS

Federal Government agencies, like private industry, are more than ever dependent upon the efficient use of the radiocommunications systems to effectively accomplish a myriad of functions. Spectrum-dependent systems afford agencies the ability to leverage the benefits of technology to accomplish more demanding missions with declining financial and labor resources. While the Federal Government places heavy reliance on the private sector in providing telecommunication services, many of the required functions are uniquely governmental in nature requiring dedicated systems owned and operated by the agencies. These functions include national defense, operation of the National Airspace System, nationwide law enforcement, scientific research, space exploration, weather prediction, and natural resource management. This study focused on three of these key areas: national defense; Federal public safety; and civil space programs. For each of these areas, potentially affected Federal agencies determined that further loss of Federal spectrum through reallocations would exacerbate the challenges in accomplishment of Congressionally-directed agency missions.

The FCC's spectrum planning program strives to allocate spectrum for a variety of uses and to provide for its use by licensed or unlicensed users in a manner that will provide the greatest possible benefit to the American public. In particular, the FCC's primary objective for spectrum planning is to maximize the benefits to the public of wireless services by increasing the amount of spectrum available for use and by encouraging the efficient use of existing bands. In this way, the FCC facilitates the introduction of new technology and services to benefit the public.

The United States has experienced enormous growth in wireless communications over the past decade, and demand for a finite supply of spectrum continues to grow. For example, capital investment in the wireless mobile industry has nearly quadrupled since 1994 for a cumulative total of over $70 billion through 1999. The number of subscribers for wireless mobile service has nearly doubled since 1996 to more than 86 million subscribers through 1999, and annual revenues over the same time period has increased to over $40 billion even while rates for service continued to fall. This expansion of wireless technologies has contributed substantially to economic growth in the United States.

Spectrum planning continues to be a vital part of the spectrum management processes undertaken by NTIA and the FCC. The National Table of Frequency Allocations, developed jointly by NTIA and the FCC, serves as the foundation for spectrum use planning in the United States. Spectrum planning and other associated spectrum management processes aim for three main goals - a) identifying long range spectrum requirements, b) modifying the National Table to accommodate changing national spectrum requirements, and c) developing or modifying the associated detailed spectrum regulations, procedures, and service rules. On-going activities to accomplish these goals in which both NTIA and FCC participate include:

a) NTIA development of a Federal long range spectrum plan;
b) National preparations for World Radiocommunication Conferences under the International Telecommunication Union;
c) FCC conducting of rule making proceedings; and
d) NTIA convening of the Interdepartment Radio Advisory Committee (IRAC).

Other spectrum planning activities include the NTIA development of a series of strategic planning documents, each focused on major radio service categories. These on-going efforts have generally been very effective in accommodating the remarkable changes in telecommunications occurring over the past 10 years.

Federal costs of implementing OBRA-93 and BBA-97 through Fiscal Year 2000 are approximately $75 million. The expended costs, which include yearly recurring costs, have been borne primarily by the Federal Aviation Administration (FAA) and Federal Bureau of Investigation (FBI) as they have begun relocating fixed microwave and radar systems out of the 1710-1755 and 1390-1400 megahertz (MHz) bands. On a long term basis when all reallocation actions are complete, non-reimbursed Federal implementation costs are projected to be between $470 million and $610 million. This estimate does not include yearly recurring costs.

In accordance with the National Defense Authorization Act of 1999, Federal agencies will be reimbursed for marginal costs associated with reallocation of four of twelve frequency bands, totaling 53 MHz, identified under BBA-97 and OBRA-93, as well as any future potential reallocations. For system types where suitable alternative bands are available, these reimbursement procedures will reduce the overall impact on Federal systems. In early 2001, NTIA will issue a notice of proposed rulemaking aimed at defining the reimbursement procedures applicable for these four frequency bands as well as any future potential reallocations.

The following paragraphs expand upon these general conclusions.

PROGRESS ON NATIONAL SPECTRUM PLANNING

The FCC and NTIA exercise joint responsibility in managing the radio spectrum in the United States and cooperate in numerous forums towards achieving the broad goals and provisions of the Communications Act of 1934, as amended. Spectrum planning continues to be an essential part of that process.

NTIA has prepared three long-range plans in the last 20 years.[1] The most recent plan was approved in September 2000. A long-range strategy was published in 1983, followed by a long-range spectrum management plan in 1989. In 1992, NTIA established the Strategic Spectrum Planning program within the Spectrum Plans and Policies Directorate. This Program has produced several reports on spectrum planning, including

- *National Land Mobile Spectrum Requirements (1994)*
- *U.S. National Spectrum Requirements: Projections and Trends (1995)*
- *Land Mobile Spectrum Planning Options (1995)*
- *High Frequency (3-30 MHz) Spectrum Planning Options (1996)*
- *Radio Astronomy Spectrum Planning Options (1998)*
- *Federal Radar Spectrum Requirements (2000)*
- *Spectrum Usage for the Fixed Services (2000)*

The Federal Government uses the radio spectrum to support its provisioning of public services, ranging from resource management to national defense. The future spectrum requirements of Federal users are critical to establish the balance of spectrum allocations between Federal and public users. These future Federal requirements are identified in the current *Federal Long-Range Spectrum Plan*. Current and future uses of the radio spectrum are listed, along with any unsupported Federal spectrum requirements.

The FCC, under the Administrative Procedures Act, reviews petitions from the private sector regarding spectrum requirements and new spectrum-dependent telecommunications services, and initiates rulemakings that take into account public comments, the current rules, the state of technology, and

[1] *A Long-Range Strategy for Spectrum Management*, NTIA, 1983; *Long-Range Plan for Management and Use of the Radio Spectrum*, NTIA Special Publication 89-22, June 1989; *Federal Long-Range Spectrum Plan*, NTIA, September 2000.

comments, if any, from NTIA. The FCC continually revises its rules to accommodate new uses of the radio spectrum.

In the last 10 years, NTIA and the FCC have closely coordinated on spectrum planning in various forums, including preparations for the international radio conferences of 1992, 1995, 1997, and 2000. The FCC is a liaison member of the IRAC, and presents FCC rulemaking proposals and orders for Federal Government review and comment. The FCC is also represented on the various IRAC Subcommittees and Ad Hoc Groups that are responsible for spectrum planning advice to NTIA. Extensive staff-to-staff contacts between NTIA and FCC foster cooperation and an understanding of the difference in Federal and private sector spectrum use.

As a result of these spectrum planning efforts, the National Table of Frequency Allocations has been revised many times to reflect the changing spectrum requirements of the nation, and to assure that the United States has the spectrum resources to fully support its growing telecommunications industry, the Federal Government's spectrum use, and the American citizen's use of spectrum-dependent devices.

IMPLICATIONS OF DIRECTED FEDERAL SPECTRUM REALLOCATIONS UNDER OBRA-93 and BBA-97

The process of directing, via Congressional legislation, the reallocation of spectrum from Federal to private-sector use began with the enaction of Title VI of OBRA-93 and was later expanded under Title III of BBA-97. Under these acts, NTIA identified a total of 255 MHz for reallocation.[2]

Objectives of Congressional-Directed Reallocation

Under requirements of OBRA-93, the criteria for identification of frequencies for reallocation included factors, *inter alia*, stimulating the development of new technologies, potential for productive uses and public benefits, and avoiding excessive costs to the Federal Government. The OBRA-93 legislation required the FCC to auction licenses at least 10 MHz of the identified spectrum. The BBA-97 legislation required the FCC to auction licensees for all of the additional 20 MHz of spectrum identified for reallocation.

Reallocation Status

Because OBRA-93 required the FCC to gradually allocate and assign frequencies over the course of 10 years, much of the reallocation process is still under way for the majority of the 235 MHz identified for

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2 Eight MHz of spectrum was subsequently reclaimed per Congressional direction. *See* Section 1062(c) of NDAA-2000, Pub. L. 106-65 (1999).

reallocation under that act. In contrast, BBA-97 imposed a strict deadline for NTIA to identify for reallocation and the FCC to reallocate, auction, and assign licenses by September 2002 for the additional 20 MHz of Federal spectrum. In 1999, the FCC issued a policy statement setting forth guiding principles for spectrum management activities providing a spectrum plan for the 255 MHz and other spectrum. The following summarizes, as of July 2000, the reallocation status and plans for the spectrum identified for reallocation under OBRA-93 and BBA-97, as amended.

	TOTALS
a. Completed FCC Rulemaking	**88 MHz**
25 MHz allocated for amateur and unlicensed devices 5 MHz allocated for wireless communications service 8 MHz allocated for wireless medical telemetry service 50 MHz allocated for fixed wireless access	
b. Currently Active FCC Rulemaking (as of July 2000)	**74 MHz**
50 MHz proposed for auction for general wireless service 24 MHz proposed for land mobile services	
c. FCC Rulemaking Planned for 2000-2001	**45 MHz**
45 MHz planned for Advanced Mobile (3G)	
d. Reserve – to be addressed in future FCC Rule Making	**40 MHz**
e. Withdrawn by NDAA-2000	**8 MHz**
8 MHz reclaimed for Federal Government use	

Anticipated Federal Cost Impact

The final spectrum reallocation reports prepared by NTIA in response to OBRA-93 and BBA-97 identified estimates of implementation costs to Federal agencies of approximately $1.5 billion based on data provided by the major Federal agencies. Subsequent modifications to these estimates have been made based on a report to Congress from the Department of Defense (DoD), changes to the reallocation plan as directed by NDAA-2000, and additional Federal agency inputs. Taking these factors into account, the current non-reimbursable and reimbursable long-term cost estimates to Federal agencies of implementing the spectrum reallocations under OBRA-93 and BBA-97 are as follows:

Federal Activity	Non-Reimbursable	Reimbursable
National Defense	$230 - $350 million	$200 - $500 million
Public Safety	$130 million	$150 - $200 million
Civil Space Program	$0	$5 million
Other Federal	$110 - $130 million	$110 million
Totals (approximate)	$470 - $610 million	$465 - $815 million

Although these long term estimated cost impacts to the Federal Government are high, the actual cost or operational impact to-date to the Federal agencies has been more limited. This is primarily because most Federal operations in the affected bands have been authorized to continue operation on a non-interference basis until completion of the FCC rulemaking processes and the frequencies are needed by the private sector.

Potential Major Impact to National Defense and U.S. Civil Space Programs Averted

In two instances, potential major mission impacts to the National Defense and U.S. Civil Space Programs were averted through exercise of the Presidential authority to substitute for frequencies previously identified under OBRA-93 and BBA-97. In the first instance, a study completed by the General Accounting Office in 1997 concluded that the transfer of one 50 MHz portion of the 1995 reallocation plan could impair the operational potential of a major new DoD system, the Cooperative Engagement Capability (CEC). This $3 billion system underwent major Congressional redirection and expansion about the same time as the completion of the 1995 reallocation plan. Subsequent study within the DoD raised even graver concerns, concluding that proceeding forward with the original 1995 reallocation plan would "seriously jeopardize the national defense interests of the United States."

In the second instance, BBA-97 required the FCC, *inter alia*, to reallocate 15 MHz from within the 1990-2110 MHz band, a portion of which serves as the command and control foundation of the entire U.S. civil space program managed by the National Aeronautics and Space Administration (NASA) and National Oceanic and Atmospheric Administration (NOAA). Loss of Federal access to this band would have adversely affected major space programs including the space shuttle, international space station, Hubble telescope, NOAA weather satellites, and numerous other scientific programs.

In each of these instances, NTIA, in coordination with the affected agencies, identified alternative frequencies and notified the FCC of the substitution using procedures set forth in NTIA's authorizing statute.

ANTICIPATED IMPACT OF FUTURE POTENTIAL REALLOCATIONS

The allocated radio spectrum extends up to 300 GHz and accommodates 33 authorized radio services. Within these radio services hundreds of distinct categories of radiocommunications systems are operated, many of which are used by the Federal Government in varying degrees. It is beyond the scope and intent of this report to provide an in-depth evaluation of the potential impact that future potential reallocations might have on this vast number of systems. Alternatively, this study focused exclusively on the three critical areas defined in the NDAA-2000 as follows:

National Defense

Market trends indicate the need for commercial wireless products and services is increasing, both within the United States and internationally. Finding spectrum for new wireless commercial applications is increasingly difficult. Likewise, identifying frequency bands, with no or minimal operational impact on the DoD systems is also increasingly complex. Future DoD operational concepts, embraced by Joint Vision (JV) 2010 and JV 2020, require improved command, control, communications, and intelligence. The ability to collect, process, and disseminate an uninterrupted flow of information, while exploiting or denying the enemy's ability to do the same, is paramount to the success of these new concepts. Assured access to the radio frequency spectrum will be far more critical to the military in the future than it is today.

The DoD conducted an analysis based on the electromagnetic access to support the projected information exchange requirements of U.S. forces through the year 2010 with the intent of gaining an understanding of the long-term trend of DoD's spectrum access needs. Though limited in scope and time, the findings of the analysis are as follows:

- DoD's requirements for spectrum will grow in all spectrum categories over the next decade, irrespective of planned and programmed modernization efforts;
- DoD's spectrum requirements growth occurs in the same congested spectrum bands in which commercial wireless demands are increasing the most rapidly, that is below 3 GHz;
- DoD also projects a growth in requirements for spectrum in bands above 3 GHz. While some of these bands are not as heavily occupied as the lower bands today, they are critical to future warfighting systems;
- Employment of current (pre-JV 2010) warfighting systems and capabilities severely stresses available spectrum resources. Consequently, future spectrum requirements growth and the

associated JV 2010 operational concepts will not be fully supportable without advances in spectrum utilization technologies and practices; and

! Any loss of spectrum access through reallocation or other means will exacerbate DoD's challenges to meet future warfighting requirements.

The DoD's greatest concern is the operational impacts for today and in the foreseeable future that will result from spectrum reallocation. The DoD is confronted by very complex challenges and assessing these challenges is not a simple process. It continues to investigate methods to address, assess, and solve the spectrum challenges to support the "warfighter."

Another major concern is the increasingly rapid rate at which reallocation is mandated and the extremely short time-frame that is provided to assess and report potential impacts of such reallocations. Adequate time is necessary to conduct the research and perform appropriate analysis required to identify the operational impacts of spectrum reallocation.

Federal Public Safety

Nearly every major Federal department or agency includes a Federal public safety function, with the Departments of Justice, Treasury, Agriculture, Interior, Federal Emergency Management Agency and Energy having particular important roles as a result of their mandated missions. Most of the radio requirements supporting these Federal public safety programs are concentrated primarily in three bands; 162-174 MHz, 406.1-420 MHz, and 1710-1850 MHz. Total investment in radiocommunications equipment supporting public safety functions exceeds $1.2 billion. Recent reallocation of the 1710-1755 MHz band to the private sector will result in significant restructuring of these communications systems. Any loss of access to the 162-174 and 406.1-420 MHz bands would be particularly harmful to Federal public safety activities, since no suitable alternative replacement bands are available.

Civil Space Program

The civil space programs managed by NASA, NOAA, and the Federal Aviation Administraton have evolved to include a very wide array of programs and applications. Virtually every space endeavor undertaken by these agencies demands communications or data transfer via the radio spectrum. The major space initiatives - space exploration; scientific research; aeronautics and space technology development; weather satellites; and remote sensing - include a combined investment in spectrum-dependent equipment of over $80 billion. Spectrum requirements for operational systems extend from bands around 400 MHz to over 38 GHz, with scientific research programs extending to nearly 300 GHz. Many of the frequencies used in these programs are optimized based on the physical properties of radio propagation and may have few, if any, alternatives if future directed reallocation of spectrum impacts key bands. Recent reductions in spectrum available, for example a 25 percent reduction in frequencies supporting telemetry, has occurred while requirements are increasing.

CONTENTS

SECTION I
INTRODUCTION

SECTION II
PROGRESS ON NATIONAL SPECTRUM PLANNING

SECTION III
IMPLICATIONS OF SPECTRUM REALLOCATION UNDER OBRA-93 AND BBA-97

CONTENTS
(Continued)

Page

SECTION IV
ANTICIPATED IMPACT OF POTENTIAL FUTURE ALLOCATIONS

CONTENTS
(Continued)

SECTION V
RECENT REALLOCATION ACTIONS OF THE FEDERAL COMMUNICATIONS COMMISSION

Page

CONTENTS
(Continued)

LISTS OF TABLES

TABLE **Page**

APPENDIXES

LIST OF ACRONYMS AND ABBREVIATIONS

ACE	Army Corps of Engineers
AMFCS	Advanced Mobile and Fixed Communications Service
APTs	Automatic Picture Transmissions
ARSR	Air Route Surveillance Radar
ATC	Air Traffic Control
ATM	Aeronautical Telemetry
BAS	Broadcast Auxiliary Service
BBA-97	Balanced Budget Act of 1997
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BOR	Bureau of Reclamation
CDA	Command and Data Acquisition
CID	Compliance and Investigation Division
CIRIS	Completely Integrated Reference Instrumentation System
DARS	Digital Audio Radio Service
DEA	Drug Enforcement Administration
DLS	Data Link System
DMSP	Defense Meteorological Satellite Program
DoD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOJ	Department of Justice
DSB	Direct Sounder Broadcasts
DSN	Deep Space Network
DTV	Digital Television
EESS	Earth Exploration Satellite Service
ELTs	Emergency Locator Transmitters
ELV	Expendable Launch Vehicle
EPIRB	Emergency Position-Indicating Radiobeacon
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FPA	Federal Power Agency
FWS	Fish and Wildlife Service
GHz	Gigahertz
GOES	Geosynchronous Operational Environmental Satellite
GPS	Global Positioning System
GMF	Government Master File
GN	Ground Network

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

GWCS	General Wireless Communications Service
HAZMAT	Hazardous Materials
HF	High Frequency
HRDV	High Resolution Digital Video
IMT-2000	International Mobile Telecommunications-2000
INS	Immigration and Naturalization Service
IRAC	Interdepartment Radio Advisory Committee
ISM	Industrial, Scientific, and Medical
ISS	International Space Station
ITN	Integrated Treasury Network
ITS	Intelligent Transportation Service
kHz	Kilohertz
JSOW	Joint Standoff Weapon
JSS	Joint Surveillance System
JWN	Justice Wireless Network
LEO	Low Earth Orbit
LMCC	Land Mobile Communications Council
LMR	Land Mobile Radio
LUT	Local User Terminal
MDS	Multipoint Distribution Service
MHz	Megahertz
MSE	Mobile Subscriber Equipment
MSS	Mobile Satellite Service
MTS	Medical Telemetry Service
NAIC	National Astronomy and Ionosphere Center
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications
NCC	Network Control Center
NDAA-2000	National Defense Authorization Act For Fiscal Year 2000
NEST	Nuclear Emergency Search Team
NIB	Non-interference Basis
NIFC	National Interagency Fire Center
NIST	National Institute of Standards and Technology
NMI	Nautical Miles
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Inquiry
NPOESS	National Polar-orbiting Environmental Satellite System
NPP	NPOESS Preparatory Program
NPS	National Park Service

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

NSF	National Science Foundation
NTIA	National Telecommunications and Information Administration
NTTR	Nellis Test and Training Range
NWS	National Weather Service
OBRA-93	Omnibus Budget Reconciliation Act of 1993
OMB	Office of Management and Budget
PCS	Personal Communications Services
PLBs	Personal Locator Beacons
PSWAC	Public Safety Wireless Advisory Committee
RAJPO	Range Joint Program Office
RCS	Radar Cross-Section
RF	Radio Frequency
RPV	Remotely Piloted Vehicle
RMS	Rainbow Microwave System
SARSAT	Search and Rescue Satellite System
SDR	Software Define Radios
SGLS	Space Groundlink Subsystem
SN	Space Network
SPAC	Spectrum Planning and Policy Advisory Committee
SPASUR	Space Surveillance
SPS	Spectrum Planning Subcommittee
SRS	Space Research Service
SSP	Strategic Spectrum Planning
STDN	Spaceflight Tracking and Data Network
Table	National Table of Frequency Allocations
TARS	Tethered Aerostat Radar System
TAS	Target Acquisition System
TDRSs	Tracking and Data Relay Satellites
TDRSS	Tracking and Data Relay Satellite System
TRITAC	Tri-Service Tactical Communications
TSD	Transportation Safeguards Division
UAV	Unmanned Air Vehicle
UHF	Ultra High Frequency
USCS	Unite States Customs Service
USDA	United States Department of Agriculture
USCG	United States Coast Guard
USGS	United States Geological Survey
USSS	Unite States Secret Service
UWB	Ultra-wideband

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

VDOPS	Vector Doppler Scoring System
VHF	Very High Frequency
WCS	Wireless Communication Service
WMTS	Wireless Medical Telemetry Service
WRC	World Radiocommunication Conference
WSC	White Sands Complex
WSO	Weapon Systems Officer

SECTION I
INTRODUCTION

BACKGROUND

The National Telecommunications and Information Administration (NTIA), an agency of the U.S. Department of Commerce, is responsible for managing the Federal Government's use of the radio spectrum. NTIA establishes policies concerning frequency assignment, allocation and use, and provides the various Federal departments and agencies with guidance to ensure that their conduct of telecommunications activities is consistent with these policies.[1] Further, NTIA serves as the President's principal adviser on telecommunication policies pertaining to the nation's economic and technological advancements and to the regulation of the telecommunications industry.[2] NTIA develops executive branch positions to ensure that policy is effectively presented to Federal agencies, the Federal Communications Commission (FCC), the Congress, and the public.

In accordance with requirements of the Omnibus Budget Reconciliation Act of 1993 (OBRA-93) and the Balanced Budget Act of 1997 (BBA-97), NTIA identified a total of 255 megahertz (MHz) of Federal spectrum for reallocation to the private sector.[3] Based on inputs from affected Federal agencies, the two associated NTIA spectrum reallocation reports indicated the estimated Federal costs to implement these reallocations to be in excess of $1.5 billion. The magnitude of these estimated costs, as well as the potential operational impact to Federal operations, has continued to raise concerns among the affected Federal agencies.

As a result of these concerns and other factors, Congress enacted a provision in the National Defense Authorization Act for Fiscal Year 2000 (NDAA-2000) to further examine these concerns. Specifically, Title X of the Defense Act requires completion of an interagency review and assessment of impact of these and potential future reallocations of Federal spectrum.[4]

NDAA-2000 requires NTIA to convene an interagency review and assessment of certain spectrum reallocation issues in coordination with the Chairman of the FCC and with Federal

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[1] NTIA, *Manual of Regulations and Procedures for Federal Radio Frequency Management*, U.S. Department of Commerce, National Telecommunications and Information Administration, Washington, D.C., January 2000 Edition.

[2] National Telecommunications and Information Administration Act, Pub. L. 102-523, 106 Stat. 3533 (codifed at 47 U.S.C. 901-904).

[3] In accordance with the National Defense Authorization Act for FY2000, the total reallocated spectrum was subsequently reduced to 247 MHz.

[4] *See* Appendix A for the text of Section 1062 of NDAA-2000.

executive agencies via the Interdepartment Radio Advisory Committee (IRAC). The review includes:

1) Progress made in implementation of national spectrum planning; and

2) The spectrum reallocations made in accordance with the OBRA-93 and BBA-97 and the resulting implications to Federal executive agencies.

In the conduct of the review and assessment, the NDAA-2000 requires particular attention be given to:

1) The effect of the spectrum reallocations under OBRA-93 and BBA-97 on
   a) critical military and intelligence capabilities,
   b) civil space programs, and
   c) other Federal public safety systems;

2) The anticipated impact of future potential reallocations of Federal spectrum to non-Federal use on
   a) critical military and intelligence capabilities,
   b) future military and intelligence operational requirements,
   c) national defense modernization programs,
   d) civil space programs, and
   e) other Federal public safety systems; and

3) Future spectrum requirements of agencies in the Federal Government.

This report describes the results of the interagency review and assessment accomplished in accordance with the NDAA-2000. The majority of this report has, consistent with statutory directives, focused on the transfer of spectrum from Federal Government to non-Federal government use under OBRA-93 and BBA-97, as well as the anticipated impact that any future transfers may have on Federal Government programs. This report also describes progress made on national spectrum planning, primarily during that same time period. As discussed in Section II, national spectrum planning includes efforts of both NTIA and the FCC to plan for the future spectrum needs of both Federal Government and non-Federal government users. Lastly,
Section V summarizes the FCC's actions on the reallocated spectrum.

OBJECTIVE:

The objective of this study was completion of an interagency review and assessment of spectrum reallocation actions as required by provisions in Title X of the NDAA-2000.

APPROACH:

To accomplish the objective, NTIA undertook the following steps:

1) An interagency group composed of representatives of major Executive department, Federal agencies, and the FCC was formed and met as required to coordinate the study and completion of a final report;

2) Previous NTIA reports and documents on directed spectrum reallocation actions were reviewed;

3) Previous reports and documents completed by affected Federal agencies on the impact of directed spectrum reallocation actions were reviewed;

4) FCC rulemaking proceedings addressing Federal frequency bands identified for reallocation were reviewed;

5) Additional inputs provided by Federal agencies describing impact of directed spectrum reallocation, both previous and future potential actions were coordinated; and

6) A consolidated report to Congress describing the results was prepared.

SECTION II
PROGRESS ON NATIONAL SPECTRUM PLANNING

INTRODUCTION

In the United States, NTIA is the President's principal advisor on telecommunications policy and the spectrum manager for the Federal Government agencies. The FCC is the spectrum manager for the commercial and private sector, including state and local governments. The FCC and NTIA exercise joint responsibility in managing the radio spectrum in the United States and cooperate in numerous forums towards achieving the broad goals and provisions of the Communications Act of 1934, as amended. Spectrum planning continues to be an essential part of that process.

The National Table of Frequency Allocations (*Table)* is the overall spectrum plan for the accommodation of radiocommunications systems in the United States. This Table reflects the jurisdictions of these agencies, where some spectrum is exclusively allocated for Federal use under the jurisdiction of NTIA, and some is exclusively allocated for non-Federal use under the jurisdiction of the FCC. There is also some spectrum that is allocated for shared Federal/non-Federal use (shared bands). Both NTIA and the FCC perform spectrum planning on behalf of their constituents and jointly plan for spectrum use in those bands where there is joint jurisdiction. The Federal Government and the FCC have cooperated on spectrum planning activities for many years, with more intensive cooperative activity and long-range planning having occurred periodically and usually in response to rapid or significant technological change.

The *Table* is revised as a result of spectrum planning and can be revised on the Federal side by NTIA; on the non-Federal side by the FCC; and in shared bands by an FCC rulemaking in consultation with NTIA. The *Table* is also revised as a result of international radio conferences, since changes to the international Table of Frequency Allocations are treaty obligations. Allocation changes that are consistent with domestic requirements are implemented in the United States as revisions to the *Table* by FCC rulemaking in consultation with NTIA.

NTIA's SPECTRUM PLANNING PROGRAM

The Strategic Spectrum Planning (SSP) Program was established by NTIA in 1992 to provide strategic, national-level spectrum planning. This program was designed to promote effective and efficient use of the spectrum so that both near-term and long-range spectrum needs of the Federal Government and the private sector can be met. The program was also envisioned to provide the leadership and supervision to establish, implement and administer a three-phase strategic spectrum planning program.

The first phase of the program was to determine the future Federal Government and private sector broad-based spectrum requirements and technology trends that might influence future spectrum requirements. Spectrum requirements were based on inputs from an NTIA Notice of Inquiry (NOI),[1] the FCC, the IRAC, the NTIA Spectrum Planning and Policy Advisory Committee (SPAC), individual Federal agency and private sector spectrum requests, international spectrum planning activities, and other sources as appropriate.

NTIA released its NOI in 1992. In this Notice, NTIA requested broadly-based technical and marketplace information on spectrum requirements for different radio services and classes of users over the next ten year period (1992-2002).[2] This information was requested from users, manufacturers and service providers in the private sector, as well as users, system developers, and system managers in Federal, state, and local governments.

Using inputs derived from the NOI, NTIA released two reports in 1995 prepared by its Strategic Spectrum Planning Program. The first, *U.S. National Spectrum Requirements: Projections and Trends*, was released in April 1995. This report projected the 10-year spectrum requirements for 18 major radio services in the United States. Both Federal Government and non-Federal government spectrum requirements were included. The report found that the land mobile service was in immediate need of additional spectrum, totaling 204 MHz for both conventional land mobile and the emerging Intelligent Transportation System.

The second report, *Land Mobile Spectrum Planning Options*, was released in October 1995. This report was the first of the "Phase II" studies called for in the Program Plan. This report identified frequency bands that could be made available to satisfy the spectrum requirements for the land mobile service identified in the NTIA spectrum requirement report above. Portions of the 235 MHz of Federal spectrum to be transferred to the FCC were identified for possible land mobile use. Additionally, portions of the VHF television band that will be vacated in the future were included for future land mobile use.

The second Phase II report, *High Frequency (3-30 MHz) Spectrum Planning Options*, was approved for publication in December 1996. This report addressed the spectrum requirements for the radio services requiring use of the high frequency (HF) radio spectrum from 3 to 30 MHz. The HF spectrum is important because of its many national and international uses. Many nations use HF for communications with vessels and aircraft, for amateur operations, and for international broadcasting. Developing countries still use HF for domestic, internal communications, where the telephone and high-capacity fixed service infrastructure is not mature.

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1 *Current and Future Requirements for the Use of Radio Frequencies in the United States*, Notice of Inquiry and Requests for Comments, Docket No. 920532-2132, 57 Fed. Reg 25,010 (1992).

2 *Id.*

The SSP Program, in conjunction with members of the Public Safety Wireless Advisory Committee (PSWAC), a Federal Advisory Committee chartered jointly by NTIA and the FCC, evaluated the spectrum requirements for the public safety agencies through the year 2010. The PSWAC's Spectrum Requirements Subcommittee held periodic meetings for 12 months, starting in September 1995. The resulting spectrum requirements were documented in the Final Report of the PSWAC, published in September 1996. Further, the recommendations in the PSWAC Final Report were considered in an FCC rulemaking addressing public safety use of 24 MHz in the 700 MHz band.

In 1998 NTIA continued its long-range spectrum planning effort by publishing the *Radio Astronomy Spectrum Planning Options* report. This report detailed the requirements for a viable radio astronomy service and the increased spectrum requirements brought about by new technology and the ability to probe the cosmos even deeper, in search of scientific knowledge.
NTIA provided the convener of the IRAC Ad Hoc Group 212, responsible for Federal spectrum planning above 30 gigahertz (GHz). The Ad Hoc Group reviews FCC rulemakings and provides recommendations to the IRAC. As a result of spectrum planning, Ad Hoc Group 212 recommended a reallocation of 1100 MHz of spectrum to improve sharing between Federal agencies and commercial users. The FCC responded positively on these requests, and the *Table*.

As a first step in producing a comprehensive spectrum plan, NTIA published a draft U.S. Spectrum Plan that contains a forward-looking *Table*, in addition to tables of current and planned spectrum use for both the Federal Government and the private sector. The Plan covers the spectrum range from 30 MHz to 300 GHz. This plan includes both Federal and non-Federal spectrum uses, both current and planned by NTIA and the FCC.

In May 2000, NTIA released a report that detailed the frequency bands that would be needed to be retained for the next 20 years in support of national radiolocation (radar) requirements. This report, *Federal Radar Spectrum Requirements*, documents the erosion of available radar spectrum as a result of international radio conferences, and the on-going requirements for radar, both for national security, and for domestic civil use.

NTIA, in coordination with the Federal agencies represented on the IRAC, has prepared a long-range plan for the use of the radio spectrum by the Federal agencies. This long-range plan details the current and planned use of the spectrum by the Federal Government.

Federal Spectrum Planning Forums

The focus of Federal spectrum planning is the IRAC. This committee is NTIA's principal advisory body on spectrum-related issues, and develops recommended Federal spectrum policy for NTIA. The IRAC also reviews FCC rulemaking items. The IRAC members and NTIA staff coordinate with FCC staff and provide inputs to the FCC on those items that may affect Federal spectrum use, and particularly in frequency bands where there is joint jurisdiction (shared bands). This process ensures that final FCC rulemakings are fully coordinated with the Federal Government when released. As part of the IRAC structure, several Subcommittees and Groups are also directly involved with spectrum planning. These include the Spectrum Planning Subcommittee (SPS), which reviews all major Federal radiocommunications systems; the Space Systems Group, which reviews domestic and foreign international notifications for space systems; Ad Hoc Group 212, which determines Federal spectrum requirements above 30 GHz; and Ad Hoc Group 214, which develops Federal requirements for public safety communications.

NTIA and FCC staff interact regarding spectrum planning in all the above activities, in addition to the normal staff-to-staff contacts that occur on a daily basis.

FCC'S SPECTRUM PLANNING PROGRAM

The FCC's spectrum planning program strives to allocate spectrum for a variety of uses and to provide for its use by licensed or unlicensed users in a manner that will provide the greatest possible benefit to the American public. The FCC balances competing spectrum demands from a diverse group of users, including commercial and private entities; non-Federal government entities (*i.e.*, state and local jurisdictions); public safety users; and users of consumer and industrial/scientific devices (*i.e.*, unlicensed devices). The process used to identify the spectrum needs of each user group takes into consideration a number of factors, including, for example, the type of service to be provided; the amount of bandwidth needed; the spectrum propagation needs; and the availability of alternative communication media.

To accommodate as many needs as possible, the FCC relies on various methods to promote spectrum efficiency. Based on technical and operational compatibility, the FCC often allocates spectrum to two or more services on a shared basis, and many bands are shared between Federal Government and non-Federal government operations. In those cases where band sharing is not possible, the FCC reallocates spectrum from one use to another, and incumbent operations are relocated to other, generally higher, frequency bands or removed from the frequency bands. In addition, the FCC identifies technical and operational parameters to facilitate non-interference operations, both within bands and between adjacent bands. In some cases where services have been able to operate using new, more efficient technology and thereby increase the amount of information that can be transmitted in a given bandwidth, the FCC has reallocated reclaimed spectrum to other uses.

In summary, the FCC's primary objective for spectrum planning is to maximize the benefits to the public of wireless services by increasing the amount of spectrum available for use and by encouraging the efficient use of existing bands. In this way, the FCC facilitates the introduction of new technology and services to benefit the public.

Meeting the Challenge for New and Growing Services

The growth in wireless communications services over more than a quarter century is a good example of how the FCC, in cooperation with Federal Government agencies, has promoted efficient use of spectrum and thus made spectrum available for reallocation to new technologies and services. In the mid-1960s, the Federal Government informed the FCC that 26 MHz within the 890-942 MHz band could again be made available for non-Federal government use. In 1968, the FCC proposed to use that transfer spectrum in conjunction with other spectrum that it would reallocate from television broadcasting and other services, for common carrier and private land mobile services, including a nascent cellular communications service. In 1970, the FCC reallocated 115 MHz of spectrum for land mobile services using the frequency bands 806-890 MHz (channels 70-83 of the television broadcasting service), 890-942 MHz (Federal Government), and 942-947 MHz (broadcast auxiliary service). The reallocation of television broadcasting spectrum relied, in part, on the relocation of existing ultra-high frequency (UHF) broadcast stations to lower frequencies, traditional spectrum management techniques, and improvements in broadcasting technology that occurred over time. In 1974, the FCC specified that, of the reallocated 115 MHz of spectrum, 40 MHz would be used for common carrier cellular communications services and 30 MHz for private uses and the balance was held in reserve. Two experimental cellular systems were deployed, and the FCC followed the technological capability and market viability of this developing service. The experience gained from the experimental cellular systems allowed the FCC, in 1981 and in 1984, to allocate the reserve spectrum in a more efficient fashion for various land mobile services, including cellular communications services. Because of technological developments in the provision of cellular communications services, the FCC was able to license more stations with greater capacity to serve more customers using less spectrum than envisioned in the early 1970s. These early reallocation actions served many of the nation’s needs for wireless communications services until the early1990s, when the FCC again undertook a major reallocation program that provided spectrum for personal communications services (PCS).

The United States has experienced enormous growth in wireless communications over the past decade, and demand for a finite supply of spectrum continues to grow. For example, capital investment in the wireless mobile industry has nearly quadrupled since 1994 for a cumulative total of over $70 billion through 1999. The number of subscribers for wireless mobile service has nearly doubled since 1996 to more than 86 million subscribers through 1999, and annual revenues over the same time period has increased to over $40 billion even while rates for service continued to fall. Advancements in radio technologies in recent years (e.g., integrated circuitry, signal processing and digital systems) have enabled the introduction of new radio communications services such as PCS, advanced paging systems, intelligent transportation services (ITS), mobile satellite service (MSS) and two-way multipoint distribution service (MDS). This expansion of wireless technologies has contributed substantially to economic growth in the United States.

As discussed above, NTIA in 1992 established the SSP Program and since that time has undertaken various spectrum planning studies. During this same period of time, the FCC has undertaken the reallocation of significant amounts of spectrum from both incumbent non-Federal government and Federal Government users to other services. For example, 590 MHz of spectrum is being reallocated to meet a wide range of needs (*see* Section V of this report for additional information). Three hundred forty-three (343) MHz of spectrum is being reallocated between non-Federal government uses as the result of two major FCC initiatives, the Emerging Technologies proceeding and the digital television (DTV) transition; and 247 MHz of spectrum has been or will be reallocated from Federal Government to non-Federal government uses under OBRA-93 and BBA-97. Over the past eight years alone, the FCC has provided spectrum to new technology services such as PCS, MSS, and ITS. Both commercial and public safety services have received additional allocations to meet increasing demand or to introduce new services. A new Wireless Medical Telemetry Service (WMTS) will ensure that health care services will be provided on an interference-free basis. Proceedings are underway which propose to allocate spectrum for new satellite broadband services and fixed wireless services. The reallocation of spectrum will provide numerous benefits to the American public, including increased competition and consumer choice; reduction in the cost of service; availability of new or expanded services as evidenced by increased revenues and number of subscribers; and improved public safety. Reallocation of spectrum and relocation of incumbent users, as needed, require that sufficient time is provided to transition from existing to new uses. Consequently, reallocation proceedings and relocation of incumbents are ongoing.

Making More Efficient Use of Non-Federal Government Spectrum

In addition to spectrum transferred from the Federal Government since 1993, the FCC during the past decade initiated its own proceedings to reclaim significant amounts of spectrum from incumbent uses and reallocate it for other services. For example, in its 1992 Emerging Technologies proceeding, the FCC reallocated 220 MHz of spectrum in the 2 GHz band from incumbent fixed uses to new technology services, including mobile satellite services and PCS. In providing for the introduction and deployment of DTV service, the FCC identified 108 MHz of spectrum for reallocation from broadcast television service to other services, which will be made available as television stations transition to DTV. Sixty (60) MHz of this spectrum has been reallocated, in part for new broadband fixed and MSS and in part for expanded public safety needs. The FCC also recently reallocated 35 MHz of spectrum in the 1.9-2.2 GHz band from broadcast auxiliary service (BAS) to mobile satellite service and simultaneously reduced the channel bandwidth for the remaining 85 MHz allocated for BAS at 2 GHz.

Reallocation of spectrum imposes costs on both incumbents and new entrants, which have to be balanced against the benefits to the American public of providing spectrum for new technology services. The 2 GHz reallocations affect thousands of licensees in a variety of services, including public safety services. The FCC adopted requirements for new entrants to assume the cost to relocate incumbent users to comparable facilities in other frequency bands. These relocation costs are in addition to whatever costs new entrants assume for building their own new facilities and, in some cases, costs to acquire the license through auction. Television broadcast stations, including publicly funded stations, are assuming the costs of upgrading their facilities to DTV.

The FCC has employed methods other than reallocation to increase spectrum efficiency. One of the FCC's most successful efforts has been its ability to increase the number of land mobile users by, in part, reducing the bandwidth of assigned channels over the past 45 years. For example, in the mid-1950s, the FCC reduced channel bandwidth in the 152-162 MHz band from 60 kilohertz (kHz) to 30 kHz. In its most recent "refarming" effort initiated in 1992, the FCC is gradually reducing channel bandwidth in several frequency bands below 512 MHz from 25 kHz to eventually 6.25 kHz, the objective being a 4 to 1 increase in capacity. The success of this recent effort will depend in large part on the introduction of new technology that meets more efficient technical and operational standards. Land mobile users, which include public safety, industrial and other private entities, will bear the primary expense as they gradually convert their systems to use smaller bandwidth channels when they decide to replace existing equipment.

Market-Based Approaches to Promote Spectrum Efficiency

The FCC's spectrum planning program relies, to the extent practicable, on market-based processes to promote spectrum efficiency. For example, under its recent reallocation program, the FCC has allocated 30 MHz of spectrum to the WCS, in which licensees may provide fixed, mobile or radiolocation services. With flexible allocations, licensees will be able to provide the highest-valued service in these bands. On the other hand, the FCC continues to allocate spectrum for specific services when, for example, reliance on market forces is inappropriate and interference protection is needed nationwide (e.g., for MTS, ITS, and public safety).

Spectrum efficiency also is achieved when technical and service rules give licensees flexibility to offer new services in competitive markets, rather than making additional allocations. For example, cellular service rules were modified in 1988 to allow for the use of digital technology, thus effectively increasing capacity within allocated spectrum and allowing the introduction of new services at the same time. The use of digital technology by various mobile telephone providers has contributed to the growth of these services. By the end of 1999, approximately 51 percent of all mobile telephone subscribers used digital technology. In the MDS, the FCC recently modified its rules to allow MDS licensees to provide two-way service, rather than limit them to one-way service, in existing bands. In some wireless communications services, licensees are allowed to partition or aggregate spectrum in a given area, thereby providing flexibility in the bandwidth available to provide different types of services in response to market demand.

The FCC also relies on market-based processes to assign spectrum to many types of commercial users. By using auctions to award licenses when mutually-exclusive applications are filed, spectrum is assigned to those entities who will deploy it for the highest-valued use. The FCC received authority in 1993 to conduct auctions and has found the auction process to be an efficient way to bring spectrum into use, since it avoids the historic delays involved with comparative hearings and appeals that often accompanied the licensing process. As of July 2000, the FCC has conducted 28 auctions for over 16 services; approximately 10,800 licenses have been won by bidders; and net high bids have totaled nearly $24 billion. The FCC also recently stated its intention to explore ways to develop a secondary market for spectrum, thereby further promoting efficient spectrum utilization.[3]

Contribution of Federal Government Spectrum

Under OBRA-93 and BBA-97, 247 MHz of spectrum transferred from Federal Government to non-Federal government use. There are a number of factors that will influence how best to use this spectrum to satisfy non-Federal government needs. In order to give incumbent Federal Government users time to transition to other bands or technology, the spectrum is being transferred over a period of years. Some of the transfer spectrum will be shared bands, having both Federal Government and non-Federal government users. Other bands will have grandfathered Federal Government facilities or secondary non-Federal government facilities. All of these encumbrances could limit the deployment of new services. Although some spectrum blocks contain sufficient bandwidth to support broadband services, other blocks are narrow or the spectrum blocks are non-contiguous and not readily paired with others for two-way service. The FCC issued a report in 1996 on its plans for spectrum transferred under OBRA-93 and issued a report in 1999 for spectrum transferred under both OBRA-93 and BBA-97. The FCC has reallocated some of the transfer spectrum for a variety of needs, including Wireless Communications Service (WCS), unlicensed devices, amateur service and the new wireless Medical Telemetry Service, and it has underway proceedings or plans to reallocate the remainder of the transfer spectrum.

Fostering New Technology and Services

The FCC also has been in the forefront of facilitating the introduction of new technology and services as another means of promoting efficient use of spectrum. The FCC recently modified its rules for spread spectrum devices to allow new broadband applications using this technology, while still enabling these devices to share frequency bands with other services. The agency, in coordination with NTIA, has allowed three entities to introduce, on a limited basis, ultra-wideband (UWB) technology and has initiated a rulemaking proceeding to explore further the implementation of this technology in multiple shared bands. A rulemaking proceeding is underway to explore a number of sharing techniques in multiple frequency bands to facilitate the introduction of global broadband services by non-geostationary orbit fixed satellites. The agency also recently initiated an inquiry on the development of software defined radios (SDR), which would be able to operate over a wide range of frequencies and to emulate any desired transmission format by changing the software that controls the radio rather than upgrading the hardware.

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3 The FCC Statement Policy, *Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millennium*, (November 18, 1999).

FCC Spectrum Planning Processes

The FCC's spectrum management program utilizes a variety of processes.

- *Public forums*. The FCC has sponsored numerous public forums to identify new technologies and services and to facilitate a dialogue between the FCC and industry about how best to accommodate new technology and services.
- *En banc hearings.* The FCC has conducted a number of hearings on spectrum management, inviting both proponents and opponents of new technologies and services to present their views for further agency consideration.
- *Federal Advisory Committees*. The FCC establishes public committees, as needed, to foster a dialogue on and make recommendations for future agency action. The Technical Advisory Committee is currently chartered to advise the agency on several spectrum management and new technology issues.
- *Experimental licensing*. FCC licensing of new technologies on an experimental basis is a useful way for industry to refine its proposals as well as for the FCC to gather information that can be used in future allocation or licensing decisions.
- *Inquiries*. On several occasions, the FCC has initiated inquiries to gather information on the record that can form the basis for future agency action.
- *Policy Statements*. The FCC has issued several policy statements about its spectrum management plans.
- *Rulemaking proceedings*. This is the primary method used for spectrum planning. By conducting rulemaking proceedings open to public participation, the FCC modifies the Table of Allocations and adopts technical and service rules to accommodate new technology and new services.

As already noted, the FCC and NTIA consult and coordinate on any proceeding in which Federal Government and non-Federal government operations share spectrum. The FCC also is an active participant in ITU radio management proceedings, including World Radiocommunication Conferences (WRCs) and technical standards activities. All of these interactions ensure that the FCC's spectrum management program is integrated with Federal domestic issues and international issues that affect domestic program implementation.

CURRENT SPECTRUM PLANNING ISSUES

There are usually on-going spectrum planning issues on which NTIA and the FCC are collaborating. Currently, four major items of interest for spectrum planning are: (1) the accommodation of UWB devices, (2) the accommodation of third generation (3G) wireless communications systems, (3) the implementation of the results of the recently-completed World Radiocommunication Conference-2000 (WRC-2000), and (4) spectrum sharing between Federal and commercial users where the FCC has granted area-wide licenses for commercial use.

Ultra-wideband Devices. Ultra-wideband devices are characterized by having a bandwidth approximately equal to the value of the center frequency of operation. Devices proposed for unlicensed operation under Part 15 of the Commission's Rules would transmit across restricted frequency bands, including the frequencies used by the Global Positioning System (GPS). Following coordination with NTIA, the FCC authorized three manufacturers to introduce, on a limited waiver basis, UWB equipment. Both agencies are in the process of a measurement effort to determine the degree of compatibility of the UWB systems with currently allocated radio services, and the FCC has initiated a rulemaking proceeding to explore further the implementation of this technology.

Accommodation of 3G Systems. Over the past decade, there has been enormous worldwide growth in the use of cellular-type personal mobile communications systems. Many countries, including the United States, initially introduced analog systems (1st generation) and are now transitioning to digital systems (2nd generation). Studies in the ITU and elsewhere indicate that this growth in personal communications is likely to continue.

Third generation (3G) wireless systems will provide terrestrial and satellite-based broadband and multi-media capabilities and represent a path for the evolution of existing cellular and personal communications services. The United States recognizes that identifying spectrum for advanced mobile telecommunications systems is vital for national spectrum planning, industry planning of future marketplace needs, and economic growth.

The International Mobile Telecommunications-2000 (IMT-2000) system is an advanced mobile communications concept and is considered a third generation wireless system for implementation in the United States. Possible frequency bands include all or parts of the 1710–1850 MHz and 2500–2690 MHz frequency ranges. NTIA and the FCC are working on spectrum studies that will form the basis for the decision on the appropriateness of these bands to accommodate IMT-2000.

Implementation of WRC-2000. The IRAC has an Ad Hoc Group (Ad Hoc 206) that reviews the results of international radio conferences and recommends appropriate revisions to the *Table*, consistent with revisions made to the international allocation table and domestic requirements. Ad Hoc 206, comprised of members of NTIA, the FCC, and certain Federal agencies, is preparing recommendations for the implementation of WRC-2000 decisions. The recommendations will be acted on by both NTIA and the FCC and should result in changes to both the Federal Government and non-Federal government allocations.

<u>Spectrum Sharing</u>. In frequency bands where NTIA and the FCC have joint jurisdiction (shared bands), spectrum planning is complicated by the difference in the processes by which each agency grants licenses and frequency assignments. Sharing is problematical in those bands where the FCC grants area-wide licenses because individual station locations within a geographic area are not reported to the FCC, thus complicating coordination between Federal facilities and FCC licensees. NTIA and the FCC are in discussions regarding this spectrum sharing issue.

SECTION III
IMPLICATIONS OF SPECTRUM REALLOCATION UNDER OBRA-93 AND BBA-97

INTRODUCTION

On August 10, 1993, OBRA-93 was signed into law.[1] One of the objectives of Title VI of this Act was communications licensing and spectrum reallocation improvement to increase the efficiency of spectrum use and the effectiveness of spectrum management. Another objective was to promote and encourage the use of new spectrum-based technologies in telecommunications applications. To facilitate these objectives, Title VI of OBRA-93 directed the Secretary of Commerce to transfer at least 200 MHz of spectrum below 5 GHz, currently used by the Federal Government, to the FCC for licensing to the private sector. Subsequently, on August 8, 1997, Title III of BBA-97 was signed into law.[2] Title III required that the FCC and NTIA, identify at least 120 MHz of spectrum (20 MHz of Federal Government spectrum and 100 MHz of non-Federal spectrum) below 3 GHz for auction. In response to these Congressional directives, NTIA identified a total of 255 MHz of spectrum for reallocation to the private sector.[3] Table 3-1 summarizes the reallocated frequency bands and their respective schedules for reallocation. Title III also includes language that would allow Federal users of spectrum that are reallocated to be voluntarily compensated for the cost of moving by the new spectrum users.

On October 17, 1998, the President signed into law the Strom Thurmond National Defense Authorization Act for 1999.[4] Section 1064 of the Act amended Section 113(g)(1) of the NTIA Organization Act, 47 U.S.C. 923(g)(1), to require private sector entities to reimburse Federal users for relocation due to reallocation. The statute also required DoD to report to Congress on the spectrum reallocation cost impacts to the DoD as well as operational impacts (see Appendix B).

The NDAA-2000 was enacted into law on October 5, 1999. Among other things, Title X of the law required the Secretary of Commerce, acting through the Assistant Secretary and in coordination with the Chairman of the FCC, to review and assess the reallocation of Federal Government spectrum to non-Federal use, in accordance with the amendments made by Title VI of OBRA-93 and Title III of BBA-97 and the implications for such reallocations to the affected Federal executive agencies. In particular, they are to assess the effect on critical military and

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1 Omnibus Budget Reconciliation Act of 1993, Pub. L. 103-66; 107 Stat. 379 (1993).

2 Balanced Budget Act of 1997, Pub. L. No. 105-33; 111 Stat. 251 (1997).

3 In accordance with the National Defense Authorization Act for FY2000, the total reallocated spectrum was subsequently reduced to 247 MHz.

4 Thurmond Act, Pub. L. 105-261, 112 Stat. 1920 (1999).

TABLE 3-1: SUMMARY OF THE REALLOCATED FREQUENCY BANDS FROM THE FEDERAL GOVERNMENT TO THE PRIVATE SECTOR

Freq. Band (MHz)	Legislation	Bandwidth (MHz)	Schedule
1390-1400	OBRA-93	10	January 1999
1427-1432	OBRA-93	5	January 1999
1670-1675	OBRA-93	5	January 1999
1710-1755	OBRA-93	45	January 2004 [b]
2300-2310	OBRA-93	10	August 1995
2390-2400	OBRA-93	10	February 1995
2400-2402	OBRA-93	2	August 1995
2402-2417	OBRA-93	15	February 1995
2417-2450	OBRA-93	33	August 1995
3650-3700	OBRA-93	50	January 1999
4940-4990	OBRA-93 [a]	50	January 1997
216-220	BBA-97	4	January 2002
1432-1435	BBA-97	3	January 1999
2385-2390	BBA-97	5	January 2005

[a] The 4940-4990 MHz band was a replacement to the 4635-4660 MHz and 4660-4685 MHz bands that were previously identified for reallocation under OBRA -93, as part of the 235 MHz of spectrum.

[b] In the NTIA Spectrum Reallocation Final Report (NTIA Special Publication 95-32), there was a provision for this band for early reallocation (i.e., 1999) for the top 25 major cities in the United States, with the private sector reimbursing the Federal users. Subsequently, Title III-Communications and Spectrum Allocation Provisions- of BBA-97 accelerated the reallocation of this band for competitive bidding commencing after January 1, 2001.

intelligence capabilities, civil space programs, and other Federal Government systems used to protect public safety applications of the reallocated spectrum.

This Section provides an assessment of congressionally directed reallocation of radio spectrum from Federal to private sector use in accordance with the requirements of Title VI of OBRA-93 and Title III of BBA-97. Specifically, this section documents the mission/operational and cost impacts to critical military and intelligence capabilities, civil space programs and other public safety systems due to the reallocated spectrum from the Federal Government use to private use. A band-by-band discussion on such impacts is presented to emphasize the different radio services, major systems and/or programs affected in each reallocated frequency band due to the reallocation, as well as, the associated reallocation costs. Finally, this section provides the potential benefits that the public may realize (or may have already realized) due to the reallocation of spectrum.

MISSION/OPERATIONAL and COST IMPACTS

All of the frequency bands identified for reallocation under OBRA-93 and BBA-97 were or are being used by the Federal Government agencies, in varying degrees, to support their mission requirements. Thus, all the reallocated spectrum entailed some operational impacts and cost to the Federal Government. Some of the principal criteria set forth in the statute for final frequency band selection were the costs to the Federal Government and loss of services or benefits to the public in relation to the benefits to the public of new non-government services. As such, the spectrum identified for reallocation represents a reasonable balance with respect to the costs and operational impacts to the Federal Government users and potential benefits to the public. The final spectrum reallocation plans for frequency bands reallocated under the requirements of OBRA-93 and BBA-97 are shown in Appendixes C and D, respectively.

The following paragraphs discuss in general terms the extent that missions and/or operations of Federal Government agencies are affected, along with the associated reallocation costs. This subsection also contains brief description of the major systems and/or programs that are potentially affected because of the reallocation.

Mission/Operational Impacts for Bands Reallocated Under OBRA-93

There was a total of 235 MHz of spectrum reallocated from Federal Government use to private use as a result of OBRA-93. One hundred thirty five (135) MHz of these are below 3 GHz and the remaining 100 MHz are between 3 and 5 GHz.

1390-1400 MHz Band

Table 3-2 is an overview of the Federal Government agencies affected by the reallocation of the 1390-1400 MHz band segment, the types and functions of the systems operating in the band, the reallocation impact and potential reallocation approach. Below is a discussion on a per-agency basis of the potential effect of the reallocation. Note, however, that the reallocation

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	33	1215-1400	Radars are in remote sites with limited access for hardware replacement. Sites in Alaska .are protected.	Radar operations can continue in Alaska on a secondary basis, however if interference occurs modification or replacement may be necessary. The reallocation cost is $60M.
AF	FPS-124	Air defense radar	40	1218-1398	Radars are in remote sites with limited access for hardware replacement. Sites in Alaska .are protected.	Radar operations can continue in Alaska on a secondary basis, however, if the radars must be replaced their cost is estimated to be $27M.
AF	PPQ-2(V)1	Tactical radar	11	1220-1400	Loss in tuning range/operational capability	Redesign radar to operate in the 1220-1390 MHz band at a cost of an estimated $5M.
N	MK-23	Shipborne radar	58	1215-1400	Loss in tuning range/operational capability	Restrict tuning to below 1390 MHz.
N	TPS-59	Tactical radar	15	---------	Loss in tuning range/operational capability	Restrict tuning to below 1390 MHz.
AR	MPQ-49 TPQ-32	Tactical radars	180	---------	Loss in tuning range/operational capability	Restrict tuning to below 1390 MHz.
AR	GSS-1	Transportable radar	10	1215-1400	Loss in tuning range/operational capability	Restrict tuning to below 1390 MHz.
AR & AF	GRC-226, 103(V)4	Tactical radio relay	2650	1350-1850	Loss in tuning range/operational capability	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.
T	L-88	Aerostat radar	15	1215-1400	Loss in tuning range/operational capability	Restrict tuning to below 1390 MHz.
FAA & AF	ARSR-4	Air Traffic Control Radar	44	1215-1400	Will lose 4 frequency pairs for frequency hopping operations and new crystals would have to be installed at each site.	Reallocation will, at a minimum, require the development of filters and hardware modifications estimated at $45M (AF=$10M & FAA=$35M).
AF	RAJPO	Air/ground data link	18	1350-1400 & 1427-1435	Loss in tuning range/operational capability	Hardware modification may be necessary if spectrum loss limits schedule for test events. Estimated low and high costs are $50M and $170M.

impact to the DoD is mitigated due to the protection afforded to the 17 sites for which operations of Federal systems in this band will be continued for 9 more years (2009), as shown in Table 3-3.[5]

The DoD's reallocation low cost estimate for the 1390-1400 MHz band is $152.0 million.[6] This estimate is based on the assumption that the air defense mission remains and that civil systems that will be using this band are compatible with the military systems which will continue to operate in adjacent spectrum. The low cost estimate includes the costs of modifications to the radar systems and the minimum estimated amounts for replacing the Range Joint Program Office (RAJPO) data links. The DoD high cost estimate for reallocation of this band is $272.0 million.[7] This estimate is based on the assumption that the remaining available frequencies will not provide sufficient spectrum resources to support today's air defense radar systems and that major hardware modifications will be required. The high costs estimate includes estimates for replacing the RAJPO data links.

<u>Navy.</u> The reallocation of the 1390-1400 MHz band segment primarily affects Navy's shipborne radars, resulting in a 6 percent loss of frequencies available for operation. 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 and interference margin of the radars and render them more susceptible to interference from new and existing systems within the remaining portion of the band. The high-power requirements of shipborne 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 will reduce the number of ships that could operate in close proximity within naval task force formations. Engineering studies will be necessary to analyze the specific impact and provide guidance on measures to avoid electromagnetic interference.

The Navy stated an example of the types of interference problems that can occur as a result of the loss of the 1390-1400 MHz band. The Navy's MK 23 Target Acquisition System (TAS) provides target information to the NATO SEASPARROW Surface Missile System. The reallocation of the 1390-1400 MHz band segment has reduced 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 reduction of available channels when operating within 200 nmi off shore is because of radiation restrictions already imposed on MK 23 TAS to

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[5] In addition to these protected sites, the DoD has also indicated that a 160 km protection contour, centered at 37E29'N/116E14'W, needs to be provided for the Nellis Test and Training Range (NTTR)

[6] The Department of Defense Letter Report to Congress (i.e., The Honorable Strom Thurmond, Chairman Committee on Armed Services, U.S. Senate), Spectrum Reallocation Cost Impacts: OBRA-93, dated Dec. 16, 1998.

[7] *Id.*

TABLE 3-3: SITES AT WHICH FEDERAL SYSTEMS IN THE 1390-1400 MHz BAND WILL BE CONTINUED FOR NINE MORE YEARS (2009) [a]

Location	Coordinates	Radius of Operation
Eglin AFB, FL	30E28' N 86E31' W	80 km
Dugway Proving Grounds, UT	40E11' N 112E53' W	80 km
China Lake, CA	35E41' N 117E41' W	80 km
Edwards AFB, CA	34E54' N 117E53' W	80 km
Ft. Huachuca, AZ	31E33' N 110E18' W	80 km
Cherry Point, NC	34E57' N 76E56' W	80 km
Patuxent River, MD	38E17' N 76E25' W	80 km
Aberdeen Proving Ground, MD	39E29' N 76E08' W	80 km
Wright-Patterson AFB, OH	39E50' N 84E03' W	80 km
Ft. Greely, AK	63E47' N 145E52' W	80 km
Ft. Rucker, AL	31E13' N 85E49' W	80 km
Redstone, AL	34E35' N 86E35' W	80 km
Utah Test Range, UT	40E57' N 113E05' W	80 km
White Sands Missile Range, NM	32E10' N 106E21' W	80 km
Holloman AFB, NM	33E29 N 106E50 W	80 km
Yuma, AZ	32E29 N 114E20 W	80 km
Pacific Missile Range, CA	34E07 N 119E30 W	80 km

[a] In addition to these sites, the DoD's updated plans require that a 160 km protection contour, centered at 37E29'N/116E14'W, needs to be provided for the Nellis Test and Training Range.

prevent interference to FAA air traffic control radars. Furthermore, there are many systems operated by the 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.

Army. The loss of access to the 1390-1400 MHz band will require that the Army relocate approximately 163 permanent assignments at 53 different locations in 25 states and trust territories to other frequencies within the tuning range of the equipment, modify the equipment to tune to available frequencies in another portion of the spectrum, or acquire new equipment for operations in another portion of the spectrum. Twenty-one locations have five permanent assignments each for training and the National Training Center at Ft. Irwin, California has seven assignments for training. The greatest potential adverse impact to Army will be on their Mobile Subscriber Equipment (MSE) radio relay communications for tactical training. Loss of the 10 MHz of spectrum will effectively delete four high-data rate channels that are presently available for radio relay operations.

The Army uses the 1350-1400 MHz band for tactical transportable radio relay systems and for radars. The tactical radio links the various headquarter and functional nodes into an area-wide integrated network, for such systems as MSE and Tri-Service Tactical (TRITAC) communications. The loss of 1390-1400 MHz will have a long-term impact on military training and operations using tactical radio relay systems at most Army bases. Options of moving operations into one of the other bands are difficult and present complex doctrinal and operational issues that are further complicated because these other bands are also fully used and congested.
The tactical radio relay systems used by the Army are tunable over the 1350-1850 MHz frequency range. Although the reallocation of 1390-1400 MHz represents only a small portion of the operational bandwidth of these systems (2 percent), the availability of authorized frequencies has continued to dwindle.

The overall economic impact of radar operations by reducing and 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 and interference margin of the radars and render them more susceptible to interference from new and existing systems within the remaining portion of the band. The high-power requirements of radars, combined with the physics of radio propagation, result in an extended interference range. Engineering studies will be necessary to analyze the specific impact and to provide guidance on measures to avoid electromagnetic interference.

Frequencies in the 1390-1400 MHz band are deemed by Army as critical to the configuration and operations of the MSE and TRITAC equipment because of the nature of the duplex operations of the radio system that require pairing these low frequencies with higher band frequencies in the 1755-1850 MHz band. The lower bands available for duplex operations were 55 MHz but were reduced by 18 MHz from the loss of 1390-1400 MHz, 1427-1432 MHz, and 1432-1435 MHz.

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 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.

Two Air Force radars affected 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. To avoid unnecessary and costly disruption of Federal operations in remote locations, the NTIA reallocation plan permitted the Federal radiolocation service to continue on a secondary basis in Alaska. The Air Force stated 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 stated that the following transition actions will be necessary:

» 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; and

» 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.

A similar transition actions will also be necessary for the AN/FPS-124 or a complete redesign of the radar system, if interference exists.

The RAJPO is a new data link in the 1350-1400 MHz band that Air Force began using in January 1994. This data link re-broadcasts 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. A total procurement of 719 units has been authorized for use at 18 sites throughout the United States and possessions. Each airborne RAJPO unit re-broadcasts 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 multi-path effects may be more pronounced. The number of channel pairs required varies with the scale of the operations.

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, but still incur costs. These potential program delay costs are not included in Table 3-2, due to uncertainties involved. Examples of estimated costs for various platforms are: Advanced Range Instrumentation Aircraft, $5,000/hour flying time; 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. Modifications will result in an estimated nonrecurring cost of $50 million and an estimated recurring cost totaling $170 million.

Federal Aviation Administration (FAA)/Air Force. The Air Route Surveillance Radar-4 (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 joint FAA and Air Force program. The radar has an operational frequency range of 1215-1400 MHz and operates on dual-channel. The ARSR-4 also employs frequency-hopping technology for long-range anti-jam search and tracking, and is capable of detecting small objects by minimizing clutter, and weather and multi-path effects.

The reallocation of the 1390-1400 MHz band segment reduced the number of available channels by four out of the 44 frequency pairs. With additional loss of frequencies to other systems, the reallocation of 1390-1400 MHz will impact the frequency-hopping capability that is key to the ARSR-4 design. Reallocation will, at a minimum, require the development of radio frequency (RF) filters and hardware modifications estimated to cost $45 million.

The spurious emissions of all existing FAA radar systems in the 1215-1400 MHz band are high and the RF 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.

Federal agencies' concern in the reallocation of this band for commercial or public-safety applications was that high-power radar systems will be in the adjacent band. Numerous case histories existed 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.

National Science Foundation (NSF). 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 detected using the hydrogen spectral line and the associated red-shift frequency occur in the 1350-1400 MHz region of the spectrum. Spectral lines, by their nature, are tied to specific frequencies; therefore, re-accommodation of radio astronomy observations to other bands is not a feasible option.

Although radio astronomy observations using the 1350-1400 MHz band are on an unprotected basis, the band is nevertheless extremely important to the success of many domestic and international scientific studies. To reduce the impact on important Federal and university radio astronomy operations, the Preliminary Report concluded that the reallocation of the 1390-1400 MHz band for non-Federal use must include restrictions on space-to-Earth links, and Footnote US311 from the *Table* must remain in effect. Provided that these restrictions are observed, NSF expects no major operation or economic impact as a result of reallocating the 1390-1400 MHz band segment.

1427-1432 MHz Band

The Federal Government agencies primarily affected by the proposed reallocation of this band are the Navy, Army, and Air Force. The following paragraphs describe the systems operating in the band and transition plans, costs, and options for each of the affected agencies. The reallocation impact to the DoD is mitigated due to the protection afforded to14 sites for which operations of Federal systems in this band will be continued for four more years (2004), as shown in Table 3-4.[8] However, the DoD has indicated that the protection zones are far too small to protect normal operations at those sites. The radius of operation for air vehicles generally exceeds the protection zones and the radio line-of-sight for an aircraft at a typical flight test altitude of 36,000 feet is over 400 km.

The DoD cost estimate for reallocation of this band is $23 million. This cost is based on a portion of the cost as stated in the DoD's Letter Report to Congress (*see* Appendix B) for the bands 1427-1432 MHz and 1432-1435 MHz. This estimate is also based on the assumption that the range telemetry can continue to operate in the 1432-1435 MHz band and that the loss of spectrum will not severely degrade the system's capability. Degraded operation of range telemetry equipment will cause scheduling delays, and modifications will be required to control systems to maintain safe and reliable telecommand of launched missiles, range scoring systems, and Tethered

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[8] In addition to these sites, updated RAJPO deployment plans require a 100 km protection contour for Edwards AFB, California centered at 35E29'N/117E16'W, and a 160 km protection contour for NTTR centered at 37E29'N/116E14'W.

TABLE 3-4: SITES AT WHICH FEDERAL SYSTEMS IN THE 1427-1432 MHz BAND WILL BE CONTINUED FOR FOUR MORE YEARS (2004) [a]

Location	Coordinates	Radius of Operation
Patuxent River, MD	38E17' N 76E24' W	70 km
NAS Oceana, VA	36E49' N 76E02' W	100 km
MCAS Cherry Point, NC	34E54' N 76E52' W	100 km
Beaufort MCAS, SC	32E26' N 80E40' W	160 km
NAS Cecil Field, FL	30E13' N 81E52' W	160 km
NAS Whidbey Is., WA	48E19' N 122E24' W	70 km
Yakima Firing Ctr. AAF, WA	46E40' N 120E15' W	70 km
Mountain Home AFB, ID	43E01' N 115E50' W	160 km
NAS Fallon, NV	39E24' N 118E43' W	100 km
Nellis AFB, NV	36E14' N 115E02' W	100 km
NAS Lemore, CA	36E18' N 119E47' W	120 km
Twenty Nine Palms, CA	34E15' N 116E03' W	80 km
China Lake, CA	35E29' N 117E16' W	80 km
Yuma MCAS, AZ	32E39' N 114E35' W	160 km

[a] In addition to these protected sites, the DoD updated plans for RAJPO deployment require a 100 km protection contour for Edwards AFB, California centered at 35E29'N/117E16'W, and a 160 km protection contour for NTTR centered at 37E29'N/116E14'W.

Aerostat Radar System (TARS). It is also assumed that airborne weapon command and guidance systems need to be retrofitted to use the1432-1435 MHz band if they are presently wired for the 1427-1432 MHz band.

Army. The Army uses this band extensively for tactical radio relay. This band is also used for aeronautical telemetry on the Army test ranges. The major impact to the Army is to the operations and training due to the reduction in number of available channels within the tuning range of the tactical radio relay equipment and Army training installations not being on the list for continued service or protection. The tactical radio relay equipment is critical to the wide area network because it provides the link connectivity between nodal centers of the area communications network system of the MSE and TRITAC. Although the tactical radios tune between the

1350-1850 MHz frequency range only a small fraction of the total 500 MHz is authorized for use. Prior to OBRA 93 the Army could use 195 MHz out of the 500 MHz. After OBRA 93 and BBA 97, the Army lost a total of 63 MHz from the 195 MHz, a 32 percent loss.

Frequencies in the 1427-1432 MHz band are deemed by Army as critical to the configuration and operations of the MSE and TRITAC equipment because of the nature of the duplex operations of the radio system that require pairing these low frequencies with higher band frequencies in the 1755-1850 MHz band. The lower bands available for duplex operations were 55 MHz but were reduced by 18 MHz from the loss of 1390-1400 MHz, 1427-1432 MHz, and 1432-1435 MHz. Although Federal systems will continue to operate on frequencies in the 1427-1432 MHz band at selected sites until January 2004 to protect essential operations, not all of the major Army installations and training locations are included on the protected sites. The greatest impact will be on Army training facilities not on the protected list that have large, high-bandwidth radio relay requirements such as Ft. Bragg, Ft. Campbell, Ft. Drum, Ft. Hood, Ft. Lewis, Ft. Gordon, Ft. Greeley, Ft. Richardson, Ft. Wainwright, Schofield Barracks, the National Guard and Reserve training areas and units, and for radio relay requirements outside of the Army installations.

The Army has permanent assignments recorded in this band. However, the bulk of the Army assignments are temporary assignments from the tactical radio relay equipment during training and operations that are not required to be recorded in the national database as are permanent assignments. The training and operational exercises are situational and vary in size and typically the number of tactical assignments can range in the tens to the hundreds per exercise.

Navy. The Navy operates a number of mobile communications systems in this band whose functions include: command, control, and telemetry links for remotely piloted vehicle (RPV) operations; airborne missile command and guidance; and ship sensor and navigation accuracy verification. The loss of this band will impair the operations of Navy missile command and guidance telemetry systems, ultimately affecting weapon system testing and training. Specific Navy reallocation options, transition plans, or reallocation cost estimates for this band are not available. However, a comprehensive reallocation cost between $30 to $113 million was provided by the Navy for the various frequency bands for reallocation. This cost could increase by up to $63 million if unacceptable interference to or from non-Federal users necessitates retrofit of Navy systems in some of the bands for reallocation.

Air Force. One of the major systems in this band is the $70 million DoD-sponsored RAJPO GPS Data Link. Initiated in January 1994, RAJPO is being installed at 18 sites throughout the United States and its possessions. The reallocation of the full 1427-1435 MHz band limits Air Force's ability to effectively schedule test-range events. Redesign of the system in an alternative band to regain full capability is estimated to cost DoD $23 million. In addition to the protected sites presented in this band, additional protected sites which may or may not be RAJPO sites are shown in Table 3-11 (*See* discussion on 1432-1435 MHz band).

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.

Department of Commerce. Most of the 111 frequency assignments in this band are for radiosonde stations operated by the National Oceanic and Atmospheric Administration (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. 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. 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. 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 three (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. NOAA estimated the 15-year cost for all of the necessary changes to be $35-55 million.

Termination of the Geostationary Operational Environmental Satellite (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.

Air Force. The Air Force reports that it operates a number of radiosondes and Meteorological Satellite Ground Terminals in this band. The cost to modify the radiosondes in order to comply with the reallocation plan is approximately $500,000.

Army. The Army has Radiosonde operations in this band. The Army has 16 radiosonde assignments in the 1670-1675 MHz band. The Army has not estimated the cost to relocate these radiosondes.

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. Note that Federal agencies' fixed microwave links in the 1710-1755 MHz band may be paired with links in the 1755-1850 MHz band. As such, in some occasions, discussion of their use and costs estimates may encompass the entire 1710-1755 MHz band. In addition, Federal agencies’ operations of fixed microwave, tactical radio relay, and aeronautical mobile stations in this band will be retained indefinitely at selected sites, as shown in Table 3-5.

The following paragraphs describe the systems operating in the band and transition plans, costs, and options for each affected agency. In accordance with the National Defense Authorization Act for FY99, full reimbursement to Federal agencies for relocation costs is required in this band. As such, these relocations will be subject to reimbursement.

Army. The most significant impact to the Army was the reallocation of the 1710-1755 MHz band. The Army is a land mobile force and highly dependent on the mobile and fixed allocations for their command, control, and communications network, both for fixed microwave and tactical communications networks.

The most significant impact of this band to the Army is tactical radio relay for the area communications network. Combining this band with the 1390-1400 MHz and the 1427-1432 MHz loss has major impacts to the communications network. Specifically, Army uses the 1350-1850 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 dynamic network and flexible to the tactical tempo and operational conditions. Lightweight, transportable communications equipment that has the capacity for rapid installation, break down, and camouflage is stated by Army to be a fundamental tactical requirement. The transmitter power, propagation characteristics, available bandwidth, and other technical factors support 1350-1850 MHz as the optimum band for use on the dynamic air-land battlefield. The Army has indicated that options of moving into one of the other bands are extremely difficult and 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, control communications network. While noting the equipments' 1350-1850 MHz tuning range, Army notes this loss is significant because it compresses the authorized frequency bands and complicates tactical frequency assignments. Specific costs associated with this 10 percent loss in tuning flexibility were not available.

Loss of access to this 45 MHz of spectrum is significant due to the number of channels involved and its frequency separation from the lower available 1350-1390 MHz and 1427-1432 MHz segments of the spectrum. Each radio link requires two 1.2-MHz channels separated by a minimum of 50 MHz. In addition, each transmitter frequency must be separated by a minimum of 10 MHz on parallel shots and 7.5 MHz for other links. This is a significant portion of the spectrum that allows the required separation for transmit and receive channels in an individual radio and other frequency separation requirements. Retention of access to both this quantity of spectrum and its relative location in the upper portion of the band is critical for the Army’s tactical communications networks.

TABLE 3-5
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

Location	Coordinates	Radius of Operation
China Lake, CA	35E41' N 117E41' W	120 km
Eglin AFB, FL	30E28' N 86E31' W	120 km
Yuma, AZ	32E29' N 114E20' W	120 km
Cherry Point, NC	34E57' N 76E56' W	100 km
Pacific Missile Range, CA	34E07' N 119E30' W	80 km
Nellis AFB, NV	36E14' N 115E02' W	160 km
Hill AFB, UT	41E08' N 115E58' W	160 km
Patuxent River, MD	38E17' N 76E25' W	80 km
Holloman AFB, NM	33E29' N 106E50' W	80 km
Ft. Irwin, CA	35E16' N 116E41' W	50 km
Ft. Rucker, AL	31E13' N 85E49' W	50 km
Ft. Bragg, NC	35E09' N 79E01' W	50 km
Ft. Campbell, KY	36E41' N 87E28' W	50 km
Ft. Lewis, WA	47E05' N 122E36' W	50 km
Ft. Benning, GA	32E22' N 84E56' W	50 km
Ft. Stewart, GA	31E52' N 81E37' W	50 km

The affects of the reallocation of that band were mitigated by the retention of the protected, continued use of 1710-1755 MHz at certain installation locations indefinitely. The protected status of operations at certain sites is an important factor in retaining the required access to the spectrum at many locations. However, other installations with large tactical requirements in this band such as Ft. Hood, Ft. Drum, Ft. Carson, Schofield Barracks, Ft. Greeley, Ft. Richardson, Ft Wainwright, Ft Gordon, Ft. Riley, and the National Guard and Reserves training areas are not included on the protected list. The impact of the reallocation of this spectrum on their operations will depend on the new service introduced and the usage within interference distance of the training areas.

This band, 1710-1755 MHz, is used by the Army Corp of Engineers (ACE) for its fixed microwave radio systems that provides the backbone communications in the Continental United States Engineer Districts. Functions that use this microwave network system 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. Army estimates the cost to recrystal and realign approximately 260 sites, to relocate, to be in excess of $23 million.

The Army has approximately 600 permanent assignments in the 1710-1755 MHz band. The frequency assignments are used primarily for radio relay/MSE communications, various backbone and other microwave communications links, RDT&E, and test range support. The bulk of the Army assignments are temporary assignments from the tactical radio relay equipment during training and operations that are not recorded in the national database as are the permanent assignments. The exercises are situational and vary in size and typically the number of tactical assignments can range in the tens to the hundreds per exercise.

Air Force. Air Force microwave operations in this band include provisions for communications link connectivity between geographically separated gap-filler, air defense 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. The Air Force estimates the cost to relocate this system to be in excess of $8 million. An additional estimated $7 million is necessary to re-tune and replace range communications equipment at Patrick AFB, Florida currently in this spectrum.

This band is used by DoD for guided munitions (e.g., AGM-130 and GBU-15) that are designed for employment against fixed, high-value targets in all weather conditions, day or night. These weapons, in the 2000-pound class of weapons, are launched from tactical aircraft from either low or high altitude at ranges from five to (or in excess of) 30 nautical miles. Equipped with video or infrared sensors and aided by the GPS, these weapons provide operators the ability to attack targets at all weather conditions, day or night. These weapons can be controlled from either the launch aircraft or a standoff aircraft at a range of more than 100 nautical miles. Operators require access to a video and a command uplink frequency at any time during the mission, including ground operations, post-take-off pre-launch operations, and post-launch weapon flight operations. Access to frequencies is critical during all training operations – these operations require use of the frequencies for two hours at a time.

The weapon control data link systems provide operators with the ability to control the precision guided weapons. Video from the weapon seeker is transmitted to a weapon systems officer (WSO) who identifies the target and manually controls the bomb to the designated impact point. The AGM-130 provides a longer range, compared to the GBU-15, because its flight is assisted with a rocket powered motor. Both the AXQ-14 and ZSW-1 data links utilize multiple frequencies within the 1710-1850 MHz band.

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 percent, and render the guidance links less effective in the presence of jammers should modifications to the system be necessary. A total re-engineering of approximately 1000 units is required at an estimated cost of over $100 million.

The DoD low cost estimate for reallocation of this band is $38 million. This cost is based on re-engineering and modifying systems to operate in adjacent parts of the spectrum. The high cost estimate is $138 million. This cost is also based on re-engineering and modifying systems to operate in adjacent parts of the spectrum and re-tuning weapon command and control links.

Department of Transportation. FAA and the United States Coast Guard (USCG) enforce rules and safety for air and waterways navigation, respectively. These agencies provide not only navigational aids but also 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 very high frequency (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. For the USCG, the most significant cost impact from the reallocation process is the loss of its microwave links in the 1710-1755 MHz band. USCG provides an estimated relocation cost at $11 million non-recurring and $2 million recurring costs. However, both FAA and USCG reallocation costs for the 1710-1755 MHz band are reduced as a result of the protection of certain sites.

Department of the Interior. The Department of the 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 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.

Department of Energy. The majority of the Department of Energy’s (DOE's) fixed microwave operations in the 1710-1755 MHz frequency range are in support of the Electrical Power Marketing Program. The Federal Power Agencies (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 FPAs' 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 band. 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.

Department of Justice. The Department of Justice (DOJ) makes broad use of radio frequencies in the 1710-1755 MHz band for 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, the FBI began a program in 1991 to convert its microwave systems in the 1710-1755 MHz band to leased wireline. Replacement of fixed microwave links involves the removal of the microwave system and the procurement of a radio system infrastructure and devices necessary for implementing other linking mechanisms. Most often the linking media utilized is terrestrial commercial services available from both local telephone companies and long distance carriers. The initial 15-year cost estimates in 1995 by the FBI showed the conversion of the 427 fixed microwave sites operating in the 1710-1850 MHz band to exceed $121 million. Funding for the conversion began in 1998 with completion expected to be incorporated in the implementation of the consolidated Justice Wireless Network (JWN). As of FY00 only $13.2 million has been appropriated for the microwave replacement program. These costs include site lease, services and equipment for conversion to leased wireline. In addition to these costs there are monthly recurring leased circuit costs that show significant growth as the leased service expands. As an example, prior to the conversion of the microwave equipment in the 31 FBI offices affected by the reallocation, the annual leased circuit costs in FY95 totalled $1.7 million and in FY00 the total is expected to be $5.5 million. Between FY95 and FY00, a total of $18.5 million recurring cost has been expended for leased circuit.

An updated estimate of the 15-year costs for conversion of the FBI microwave systems in the 1710-1850 MHz band based on new cost figures is $113 million. However, this estimate does not include the three offices that will be converted as part of the JWN program and supported by leased circuit costs that are part of the consolidated system design. The new cost figure does include the site lease, services and equipment for conversion and additional leased circuit costs incurred to date, and based on actual expenditures, projected estimates for the remaining years.

The use of leased wireline became a viable option as the technology developed and improved in the last few years. These technology improvements have provided an equal or better grade of service than bureau owned and maintained microwave systems. This improved service, however has resulted in increased costs to users. Although improvements in wireline technology have been realized, they were not a direct consequence of the spectrum reallocation, but merely a progression of independent technology development.

The INS, in 1995, planned to relocate their fixed microwave links currently in the 1710-1850 MHz to the 7/8 GHz band at an estimated cost of $23 million. While this transition has not taken place, the most recent estimate for the mandated reallocation is projected at $55 million. DEA is in the process of reprogramming their video transmission systems on a multi-year schedule to minimize the impact to the user. The original estimates provided in 1995 were $350 per unit for a total cost of $180,000. The current estimate is negligible since the change out of equipment was handled as the equipment was replaced in the normal life cycle. Combining these three components' cost estimates shows the DOJ current cost for reallocation from the 1710-1850 MHz to be $168 million. This new cost is up from the original estimate of $144 million in 1995.

The DOJ believes 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.

Department of the Treasury (Treasury). The U.S. Customs Service (USCS) currently operates and maintains an analog microwave system, commonly referred to as the Rainbow Microwave System (RMS) which provides a 120-channel intra- and inter-island backbone system throughout the Hawaiian islands. The RMS users include the Coast Guard, Drug Enforcement Administration, Navy, Hawaii State Forestry Service and local police and fire departments. The system carries search, rescue, and emergency distress information and other high priority communications pertinent to agent safety during drug interdiction, counterfeit, fraud and forgery investigations.

The RMS was included in the list of Federal stations that will remain in the 1710-1755 MHz band due to the high priority, public safety missions it supports and currently employs frequencies throughout the1710-1850 MHz band. Although the RMS is protected from interference under the mixed use criteria established by Title VI of OBRA 93, there is a study underway to replace the analog microwave system with a state-of-the-art digital microwave system, tentatively called the *Rainbow Digital Project*. The digital microwave system must operate in higher frequency bands due to the data rates the system must transmit. The project will be more expensive because of the propagation characteristics of higher bands and will require more sites, approximately 30 versus 16 sites in the current system. The initial cost projections for the digital system is about $46 million.

Additionally, Treasury maintains two microwave systems with two sites each in the Dallas, Texas and Los Angeles, California areas. The systems provide broadband connectivity for the U.S. Secret Service (USSS) offices during their investigations of coins, currency, stamps, Government bonds, checks, credit and debit card fraud, computer fraud, false identification crimes, and protection of our nation's leaders and visiting heads of state. The Secret Service is currently investigating replacing the microwave links with commercially provided leased lines. It is estimated that the one-time installation charge for each city will be between $10,000 and $12,000 dollars and the monthly recurring charge for each city will be approximately $60,000 or $120,000 per year for both cities.

Treasury's Inspector General for Tax Administration, Bureau of Alcohol, Tobacco and Firearms, USCS and USSS employ low-power video surveillance systems that are authorized for use throughout the United States and Possessions for both protective operations and criminal investigations. The video footage obtained during these investigations is critical in order to provide quick reaction forces to support undercover officers and agents, and is used as evidence during criminal trials and procedures.

Anticipated costs for procuring new video surveillance transmitters, receivers, disguise devices, and associated ancillary equipment to replace the current inventory operating in the 1710-1755 MHz band is approximately $3.9 million.

Department of 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 is not available.

Department of Agriculture. The Forest Service of the United States Department of Agriculture (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 percent 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 4/5 GHz or 7/8 GHz bands and procuring new equipment at an estimated cost of $48 million.

2300-2310 MHz Band

The 2300-2310 MHz band is one of the bands that was reallocated immediately (i.e., August 1995) from the Federal Government use to non-Federal use. This band was formerly used by the DoD for radar target scatter and identification systems, and threat simulators and test equipment used in specialized electronic warfare training exercises at various test and training ranges throughout the United States. The DoD has implemented the scheduled reallocation of this band by restricting its use to coordinated operations at selected test ranges and by discontinuing use of the band at other sites. There is no cost impact incurred by the DoD.

National Aeronautics and Space Administration (NASA). The main concern expressed by NASA regarding the reallocation of the 2300-2310 MHz band is the potential interference from as-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 RF signals. NASA believes 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. In light of this concern, the Spectrum Reallocation Final Report included, among others, the following constraints on the reallocation of the 2300-2310 MHz band:

- ❏ 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; and
- ❏ Unwanted emission levels of commercial applications on any frequency below 2300 MHz must be attenuated below the mean power of the unmodulated carrier output by -70 dB.

Given these constraints and depending on 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.

Army. The Army uses this band for test and evaluation. The Army operates equipment at various test ranges to transmit audio and video data from mobile vehicles under test to a base station between 0.1 and 8 km distance. The Army has not estimated the costs to relocate or replace these equipment.

2390-2400 and 2402-2450 MHz Bands

An overview of the Federal Government agencies affected by the reallocation of the 2390-2400 and 2402-2450 MHz bands for non-Federal sector use is given in Table 3-6. The following paragraphs discuss the reallocation impact and the options for each of the agencies affected by the loss of the 2390-2400 MHz and 2402-2450 MHz bands. For the military, some of the systems that operate in these bands generally have wide tuning ranges that can accommodate the reallocation. The operational impacts of the reallocation of these bands are difficult to quantify, but the inability to conduct special research projects does ultimately impact advances in science and technology for both the Federal and non-Federal sectors.

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 2402-2450 MHz band for test and training range instruction, telemetry control and data links, and threat simulation.

Target scattering and identification radars, as well as radar simulators in the 2390-2400 MHz and 2402-2450 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.

Ground-based telemetry systems are capable of being tuned. Flexibility in airborne units is limited and will require redesign or re-crystallization in most cases. The conversion of telemetry receivers

TABLE 3-6: OVERVIEW OF REALLOCATION IMPACT FOR THE 2390-2450 MHz BAND

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/ operational capability	Restrict tuning in the reallocated band segments.
N	DSQ-50	Miss distance measurement	200	2300 - 2400	Loss in tuning range/ operational capability	Restrict tuning in the reallocated band segments.
N	Cts-515	Telemetry	200	2300 - 2450	Loss in tuning range/ operational capability	Restrict tuning in the reallocated band segments.
AF	Range test equipment	Telemetry	34	2300 - 2450	Loss in tuning range/ operational capability	The conversion of 36 telemetry receivers and equipment 4 auto tracking antenna systems is estimated to cost $2.5M. Nodification 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 (CIRIS)	Airborne interrogator & Ground transponder	398	2412.4, 2347.2 & 2347.2, 2412.4	Interrogator transmitter & Transponder receiver impacted.	CIRIS interrogators will require redesign. Estimated reallocation cost is $36M.
AF	MST-T1A	Training	36	2300 - 2450	Loss in tuning range/ operational capability	Modifications to electronic warfare equipment to lock-out the band segments planned for reallocation are estimated to total $1M in software changes.
AR	MA-25MX	Test & Evaluation				

and autotracking antenna systems will cost approximately $2.5 million. Modification and/or replacement of various telemetry equipment is estimated at $600,000. The Completely Integrated Reference Instrumentation System (CIRIS) is used by to certify navigation systems. It is the only source of continuous (i.e., range dependent) time, space and position information for 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. CIRIS is fixed-tuned on 2412.4 (interrogator) and 2347.2 MHz (transponder). Reallocation of the 2402-2450 MHz band segment will impact the CIRIS interrogators. The estimated reallocation costs is $36 million.

The Air Force operates the AN/DPQ-9 Vector Doppler Scoring System (VDOPS), a pulse doppler radar system installed on all aerial targets in the Air Force inventory, at Tyndall AFB, Florida and Holloman AFB, New Mexico. This system operates on the discrete frequency of 2433.5 MHz which is in the middle of the reallocated 2417-2450 MHz band. VDOPS is a fixed frequency radar and used to track endgame trajectory of missiles fired at aerial targets. If VDOPS can no longer operate at this frequency, all of the VDOPS sensors, antennas, ground stations, and test sets will have to be replaced or extensively reworked. The non-recurring engineering required to design and test a VDOPS system at a new frequency is estimated at approximately $50,000 per target. There are about 200 targets that need to be retrofitted, for a total cost of $10 million. Additionally, all of the test sets and ground stations will require replacement, at an estimated cost of $1 million, adding up to a total estimated cost of at least $12 million. Without VDOPS, the Air Force will be unable to verify the success of any air-to-air missile test conducted.

Army. The Army operates wideband radar cross-section (RCS) measurements of static low-RCS targets in the 2390-2400 MHz range. Similar measurements are performed with this very same system by the Air Force at WSMR, NM. The Model 66320 is a constituent part of the Radar Target Scatter Division Advanced Measurement System.

In the 2402-2450 MHz band, the Army uses it for test and evaluation. The Army operates equipment at various test ranges to transmit audio and video data from mobile vehicles under test to a base station between 0.1 and 8 km distance. The Army has not estimated the costs to relocate or replace these equipment.

The Army has a total of ten permanent frequency assignments recorded for mobile operations of two models of transmitter and receiver equipment. These assignments between 2400 and 2417 MHz are on a non-interference basis to authorized non-Federal government operations, and such operations shall not hinder the implementation of any non-Federal government operations.

National Science Foundation. The 2390-2400 and 2402-2450 MHz bands are adjacent to the 2370-2390 MHz band used for planetary radar research. The National Astronomy and Ionosphere Center (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. 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.

Unrestricted use of the 2390-2400 MHz and 2400-2410 MHz bands by the non-Federal entities will necessitate re-tuning 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 will 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 3-7. 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. The reallocation impact to the Navy is mitigated due to the protection afforded to the three sites for which operations of Federal systems in this band will be continued indefinitely. These sites are shown in Table 3-8. Note, however, that one of the former sites (Memphis, Tennessee site) identified in the NTIA's Spectrum Reallocation Final Report has been replaced by the site in Pensacola, Florida.

Navy. The major systems operating in the 3600-3700 MHz band are Navy shipborne radars that serve as the primary air traffic control (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.

The reallocation of the 3650-3700 MHz band on a mixed use basis provides a reasonable compromise between the needs of the non-Federal users and the requirements by Navy to use the radar in this band for the daily need for carrier take-off and landing proficiency training operations involving the radar controllers and aircraft pilots. The use of the 3650-3700 MHz band on a mixed use basis will eliminate need for replacement of the radars, but will 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.

Air Force and Army. The Air Force and the Army use this band for electronic countermeasures training and advanced development research for hypersonic air vehicles. Testing and electronic warfare training activities will suffer some adverse impacts, in terms of the ability to acquire data,

TABLE 3-7: 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	Loss in tuning range/ operational capability	Re-engineer channel plan for the band.
N	SPN-6	Shipborne radar	1	3600-3700	Loss in tuning range/ operational capability	SPN-6 being replaced by the SPN-43.
N & AF	SPQ-11	Shipborne radar	1	2000-4000	Loss in tuning range/ operational capability	Restrict tuning in the reallocated band segment.
AR	Various	Ground based equipment	1680	3675-3700	Loss in tuning range/ operational capability	Intercept receivers have an operational tuning equipment range of 500-40,000 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/ operational capability	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 conduction ECM in spectrum adjacent to reallocated spectrum.
AF	HySTP	Research	----	3600-4200	Loss in tuning range/ operational capability	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 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

due to the loss of tuning range but will implement operational work around to accommodate the reallocation. Additional use is made by Air Force satellite augmentation and target cross section and scatter tests on military ranges and by Army intercept receivers.

4940-4990 MHz Band

The 4940-4990 MHz band segment is a part of the bigger Federal Government fixed and mobile services band in the 4400-4490 MHz. The 4940-4990 MHz band segment was the substitute band for the 4635-4685 MHz band that was reclaimed by the President for continued Federal use.[9] The Navy intends to operate a new DoD system in this band, the Cooperative Engagement Capability (CEC) System. A study completed by the General Accounting Office in 1997 concluded that the transfer of one 50 MHz portion of the 1995 reallocation plan (i.e., the 4635-4685 MHz band) could impair the operational potential of the CEC. This $3 billion system underwent major Congressional redirection and expansion about the same time as the completion of the 1995 reallocation plan. Subsequent study within the DoD raised even graver concerns, concluding that proceeding forward with the original 1995 reallocation plan would "seriously jeopardize the national defense interests of the United States."

The Army and Air Force conduct tactical point-to-point and troposcatter communications in the 4940-4990 MHz band. In addition, military airborne telemetry and data links systems also operate in this band. The operational and cost impacts have not yet been provided by the military.

Navy. The reallocation of the 4940-4990 MHz segment impacts the AN/USG-1, AN/USG-2, and AN/USG-3 CEC. The CEC is currently undergoing deployment as a Navy system, and is in development for future deployment by the Army, Marine Corps, Air Force, and Royal Navy of the United Kingdom. The CEC is a system that: (1) increases war fighting effectiveness by allowing individual units participating in a CEC network to function as a single, coordinated battle force, and (2) increases war fighting capability by combining data from distributed sensors to form a composite track and identification data base that facilitates the use of advanced tactics and doctrine.

TABLE 3-8: SITES AT WHICH FEDERAL SYSTEM IN THE 3650-3700 MHz BAND WILL BE RETAINED INDEFINITELY

Location	Coordinates	Radius of Operation
St. Inigoes, MD	38E10' N 76E23' W	80 km
Pascagoula, MS	30E22' N 88E29' W	80 km
Pensacola, FL	30E21' N 87E16' W	80 km

9 Letter from Larry Irving, Assistant Secretary for Communications and Information, and Administrator, sent on behalf of the President to Congress and the FCC identifying the 4940-4990 MHz band as the substitute band for the reclaimed 4635-4685 MHz band, dated March 30, 1999.

Impact to CEC Operation

The major operational impact of the decrease in the RF bandwidth allocated to CEC is a decrease in the number of units that can simultaneously participate in a CEC network. Additionally, the reduced bandwidth decreases both CEC resistance to intentional jamming from hostile systems and CEC resistance to unintentional interference from co-located, friendly systems. The decrease in bandwidth, then, degrades the overall warfighting capabilities of a CEC network, the individual combatants that comprise the network, and the individual combatants that must be purposely omitted from the network. The following paragraphs provide a detailed description.

Each unit that participates in CEC increases the warfighting effectiveness of the battle force by providing: (1) sensors that uniquely contribute to the formation and update of a composite track and identification data base, and/or (2) weapon systems that uniquely contribute to target engagement based on that composite data base. The unique contributions result from diversity in both positional geometry and operational characteristics. The omission of combat elements from CEC decreases the overall diversity of sensors and weapons in a network and has several significant impacts. A decrease in sensor diversity increases the risk that threats will not be time-critically detected, continuously tracked, or properly identified. As a result, hostile targets may remain unengaged, and friendly forces may become inadvertently engaged. A decrease in weapon diversity reduces the ability to accomplish resource management for optimized weapon-target pairing that is coordinated throughout the battle force. Targets may be engaged with insufficient, inappropriate, or excessive weapon resources.

The composite sensor track and identification database allows a CEC battle force to utilize advanced tactics and doctrine. The battle force can accomplish cooperative engagements in which one or multiple units provide track data for an engagement and a second unit provides the weapon system to accomplish the engagement. Tactics can then be deployed that are otherwise impossible to implement, and threats can then be engaged that are otherwise impossible to engage. The omission of combat units reduces the ability to accomplish cooperative engagements, and may result in certain targets not being engaged.

Additionally, the warfighting capabilities of combat elements omitted from participation in CEC are not fully utilized. As an example, the composite track and identification database overcomes certain limitations of own-platform sensors. A unit is able to utilize the composite data with own-platform weapons to engage targets when own-platform sensors are not providing target track data due to electronic countermeasures, RF propagation effects, or own-platform sensor emission control. Omission from CEC denies a combat element access to the composite database and, as a result, may preclude engagement of certain targets.

The exchange of sensor and weapon data is the critical function that allows the individual combat units participating in a CEC network to increase war fighting capability by forming a composite sensor track and identification data base. Each pair of combatants participating in a network requires a finite and unique RF bandwidth to accomplish these data exchanges at the rates and in the times necessary to form the composite data base and support weapons engagements. The total RF bandwidth required for a network, then, depends on the number of combatants participating in that network.

Maximum war fighting effectiveness and capability are achieved when the greatest number of units participate in CEC. Since CEC is designated for deployment aboard nearly all U.S. Navy major surface combatants and E-2C aircraft, and future deployment with joint service assets is expected, a significant number of units will be available to participate in CEC. Maximum war fighting effectiveness and capability, then, are realized via the utilization of a total RF bandwidth that allows participation of the maximum number of units and facilitates the required data exchanges among those units. The number of units that actually can participate, however, is determined by the total RF bandwidth allocated to CEC.

The result of a spectrum allocation to CEC that supports participation of less than the maximum number of units is to require a battle force commander to decide which elements of the battle force to omit from CEC. CEC effectiveness is reduced, and, consequently, the warfighting effectiveness of the battle force is reduced. Likewise, the warfighting capability of each combat element omitted from CEC is underutilized.

The impacts of the frequency reallocation may be realized with U.S. forces deployed in potentially hostile situations. If foreign governments follow the United States and the frequency band becomes reallocated to non-government service world wide, then the potential exists for CEC to be denied operation in the band when deployed in international conflicts.

Impacts to CEC Combat Readiness

A second major impact of a reduction in the spectrum allocated to CEC is the effect on training and, consequently, combat readiness. The comprehensive training required to provide operational readiness in all of the capabilities of CEC is essential for effective deployment under both peacetime and wartime conditions. The training includes the development of operational tactics and doctrine to ensure that a battle force operates as a single, cohesive combat unit and realizes full CEC potential.

As noted above, the participation of the maximum number of units is essential to realize the full warfighting effectiveness. Effective and comprehensive training with the maximum number of units is then essential for a unified battle force to become thoroughly familiar with all CEC capabilities and, as a result, achieve full operational readiness. Additionally, this training must be accomplished in geographic areas that simultaneously: (1) provide environments that simulate the littoral conditions under which future conflicts are expected to occur, and (2) minimize the exposure of training forces to both security and safety risks. The coasts of and areas within the Continental United States (CONUS) and U.S. Possessions (US&P) provide such geographic areas.

Training and the development of tactics and doctrine with the maximum number of units requires allocation of spectrum to CEC that supports operation with the maximum number of units. The accomplishment of these tasks in the appropriate environment requires that this spectrum be available to CEC both along the coasts of and within the United States and US&P. A decrease in spectrum allocated to CEC forces training to occur: (1) with reduced numbers of units participating in exercises along or within the United States, (2) in an open ocean environment, (3) at a remote littoral location outside of the United States to accommodate large numbers of units, or (4) with increased reliance on computer modeling and simulation.

Training with reduced numbers of units reduces operational readiness. An open ocean environment precludes training with ground forces of the Army or Marine Corps, and does not provide a realistic littoral environment in which future conflicts are expected to occur. Training in littoral environments outside the United States risks compromise of both security and safety. The risks associated with training simulations are not fully identified.

Impacts to CEC Mission

The Navy mission for CEC is established and, as the value of CEC has been demonstrated, the mission is being expanded to include joint service forces. The "CEC Mission Needs Statement" and "CEC Operational Requirements Document" define the mission. The mission is to: (1) integrate battle force sensors and combat systems to form a single, force-wide distributed system capable of countering increasingly capable threats, and (2) provide a data distribution function for the formation of a common, force-wide composite track and composite identification data base that improves force defense capabilities.

The reallocation from the OBRA-93 legislation of a portion of the CEC RF band reduces the maximum number of units that can simultaneously participate in a CEC network. This reduction in frequency is of concern for CEC operations, especially training, within the CONUS and US&P, but does not preclude CEC from carrying out its mission. Additional Navy units are being fielded each year, and the recent action designating CEC, as a joint program will further increase the number of fielded CEC units each year. CEC will require the entire allocated RF bandwidth in order to incorporate these additional units into a network, and will soon be required to support, with a reduced spectrum allocation, joint network operations with numbers of units that exceed the original design requirements. The joint network operations include CEC participation along the coasts of the United States in the Air Force ACMD initiative.

The Navy, FCC, and NTIA jointly explored and implemented options in an effort to mitigate the effects of the reduced spectrum allocation and maintain CEC operational capability. The options implemented include: (1) relocation of the reallocated segment from near the center (i.e., 4635-4685 MHz band) to the upper edge of the CEC frequency band with the intent to reduce the size of guardbands imposed on CEC, (2) inclusion of CEC spectral emission data in FCC frequency auction announcements with the intent that commercial systems must be designed to operate in the presence of those emissions, (3) inclusion of a list of CEC operational areas in FCC frequency auction announcements with the intent to identify to commercial users where CEC emissions are likely to occur and where CEC will operate without imposition of additional frequency or power restrictions that might be proposed in order to resolve interference issues with commercial systems operating in the reallocated segment, and (4) redesign an existing Navy system to operate at frequencies significantly removed from the CEC RF band with the intent to provide additional spectrum for CEC.

Costs Associated with the 4940-4990 MHz Band Reallocation

The reallocation of the 4940-4990 MHz band under the OBRA-93 legislation imposed two major costs on the Navy. The first cost is the $127 million associated with the redesign of a Navy system that currently operates over frequencies within the CEC RF band on a non-interfering basis. The redesigned system is to operate at frequencies significantly removed from the CEC RF band to increase the spectrum available to CEC and partially offset the impacts of the OBRA legislation. The second major cost is an amount of $7.5 million associated with the redesign of the CEC frequency management and control features. The CEC was originally designed to operate with the full allocated bandwidth. Both hardware and software modifications are required to implement control options that allow CEC to preclude emissions over the 4940-4990 MHz band. Additionally, since future CEC operations will occur in regions outside of the operational areas identified to the FCC, control measures must be implemented within CEC to accommodate frequency management in these areas.

<u>Army.</u> The Army uses this band for tactical radio and data links to support command, control, and communications networks and RDT&E support. Tactical radio relay microwave and tropospheric-scatter are used to link transportable, fixed nodes in the wide area network in this band. Radio relay links are one such application that are effective for line-of-sight and troposcatter communications at distances up to 200 miles. Their link transmission bandwidths are typically 3.5 or 7.0 MHz wide. The equipment is tunable from 4400-5000 MHz. Frequencies in this upper portion of the tunable range are deemed by Army as critical due to the nature of the radio duplex operations that require pairing high and low frequencies with a separation requirement of 100 MHz. Loss of these upper band frequencies impacts the dynamic geometry and flexibility of the tactical communications network.

Multiple assignments recorded for operations in this band support training exercises involving the use of radio relay links. The majority of the 55 assignments authorize band-tuned operations throughout the entire 4400 to 4990 MHz band. Of the remaining assignments, most support tactical unmanned air vehicle (UAV) video transmission and control operations, portable line-of-sight voice and data microwave link operations, and telemetering of video data collected on helicopters involved in Hellfire missile tests. The bulk of the Army assignments are temporary assignments from the tactical microwave and troposcatter equipment during training and operations that are not recorded in the national database as are the permanent assignments. The exercises are situational and vary in size and typically the number of tactical assignments can range in the tens to the hundreds per exercise. The use of frequencies in the band for UAV will continue.

Reallocation Costs Summary for Bands Reallocated Under OBRA-93

Notwithstanding the reallocation, it is understood that Federal Government agencies must continue to perform their mandated missions. In general, the displaced Federal functions resulting from reallocation musts, in most cases, be preserved in other frequency bands at considerable costs to the Federal Government. The Federal costs associated with the reallocation under OBRA-93 were based on received comments from the various Federal agencies. A summary of the reallocation costs per agency for all the reallocated spectrum under OBRA-93 is shown in Table 3-9.

In December 1998, the DoD provided the Chairman of the Committee on Armed Services of the Senate, the Honorable Strom Thurmond, with a report detailing the DoD's reallocation costs impacts on both the OBRA-93 and BBA-97 legislation. This report is in response to Section 1064 of the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999. As a result of the reallocation costs study provided by DoD in this report and due to the reclamation of some bands that were reallocated under OBRA-93, the reallocation costs estimate originally specified in the NTIA report in 1995 has been modified as shown in the Table below.

Mission/Operational and Costs Impacts of Reallocated Bands Under BBA-97

Originally, a total of 20 MHz of spectrum was reallocated from the Federal Government use to private use because of the mandate of BBA-97. These 20 MHz of spectrum were gleaned from five distinct frequency ranges in the RF domain of the spectrum. These frequency ranges were the 139-143 MHz, 216-220 MHz, 1385-1390 MHz, 1432-1435 MHz, and 2385-2390 MHz. However, because of a subsequent legislation (NDAA-2000), the 139-143 MHz and 1385-1390 MHz frequency ranges were reclaimed by the President for continued use by the Federal Government. Therefore, mission/operational and costs impacts for these two bands will not be discussed herein.

The DoD reallocation costs are not specified for the individual bands in lieu of the total reallocation cost shown in Table 3-13. This total cost was derived from the DoD Letter Report to the Chairman of the Committee on Armed Services of the U.S. Senate (*see* Appendix B).

216-220 MHz Band

Currently, the 216-220 MHz band is allocated to the Federal Government and non-Federal maritime mobile service on a primary co-equal basis. The band is also allocated to Federal and non-Federal aeronautical mobile, fixed, and land mobile services as well as the Federal

TABLE 3-9: ESTIMATED REALLOCATION COSTS SUMMARY FOR SPECTRUM REALLOCATED UNDER OBRA-93

Federal Agency	Frequency Band (MHz)	Estimated Reallocation Costs ($M)	
		Non-Reimbursable	Reimbursable
Agriculture	1710-1755		$48
DoD	All bands	$226-$346 [a]	$38-$138
Commerce	1670-1675	$35-$55	
Energy	1710-1755		$3
Interior	1710-1755		$8-$13
Justice	1710-1755	$132	$55 [c]
NASA	1710-1755		$1
Transportation	1390-1400 & 1710-1755	$35 [b]	$109 [d]
Treasury	1710-1755		$4-$46 [e]
TOTAL		$428-$568	$266-$413

a A revised and combined reallocation costs for the DoD (i.e., Army, Navy, and Air Force) is provided in the DoD Letter Report to the Chairman of the Committee on Armed Services of the United States Senate (The Hon. Strom Thurmond), Dec. 16, 1998 (see Appendix B). However, due to some reclaimed spectrum (i.e., 4635-4685 MHz band), the ***total*** OBRA-93 reallocation costs for DoD is adjusted to $226-$346 million (non-reimbursable) and $38-$138 million (reimbursable).

b This cost is for the 1390-1400 MHz Band.

c This is an updated cost recently provided by DOJ. It includes INS links in the 1710-1850 MHz band.

d This costs is for the 1710-1755 MHz band and could significantly increase if unacceptable interference to or from non-Federal systems necessitates major hardware changes of Federal systems.

e This is an updated cost recently provided by the Treasury. The higher cost is based on whether the Rainbow Microwave System in Hawaii, which is currently on the protected list, is subject to reimbursement.

radiolocation service on a secondary basis. The use of the band by the fixed, aeronautical mobile, and land mobile services is limited to telemetering and telecommand operations. There are 563 assignments to Federal agencies in the band as reported in the Government Master File (GMF). This band is reallocated from the Federal Government to the non-Federal government on a mixed basis use in January 2002.

Navy. The Navy's primary use of this frequency band is for operation of the Navy Space Surveillance (SPASUR) system. Additional systems are operated as receive only and/or operated on a non-interference basis (NIB). Navy has an estimated investment cost of $193 million in the systems using this frequency band. Assignments made to the fixed and mobile services are on a

NIB basis to the SPASUR bi-static radar system operating on the frequency 216.98 MHz (± 1 kHz). The SPASUR system consists of three transmit sites and six receiver sites located on a great circle line across the southern part of the United States and inclined 33.57 degrees to the Equator. The SPASUR is used to maintain constant surveillance of space (un-alerted detection of Earth orbiting satellites) and to provide satellite data as directed by the Chief of Naval Operations and higher authority to fulfill Navy and national requirements. The system is the only Federal radiolocation system operating in the band.

Under a mixed-use reallocation, SPASUR operations would be protected indefinitely. The low-power telemetry systems in the band could, in many cases, be able to continue operations on a NIB, since typical operations are conducted intermittently and in remote locations; however, no protection would be afforded these systems. Those telemetry systems that require relocation may find spectrum support in the 40-42 MHz, 162-174 MHz or 23 GHz bands. Consideration should also be given to utilizing commercial satellite as a means to relay data collected at the monitoring stations.

The Navy states that contingent upon the continued protection of the SPASUR system, the reallocation impact of this band is expected to be minimal. In the specified band segment, the SPASUR radar locations listed in Table 3-10 are to be protected indefinitely.

Air Force. The Air Force currently has 52 frequency assignments in this band for systems used to measure the radar cross section of missiles, and to provide low-power, hands-free communication between Hazardous Material (HAZMAT) disposal teams. There are two locations that use this band for research, development, and testing purposes. There is one location at White Sands Missile Range that uses this band to measure the radar cross section of missiles. Air Force HAZMAT teams use this band at four locations.

The Air Force states that minimal impact is expected if the 216-220 MHz band is reallocated. The Air Force states that the greatest impact will occur at Goodfellow AFB, Texas, where the DoD Fire Academy uses the system to train students learning HAZMAT emergency response procedures.

Army. The impact is expected to be minimal due to the multi-band tuning capability of the equipment used, geographic dispersion of the requirements, the generally less populated areas of operation. The Army has permanent frequency assignments in the 216-220 MHz band. The Army uses frequencies in this portion of the spectrum for tactical training communications; research, development, test and evaluation support; test range timing; beacon, and telemetry; and contingency operations communications.

Energy. The DOE has 295 assignments within this band used primarily for land mobile applications for hazard and environmental compliance, mobile telemetry for wildlife tracking for

TABLE 3-10: SPASUR RADAR LOCATIONS TO BE PROTECTED INDEFINITELY

Transmit Frequency of 216.98 MHz		
Transmitter Location	**Coordinates**	**Protection Radius**
Lake Kickapoo Space Surveillance Station, TX	33E32'N 098E45'W	250 km
Jordan Lake Space Surveillance Station, AL	32E39'N 086E15'W	150 km
Gila River Space Surveillance Station, AZ	33E06'N 112E01'W	150 km
Receive Frequencies of 216.965-216.995 MHz		
Receiver Location	**Coordinates**	**Protection Radius**
San Diego Space Surveillance Station, CA	32E34'N 116E58'W	50 km
Elephant Butte Space Surveillance Station, NM	33E26'N 106E59'W	50 km
Red River Space Surveillance Station, AR	33E19'N 093E33'W	50 km
Silver Lake Space Surveillance Station, MO	33E08'N 091E01'W	50 km
Hawkinsville Space Surveillance Station, GA	32E17'N 083E32'W	50 km
Fort Stewart Space Surveillance Station, GA	31E58'N 081E30'W	50 km

basic ecological research and predicting environmental impacts, and fixed telemetry for seismic monitoring data that is fed into the worldwide seismic network. The systems used by DOE in this band are low power and are generally located away from heavily populated areas. The DOE estimates that the reallocation cost for their telemetry systems, assuming the operations can be re-accommodated in other frequency bands is $1.5 million. DOE low-power seismic operations could be accommodated in the 162-174 MHz or 406.1-420 MHz band. The use of commercial satellite to relay seismic data will also be given consideration.

Interior. The DOI has hundreds of low-power transmitters in use for wildlife telemetry. The seismic monitoring stations used in this band are low powered and are generally located away from heavily populated areas. However, in areas where earthquakes are more prevalent they can be located near populated areas. The DOI estimates that they have an investment of $440,000 in systems that are capable of operating in the 216-220 MHz band. The U.S. Geological Survey (USGS) uses spectrum in the 216-220 MHz band in remote areas of California, Hawaii, and Alaska to operate telemetered seismic networks. USGS operations in this band may be able to continue to operate on a NIB basis since their locations are very remote and their powers are very low. However, if they are unable to operate on a NIB, they will have to relocate to higher frequency bands such as 900 MHz at additional cost.

The DOI states that the final cost of relocating their systems may be orders of magnitude higher depending on the frequency band to which they are moved and the lack of coverage which will result from moving a low band system to a higher band. DOI further states that hundreds of transmitters used to track wildlife are attached to the wildlife and cannot be recalled. Therefore, if this band is auctioned to the private sector, several geographic areas may experience interference until the transmitters have surpassed their useful life. The estimated relocation cost for DOI's wildlife transmitters is $1.8 million. Many of these wildlife telemetry functions can be satisfied in the bands between 32-42 MHz, the 40.60-40.70 MHz band or on the interstitial channels in the 162-174 MHz band if relocation becomes necessary.

Justice and Treasury. The DOJ and Treasury use this band for the operation of low-power audio collection devices. The DOJ estimates that it will cost approximately $7 million to relocate their low-power audio equipment; however, they maintain that the effect on their operations has a much greater impact. Treasury bureaus conduct undercover law enforcement operations to transmit and receive audio and video signals and conduct covert tracking of suspected criminals or packages. Treasury agents and officers use low-powered disguised transmitters to conduct authorized investigations and collect incriminating evidence against criminal enterprises. Based on BBA-97, Treasury has been planning to transition its technical investigative systems and devices to the Treasury allotted frequencies in the VHF LMR band. Initial cost projections, through Fiscal Year 2004, are about $3 million for research and development costs associated with engineering narrowband compliant investigative equipment and $16.5 million for procurement of the transmitters, receivers and repeaters. Total cost estimate, through Fiscal Year 2004, for transitioning from this band is about $19.5 million.

1432-1435 MHz BAND

The 1427-1435 MHz band is used by the Federal Government for military tactical radio relay communications and military test range aeronautical telecommand and telemetering applications. The lower band segment (1427-1432 MHz) is already scheduled for reallocation for exclusive non-Federal use. There is a high estimated investment by the military in equipment capable of operating in this band making reallocation of the entire band for non-Federal use very costly.

This band is allocated for Federal Government fixed and mobile services, and limited primarily to the military. The fixed service is used in support of proficiency training using tactical radio relay systems at specific Army bases. These tactical radio relay systems have broad tuning ranges, which include the 200-400, 600-1000, and 1350-1850 MHz ranges. Mobile use is primarily air-to-ground telemetry and ground-to-air telecommand links to support various operational and testing programs mainly at military electronic test ranges.

Air Force. One major Air Force system that operates in this band is the RAJPO Data Link System (DLS). This system has been described previously. The Air Force also uses this band for drone control, remote control of ordnance handling robots and the data link for the TARS at Cudjoe Key, Florida (about 20 miles west of Key West and over 120 miles from populated areas in mainland Florida).

The Air Force states that if using the RAJPO DLS under the mixed-use reallocation status is found to be feasible, no reallocation cost is anticipated. However, the Air Force states that the close proximity of test ranges in the Southwest of the United States requires using all the available spectrum to prevent interference. If at some point, sharing is determined to be unfeasible, it will cost the DoD tens of millions of dollars to replace the lost functionality. The Air Force adds that since the RAJPO DLS aircraft are used at altitudes as high as 30,000 feet, devices used by the public beyond the bounds of test ranges could experience interference.

The mixed-use reallocation of this band would permit the Air Force drone control and remote control ordnance handling robot systems operating at Eglin Air Force Base, Florida to continue. If operations are not allowed to continue the robot and drone control links will be replaced. The Air Force did not have a cost estimate to replace the drone control link. The Air Force's data link to control the TARS operates on low power (0.2 watts), with a directional antenna, and remote location, thus, the Air Force believes that there is a minimal possibility to cause interference or to constrain any future commercial services if the band is reallocated on a mixed-use basis.

Navy. The 1427-1435 MHz band is used for proficiency training using various guided weapon systems by the Navy. The weapon systems and supporting data links that operate in this band include: the AWW-13 Advanced Data Link, Walleye, and SLAM. The Navy inventory currently includes approximately 200 AWW-13's, 800 SLAM, and 7,800 planned Joint Standoff Weapon Unitary variant (JSOW Unitary) weapons.

Compounding the problem are weapons in development that are planning to use the AWW-13, including the JSOW Unitary, and Expanded Response. The AWW-13 requires spectrum for both command and video functions. The Navy estimates that they have an investment cost of $567 million in equipment capable of operating in the 1432- 1435 MHz band.

The Navy states that the complete loss of the 1432-1435 MHz band segment will also affect the operations of missile command and guidance telemetry systems. The lower portion of the band will be completely lost for military use within the United States and Territories in 2008, ultimately affecting weapon system testing and training. The Navy maintains that the only other channels available for test and training use are in the 1432-1435 MHz portion of the band, which has not been used for training to date to minimize the probability of compromising the full capabilities of the weapon systems. The Navy states that the missiles in their inventory have factory-fixed frequencies of operation within the 1432-1435 MHz band segment and their expected service life runs well into this century.

For the weapon and data link systems, the Navy identified three options for dealing with the loss of the 1432-1435 MHz band: 1) change the frequency band of operation for the AWW-13 and associated weapons; 2) develop a new digital video link with frequency agility or spread spectrum techniques and apply advanced compression techniques; and 3) modify an existing radio or data link system to meet weapon data link requirements. The Navy indicates that all of these options will require significant financial and technical investments for development and retrofit of both weapon and pod subsystems. The Navy estimates that development time will take two to five years depending on the alternatives considered with retrofit taking several additional years. The Navy believes that these options would also result in a negative impact on weapons acquisition and maintenance budgets and weapon inventory readiness.

The Navy also indicates that the loss of this band for missile command operations will render their systems more susceptible to jamming effects and will impair their terminal guidance. The Navy estimates that the costs associated with the reallocation of this spectrum to accommodate missile control systems and precision strike operations will be in the tens of millions. This estimate assumes that suitable spectrum will be available for relocation such that current equipment can be re-tuned and that extensive system modifications will not be required to operate on new frequencies or to avoid interfering with new commercial users.

Army. The Army uses this band for tactical radio relay. This band is also used for aeronautical telemetry on the Army test ranges. The major impact to the Army is to the operations and training due to the reduction in number of available channels within the tuning range of the tactical radio relay equipment and Army training installations not being on the list for continued service or protection. The tactical radio relay equipment is critical to the wide area network because it provides the link connectivity between nodal centers of the area communications network system of the MSE and TRITAC. Although the tactical radios tune between the 1350-1850 MHz frequency range only a small fraction of the total 500 MHz is authorized for use. Prior to OBRA 93 the Army could use 195 MHz out of the 500 MHz. After OBRA 93 and BBA 97, the Army lost a total of 63 MHz from the 195 MHz, a 32 percent loss.

Frequencies in the 1432-1435 MHz band are deemed by Army as critical to the configuration and operations of the MSE and TRITAC equipment because of the nature of the duplex operations of the radio system that require pairing these low frequencies with higher band frequencies in the 1755-1850 MHz band. The lower bands available for duplex operations were 55 MHz but were reduced by 18 MHz from the loss of 1390-1400 MHz, 1427-1432 MHz, and 1432-1435 MHz.

Although Federal systems will continue to operate indefinitely on frequencies in the 1432-1435 MHz band at selected sites to protect essential operations, not all of the major Army installations and training locations are included on the protected sites. The greatest impact will be on Army training facilities with large, high-bandwidth radio relay requirements such as Ft. Bragg, Ft. Campbell, Ft. Drum, Ft. Hood, Ft. Lewis, Ft. Gordon, Ft. Richardson, Ft. Wainwright, Schofield Barracks, and for the National Guard and Reserve training areas and units having high-data rate radio relay requirements outside of the Army installations.

The Army has permanent assignments recorded in this band. However, the bulk of the Army assignments are temporary assignments from the tactical radio relay equipment during training and operations that are not recorded in the national database as are the permanent assignments. The training and operational exercises are situational and vary in size and typically the number of tactical assignments can range in the tens to the hundreds per exercise.

Energy. The DOE also uses this band for warehouse materials management and range airborne telemetry at the Nevada Test Site. DOE estimates that the cost to re-accommodate the warehouse materials management and range telemetry systems would be $300,000.

In balancing the public benefit and impact (mission and cost) to the Federal Government, the 1432-1435 MHz band was reallocated for non-Federal use on a mixed-use basis. This will preserve the investment made by the Federal Government and permit essential military operations to continue, while making additional spectrum available for the development of commercial wireless applications. However, essential military airborne operations at the sites listed in Table 3-11 and their associated airspace will be protected indefinitely.

2385-2390 MHz BAND

The 2385-2390 MHz band is a part of the larger 2360-2390 MHz band that is used in conjunction with the 1435-1525 MHz band for aeronautical telemetry (ATM) functions. The 2360-2390 MHz band is allocated on a primary basis to the Federal Government for the mobile and radiolocation services. Specifically, for aeronautical flight test, radars used for scientific observation, and telemetry in support for commercial launch vehicles. The military uses this band to support telemetry in the flight testing of aircraft, spacecraft, and missiles at nine major military test ranges and numerous test facilities. The use of flight test telemetry is the only way to insure that the DoD accepts a fully tested quality product. This band is used to support such programs as the F-22, the Joint Strike Fighter, B-1, B-2, F-18 E/F, and the Ballistic Missile Defense Program. To minimize the operational impact on flight test programs that are ongoing and planned to begin in the near future continued Federal use of the 2385-2390 MHz band at the selected sites listed in Table 3-12 will continue for two years after the scheduled reallocation date (2005).

NASA has two test centers that use the 2360-2390 MHz band in conjunction with the Scientific Balloon Program and the Aeronautical Telemetry Program for unmanned air vehicle. The Scientific Balloon Program currently conducts 12 to 16 flights per year. NASA’s use of the band for aeronautical telemetry averages two to four hours per day, however, it is anticipated that the total usage will increase.

NASA states that the loss of any portion of the 2360-2390 MHz band will impact the Scientific Balloon Program, which is a joint program with the Canadians. NASA states that the

TABLE 3-11: SITES AT WHICH FEDERAL SYSTEMS IN THE 1432-1435 MHz BAND WILL BE PROTECTED INDEFINITELY

Location	Coordinates	Protection Radius
China Lake/Edwards AFB, CA	35E29' N 117E16' W	100 km
White Sands Missile Range/Holloman AFB, NM	32E11' N 106E20' W	160 km
Utah Test and Training Range/Dugway Proving Ground/Hill AFB, UT	40E57' N 113E05' W	160 km
Patuxent River, MD	38E17' N 076E24' W	70 km
Nellis AFB, NV	37E29' N 114E14' W	130 km
Fort Huachuca, AZ	31E33' N 110E18' W	80 km
Eglin AFB, Tyndall AFB, FL/Gulfport ANG Range, MS/Fort Rucker, AL	30E28 'N 086E31' W	140 km
Yuma Proving Ground, AZ	32E29' N 114E20' W	160 km
Fort Greely, AK	63E47 'N 145E52' W	80 km
Redstone Arsenal, AL	34E35' N 086E35' W	80 km
Alpene Range, MI	44E23' N 083E20' W	80 km
Camp Shelby, MS	31E20' N 089E18' W	80 km
AUTEC [a]	24E30' N 078E00' W	80 km
MCAS Beaufort, SC	32E26' N 080E40' W	160 km
MCAS Cherry Point, NC	34E54' N 076E53' W	100 km
NAS Cecil Field, FL	30E13' N 081E53' W	160 km
NAS Fallon, NV	39E30' N 118E46' W	100 km
NAS Oceana, VA	36E49' N 076E01' W	100 km
NAS Whidbey Island, WA	48E21' N 122E39' W	70 km
NCTAMS, GUM [a]	13E35' N 144E51' E	80 km
Lemoore, CA	36E20' N 119E57' W	120 km
Naval Space Operations Center, ME	44E24' N 068E01' W	80 km
Savannah River, SC	33E15' N 081E39' W	3 km

a This site is located outside of the continental United States.

new transmitters purchased for the Scientific Balloon Program are multi-band and tunable over the entire 2300-2399.5 MHz band. However, NASA believes that the congestion that currently exists in the band will make it impossible to relocate this activity and that other spectrum will have to be found. NASA states that unavailability of spectrum will mean the loss of three flights per year from resulting from inadequate ground support or not having options to avoid frequency conflicts. NASA states that the direct impact could be expected during the heaviest flight schedule periods of March through October each year. NASA maintains that because of the time- sensitive nature of many of these experiments, delays resulting from the loss of spectrum will probably have the impact of tarnishing the reliability of the scientific balloon support capabilities.

The DOE uses this band for an airborne ranging system that supports Sandia National Laboratory research and development at Edwards AFB, California and in New Mexico.

Cornell University operates the NAIC under a cooperative agreement with NSF. NAIC in turn, operates a megawatt planetary research radar occupying 20 MHz of bandwidth centered at 2380 MHz as part of the $100 million Arecibo Observatory in Puerto Rico. It is the world's largest radio telescope and radar station. Radar echoes from objects such as comets, planets, and the Moon contain information about surface properties, orbit and object size. This enables controllers, for example, to guide spacecraft accurately to specific positions on other planets. The Arecibo Planetary Radar is also used to keep track of space debris, and to detect minor objects in the solar system. It is one of the only two such facilities, the other being part of NASA's Deep Space Network, at Goldstone, California. Some bi-static radar applications require simultaneous operations at both facilities.

Specific impact of the reallocation of the 2385-2390 MHz band on the Federal agencies is presented below.

Air Force. The Air Force states that reallocation of the 2385-2390 MHz band will cost them hundreds of millions of dollars for their major test ranges. Their estimate assumes that suitable spectrum will be available for relocation such that current equipment can be re-tuned and that extensive system modifications will not be required to operate on new frequencies or to avoid interfering with new commercial users. If replacement of major systems is required, relocation costs will be significantly higher.

Navy. The Navy states that the loss of the 2385-2390 MHz band will result in program slippages that will impact their ability to test and field aircraft weapon systems. The Navy maintains that losing this additional spectrum will delay the F-18 E/F test and evaluation program as well as other projects at major test ranges. The Navy estimates that the total reallocation cost will exceed $100 million. This estimate assumes that suitable spectrum will be available for relocation such that current equipment can be re-tuned and that extensive system modifications will not be required to operate on new frequencies or to avoid interfering with new commercial users. If replacement of major systems is required, relocation costs will be significantly higher.

TABLE 3-12: SITES AT WHICH FEDERAL AND COMMERCIAL SYSTEMS IN THE 2385-2390 MHz BAND WILL CONTINUE TO OPERATE UNTIL 2007 [a]

Location	Coordinates	Radius of Operation
Yuma Proving Ground, AZ	32E54' N’ 114E20' W	160 km
Nellis AFB, NV	37E48' N 116E28' W	160 km
White Sands Missile Range, NM	32E58' N 106E23 W	160 km
Utah Test Range, UT	40E12' N 112E54' W	160 km
China Lake, CA	35E40' N 117E41' W	160 km
Eglin, AFB, FL	30E30' N 86E30' W	160 km
Cape Canaveral, FL	28E33' N 80E34' W	160 km
Seattle, WA	47E32' N 122E18' W	160 km
St. Louis, MO	38E45' N 90E22' W	160 km
Palm Beach County, FL	26E54' N 76E25 W	80 km
Barking Sands, HI [b]	22E07' N 159E40' W	160 km
Roosevelt Roads, PR [b]	18E14' N 65E38' W	160 km
Glasgow, MT	48E25' N 106E32' W	160 km
Edwards AFB, CA	34E54' N 117E53' W	100 km
Patuxent River, MD	38E17' N 76E25' W	100 km
Wichita, KS	37E40' N 97E26' W	160 km
Roswell, NM	33E18' N 104E32' W	160 km

[a] The DoD has raised concerns about the need to include additional military sites in this band. NTIA and will assess the need to include additional sites and work with the FCC during the reallocation process to insure that disruption to critical military operations is minimized.

[b] This site is located outside of the continental United States.

Army. The Army also uses this band for a variety of in-flight telemetry and other telemetry uses. The Army states that their use will be accommodated in the remaining telemetry spectrum, but programs will be more expensive due to more testing time required to gather data. The Army estimates that the reallocation cost for the 2385-2390 MHz band segment will exceed $20 million.

This estimate assumes that suitable spectrum will be available for relocation such that current equipment can be re-tuned and that extensive system modifications will not be required to operate on new frequencies or to avoid interfering with new commercial users. If replacement of major systems is required, relocation costs will be significantly higher.

The military has a continuing need to flight test operational, as well as developmental aircraft. The loss of spectrum will cause a decrease in the number of simultaneous test flights that can occur. This creates additional costs for the flight test programs. Programs that may incur increased costs or delays include the F22, Airborne Laser, F-16, F-15, B-1, B-2, B-52, and Joint Strike Fighter Programs.

National Aeronautics and Space Administration. NASA states that their ATM Program would also suffer as a result of losing more spectrum in the 2360-2390 MHz band. NASA maintains that losing more spectrum without identifying spectrum to replace it is only delaying the problem to a time when it will become more serious because projects are going to higher data rates and higher resolution video. NASA states that studies on data compression have shown only minimal gains in bandwidth resolution which will not come close to keeping up with the increases in bandwidth requirements for ATM. NASA states that the transmitters used in their ATM Program are tunable, and if they are able to re-tune within the same band the estimated reallocation cost will be minimal.

Energy. The DOE states that their airborne ranging system has an 11 MHz bandwidth, with the ground uplink operating at 2315.48 MHz and the airborne downlink operating at 2379.8 MHz. The DOE states that the reallocation of the 2385-2390 MHz band will not cause a substantial impact to the airborne downlink if: 1) the authorized bandwidth can be reduced slightly from 11 MHz to 10.4 MHz and 2) the new private sector service has equipment that is not susceptible to relatively low-level emissions from the adjacent band. The DOE believes that since small frequency adjustments can be made to their system there should be no substantial impact.

In balancing the public benefits and the impact to the Federal Government, the 2385-2390 MHz is reallocated for exclusive non-Federal use in 2005. The Federal Government will retain the rest of the band (i.e., 2360-2385 MHz) to satisfy current and future ATM flight test spectrum requirements. A large majority of the equipment that operates in the 2360-2390 MHz band is tunable providing a great deal of flexibility within the band. The loss of this spectrum will have an impact on simultaneous ATM flight test operations at some test ranges. To provide protection to the Arecibo Planetary Radar, airborne transmissions and space-to-Earth transmissions will be prohibited in Puerto Rico.

In order to provide adequate time for engineering studies on spectrum efficient modulation techniques, budgeting, and modification of equipment it will require until 2005 to reallocate this band for non-Federal use. To minimize the operational impact on flight test programs that are ongoing or planned to begin in the near future, continued Federal and commercial use of the 2385-

2390 MHz band at the selected sites in Table 3-12 will continue for two years after the scheduled reallocation date.

Reallocation Costs Summary of Bands Reallocated Under BBA-97

Every effort has been made to insure that the bands identified for reallocation under BBA-97 meet the band selection criteria of Title III. However, the displaced Federal functions resulting from the reallocation must, in most cases, be preserved at a considerable cost to the Federal Government. The Federal agencies maintain that, in order to meet the time constraints of Title III of BBA-97, it is only possible to provide preliminary reallocation costs estimates since accurate data will require extensive cost and engineering analysis. Furthermore, the task of estimating reallocation costs becomes more complex as available spectrum continues to diminish. Table 3-13 summarizes the Federal reallocation costs for each of the affected Federal agencies.

TABLE 3-13: ESTIMATED REALLOCATION COSTS SUMMARY FOR SPECTRUM REALLOCATED UNDER BBA-97

Federal Agency	Frequency Band (MHz)	Estimated Reallocation Costs [a]
DoD	216-220, 1432-1435, 2385-2390	$165-$363 million [b]
Energy	216-220 & 1432-1435	$2 million
Interior	216-220	$2 million
Justice	216-220	$7 million
NASA	2385-2390	$4 million
Treasury	216-220	$20 million [c]
TOTAL		$200-$398 million

[a] These estimated reallocation costs are reimbursable in pursuant to the National Defense Act for FY1999.

[b] A revised and combined reallocation costs for the Department of Defense (i.e., Army, Navy, and Air Force) is provided in the DoD Letter Report to the Chairman of the Committee on Armed Services of the United States Senate (The Hon. Strom Thurmond), Dec. 16, 1999 (see Appendix B). However, due to some reclaimed spectrum (i.e., 139-140.5 MHz, 141.5-143 MHz, and 1385-1390 MHz bands) the ***total*** DoD estimated reallocation costs for BBA-97 is adjusted to $165-$363 million.

[c] This is a revised reallocation cost from the $4 million specified in the NTIA Spectrum Reallocation Report (Response to BBA-97).

In December 1998, the DoD provided the Chairman of the Committee on Armed Services of the Senate, the Honorable Strom Thurmond, with a report detailing the DoD's reallocation costs impacts on both the OBRA-93 and BBA-97 legislation. This report is in response to Section 1064 of the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999. As a result of the reallocation costs study provided by DoD in this report and due to the reclamation of some bands that were reallocated under BBA-97, the reallocation costs estimate originally specified in the NTIA report in 1997 has been modified as shown in the table below.

OVERALL ESTIMATED REALLOCATION COSTS SUMMARY

The overall estimated reallocation costs includes costs for all frequency bands reallocated under OBRA-93 and BBA-97, notwithstanding some bands were reclaimed by the President for continued Federal use. In pursuant to the National Defense Act for Fiscal Year 1999, private sector entities are required to reimburse Federal users for relocations due to reallocation of spectrum assignments through competitive bidding. Further, the legislation sets forth that spectrum reallocated under BBA-97 and the 1710 1755 MHz band, which was reallocated under OBRA-93, are subject to mandatory reimbursement.

Table 3-14 provides the overall estimated reallocation costs summary, including the reimbursable and non-reimbursable relocation costs. Note that in the 1390-1400 MHz band and, specifically, in the 1710-1755 MHz band, some agencies have already started the relocation process well before the enactment of the Defense Act for Fiscal Year 1999. Since, the expended costs during this relocation process were Congressionally appropriated funds, these expended costs are non-reimbursable, as can be seen in Table 3-14.

POTENTIAL PUBLIC BENEFITS FROM REALLOCATED SPECTRUM

Under the requirements of Title VI of OBRA-93, the Secretary of Commerce submitted a report to the President, the Congress, and the FCC identifying and recommending for reallocation bands of frequencies that are the most likely to have the greatest potential for productive uses and public benefits under the Communications Act of 1934, as amended, if allocated for non-Federal use.

The report identified the following factors in Section 113 of Title VI of OBRA-93, which have been used to address the public benefits of reallocating Federal Government spectrum (*see* NTIA Special Publication 95-32): a) the extent to which equipment is or will be available that is capable of utilizing the band; b) the proximity of frequencies that are already assigned for commercial or other non-Federal use; c) the extent to which, in general, commercial users could share the frequency with amateur radio licensees; and d) the activities of foreign government in making frequencies available for experimentation or commercial assignments in order to support domestic manufactures of equipment. These were some of the key factors in the final identification of the reallocated spectrum in pursuant to OBRA-93.

Similarly, the criteria of Title III of BBA-97 in identifying spectrum for reallocation involves consideration of two overriding and sometimes conflicting factors: (1) the impact on the Federal agencies, in terms of mission, costs, and potential reduction of services to the public, and (2) the benefits expected to be realized by the public. In complying with the requirements and band selection criteria of Title III, the selected spectrum for reallocation, in pursuant to BBA-97, established a reasonable balance between these criteria, among other things.

This subsection provides the potential benefits that the public may realize (or may have already realized) due to the reallocation of spectrum, as conjectured in the FCC's Policy Statement Paper,[10] and other FCC and NTIA documents. The FCC paper was the main source of information upon which the discussion on public benefits evolved that, in some cases, entire paragraph were extracted from this paper and presented herein. Usually, a band-by band presentation delineating these public benefits is preferred, however, in some cases where bands are paired to maximize the potential benefits to the public, they are grouped to facilitate a simpler discussion. Note that only spectrum reallocated under the mandates of OBRA-93 and BBA-97 are discussed below.

216-220 MHz Band

This band was originally allocated on a shared basis to the Government and non-Government for various radio services. This band was reallocated to the non-Government on a mixed-use basis in pursuant to BBA-97. Currently, this is one of the bands that the Commission has not made any proposed allocation for additional services. The 218-219 MHz portion of the band has already been auctioned for Interactive Video and Data Service operations. In addition, the band has a potential for new non-Federal fixed and mobile communications services. This band could also be used as an expansion to the existing non-Federal services.

1390-1400 MHz, 1427-1432 MHz, and 1432-1435 MHz Bands

A number of parties, including the Land Mobile Communications Council (LMCC) have expressed a need for additional spectrum for private land mobile use.[11] Private land mobile radio

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10 The FCC Statement Policy, *Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millennium*, (November 18, 1999).

11 *Id*. at 11.

TABLE 3-14 OVERALL ESTIMATED REALLOCATION COSTS SUMMARY FOR SPECTRUM REALLOCATED UNDER OBRA-93 AND BBA-97

	FREQUENCY BANDS (MHz)											
	NON-REIMBURSABLE (Millions)								REIMBURSABLE (Millions)			
Agency	1390-1400	1427-1432	1670-1675	1710-1755	2300-2310	2390-2450	3650-3700	4940-4990	216-220	1432-1435	1710-1755	2385-2390
USDA											$48	
DOE									$1.5	$0.3	$3	
DOC			$35-55									
DoD [a]	$152-$272	$23				$51			$0.37-$1	$44-$147	$38-$138	$120-$215
DOI									$2		$8-13	
DOJ				$132 [b]					$7		$55	
NASA											$1	$4
TREA									$20 [c]		$4-46 [d]	
TRAN	$35 [e]			$43 [e]							$109	
Total Non-Reimbursable = $471 - $611									Total Reimbursable = $465-$811			

[a] The DoD reallocation costs were derived from the DoD Letter Report to the Chairman of the Committee on Armed Services of the United States Senate (The Hon. Strom Thurmond), Dec. 16, 1998.

[b] Through FY2000, $32 million has already been expended by DOJ in converting fixed microwave systems to leased wireline. The $32 million was a Congressionally appropriated fund.

[c] This is a revised reallocation cost from the $4 million specified in the NTIA Spectrum Reallocation Report (Response to BBA-97).

[d] This is an updated cost recently provided by the Treasury. The higher cost is based on whether the Rainbow Microwave System in Hawaii, which is currently on the protected list, is subject to reimbursement.

[e] FAA has already expended $12.7 million, as of July 2000, in relocating radars from the 1390-1400 MHz band and $43 million in relocating fixed microwave systems from the 1710-1755 MHz band. The $ 12.7 and $43 millions were Congressionally appropriated funds.

systems are used by business to meet their specialized mobile communications requirements. The LMCC requests additional spectrum to relieve congestion in the existing private land mobile radio bands and to provide opportunities for use of new, spectrum efficient technologies that would improve and enhance business radio communications. To provide benefits to private land mobile users, the Commission considered establishing a new Land Mobile Communications Service in 15 MHz of spectrum, of which 10 MHz would be derived from the 1390-1395 MHz, 1427-1429 MHz and 1432-1435 MHz bands.[12] The Commission has stated that these bands, while not contiguous, are sufficiently close together to allow manufactures to design cost effective equipment.

Another group that might benefit from the reallocation of these bands from the Federal Government to non-Government use is the little Low Earth Orbit (LEO) satellite group. LEO satellite operators are seeking spectrum for feeder links in the region of this spectrum. As such, the Commission will consider the impact of allocations for other services on the possible use of these bands for little LEO feeder links.

The other five MHz portion of the 1390-1400 MHz band (i.e., 1395-1400 MHz) and the three MHz portion of the 1427-1432 MHz band (i.e., 1429-1432 MHz) are planned for allocation to a new wireless service. The potential beneficiaries of these bands are the new Wireless Medical Telemetry Service providers as well as the users. This service will enhance the ability of health providers to offer high quality and cost-effective care to patients with acute and chronic health care needs.[13]

1670-1675 MHz and 2385-2390 MHz Bands

The Commission intends to consider allocating the 10 MHz of spectrum at 1670-1675 MHz and 2385-2390 MHz bands for fixed and mobile services and adopt appropriate service rules to permit licensees flexibility in the types of service to be offered and the technologies used to provide those services. The planned reallocation of these bands would provide additional spectrum for expanded development of new services and technologies that may emerge.

1710-1755 MHz Band

The Commission is considering to benefit providers of a new flexible-use service available for fixed and mobile wireless services by providing a major allocation of 90 MHz for the

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12 *Id.*

13 FCC Notice of Proposed Rule Making, ET Docket 99-255, FCC 99-182, as adopted July 14, 1999.

Advanced Mobile and Fixed Communications Service (AMFCS).[14] Forty five (45) MHz of which will come from the 1710-1755 MHz band and the rest from non-Government bands. One possible use of this spectrum would be for the introduction of future "third generation" mobile telecommunications systems, also known as the IMT-2000. This would provide telecommunications services on a worldwide scale regardless of locations, network, or terminal used. The Commission believes that this allocation would provide sufficient bandwidth to support commercial AMFCS.

2300-2310 MHz, 2400-2402 MHz and 2417-2450 MHz Bands

The Commission identified 40 MHz of spectrum from the 2300-2305 MHz, 2400-2402 MHz, and 2417-2450 MHz bands as the new reserve bands. These bands were designated by the Commission to replace the 20 MHz of spectrum that they identified earlier. Therefore, the potential benefit for the public, in this case, could not yet be realized as these bands are placed in the new reserve category.

Note, that, the 2305-2310 MHz portion of the 2300-2310 MHz band has generally been transferred from the Federal Government use that became a part of the total 30 MHz allocated to the WCS for licensing that was auctioned in April 1997. As such, wireless communications providers have already benefitted from the allocation of this portion of the band.

2390-2400 MHz and 2402-2417 MHz Bands

As mentioned earlier, the Commission made the 2390-2400 MHz available for use by unlicensed PCS devices and it provided continued use of the 2402-2417 MHz band by Part 15 devices, and allocated both bands to the Amateur Radio Service. The groups that benefitted from the allocation of this 25 MHz of spectrum were the users and/or providers of unlicensed PCS data and Part 15 devices. However, the amateur radio operators also benefitted because their use of these bands was upgraded from secondary to primary use. These bands might not be auctioned due to the existing services in the band (e.g., amateur service, Part 15 devices), including Industrial, Scientific, and Medical (ISM) equipment.

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[14] The FCC Statement Policy, *Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millennium*, (November 18, 1999).

3650-3700 MHz Band

This band has been proposed by the Commission for reallocation to the fixed service.[15] Because of the contiguous spectrum and a fairly large bandwidth (i.e., 50 MHz), the full potential benefits to the public are great, especially if the entire band is offered for license as a single 50 MHz block of spectrum on either nationwide or large regional service area basis. This 50 MHz of spectrum could provide a range of new fixed point-to-point and point-to-multipoint services that could directly link residences, business, and other fixed locations to an ever-developing array of networks. Through these new links, traditional voice telephony and a wide variety of new broadband, high-speed, data and video services, such as Internet access and video conferencing, could be delivered to homes and small businesses.

This new fixed service may thus lead to new and more effective competition to existing wireline local exchange carrier services by providing for an economical means to offer competitive "local loop" or "last-mile" facilities. One such service that could directly benefit from the reallocation of this band is Fixed Wireless Access Service. Broadband satellite services are also potential beneficiaries from the reallocation of this band, specifically for tracking, telemetry, and control functions.

4940-4990 MHz Band

In establishing GWCS in August 1995, the Commission concluded that authorizing a wide variety of fixed and mobile services bounded only by international allocations comported with the Commission's statutory authority and served the public interest by fostering the provision and mix of services most desired by the public. In keeping with this conclusion and based on the spectrum swap, the Commission proposes to allocate the 4940-4990 MHz band to the non-Federal fixed and mobile services, except aeronautical mobile service, on a primary basis. Specifically, the Commission proposes that licenses in this band will be authorized to provide any fixed, land mobile, or maritime mobile service, but not aeronautical mobile service. In proposing this broad allocation, the Commission seeks to ensure that the spectrum is put to its best and most valued use and that the greatest benefit to the public is attained.

An example of a potential beneficiary of this band could be those that provide Internet services. Already, in November 1999, an Internet service provider called Global, filed a petition requesting that the Commission, among other things, designate the 4940-4990 MHz band for GWCS.

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[15] FCC Notice of Proposed Rule Making and Order, ET Docket No. 98-337, *Amendment of the Commission's Rules with Regard to the 3650-3700 MHz Government Transfer Band*, as adopted on December 17, 1998.

SECTION IV
ANTICIPATED IMPACT OF POTENTIAL FUTURE ALLOCATIONS

INTRODUCTION

The allocated radio spectrum extends up to 300 GHz and accommodates 33 authorized radio services. It is estimated that within these radio services over thousands of distinct categories of radiocommunications systems are operated, many of which are used by the Federal Government in varying degrees. It is beyond the scope and intent of this report to provide an in-depth evaluation of the potential impact that future potential reallocations might have on this vast number of systems. Reallocation cost impact is also beyond the scope of this analysis. To consider reallocation cost, a number of factors have to be known; first and foremost, what frequencies or frequency bands are being reallocated and, second, where in the radio spectrum are the reallocated operations to be moved. Other factors that have to be considered include: date of required allocation; extent of Federal use of such frequency bands; potential frequency sharing scenarios (if feasible); date of actual relocation of Federal systems; total cost of new equipment or re-design of existing equipment; and others. At this time, these factors are not known.

Alternatively, this study focused exclusively on the operational/mission impact on the major systems of the three critical areas defined in the NDAA-2000, namely: national defense; Federal public safety; and civil space programs. In subsequent paragraphs, the major programs/systems of the three critical areas are presented and discussed, including the radio frequency requirements that support these systems.

CIVIL SPACE PROGRAMS/SYSTEMS

On August 8, 1997, the President signed into law BBA-97 which required the FCC, among other actions, to reallocate 15 MHz of spectrum within the 1990-2110 MHz band for reallocation and assignment by competitive bidding. NTIA conducted a study to determine the potential impact to Federal systems operating in the 1990-2110 MHz band.[1] A result of the study indicated that substantial use of the 2025-2110 MHz portion of the 1990-2110 MHz band is made by Federal agencies, specifically NASA and NOAA, in the execution of civil space programs goals and objectives. In particular, the 2025-2110 MHz band was found to be used in the United States as the primary backbone communications link for the National Space Programs within NASA and NOAA. Some of the major space systems/programs supported in this band are the National Space Transportation Program (Space Shuttle), International Space Station Program, Hubble Space Telescope, Tracking and Data Relay Satellite, Spaceflight Tracking and Data Network, Deep Space

[1] Cerezo, E., *Reallocation Impact Study of the 1990-2110 MHz Band*, NTIA Special Publication 98-37, U.S. Department of Commerce, November 1998.

Network, the Geostationary Operational Environmental Satellite, Landsat, Polar-orbiting Environmental Satellite Systems and numerous other scientific programs. The study also indicated a substantial investments by NASA and NOAA of over $80 billion in this band. In addition, it was determined by the Office of Management and Budget (OMB) that reallocation of spectrum in this band would result in substantial costs to be incurred in the relocation of existing space assets of NASA and NOAA to other frequency bands. Consequently, the 2025-2110 MHz portion of the 1990-2110 MHz band was not considered by the FCC for assignment by competitive bidding. Alternate bands as substitution for the 15 MHz of spectrum from the 1990-2110 MHz band were provided and discussed in a NTIA Special Publication Report.[2] Thus far, the mandates of OBRA-93 and BBA-97 have minimal impact on the civil space programs of NASA and NOAA.

NASA's Space Programs/Systems

NASA's requirements for access to the radio frequency spectrum began with the formation of the agency in 1958 and have evolved and grown over the last 40 years to include a very wide array of programs and applications. Virtually every endeavor undertaken by the agency demands communications or data transfer via the radio spectrum.

Today and in the coming years, NASA will implement programs to achieve missions encompassing space exploration, scientific research, and technology development. These initiatives are required in response to directives prescribed in two Administration policy documents. These are the National Space Policy[3] and the Goals for a National Partnership in Aeronautics Research and Technology.[4]

In order to achieve agency goals, NASA has developed the Policy Directive-1000.1A NASA Strategic Plan 1998 with 1999 interim adjustments. This plan outlines the questions which must be answered and the goals to be achieved for NASA to be responsive to administration and legislative policy directives.

The following sections provide a discussion of the Agency's radio spectrum requirements in order to support its overall mission objectives. The discussion is broken down along the Agency's three major initiatives: a) space exploration; b) scientific research; and c) aeronautics and space technology development.

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2 Hurt, G. and Cerezo, E., *Identification of Alternate Bands*, NTIA Special Publication 98-39, U.S Department of Commerce, November 1998.

3 NASA's National Science and Technology Council, September 19, 1999.

4 National Science and Technology Council, Office of Science and Technology Policy, Executive Office of the President, Washington, DC 20500, September 11, 1995.

Space Exploration

NASA seeks to open the space frontier by exploring, using and enabling the development of space, and to expand the human experience into the far reaches of the solar system. In exploring space, NASA brings together a wide range of technologies, machines, and people to conduct supporting missions in the development of such programs as the Space Shuttle, the Tracking and Data Relay Satellite System (TDRSS) and the International Space Station (ISS). These programs require extremely complex and critical radio frequency sub-system components which currently include frequencies from about 100 MHz up to more than 30 GHz. As the exploration of space continues and evolves, additional spectrum will be required to support the full development of the ISS and to further the Agency's goals of Lunar and Martian exploration.

Tracking and Data Relay Satellite System (TDRSS)

Existing Constellation. The TDRSS is a communication signal relay system which provides tracking and data acquisition services between low Earth orbiting spacecraft and NASA/customer control and/or data processing facilities. The system is capable of transmitting to and receiving data from Earth orbiting spacecraft over at least 85 percent of the spacecraft's orbit.

The TDRSS space segment consists of six on-orbit Tracking and Data Relay Satellites (TDRSs) located in geosynchronous orbit. Three TDRSs are available for operational support at any given time. The operational spacecraft are located at 41, 174, and 275 degrees West longitude. The other TDRSs in the constellation provide ready backup in the event of a failure to an operational spacecraft.

The TDRSS ground segment is located near Las Cruces, New Mexico, and consists of two functionally identical ground terminals named Cacique and Danzante, known collectively as the White Sands Complex (WSC). Customer forward data is up-linked from the ground segment to the TDRS and from the TDRS to the customer spacecraft. Customer return data is down-linked from the customer spacecraft via the TDRS to the ground segment and then on to the customer designated data collection location.

Follow-on Constellation. TDRS-H, launched June 30, 2000 is the first of three newly designed TDRS satellites that will help replenish the existing on-orbit TDRS fleet. TDRS-H will augment the system's existing 2-4 GHz (S-band) and 12-18 GHz (Ku-band) frequencies by adding 27-40 GHz (Ka-band) capability, allowing for higher data rates less susceptibility to interference from the increasingly busy radio environment. To support this increased capability, NASA has upgraded the WSC ground stations.

TDRS-I and TDRS-J, to be launched 2002 and 2003, respectively, and TDRS-H will also includes a more capable "multiple-access" system, which can support five user spacecraft simultaneously at higher data rates than the existing TDRS fleet.

TDRSS Mission Support. The following user spacecraft rely on TDRSS to deliver command data to a payload and deliver telemetry data to scientists and operations personnel. The scientists collect and analyze experiment and sensor data, and operations personnel use satellite engineering data to manage the satellite itself.

Current Spacecraft.

Space Shuttle	International Space Station (ISS)
Hubble Space Telescope (HST)	Landsat Program
Upper Atmosphere Research Satellite (UARS)	STARlink
Earth Resources Budget Satellite (ERBS)	Earth Observing System (EOS)
Ocean Topography Experiment (TOPEX)	X-Ray Timing Explorer (XTE)
Extreme Ultraviolet Explorer (EUVE)	GLOBE
Long Duration Balloon Program (LDBP)	ETS-VII
Tropical Rainfall Measuring Mission (TRMM)	Expendable Launch Vehicles (ELVs)
Far Ultraviolet Spectroscope Explorer (FUSE)	

Future Spacecraft/Month-Year.

New Millennium Program Earth Orbiter-1 (NMP/EO-1)/10-2000
Earth Observing System PM (EOS-PM)/12-2000
Microwave Anisotropy Probe (MAP)/04-2001
Galaxy Evolution Explorer (GALEX)/09-2001
Solar Radiation and Climate Experiment (SORCE)/07-2002
Earth Observing System CHEM (EOS-CHEM)/06-2003
SWIFT/09-2003
Vegetation Canopy Lidar (VCL)/To be determined.

TDRSS Spectrum Support Requirements. The current TDRSS supports mission spacecraft through the dependence upon links in the 2-4 GHz and in the 12-18 GHz bands. These frequencies provide for links to and from Earth orbiting mission spacecraft and the Ku portion of the spectrum is used for links between the TDRS satellites themselves and the control facility at White Sands, New Mexico. The radio frequency links of critical importance to the TDRSS are listed in Table 4-1. Included in this Table are links to be provided in the Ka portion of the spectrum for TDRS H, I and J satellites.

International Space Station (ISS)

The ISS Program is the largest scientific cooperative program in world history, drawing on the resources and scientific expertise of 16 nations: the United States, Belgium, Brazil, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, Russia, Spain, Sweden, Switzerland, and the United Kingdom.

TABLE 4-1: CRITICAL TDRSS SPECTRUM SUPPORT REQUIREMENTS

Function	RF Link	Frequency	Bandwidth
S-Band Multiple Access	Forward Return	2106.4 MHz 2287.5 MHz	6 5
S-Band Single Access	Forward Return	2030-2123 MHz 2219-2290 MHz	20 12
Ku Band	Forward Return	13.775 GHz 15.034 GHz	50 225
TDRSS/ White Sands	Uplink Downlink	14.6-15.23 GHz 13.4-14.05 GHz	650 650
Ka Band TDRS H, I and J	Forward Return	22.55-23.55 GHz 25.25-27.5 GHz	TBD TBD

The ISS program will help focus the aerospace industry of Russia and other countries on non-military pursuits; will provide international commercial opportunities for U.S. companies; tap into the Russian's vast experience in long-duration space flight to benefit the international partnership; and serve as a symbol of the power of nations to work together on peaceful initiatives.

The ISS program draws significant financial support from the partner nations, which will collectively add more than $10 billion to the U.S. contribution. The partners from Russia, the European Space Agency, Canada, and Japan have already expended more than $6 billion on their development programs.

<u>ISS Spectrum Support Requirements</u>. Due to the wide range of activities and required support functions concomitant with ISS operations, access to many different radio frequencies is mandatory. Each application within the ISS has its own physical requirements, data rate needs and antenna limitations, all of which drive the choice of radio frequency. Table 4-2 presents critical elements of spectrum utilization for the ISS.

TABLE 4-2: CRITICAL ISS SPECTRUM SUPPORT REQUIREMENTS

(See Table 4-4 for acronyms used in this table)

ISS COMMUNICATION SYSTEM	CENTER FREQUENCY	BANDWIDTH
SSCS (EMU-EMU)	414.2 MHz	1.4 MHz
SSCS (EMU-SSO)	414.2 MHz	1.4 MHz
SSCS (EMU-ISS)	414.2 MHz	1.4 MHz
SSCS (SSO-EMU)	414.2 MHz	1.4 MHz
SSCS (SSO-ISS)	414.2 MHz	1.4 MHz
SSCS (ISS-EMU)	414.2 MHz	1.4 MHz
SSCS (ISS-SSO)	414.2 MHz	1.4 MHz
ACS SSAF (HDR)	2085.6875 MHz	6 MHz
ECOMM SSAF KCA	2106.4 MHz	6 MHz
ECOMM SSAF CMD	2106.4 MHz	6 MHz
ACS SSAR (HDR)	2265 MHz	6 MHz
ACS SSAR (LDR)	2265 MHz	6 MHz
ECOMM SSAR KCA	2287.5 MHz	6 MHz
ECOMM SSAR TLM	2287.5 MHz	6 MHz
KSAF	13775 MHz	6 MHz
KSAR	15003.4 MHz	100 MHz
Ka Band/TDRSS	22.55-23.55 GHz	Not available
Ka Band/TDRSS	25.25-27.5 GHz	Not available
Ka Band/Proximity Link	25.25-27.5 GHz	Not available

National Transportation System (Space Shuttle)

Today's Space Shuttle is less than one-quarter of the way through its design lifetime. It is safer, more capable, and less expensive to fly than ever before thanks to enhancements from new technologies incorporated into the original Shuttle design and improvements to the Shuttle's operation.

Since the first flight of Columbia in 1981, the Space Shuttle has launched more than 2 million pounds of cargo and over 500 passengers into orbit. The Shuttle continues to be the most reliable launch vehicle in the world, with unique capabilities that are unmatched. Each Space Shuttle orbiter was designed for 100 flights, yet the most completed so far are 25 each by Columbia and Discovery.

The annual cost of operating the Space Shuttle has decreased by almost 40 percent when adjusted for inflation. In the next five years, costs are projected to decrease by hundreds of millions more dollars as operations continue to gain efficiency.

During the next 10 years, continued upgrades that take advantage of new technologies are envisioned to achieve long-range goals for the Space Shuttle that include: more than double the estimates of overall Shuttle safety from what they are today; provide the capability to accommodate as many as 15 flights a year; further reduce the time required to prepare a Shuttle for launch by almost two-thirds; and further reduce the cost of launching a pound into orbit on the Shuttle to half of what it is today.

Space Shuttle Spectrum Support Requirements. The nature of the Space Shuttle dictates very unique spectrum support requirements. Of these requirements safety-of-life considerations for the astronauts is foremost. The tasks which must be performed by the Shuttle necessitate several spectrum bands to be utilized. These required bands are listed in Table 4-3.

Spaceflight Tracking and Data Network (STDN)

NASA Spaceflight Tracking and Data Network (STDN) is composed of three major tracking and data system elements: the Space Network (SN); the Ground Network (GN); and the Deep Space Network (DSN). The major SN elements are TDRSS, Second TDRSS Ground Terminal, and the Network Control Center (NCC). The NCC schedules and configures the TDRSS and monitors the status data sent back for ongoing scheduled satellite services. NCC operators schedule emergency services, isolate any problems in the system and restore faulty user services. The NCC has the ability to communicate with, and direct the resources of all other ground tracking stations through the NASA Communications (NASCOM) Network. The NCC manages the total SN, and GN in support of NASA's low Earth orbiting science satellites.

The current GN is comprised of Merritt Island Launch Area/ Ponce De Leon (MIL/PDL), near Cape Canaveral, Florida, USA, and Bermuda Ground Station (BDA), Bermuda, United Kingdom. The GN utilizes NASA's NASCOM to provide telemetry, command, tracking, data flow, and playback services to GN user spacecraft. A small facility for STS air ground communications is also operated at Dakar, Senegal (DKR). Table 4-5 presents the STDN spectrum support requirements.

Scientific Research

Earth Science. Earth Science research at NASA has turned space-based observing technology and scientific expertise to the study of our home planet. Planet Earth is an integrated system of land, ocean, atmosphere, ice, and biological process. From the vantage point of space, we are beginning to understand how they work and how they interact. The questions posed and

TABLE 4-3: CRITICAL SPACE SHUTTLE SPECTRUM SUPPORT REQUIREMENTS

(*See* Table 4-4 for acronyms used in this table)

SSO COMMUNICATION SYSTEM	CENTER FREQUENCY	BANDWIDTH
UHF SSO-EVA	259.7 MHz	2.8 kHz
UHF SSO-EVA	279 MHz	2.8 kHz
UHF SSO-GSTDN	296.8 MHz	3 kHz
UHF GSTDN-SSO	296.8 MHz	2.8 kHz
UHF SSO-AFSCF	296.8 MHz	3.0 kHz
UHF AFSCF-SSO	296.8 MHz	2.8 kHz
UHF SSO-EVA	296.8 MHz	3.0 kHz
UHF SSO-DFRC	296.8 MHz	3.0 kHz
UHF DFRC-SSO	296.8 MHz	2.8 kHz
TACAN SSO-GROUND	1213 MHz	600 kHz
TACAN GROUND-SSO	1213 MHz	600 kHz
AFSCF-SSO	1831.787 MHz	
AFSCF-SSO	1831.787 MHz	150 kHz
SSO-DOD Example	1840 MHz	
GSTDN-SSO	2106.4 MHz	
GSTDN-SSO	2106.4 MHz	3.5 MHz
TDRSS-SSO	2106.4 MHz	
DOD Example-SSO	2297.5 MHz	2.1 MHz
NASA Payload-SSO	2299.8 MHz	2.1 MHz
Radar Altimeter	4300.0 MHz	28.6 MHz
TDRSS-SSO	13775 MHz	6 MHz
TDRSS-SSO	13775 MHz	
Ku-band Radar SSO-Target	13883 MHz	17 MHz
SSO-TDRSS	15003.4 MHz	
SSO-TDRSS	15003.4 MHz	200 MHz
MSBLS SSO-GROUND	15688 MHz	7 MHz
MSBLS GROUND-SSO	15688 MHz	7 MHz
TDRSS-SSO	2106.4 MHz	22.5 MHz
SSO-NASA Payload	2119.8 MHz	36 kHz
SSO-GSTDNDownLink TV	2250 MHz	14.4 MHz
SSO_AFSCF	2250 MHz	10 MHz
EMU-TV-SSO	2250 MHz	40 MHz
SSO-GSTDN	2287.5 MHz	
SSO-GSTDN	2287.5 MHz	3.5 MHz
SSO-AFSCF	2287.5 MHz	
SSO-AFSCF	2287.5 MHz	3.5 MHz
SSO-TDRSS	2287.5 MHz	
SSO-TDRSS	2287.5 MHz	1.2 MHz

TABLE 4-4: LIST OF ACRONYMS USED IN TABLE 4-2 AND TABLE 4-3

Acronym	Function	Comment
SSO	Space Shuttle Orbiter	
EVA	Extra Vehicular Activity	
GSTDN	Ground Spaceflight Tracking & Data Network	
AFSCF	Air Force Satellite Control Facility	
TACAN	Tactical Air Navigation	Use during landing
MSBLS	Microwave Scanning Beam Landing System	Use during landing
EMU	Extravehicular Mobility Unit	EVA suit
SSCS	Space-to-Space Communications System	Provides comm. between SSO & ISS during rendezvous/departure and for EVAs
ACS	Assembly Contingency System (ISS S-band system)	Primary command/telemetry paths between ISS and Ground thru TDRSS
ECOMM	Early Comm System (ISS S-band system)	Activated on flight 2A to provide early command/telemetry capability prior to ACS activation
SSAF/SSAR	S-band Single Access Forward/Return	TDRSS S-band SA services
HDR/LDR	High Data Rate/Low Data Rate	
KCA	Ku-band Communications Adaptor	JSC In-house developed device enabling file transfer capability through the Ku-band system
KSAF/KSAR	Ku-band Single Access Forward/Return	TDRSS Ku SA Services
WVS	Wireless Video System	Portable camera system mounted on the helmet of EMU
LAN	Local Area Network	Internal ISS wireless comm. between laptops
WIS/IWIS/SWIS	Wireless Instrumentation System/ISS WIS/Shuttle WIS	Instrumentation/sensors located on structure – RF link for command/telemetry back to Shuttle/ISS

answers found in this grand scientific inquiry not only satisfy our curiosity, but yield knowledge of substantial practical value to society -- in weather and climate forecasting, in agriculture, in natural resource management, in urban and regional planning, and elsewhere.

NASA's Earth Science endeavors are dedicated to understanding the total Earth system and the effects of natural and human-induced changes on the global environment. NASA is pioneering the new discipline of Earth system science, with a near-term emphasis on global climate change. Space-based and in situ capabilities presently being used or developed yield new scientific understanding and practical benefits to the Nation.

NASA's objectives are to provide the long-term observations of Earth's climate and terrestrial and marine ecosystems and the supporting information system necessary to develop a

TABLE 4-5: STDN SPECTRUM SUPPORT REQUIREMENTS

Function	RF Link	Frequency (MHz)	Bandwidth
Uplink Command/Voice	Mission Control Center - ground station - Shuttle	2106.4063 or 2041.9479	2 MHz
Downlink Telemetry/Voice	Shuttle - ground station - Mission Control Center	2287.5 or 2217.5	5 MHz

comprehensive understanding of how the Earth functions as a unified system. This improved understanding, combined with improvements in predictive Earth system models, will provide government and the public with the basis for scientifically well-founded environmental and resource management policy formulation.

Through 2002, NASA will deploy the Tropical Rainfall Measuring Mission and the first series of Earth Observing System missions including Landsat 7. This period will also see the first launches of Earth System Science Pathfinder small satellite missions for new science and of new millennium program missions for Earth science instrument technology development.

Earth Science Spectrum Support Requirements. In order to support the intermediate and long term goals of understanding the Earth, NASA has developed numerous radio frequency sensors designed to fly onboard spacecraft. These sensors will allow global “pictures” to be taken of the Earth on a daily basis in a wide range of frequencies.

NASA is flying and plans to launch sensors on spacecraft platforms which are both passive and active in nature. Passive sensors emit no energy and are reliant on receiving the emissions of the Earth’s and atmospheric constituent in order to provide a description of the Earth's environment. By virtue of their required operations, passive sensors are particularly prone to radio frequency interference from other emitters. Consequently, if possible, these sensors need exclusive allocations in bands of critical importance.

Active sensors (spaceborne radars) utilize radar bands and provide information on the geological structure of the Earth and the state and movements of the Earth's oceans. Table 4-6 presents a list of applications and required spectrum bands in order to support the goals of Earth Science passive sensing.

Space Science. NASA's Space Science endeavors are intended to examine the mysteries of the universe from origins to destiny, to explore the solar system, to discover planets around

TABLE 4-6: CRITICAL PASSIVE SENSOR SPECTRUM REQUIREMENTS

Frequency (GHz)	Necessary Bandwidth (MHz)	Measurements
1.4-1.427	27[(1)]	Soil moisture, salinity, sea temperature, vegetation index
2.655-2.7	45	Salinity, soil moisture
4.2-4.4	200	Ocean surface temperature
6.425-7.25	800[(2)]	Ocean surface temperature
10.6-10.7	100	Rain, snow, ice, sea state, ocean wind
15.2-15.4	200	Water vapour, rain
18.6-18.8	200	Rain, sea state, ocean ice, water vapour
21.2-21.4	200	Water vapour, liquid water
22.21-22.5	300	Water vapour, liquid water
23.6-24	400	Water vapour, liquid water
31.3-31.8	500	Ocean ice, water vapour, oil spills, clouds, liquid water
36-37	1 000	Rain, snow, ocean ice, water vapour
50.2-50.4	200	Temperature profiling
52.6-59.3	6 700[(3)]	Temperature profiling
86-92	6 000	Clouds, oil spills, ice, snow
100-102	2 000	N_2O
109.8-111.8	2 000	Ozone
114.25-122.25	8 000[(3)]	Temperature profiling, CO
148.5-151.5	3 000	N_2O, Earth, cloud parameters
155.5-158.5[(4)]	3 000	Earth and cloud parameters
164-167	3 000	N_2O, cloud water and ice, rain, CO, ClO
174.8-191.8	17 000[(3)]	Water vapour profiling, N_2O, ozone
200-209	9 000	N_2O, water vapour, ozone
226-231.5	5 500	Clouds, humidity, N_2O, CO
235-238	3 000	Ozone
250-252	2 000	N_2O
275-277	2 000	NO, N_2O
294-306	12 000	NO, ozone, oxygen, HNO_3, HOC1,
316-334	18 000	Water vapour profiling, ozone, HOC1
342-349	7 000	CO, HNO_3, CH_3C1, ozone, oxygen, HOCl
363-365	2 000	Ozone
371-389	18 000	Water vapour profiling
416-434	18000	Temperature profiling
442-444	2 000	Water vapour, ozone[(5)], HNO_3[(5)], N_2O[(5)], CO[(5)]
496-506	10 000	Ozone, CH_3C1, N_2O, BrO, C1O
546-568	22 000	Temperature profiling
624-629	5 000	HC1, BrO, ozone, HC1, SO_2, H_2O_2
634-654	20 000	CH_3C1, HOC1, C1O, water vapour, N_2O, BrO,ozone
659-661	2 000	BrO
684-692	8 000	ClO, CO, CH_3Cl
730-732	2 000	Oxygen, HNO_3
851-853	2 000	NO
951-956	5 000	Oxygen, NO

(1) 27 MHz have been allocated, but the need is for 100 MHz.
(2) A 200 MHz interval is needed in this 800 MHz wide region.
(3) Multiple channels occupy this bandwidth.
(4) This band is needed until 2018 to accommodate existing and planned sensors.
(5) Species to be confirmed.

HNO_3: Nitric acid
HOCl: Hypochlorous acid
CO: Carbon monoxide
CH_3Cl: Methyl chloride
N_2O: Nitrous oxide
BrO: Bromine monoxide
ClO: Chlorine monoxide
HCl: Hydrochloric acid
SO_2: Sulphur dioxide
H_2O_2: Hydrogen peroxide
NO: Nitric oxide

other stars, to search for life beyond Earth, and to chart the evolution of the universe and understand its galaxies, stars, planets, and life.

Within these endeavors, NASA studies the origins, as well as the evolution and destiny of the cosmos, by establishing a continuum of exploration and science. It creates a virtual presence in the solar system, exploring new territories, and investigating the solar system in all its complexity. It simultaneously probes the universe to the beginning of time, looking ever deeper with increasingly capable telescopes, scanning the entire electromagnetic spectrum from gamma rays to radio wavelengths. It also sends probes into interstellar space, beginning a virtual presence even beyond the solar system.

A key aspect of NASA's strategic planning in this arena is to ensure the Agency acquires the advice of the science community, and in particular the National Academy of Sciences. In addition, there is extensive collaboration with international partners and with other Federal agencies, such as the NSF, DoD, and DOE.

Deep Space Network (DSN). NASA Deep Space Network - or DSN - is an international network of antennas that supports interplanetary spacecraft missions and radio and radar astronomy observations for the exploration of the solar system and the universe. The network also supports selected Earth-orbiting missions. The DSN's missions and instruments are shown in Table 4-7.

The DSN currently consists of three deep-space communications facilities placed approximately 120 degrees apart around the world: at Goldstone, in California's Mojave Desert; near Madrid, Spain; and near Canberra, Australia. This strategic placement permits constant observation of spacecraft as the Earth rotates, and helps to make the DSN the largest and most sensitive scientific telecommunications system in the world.

NASA's scientific investigation of the solar system is being accomplished mainly through the use of unmanned automated spacecraft. The DSN provides the vital two-way communications link that guides and controls these planetary explorers, and brings back the images and new scientific information they collect.

Deep-space missions require highly reliable communications over long periods of time and great distances. For example, a spacecraft mission to gather scientific information at the planet Neptune takes eight years and requires telecommunication over a distance of 4.65×10^9 km. The need for high equivalent isotropically radiated power (e.i.r.p) and very sensitive receivers at earth stations is a result of the large communication distances involved in deep-space research.

Continuous usage of deep-space communication bands is a consequence of the several missions now in existence and others being planned. Because many deep-space missions continue for periods of several years, and because there are usually several missions in progress at the same time, there is a corresponding need for communication with several spacecraft at any given time.

TABLE 4-7: DSN MISSIONS AND INSTRUMENTS

Solar System Exploration	Earth Sciences	Astrophysics
	Current	
Cassini Deep Space 1 Galileo Mars Global Surveyor Stardust Voyager Ulysses	Advanced Space Thermal Emission Radiometer ACRIMSAT Active Cavity Radiometer Airborne SAR ATMOS Microwave Limb Sounder Ocean Topography QuikScat Shuttle Radar Topography	2 Micron All Sky Survey Infrared Processing and Analysis Keck Interferometer Origins Program US Space VLBI Project Wide Field Planetary Camera-2
	Potential Future	
Deep Impact Europa Orbiter Mars Surveyor 2001 Rosetta Orbiter MUSES-CN Mars Network Mars Surveyor 2003 Mars Surveyor 2005 Pluto-Kuiper Express Solar Probe	Atmospheric Emissions Spectrometer Atmospheric Infrared Sounder CloudSat Geographic SAR GRACE Jason 1 Light SAR Seawinds on ADEOS II Tropospheric Emission Spectrometer	Space Technology 3 Galaxy Evolution Explorer Genesis Space Infrared Telescope Facility Advanced Radio Interferometry between Space and Earth Far Infrared and Submillimeter Space Telescope Laser Interferometer Space Antenna Space Interferometry Mission Terrestrial Planet Finder

NASA's DSN operates in a number of frequency bands in order to support the wide variety of missions it must undertake. Table 4-8 provides a list of the critical elements of this spectrum support.

Radio Astronomy

Radio astronomy is a passive radio service that detects very faint radio emissions from cosmic sources. From its observations and studies of these radio emissions, the radio astronomy community has contributed significantly to humankind's knowledge of stellar physics, star formation, the interstellar medium, and the evolution of the Galaxy. They have also benefitted the public as a result of many scientific discoveries and development of innovative technologies.

Radio astronomy is a relatively new radio service based on the reception of radio waves of cosmic origin through the use of radio telescopes. Unlike other radio services with which it shares the radio frequency spectrum, radio astronomy is a passive radio service and deals only

TABLE 4-8: CRITICAL DSN SPECTRUM SUPPORT REQUIREMENTS

Function/Notes	RF Link	Frequency	Bandwidth
S-Band Deep Space (2), (4)	Command/Ranging Telemetry/Ranging	2110-2120 MHz 2290-2300 MHz	10 MHz 10 MHz
S-Band Near Earth (1), (3)	Command/Ranging Telemetry/Ranging	2025-2110 MHz 2200-2290 MHz	2 MHz per mission 2 MHz per mission
X-Band Deep Space (5), (6)	Command/Ranging Telemetry/Ranging	7145-7190 MHz 8400-8450 MHz	2 MHz per mission 8 MHz per mission
X-Band Near Earth (9)	Command/Ranging Telemetry/Ranging	7190-7235 MHz 8450-8500 MHz	2 MHz per mission 2 MHz per mission
Ka-Band TT&C (7), (8)	Command Telemetry	34.2-34.7 GHz 31.8-32.3 GHz	12 MHz per mission >12 MHz per mission
Ku-Band Space VLBI Ka-Band Space VLBI	Phase Transfer Telemetry TBD TBD	15.3 GHz 14.2 GHz 15.06 GHz 37-38.6 GHz 74-84 GHz	1 KHz 128 MHz (VSOP) 144 MHz (Radio Astronomy) TBD TBD

TABLE NOTES:

(1) 2025-2110 MHz:

NASA supports uplinks of the following high earth orbiter missions from now till 2016: Geotail, SOHO, Polar, ACE, CXO, MAP, IMAGE, ClusterII, INTEGRAL, NGST, Constellation-X, SAFIR, MAXIM.

(2) 2110-2120 MHz:

NASA usage includes uplink support for the following deep space missions: Voyager, Galileo, Ulysses Nozomi (ISAS), Mars Express (ESA), and Rosetta (ESA) missions.

(3) 2200-2285 MHz:

NASA tracks the downlinks of the following high earth orbiter missions from now till 2010: Geotail, SOHO, Polar, ACE, CXO, MAP, IMAGE, ClusterII, INTEGRAL, NGST, Constellation-X.

(4) 2290-2300 MHz:

NASA usage includes downlink support for the following deep space missions: Voyager, Galileo, Ulysses, Nozomi, Mars Express, Rosetta.

(5) 7145-7190 MHz:

NASA usage includes uplink support of the following deep space missions: 29 missions either existing or with planned launch dates before year 2010, and 6 missions proposed to be launched between 2010 and 2020. The first group includes NEAR, MGS, Cassini, DS1, Stardust, Mars'01, SIRTF, MUSE-CN, CONTOUR, Mars'03, Mars Express, Rosetta, Deep Impact, MESSENGER, Pluto/kuiper, STEREO, Solar Probe, Solar Probe Imager, SMars Recon Orbiter, Mars SAR, Europa Orbiter, ST3, MSSR, CNSR, SIM, ERO & Netlanders, MSR'09, LISA, Titan Explorer.

NASA supports uplinks of the following high Earth orbiter missions: SVLBI (existing) and future missions to be launched in the 2009-2013 time frame (Magnetospheric constellation, Terrestrial Planet Finder, Constellation-X).

(6) 8400-8450 MHz:

NASA usage includes downlink support of the deep space missions. There are 32 such missions either existing or with launch date planned before 2010. They include Voyagers, Ulysses, Nozomi, NEAR, MGS, Cassini, DS1, Stardust, Mars'01, SIRTF, MUSE-CN, CONTOUR, Mars'03, Mars Express, Rosetta, Deep Impact, MESSENGER, Pluto/kuiper, STEREO, Solar Probe, Solar Probe Imager, SMars Recon Orbiter, Mars SAR, Europa Orbiter, ST3, MSSR, CNSR, SIM, ERO & Netlanders, MSR'09, LISA, Titan Explorer. There are 6 missions with proposed launch dates between 2010 and 2020.

(7) 8450-8500 MHz:

NASA supports downlink of high earth orbiter missions as follows: SVLBI (existing) and future missions to be launched in the 2008-2016 time frame (NGST, MMS, MC, TPF, Constellation-X, SAFIR, MAXIM)

(8) 31.8 - 32.3 GHz:

NASA usage includes downlink support to the existing and planned deep space missions as follows: MGS, DS1, Cassini, SIM, MARSAT 1&2, SRO, Solar Probe, Solar Polar Imager, Solar Farside Observer, OHRI(Outer Heliosphere Radio Imager), HIGGS(Heliosphere Imager & Galactic Gas Sampler, Interstellar Probe.

(9) 34.2 - 34.4 GHz:

NASA usage includes uplink support to the existing and proposed future deep space missions as follows: Cassini, MARSATS 1&2, SRO, OHRI, HIGGS, Interstellar Probe.

with the reception of radio waves—cosmic radio waves. The radio astronomy community not only makes observations and conducts research in the radio frequency spectrum but in other portions of the electromagnetic spectrum as well. The study of the very faint radio emissions it receives help humankind's knowledge of stellar physics, star formation, the interstellar medium, the evolution of the Galaxy and the universe. The contributions and innovations developed by radio astronomy research have benefitted the public in many areas such as telecommunications, medicine, and industry, and it is very likely that radio astronomy will continue to benefit the public.

Support of ground based radio astronomy in the United States is the responsibility of NSF. In fulfillment of this mission, NSF supports the facilities of the National Radio Astronomy Observatory and the National Astronomy and Ionosphere Center, through cooperative agreements with Associated Universities for Research in Astronomy and Cornell University, respectively. NSF also supports radio astronomy research through grants to various universities and university radio observatories.

Radiometric observations are made in numerous bands. Some of the more critical bands used by the radioastronomy community include those listed in Table 4-9.

NASA supports radio astronomy observations with the DSN allowing for increased coverage and resolution provided by the 70 meter antennas at the DSN locations around the world. In providing this support, NASA works closely with the National Academy of Science and NSF.

Aeronautics and Space Technology Development

The focus of this endeavor is to pioneer the identification, development, verification, transfer, application, and commercialization of high-payoff aeronautics and space transportation technologies. Through research and technology accomplishments, NASA promotes economic growth and national security through a safe, efficient national aviation system and affordable, reliable space transportation. NASA's plans and goals directly support national policy in both aeronautics and space, documented in "Goals for a National Partnership in Aeronautics Research and Technology" and "National Space Transportation Policy." NASA works in alliance with its aeronautics and space transportation customers, including U.S. industry, the academic community, the DoD and the FAA to ensure that national investments in aeronautics and space transportation technology are effectively defined and coordinated and that NASA's technology products and services add value, are timely, and have been developed to the level at which the customer can confidently make decisions regarding the application of those technologies. The Agency also provides for technology transfer and commercialization of new technological advances. This function is provided as an Agency-wide service to ensure wide, rapid transfer of NASA-developed technologies to U.S. industry for the social and economic benefit of all U.S. citizens.

TABLE 4-9: RADIOASTRONOMY OBSERVATION BANDS

Substance	*Rest frequency*	*Suggested minimum band*
Deuterium (DI)	1 327.384 MHz	1 327.0-327.70 MHz
Hydrogen (HI)	1 420.406 MHz	1 370.0-1 427.00 MHz
Hydroxyl radical (OH)	1 612.231 MHz	1 606.8-1 613.80 MHz
Hydroxyl radical (OH)	1 665.402 MHz	1 659.8-1 667.10 MHz
Hydroxyl radical (OH)	1 667.359 MHz	1 661.8-1 669.00 MHz
Hydroxyl radical (OH)	1 720.530 MHz	1 714.8-1 722.20 MHz
Methyladyne (CH)	3 263.794 MHz	3 252.9-3 267.10 MHz
Methyladyne (CH)	3 335.481 MHz	3 324.4-3 338.80 MHz
Methyladyne (CH)	3 349.193 MHz	3 338.0-3 352.50 MHz
Formaldehyde (H_2CO)	4 829.660 MHz	4 813.6-4 834.50 MHz
Methanol (CH_3OH)	6 668.518 MHz	6 661.8-6 675.20 MHz
Helium ($3He^+$)	8 665.650 MHz	8 657.0-8 674.30 MHz
Methanol (CH_3OH)	00 12.178 GHz	012.17-012.19 GHz
Formaldehyde (H_2CO)	00 14.488 GHz	014.44-014.50 GHz
Cyclopropenylidene (C_3H_2)	00 18.343 GHz	018.28-018.36 GHz
Water vapour (H_2O)	00 22.235 GHz	022.16-022.26 GHz
Ammonia (NH_3)	00 23.694 GHz	023.61-023.71 GHz
Ammonia (NH_3)	00 23.723 GHz	023.64-023.74 GHz
Ammonia (NH_3)	00 23.870 GHz	023.79-023.89 GHz
Silicon monoxide (SiO)	00 42.821 GHz	042.77-042.86 GHz
Silicon monoxide (SiO)	00 43.122 GHz	043.07-043.17 GHz
Carbon monosulphide (CS)	00 48.991 GHz	048.94-049.04 GHz
Deuterated formylium (DCO^+)	00 72.039 GHz	071.96-072.11 GHz
Silicon monoxide (SiO)	00 86.243 GHz	086.16-086.33 GHz
Formylium ($H^{13}CO^+$)	00 86.754 GHz	086.66-086.84 GHz
Silicon monoxide (SiO)	00 86.847 GHz	086.76-086.93 GHz
Ethynyl radical (C_2H)	00 87.300 GHz	087.21-087.39 GHz
Hydrogen cyanide (HCN)	00 88.632 GHz	088.34-088.72 GHz
Formylium (HCO^+)	00 89.189 GHz	088.89-089.28 GHz
Hydrogen isocyanide (HNC)	00 90.664 GHz	090.57-090.76 GHz
Diazenylium (N_2H^+)	00 93.174 GHz	093.07-093.27 GHz
Carbon monosulphide (CS)	00 97.981 GHz	097.65-098.08 GHz
Carbon monoxide ($C^{18}O$)	0 109.782 GHz	109.67-109.89 GHz
Carbon monoxide (^{13}CO)	0 110.201 GHz	109.83-110.31 GHz
Carbon monoxide ($C^{17}O$)	0 112.359 GHz	112.25-112.47 GHz
Carbon monoxide (CO)	0 115.271 GHz	114.88-115.39 GHz
Formaldehyde ($H_2{}^{13}CO$)	0 137.450 GHz	137.31-137.59 GHz
Formaldehyde (H_2CO)	0 140.840 GHz	140.69-140.98 GHz
Carbon monosulphide (CS)	0 146.969 GHz	146.82-147.12 GHz
Water vapour (H_2O)	0 183.310 GHz	183.12-183.50 GHz
Carbon monoxide ($C^{18}O$)	0 219.560 GHz	219.34-219.78 GHz
Carbon monoxide (^{13}CO)	0 220.399 GHz	219.67-220.62 GHz
Carbon monoxide (CO)	0 230.538 GHz	229.77-230.77 GHz

TABLE 4-9: RADIOASTRONOMY OBSERVATION BANDS (Cont.)

Substance	Rest Frequency	Suggested Minimum Band
Carbon monosulphide (CS)	0 244.953 GHz	244.72-245.20 GHz
Hydrogen cyanide (HCN)	0 265.886 GHz	265.62-266.15 GHz
Formylium (HCO^+)	0 267.557 GHz	267.29-267.83 GHz
Hydrogen isocyanide (HNC)	0 271.981 GHz	271.71-272.25 GHz
Diazenylium (N_2H^+)	279.511 GHz	279.23-279.79 GHz
Carbon monoxide ($C^{18}O$)	312.330 GHz	329.00-329.66 GHz
Carbon monoxide (^{13}CO)	330.587 GHz	330.25-330.92 GHz
Carbon monosulphide (CS)	342.883 GHz	342.54-343.23 GHz
Carbon monoxide (CO)	345.796 GHz	345.45-346.14 GHz
Hydrogen cyanide (HCN)	354.484 GHz	354.13-354.84 GHz
Formylium (HCO^+)	356.734 GHz	356.37-357.09 GHz
Diazenylium (N_2H^+)	372.672 GHz	372.30-373.05 GHz
Water vapour (H_2O)	380.197 GHz	379.81-380.58 GHz
Carbon monoxide ($C^{18}O$)	439.088 GHz	438.64-439.53 GHz
Carbon monoxide (^{13}CO)	440.765 GHz	440.32-441.21 GHz
Carbon monoxide (CO)	461.041 GHz	460.57-461.51 GHz
Heavy water (HDO)	464.925 GHz	464.46-465.39 GHz
Carbon (CI)	492.162 GHz	491.66-492.66 GHz
Water vapour ($H_2{}^{18}O$)	547.676 GHz	547.13-548.22 GHz
Water vapour (H_2O)	556.936 GHz	556.37-557.50 GHz
Ammonia ($^{15}NH_3$)	572.113 GHz	571.54-572.69 GHz
Ammonia (NH_3)	572.498 GHz	571.92-573.07 GHz
Carbon monoxide (CO)	691.473 GHz	690.78-692.17 GHz
Hydrogen cyanide (HCN)	797.433 GHz	796.64-789.23 GHz
Formylium (HCO^+)	802.653 GHz	801.85-803.85 GHz
Carbon monoxide (CO)	806.652 GHz	805.85-807.46 GHz
Carbon (CI)	809.350 GHz	808.54-810.16 GHz

NASA develops technological advances in three broad areas:

Global Civil Aviation. This Nation's economic growth has been fueled by technology-driven productivity improvements. Information technology and high-speed digital communications are expanding our economy in new ways. While this digital revolution is leading the way, communications and transportation remain integrally linked.

Today, aviation enables the high-speed movement of people and goods over long distances, a requirement in today's fast-paced economy. Unfortunately, the growth in air traffic is beginning to push the aviation system to its limits. Constraints threaten to halt the growth that is required to support our economy. Therefore, NASA's effort in global civil aviation is focused on developing technology solutions that eliminate barriers to growth for the global civil aviation system.

Revolutionary Technology. NASA envisions the expansion of our air transportation system along the dimension of much faster doorstep-to-destination speeds. High-speed, supersonic transports will cut in half the time required for long-distance, transoceanic travel. New, safe and efficient small aircraft and smart small airports will create a new air transportation network that will connect small suburban and rural communities with each other and with major cities and airports. These innovations and the resulting major expansion in personal mobility will be a hallmark of the new millennium.

Advanced Space Transportation. Space is the next frontier for evolving transportation systems. Advancements in technology will extend our reach, enabling us to explore further into space. Also, as NASA stays at the leading edge of space exploration, technological advances will allow commercial ventures to establish space operations and develop the commercial potential of space--starting first with safe, reliable, low-cost access to space. This will require developing technologies that enable new launch and in-space transportation systems with orders of magnitude improvement in safety, cost and reliability.

Technology Development Spectrum Support Requirements. NASA requires access to the radio spectrum in order to conduct test and development phases of new technology endeavors in aeronautics and space transportation. The Agency conducts testing in the areas of aviation, flight research, airframes, aeropropulsion, space transportation and rocket propulsion.

In many cases, new technological design test-rigs and/or prototypes undergo their various test and validation phases using conventional fixed and/or mobile spectrum allocations. In many other cases, spectrum support is achieved via experimental bands used in laboratories and test facilities on a non-interference basis.

For links between in-flight aerospace vehicles and ground systems, NASA requires access to aeronautical telemetry frequency allocations. Currently the RF spectrum is used to provide real time data information from test vehicles to the ground, real time video of cockpit or project information, and real time command and control of the vehicle, including flight termination. Telemetry is used for the real time monitoring of flight research/test parameters that are necessary in order to minimize the risk to the pilot and aircraft during the performance of maneuvers intended to push the flight envelope of flight test vehicles.

As newer and more complex aerospace/aeronautical vehicles enter the test and evaluation phases of their development, greater demand is placed on the available ATM spectrum to support such testing. In the past, the following frequency bands were available for ATM.

Frequency Range	Bandwidth
1435 – 1535 MHz	100 MHz
1710 – 1850 MHz	140 MHz
2200 – 2290 MHz	90 MHz
2310 – 2390 MHZ	80 MHz
Total	410 MHz

As a result of OBRA-93, the WARC-92, and BBA-97, the following bands are currently available for ATM.

Frequency Range	Bandwidth	Lost
1435 – 1535 MHz	100 MHz	
1755 – 1850 MHz	95 MHz	- 45 MHz
2200 – 2290 MHz	90 MHz	
2360 – 2385 MHZ	25 MHZ	- 55 MHz
Total	310 MHz	- 100 MHz

Currently, the amount of spectrum available for ATM is only 76 percent what it was in 1992. Of concern to NASA is that further reductions in available ATM spectrum are a possibility given the current trend of auctioning spectrum previously assigned to the Federal Government and the private sector for commercial use.

NASA’s Future Spectrum Requirements

This section provides a brief summary of NASA's long-term goals as identified in the 2010 to 2023 timeframe of the Agency s Strategic Plan. Achievement of each of these goals is predicated on continued access to the RF spectrum in an interference-free environment.

Advance and communicate scientific knowledge and understanding of the Earth, the solar system, and the universe, and use the environment of space for research -

Create an international capability to forecast and assess the health of the Earth system.

Expand scientific knowledge of the Earth system using NASA's unique vantage points of space, aircraft, and in situ platforms by forecasting and assessing the state of the Earth.

Create a virtual presence throughout our solar system and probe deeper into the mysteries of the universe and life on Earth and beyond.

Use our understanding of nature's processes in space to support research endeavors in space and on Earth.
Share our understanding of the Earth system and the mysteries of the universe with our customers and contribute to the achievement of the Nation's educational goals.

Explore, use, and enable the development of space for human enterprise-

Conduct international and/or U.S. human and robotic missions to planets and other bodies in our solar system to enable human expansion.

Provide safe and affordable space access, orbital transfer, and interplanetary transportation capabilities to enable research, human exploration, and the commercial development of space.

Research, develop, verify, and transfer advanced aeronautics, space, and relatedResearch, develop, verify, and transfer advanced aeronautics, space, and related technologies-

Develop cutting-edge aeronautics and space systems technologies to support highways in the sky, smart aircraft, and revolutionary space vehicles that will provide faster, safer, more affordable air and space travel with less impact on the environment and enable expanded research of our planet and the universe.

Support the maturation of aerospace industries and the development of new high-tech industries such as space-based commerce through proactive technology transfer.

Specific Agency Spectrum Allocation Initiatives

In order to achieve the long range goals outlined above, NASA requires continued access to critical spectrum as outlined in previous paragraphs. These bands currently provide the backbone of NASA's ability to command and control spacecraft and to bring to the scientific community the data by which these goals can be realized.

In addition to these frequency allocations, NASA has identified additional spectrum requirements which will be the focus of future national and international spectrum allocation and radio frequency interference protection initiatives.

Protection of the Global Positioning System (GPS)

The GPS is a constellation of 24 satellites that broadcast signals that can be used to derive precise timing, location and velocity any where on the earth and in orbit about the earth. GPS, originally developed by the DoD for its own use, has also implemented civilian signals for use by private and public sectors. In 1983, with the downing of Korean Flight 007, President Reagan issued a directive that guaranteed the GPS signal would be available to everyone with no direct user fees. The promise of this new technology coupled with this guarantee of availability has resulted in the integration of GPS into many of todays and tomorrows systems.

At the recently concluded WRC held in Istanbul, Turkey, the United States was able to protect GPS from potential radio frequency interference from MSS proposals in the current L1 GPS frequency at 1559-1610 MHz band. In addition to protecting the L1 frequency, the United States was able to secure additional GPS allocations at 1215-1260 MHz band referred to as L2 GPS band and 1164-1188 MHz referred to as L5 GPS band. Added protection for Radio Navigation Satellite Services came in the form of a space-to-space allocation.

NASA has extensive plans to use GPS for all of its current and future spaceflight missions. The protection of this service from radio frequency interference sources must be recognized as paramount to its ability to offer the benefits for which it was designed.

Aeronautical Telemetry Wideband Allocations

Emerging future aeronautical requirements will place significantly larger demands on the existing aeronautical RF spectrum. New and next generation aerospace vehicles are becoming considerably more complex and require correspondingly more spectrum bandwidth in order to conduct safe and successful flight research/test programs. Real time telemetry requirements for the newer and planned future projects are becoming substantially larger and more complex than those programs of the past with expected data rates for such technologies as High Resolution Digital Video (HRDV) to be as high as 1 Gigabits per second or more.

NASA intends to be in the forefront of the implementation of new HRDV technology. NASA's goal is to be able to send real time HRDV data at high rates directly from an in-flight aerospace vehicle to NASA centers. There is no spectrum currently allocated for aeronautical telemetry and flight test that can support these requirements. As a result, NASA has supported the inclusion of WRC-2006 Agenda Item 2.1.2 which reads ***"To consider spectrum requirements for wideband aeronautical telemetry in the bands between 3 GHz and 30 GHz."***

Additional Allocations for Earth Exploration-Satellite Service (EESS) and Space Research Service (SRS) Near 5 GHz

Active space-based sensors, like terrestrial radars, receive signals that they have transmitted and are reflected by land, ocean and atmospheric surfaces. Measurements around 5 GHz from active space-based sensors provide data to study ocean dynamics and their effects on climatology and meteorology. Additional EESS allocations in the frequency range 5460-5570 MHz are required for the purpose of providing additional spectrum for space borne radio-altimetry and synthetic aperture radar imaging to improve the ability to make long-term environmental measurements.

Review Allocations to Accommodate Space Science Services (Space-to-Earth links)

Data rates associated with the transmission of mission data of Earth-orbiting satellites operating in the SRS are increasing beyond those that may be accommodated in the 2025-2110 MHz, 2200-2290 MHz, and 8450-8500 MHz bands. Satellites in the EESS requiring accommodation are typically of the low-cost explorer satellite being planned for the future. The technical, schedule and cost advantages of this class of satellites could be compromised should they be required to operate in the next higher set of frequency bands that are currently available for the space science services, these are the 37 GHz and 40.5 GHz bands.

Bands suitable to accommodate the future requirements of EESS satellites include the bands around 15 GHz and 25.5-27.0 GHz. The technology and the infrastructure that has been developed and implemented in these bands are rather extensive. A primary allocation to the SRS in these bands or similar bands below 30 GHz will promote the efficient use of the spectrum and the investments that have been made in the technology and infrastructure to support EESS missions.

NASA believes that these allocations at 15 and 26 GHz with the proper status could well satisfy its needs without resorting to new additional spectrum.

Review Allocations for SRS and ISS in 32-32.3 GHz Band

The introduction of high density fixed service into this band has changed the sharing environment and there is a need to make sure that there is a full understanding in the relationship that now exists between the two space services (deep space research and inter-satellite) in the band. WRC-2003 will review the ITU-R studies to determine if any allocation changes need to be made to accommodate these two space services.

Consideration of Allocations in the Frequency Bands Above 275 GHz

The International Table of Frequency Allocations stops at 275 GHz and does not allocate bands to specific radio services above this level. Frequency bands above 275 GHz may be used by administrations for experimentation with and development of various active and passive services. Currently, some bands above 275 GHz have been identified for use by the radio astronomy, earth exploration-satellite (passive) and space research (passive) services. Researching this largely unexplored spectral region has revealed bands of interest to various service users and WRC-2000 has placed an agenda item on the preliminary agenda for WRC-2006 to review studies and consider allocations in the frequency bands above 275 GHz.

NOAA's SPACE CIVIL PROGRAMS/SYSTEMS

NOAA manages, conserves and monitors marine resources and predicts atmospheric and marine conditions for the protection of life and property. NOAA is composed of several main line components each of which depends on the use of the spectrum to meet its mission. The major components are: National Weather Service (NWS), National Environmental Satellite, Data, and Information Service (NESDIS), National Marine Fisheries Service (NMFS), National Ocean Service (NOS), and National Institute of Standards and Technology (NIST).

NOAA Agencies Use of Spectrum

NWS, with personnel located at 121 Weather Forecast Offices through out the United States, is charged with observing and reporting the weather, issuing forecasts and warnings of weather and flood conditions affecting national safety, welfare, and economy. Its seven National Centers for Environmental Prediction are key centers in long range and regional forecasting for the World Meteorological Organization (WMO) of the United Nations. Its Tropical Prediction Center also tracks hurricanes and forecasts their movement and intensity to provide early warnings to populated areas in the storm path.

NWS operates about 120 weather radars, 102 weather balloons stations, 503 NOAA Weather Radio Stations, and together with state and local governments, 3,437 hydrological data collection and warning stations. It also operates many other radio stations serving the hydrologic telemetry program, the fire-weather program, the hurricane backup communications program, the weather reconnaissance aircraft program, and other miscellaneous radio communications.

The NESDIS operates the nation's environmental/meteorological satellites which make day and night observations of weather (clouds, temperature, and winds), ocean state (sea surface temperature), surface and agricultural features of the world. These data and other environmental data are transmitted to ground stations by satellite transmitters using radio frequencies. The data are gathered at the ground and re-transmitted via commercial satellites to a central processing center. The meteorological satellite systems (GOES and the National Polar Orbiting Environmental Satellite System (NPOESS)) also provide for the collection and radio relay of data from fixed and mobile environmental observing platforms (ships, aircraft, ocean buoys, and remote surface sites).

The NOAA Data Buoy Center develops and operates environmental data buoys for weather monitoring, prediction, and various other scientific programs. Data sent from the buoys and platforms via UHF signals through the GOES and NOAA satellites to land via downlinks near 1700 MHz. There are over 10,000 data collection platforms currently using the data collection radio relay service of the meteorological satellites. These observation platforms are operated by NOAA, other government agencies, and private industry to obtain data on stream flow and water quality, snow depth, and rainfall in remote areas, ocean measurements from buoys and remote islands, and wind and temperature information from commercial aircraft.

The polar-orbiting weather satellites of NOAA include Search and Rescue Satellite System (SARSAT) packages that detect distress signals sent by radio to the satellite and provides location information with a 2-5 km accuracy. There are presently 7 ground stations in the United States, as well as locations in 20 other countries, totaling 35 worldwide, that receive the transmitted data from the SARSAT. In addition, NESDIS operates the National Geophysical Data Center collecting data from 33 worldwide ionospheric sounders (low frequency through high frequency bands).

The NMFS conducts exploratory fishing as well as fish and marine mammal population research programs using HF and VHF radio equipment to provide tracking and migration information as well as communications between major fishery centers and research ships of the NOAA Corps fleet. NMFS also enforces Federal fish and wildlife conservation laws relating to the living marine resources within the U.S. 320-kilometer jurisdictional conservation zone. VHF radio communications are an essential factor during these operations.

The NOS radiocommunication facilities are used to support 23 ships and 18 mobile field parties engaged in oceanographic, marine, and geodetic surveys, and NMFS activities. These programs, activities, and related radiocommunications are conducted by the NOS to measure the Earth's surface, its coastlines, and its undersea structure and to provide information on the marine environment and its resources for use by scientists and the public. Communications are principally for safety, control of navigation, operations, medical emergencies, and administrative messages between ships conducting joint operations and between ships and shore stations using NOS, NMFS, Navy, and Coast Guard commercial communication circuits. The Charting and Geodetic Services, an office of NOS, also use frequencies in the visible and infrared spectrum for very precise distance measurements. The VHF frequency band is used for voice communication between field parties. The Office of Oceanography and Marine Assessment uses radio communications to coordinate clean-up teams and track movement of contamination when responding to oil and hazardous chemical spills.

The NIST, through its Boulder, Colorado facilities, is responsible for primary time and frequency standards, and dissemination of these data through radio stations WWV and WWVB in Colorado and WWVH in Hawaii to more than 100,000 listeners throughout the world. Data is also disseminated through dail-up telephone service (2,000,000 users per year) as well as GOES and GPS satellites. High precision time signals are sent and received from domestic communication satellites at 12 GHz and 14 GHz. NIST also conducts extensive experimentation using radio spectrum in such areas as testing instruments for earthquake calibration measurements. Specific areas of radio usage include communication, data telemetry, and satellite transfer of information.

Potential Impacts Due to Future Spectrum Loss

<u>1675-1710 MHz Band</u>.

This band was thoroughly discussed during the WRC-97 preparatory effort and it was determined that there is no spectrum to spare. Existing meteorological satellite (Metsat) downlinks already occupy the band between about 1683-1710 MHz, so 1675-1683 MHz is the only band segment in which radiosondes can operate without causing harmful interference to satellite links. The NWS has been unable since 1993 to obtain funding for upgrades to its existing radiosonde systems, needed to vacate the 1670-1675 MHz band lost under OBRA-93. Even if the money were made available for a system upgrade to provide narrowband equipment, the increased costs of radiosondes (disposable equipment procured for one-time use) would require a significant increase in NWS's budget. The loss of any part of 1675-1710 MHz would have huge impacts on NOAA’s Metsats and meteorological aids satellites.

<u>2025-2110 MHz</u>.

Geostationary Satellites Needs:

! Ongoing requirement for continuous picture coverage of Western Hemisphere for accurate weather prediction;

! Picture coverage provided by the GOES located at 75E West longitude and 135E West longitude;

! GOES receives command and data uplinks from NOAA Command and Data Acquisition (CDA) facility at Wallops Island, Virginia using frequencies transmitted in the 2025 to 2035 MHz frequency band;

! NOAA presently commanding GOES-8 (75E W) and GOES-10 (135E W), and recently launched GOES-11 to be stored in orbit at 105 W to replace the first GOES that fails;

- Present budgetary plans identify GOES-M, and continuation series, GOES-N, -O, -P and -Q, to use same uplink frequency band of 2025-2035 MHz through 2020; and

- The OMB has asked NOAA to develop a backup GOES CDA facility (located at Goddard Space Flight Center, Greenbelt, Maryland) which will also use 2025-2035 MHz band for command uplink transmissions.

Consequences for Geostationary Satellites

- If 2025-2035 MHz band becomes unavailable;
  - Detailed study needed to identify alternative uplink command band,
  - GOES -M is presently being constructed, making an uplink change costly in both time and money,
  - Continuation series (GOES-N, -O, -P and -Q) is first viable opportunity to use new command uplink frequency; however, decision to change would have some impact on existing procurement schedule,
  - Command facilities at Wallops Island, Virginia and new backup facility (Greenbelt, Maryland) would require completely new antennas designed, built and installed,
  - Such extra expenditures, not presently envisioned, would be $50-100 million, and
  - Total relinquishment of 2025-2035 MHz for geostationary satellite command uplink not achievable until 2010, assuming timely availability of funds.

2025-2110 MHz Requirements for Polar-orbiting Satellites:

- NOAA has a worldwide commitment through the WMO to provide detailed picture information to 176 WMO members. This detailed worldwide information is crucial to U.S. weather forecasting;
- NOAA K, L, and M satellites are replacing TIROS-N series of satellites, in use since 1978 and reaching the end of its technological usefulness. The requirement remains to have one morning satellite and one afternoon satellite pass, resulting in full Earth coverage, four times per day;
- NOAA K, L, and M series of satellites will use command uplink at 2026 MHz from Wallops Island, Virginia and Fairbanks, Alaska;
- NOAA K, L, and M series satellites including -N and -N' are either launched or in the final stages of construction, and redesign of the command uplink would be prohibitively expensive at this late date, and
- First realistic opportunity for a new command uplink band would be with the follow-on NPOESS which will not have its first satellite launched until about the year 2009.

2025-2110 MHz Requirements for Land-remote Sensing Satellites:

- Landsat-5 is still operational and uses an uplink data command frequency of 2106.4 MHz to be common with NASA's TDRSS uplink;
- Landsat-7 also has 2106.4 MHz command frequency;
- Landsat-5 is presently being commanded at Norman, OK. Landsat-7 is commanded primarily from Sioux Falls, South Dakota (Also occasionally from Fairbanks, Alaska, or TDRSS); and
- Landsat-7 has a 5-year design life, but may remain functionally operational until 2015 or even beyond.

<u>2200-2290 MHz Band (NOAA Requirements)</u>

- Early orbit and emergency contingency use by GOES spacecraft to deep space network at 2208.586 MHz and 2209.086 MHz.
- Early orbit and emergency contingency use by polar-orbiting spacecraft at 2247.5 MHz.
- Landsat-4 and -5 at 2287.5 MHz to TDRSS, limited use.
- Landsat-7 at 2287.5 MHz to TDRSS.
- Use in the 2200-2290 MHz band by NOAA spacecraft, except for Landsat-5, expected to continue, minimally, through 2010.

If current Metsat allocations are not maintained, millions of dollars would be required to change equipment on satellites that are already built or are in some stage of completion. Additional funds would be required to upgrade NOAA's CDA's stations to acquire and/or transmit on an additional set of frequencies. The total cost to NOAA would be in the tens to hundreds of millions of dollars.

<u>2700-2710 MHz Band</u>.

The NWS currently operates 14 Next Generation Weather Radars (NEXRAD) or the WSR-88D radars in this band. If NWS is required to vacate the band, the total impact would depend on a number of unknowns which would need to be resolved on a case-by-case basis in order to determine the overall impact. These include:

- the potential need to re-tune additional radars operating outside the band because the congested condition of the band may cause a domino effect;
- the need to coordinate with Canada the new frequencies of radars close to our common border. Not that it may also be necessary to compensate Canadian stations for the cost of their own re-tuning occasioned by the aforementioned domino effect (We have had to cover these costs on some past occasions);

- the possible need for narrow-band filters in areas which lie within the "congested areas" defined by the NTIA manual, or which may become part of new "congested areas" as the result of spectrum loss;
- the uncertain availability of funds to cover the costs of re-tuning; and
- the possible need to qualify a second vendor to obtain certain critical parts.

Current Use and Future Spectrum Requirements

121.5 MHz, 243 MHz, and 406-406.1 MHz Bands

These spectrum are for SARSAT. Emergency Locator Transmitters (ELTs), Emergency Position-Indicating Radiobeacons (EPIRBs), and Personal Locator Beacons (PLBs) operating on 121.5 MHz, 243 MHz, and 406-406.1 MHz transmit emergency signals detected by NOAA's polar-orbiting and geostationary (406-406.1 MHz only) satellites. The information is sent from the receiving satellite to Local User Terminals (LUTs) on the ground. After receipt of the distress signal, the LUT locates the beacons by Doppler processing with an accuracy of approximately 20 km for the 121.5 MHz and 243 MHz frequencies and to about 4 km for the 406-406.1 MHz frequency band. The LUT forwards the located information to a corresponding Mission Control Center, which, after further processing, forwards the information to an appropriate Rescue Coordination Center which effects search and rescue.

The need for these critical frequencies will continue into the foreseeable future and are protected worldwide by the ITU for the reception onboard satellites of emissions from EPIRBs.

137-138 MHz Band

This band is for meteorological polar-orbiting satellite space-to-Earth broadcasts. Frequency use in this range consists of four subbands, two for Automatic Picture Transmissions (APTs) and two for Direct Sounder Broadcasts (DSBs), that provide NOAA's polar-orbiting satellite space-to-Earth links for transmitting imagery (visible and infrared on APT) and sounding data (on DSB). These data, sent via direct broadcast for more than 30 years, are available freely and openly to thousands of users located in the Untied States and more than 100 countries. Information sent on these four frequencies can be received on relatively inexpensive equipment (< $1000). In order to avoid co-frequency sharing with the MSS, NOAA satellites will migrate from the current APT frequencies of 137.5 MHz and 137.62 MHz to 137.1 MHz and 137.9125 MHz with the launch of NOAA N, expected around 2004.

Use of the DSB bands at 137.35 MHz and 137.77 MHz will terminate with the expiration of NOAA-N', expected about 2015. The same may hold true for the APT, as the converged polar-orbiting constellation known as NPOESS may continue to support these two frequencies.

400.15-401 MHz Band

This band is for meteorological polar-orbiting satellite space-to-Earth broadcasts. Vital satellite sensor data for use by military field units is planned beginning with the launch of the next Defense Meteorological Satellite Program (DMSP) satellite in early 2001. The need for this direct broadcast band will exist into the foreseeable future to be used on the converged NPOESS.

401-403 MHz Band

This band is for data collection platform Earth-to-space transmissions. Extensive use of this two (2) MHz uplink by data collection platforms (>10,000) to both geo- and nongeo-stationary meteorological satellites provides a vital link on which important environmental data (streamflow, rainfall, snow depth, buoy, etc. information) are provided to a myriad of Government, agencies and private sector businesses. Continued access to this two (2) MHz band is critical and will be required into the foreseeable future.

468.825 MHz and 468.8375 MHz

These frequencies are for data collection platform interrogation from GOES spacecraft. NOAA GOES spacecraft use these secondary allocations to interrogate several hundred data collection platforms to send critical environmental data. The need will continue into the foreseeable future.

1227.6 MHz and 1575.42 MHz

These frequencies are for receiving information from the GPS. The NPOESS constellation will require receipt of GPS signals onboard the spacecraft during the existence of the constellation, at least until 2020.

1544-1545 MHz Band

This band is for SARSAT space-to-Earth transmissions. This downlink is used by both geostationary and non-geostationary NOAA spacecraft to transmit search and rescue information received from PLBs/ELTs/EBIRBs (*see* 121.5 MHz, 243 MHz, and 406-406.1 MHz). The use of this all-important satellite transmission to send vital information will continue uninterrupted on all NOAA satellites and is protected in all ITU regions.

1675-1710 MHz Band

This band is for meteorological satellite transmissions from both geostationary and non-geostationary spacecraft. Extensive use of this band is required to send raw sensor data captured by sensors on NOAA satellites as well as transmission of processed satellite data and a myriad of weather products. Information collected by data collection platforms (DCPs) is also sent to Earth in this band as is vital spacecraft telemetry/housekeeping statistics. The existing series of NOAA spacecraft will continue the requirement for this band through at least 2015, possibly 2020. Future spacecraft may require the use of X-band (8-12 GHz) or Ka-band to transmit much higher data rates resulting from added sensors having much higher resolution and larger number of channels. The need to retain L-band (1-2 GHz) will likely be required, but perhaps its use by NOAA's meteorological satellites will be reduced.

1791.748 MHz

This frequency is for space-to-Earth transmissions from the DMSP Block 5D-3 Satellite Network and future NPOESS. The Space Ground Link Subsystem (SGLS) uplink is used to send commands to the DMSP Block 5D-3 satellite network that is now operated by NOAA. Used exclusively for DoD spacecraft, there are plans to include this ground transmitter on the NPOESS as a backup to the uplink in 2025-2110 MHz. Future policy decisions within the Government may require consolidation of all agencies using SGLS to the region known as unified S-band (2-4 GHz). Regardless of future decisions, the need to communicate with DMSP spacecraft requires protection of this frequency through at least 2015, possibly 2020.

2026 MHz

This frequency is for NOAA polar-orbiting spacecraft Earth-to-space command link and tracking, telemetry, and command, respectively. Beginning with the launch of NOAA-15 in May 1998, the command uplink was change from 148.56 MHz to 2026 MHz. All future NOAA spacecraft, including NPOESS, will use this frequency to receive commands from the NOAA CDA stations located at Wallops Island, Virginia and Fairbanks, Alaska. The need to retain this frequency has no limit.

2025-2035 MHz Band

This band is for several uplinks to GOES from Wallops Island, Virginia and the back-up site at Goddard Space Flight Center, Maryland. NOAA's GOES satellites receive data in six bands in this 10 MHz of spectrum which include commands, processed satellite sensor data, DCP data, as well as, the Weather Facsimile (WEFAX) and Emergency Managers' Weather Information Network (EMWIN) information. The need for the protection of the Wallops Island Command and Data Acquisition station continues through at least 2020.

2106.4 MHz

This frequency is for command uplink for Landsat-7. Landsat-7, currently controlled by NASA and USGS (Interior), is still the responsibility of NOAA as pertains to the filing of the necessary forms with NTIA and the ITU. Landsat-7 uses this frequency to receive commands from NASA as well as to send data to NASA's TDRSS. Any successors will likely to continue the use of the band for the same purposes. Thus the need to maintain this frequency for Government operations in the Earth-to-space and space-to-space directions.

2208.586 MHz and 2209.586 MHz

These frequencies are for space-to-Earth transmissions from GOES to the DSN and Wallops Island, Virginia CDA. NOAA uses two frequencies in S-band to send telemetry and tracking information to the DSN station located in Goldstone, California and to the Wallops Island CDA in the United States and to a network of stations around the world during the launch and early orbit of one of NOAA's GOES satellites. Continuance of the network is required to provide continuity of coverage of the GOES spacecraft during the important launch and early orbit of each geostationary spacecraft. The need for these frequencies remains in effect for the foreseeable future.

2247.5 MHz

This frequency is for contingency backup for NOAA NPOESS. NOAA reserves this freqeuncy as a contingency backup to the polar-orbiting L-band downlinks around 1700 MHz. NOAA-15 currently uses this frequency as excessive interference experienced in the L-band frequencies made data unusable. The need to continue this allocation has been made quite clear. Its availability for possible use on NPOESS requires protection beyond 2020.

2207.5 MHz, 2222.5 MHz, 2237.5 MHz, 2252.5 MHz, and 2267.5 MHz

These frequencies are used by DMSP for transmission of sensor, telemetry and satellite housekeeping information. The DMSP Block 5D-3 network of satellite use these S-band frequencies to transmit sensor data to numerous ground stations worldwide. Important telemetry and spacecraft house keeping information are also sent in the data stream. The need for this 90 MHz of spectrum will continue on NPOESS. Thus protection is needed beyond 2020.

2287.5 MHz

This frequency is for Landsat-7 links to TDRSS and to Earth. Landsat-7 uses 2287.5 MHz to send information to the ground receiving station in Sioux Falls, South Dakota and receive data from the NASA TDRSS network. These established pathways are likely to continue on successors of Landsat-7 into the foreseeable future.

7750-7850 MHz Band

This band is for NPOESS Preparatory Program (NPP) and NPOESS direct broadcast transmissions of sensor data. This recently allocated (WRC-97) meteorological satellite (space-to-Earth) link (non-geostationary satellites only) will be used by NPP and NPOESS to transmit to in-situ user terminals throughout the world. Use is expected to begin about 2005 and continue into the foreseeable future.

8025-8400 MHz Band

This band is for Landsat-7 transmissions of sensor data to ground stations worldwide and possible use by NPOESS. Three bands in this 375 MHz of spectrum are used to transmit data collected by several sensors onboard the spacecraft to about 20 receiving stations around the world. The use of these bands established on earlier Landsat satellites flown in the 1980's will likely continue without interruption on future spacecraft of this series.

The need for spectrum to transmit NPOESS sensor is a major concern. Data rates may exceed 150 mbps, thus requiring significant bandwidth for sending these important environmental data to several receiving stations. The 8025-8400 MHz EESS band is one possibility that may be used for NPOESS. Until the final decision is made, this band needs to remain as a candidate, and if selected would need to be available through at least 2020.

25.5-27 GHz Band

This band is for NPOESS transmission of stored sensor data. The large volumes of stored sensor data planned for NPOESS will require substantial bandwidth for rapid download to the NOAA CDA stations. The Ka band from 25.5-27 GHz is a newly allocated space-to-Earth link (WRC-97) available to the EESS. This allocation, though untested, would provide the necessary bandwidth for sending the raw sensor data from space to the NOAA CDA stations. The use would continue at least through the lifetime of NPOESS.

59.3-64 GHz Band

This band is for inter-satellite transmissions for NPOESS. In order to provide valuable, highly perishable sensor environmental data in a timely manner, it will be necessary to use inter-satellite links on NPOESS when an Earth station is not available to meet data latency requirements. The likely candidate band would fall within the 59.3-64 GHz region and would require protection through at least 2020.

Active Sensing Bands for NPOESS Altimeter

NPOESS will carry an active sensor known as an altimeter transmitting on two frequencies (5.3 GHz and 13.575 GHz). This instrument provides accurate measurements of the sea surface height. Its need will continue throughout the NPOESS mission.

Passive Sensing Bands for NOAA Polar-orbiting Spacecraft

NOAA polar-orbiting satellites currently fly two passive sensing instruments to measure vital atmospheric temperature and moisture profiles of the globe. These measurements are used in numerical weather forecasts models by the NWS. Future satellites will contain upgraded sensors as well as additional instruments to measure other environmental parameters of the Earth. The range in frequencies is from 23.8 GHz to 189.31 GHz. All bands used on the two instruments are completely within allocated bands resulting from previous ITU World Administrative Radio Conferences and the last two WRCs. Use of passive frequencies will increase with NPOESS and possibly GOES. It is anticipated that all passive sensors will continue to use ITU allocated spectrum for this use. The need to protect these bands from active services is extremely important if the collection of vital atmospheric and environmental data is to remain available from a space platform.

IMPACT OF FUTURE SPECTRUM REALLOCATION ON FEDERAL PUBLIC SAFETY COMMUNICATIONS

In times of emergencies, the public looks to government, particularly their public safety officials, to act swiftly and correctly and do the things which must be done to save lives, help the injured, and restore order. Most disasters occur without warning, but people still expect a rapid and flawless response on the part of Government. There is no room for error. Whether a vehicle accident, crime, plane crash, special event, or any other public safety incident, one of the major components of responding to and mitigating a disaster is wireless communications. These wireless communications systems are critical to public safety agencies’ ability to protect lives and property and the welfare of public safety officials.

Public safety agencies provide a vital service to the American public: to protect and preserve life, property and natural resources and to serve the public welfare. For Federal public safety agencies, this duty is prescribed by law. For instance, the DOJ enforces the law in the public interest and plays a key role in protection against criminals; ensuring healthy competition of business; safeguarding the consumer; enforcing drug, immigration, and naturalization laws; and protecting citizens through effective law enforcement. Treasury enforces Federal laws pertaining to protection of the President and other designees, as well as those dealing with counterfeiting, fraud (including credit and debit card fraud), forgery, smuggling, illegal production of alcohol beverages, explosives, and gun law violations and tax evasion. Agents and officers also protect our borders against drug traffickers and continually strive to protect our citizens and property from the treat of bombs, arson, and gun violence. An important link in being able to effectively accomplish these missions is the communications link (i.e., radio spectrum). NTIA is responsible for advancing policies that foster national safety and security and full and efficient use of telecommunications resources in a manner which encourages the most beneficial uses thereof in the public interest.[5] More recently, Congress found that improved public safety remains an important public health objective of Federal, state and local governments and substantially facilitates interstate and foreign commerce.[6]

At the most basic level, radio-based voice communications allow dispatchers to direct mobile units to the scene of a crime and allow firefighters to coordinate and to warn each other of impending danger at fires. Radio systems are also vital for providing logistics and command support during major emergencies and disasters such as earthquakes, riots, or plane crashes. Systems are now being designed to allow transmission of video and broadband data, enabling paramedics to send pictures of injuries to trauma centers while en route, permitting the use of remote-controlled robotics to defuse explosives, and making viable the tracking of wild land fires. Thus, radio-based technologies are critical to the effective discharge of public safety agencies' obligations, providing a lifeline connecting public safety officials to assistance and delivering vital information to help in their critical mission.

The PSWAC was formed as an advisory committee to offer advise to both NTIA and the FCC on Federal, State, and local public safety issues, including spectrum requirements. The PSWAC Report found that the existing Federal Government spectrum allocations will satisfy Federal public safety/public service requirements through the year 2010 provided no additional spectrum is transferred to the FCC for commercial use.[7]

Federal public safety agencies rely heavily on two radio bands: the 162-174 MHz and 406.1-420 MHz. Data extracted from the GMF indicates that assignments in the 162-174 MHz band are increasing at a rate of nearly 8 percent per year, while assignments in the 406.1-420 MHz band are increasing at

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5 47 U.S.C.§901(b)(1), 901(c)(4).

6 Wireless Communications and Public safety Act of 1999, Public Law 106-81, Sec. 2. (a)(4), 113 Stat. 1286 1999.

7 Final Report, Public Wireless Advisory Committee (PSWAC), Appendix D, September 1996.

nearly 12 percent per year. These trends indicate that Federal public safety use is increasing, and as such, the reliance on wireless devices is as well. To reallocate spectrum used by Federal public safety agencies would be detrimental in that these agencies have no other spectrum to use.

Furthermore, many Federal agencies are partnering with their state and local counterparts to provide shared and joint use systems to become more effective. Reallocating spectrum from Federal public safety uses will hinder these systems and essentially degrade the ability to provide services that the American people have a right to receive.

The impact of future reallocations of spectrum that is used primarily by Federal public safety agencies would be detrimental to operations that the American public expect. A recent report by the Public Safety Wireless Network, a Government program coordinated by Treasury, shows that the Federal Government replacement cost for public safety systems is nearly $1.2 billion.[8] Therefore, an impact analysis is presented to further explain how any reallocations would affect the Federal Government's ability to provide public safety services.

Department of Justice

Consideration of any future reallocations must be viewed as band specific, i.e., the impact will vary depending on what band is viewed for potential reallocation. The majority of spectrum use by DOJ is primarily in the 162-174 MHz band (VHF) and secondarily in the 406-420 MHz band (UHF). Both of these bands are allocated for exclusive Government LMR use. In fact, these are the two primary land mobile frequency bands for civilian agency use.

In response to the mandate by NTIA, to narrowband channel use in these two land mobile Government bands, and a Congressional directive to consolidate all of the DOJ components into a single LMR communications system, DOJ has undertaken a comprehensive effort to develop the JWN concept. The consolidated JWN is a department-wide LMR system which utilizes the VHF and UHF Government spectrum with current budget estimates of $1 billion. The JWN is planned to fulfill the following goals:

- Increase spectrum efficiency
- Improve interoperability among all department components, as well as other Federal law enforcement agencies
- Maximize efficiencies and savings through shared infrastructure and common procurement strategies

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8 Public Safety Wireless Network LMR Replacement Cost Study Report, June 30, 1998.

Use of LMR communications is critical to support the DOJ mission. In conducting this mission, DOJ engages in a wide range of operations and functions that are supported by the LMR system. Any reallocation of this exclusive Government spectrum removes any spectrum options available to the Government to relocate its operations and thereby negates the ability for DOJ to carry out its critical spectrum dependent mission. Congress has recognized the necessity of a tactical LMR system and validated the DOJ goal to provide compatible and secure communications among all DOJ components to support joint missions and sharing of infrastructure for tactical and safety of life uses. Development of the JWN concept included evaluation and application of commercial services to the maximum extent possible. The new consolidated JWN concept includes a commercial services component for administrative uses that is not part of the cost estimate for the LMR system portion. The evaluation of commercial services revealed that the DOJ critical requirement for 24 hours a day/ 7 days a week priority tactical dispatch communications support could not be met by commercial services. For a reallocation of the VHF or UHF exclusive Government spectrum to be considered, cost effective, comparable service alternatives must be provided. Without alternative spectrum, or adequate commercial services to accommodate the displaced spectrum users there will be mission impacts that must be addressed in lieu of monetary impacts. The DOJ mission is to "enforce the law and defend the interests of the [United States] according to the law, provide Federal leadership in preventing and controlling crime, seek just punishment for those guilty of unlawful behavior, administer and enforce the Nation's immigration laws fairly and effectively and ensure fair and impartial administration of justice for all Americans." In conducting this mission, DOJ engages in a wide range of operations and functions. Wireless communications are critical to successfully meeting mission requirements and in many instances provide a life line during the conduct of these missions. The inability of the DOJ to achieve its mission goals by removal of the spectrum supporting this mission must be taken into consideration in any reallocation consideration of either the VHF or UHF Government exclusive spectrum bands.

The DOJ operates equipment in other frequency bands in a variety of unique technical scenarios that supplement the investigative requirements of the law enforcement user. The cost estimates of these uses vary by band and are considerably less costly than that of the LMR communications system. These uses are however significant in the way they enhance the sophisticated response to the adversary. In some instances alternatives may be considered, but given the technical complexity of these diverse uses and the associated technical evaluation required to assess alternative approaches, DOJ will provide cost and operational impact information in response to specific band inquiries.

Department of Agriculture

Several agencies in the Department rely heavily on radio support to accomplish their missions:

Forest Service. The Forest Service, in support of its mission, accounts for over 80 percent of the Department's radio use. The Forest Service's activities include wildfire firefighting, law enforcement, search and rescue, and other normal daily administrative and operational use involving the management of 140 million acres of public land. This includes; 155 national forests, wilderness areas, national grasslands, national primitive areas, national scenic and research areas, national wild and scenic rivers, national recreation areas, national game refuge and wildlife preserves, national monument areas, national historic areas, and national volcanic monument areas.

There are many responsibilities included in this management that require reliable radio communications. Most of these are in rural areas.

Recreation Management: Includes over 330 million visitor days per year involving 5,885 campgrounds, 328 swimming developments, 1,222 boating sites, 250 winter sports sites, 124,600 miles of rivers, and 369,000 miles of roads.

Law Enforcement: Includes investigation and enforcement of wildland arson, archeological theft, timber theft, illegal drug activities, and access and control of wildfire areas. Of special interest is the "urban" environment of some national forests during recreation season. There is a substantial requirement in law enforcement support of vehicle traffic, personal property theft, and domestic violence.

Incident Support: Communications support were provided in such incidents as wildfires (in recent years over 6 million acres burned between June and October), earthquakes (San Francisco & Los Angeles), hurricanes (Andrew, Hugo, & Inike), volcanic eruptions (Mt. St. Helens Volcano), oil spills (Valdez oil spill incident), nuclear disasters (Three Mile Island). In 1996, over 6,000 radios were issued out at an average of seven times each.

Aviation: Owned fleet – 42 fixed wing (air tankers, lead planes, air attack, smokejumper, infrared scan) and one rotary. Contracted fleet – 39 fixed wing (air tankers, air attack, smokejumper) and 505 rotary. Most are used in support of wildland firefighting; however, some are also used to transport personnel and equipment to support other incidents.

Office of Inspector General. Special agents conduct investigations of violations of Federal law as they pertain to the Department. They also provide protection to the Secretary of Agriculture.

Animal Plant and Health Inspection Service. The Animal Plant and Health Inspection Service's primary activities include inspection and eradication of plant pests, animal diseases, and wildlife damage. Radio support for these activities include air to ground, ground to ground, and telemetry. Inspection officers often work with port authorities for the inspection of cargo on international arrivals. Field veterinarians work in both local and remote sites to help diagnose animal disease in hopes of controlling or preventing disease spread.

The Food Safety and Inspection Service. Compliance and Investigation Division (CID), requires radio support for its investigations of violations involving meat, poultry, and/or egg products laws and regulations. CID interests are in the prevention of potential threat to human health and safety that could occur when clandestinely slaughtered livestock or adulterated products are placed in the human food channels.

Most of the Department's radio requirements are concentrated in three bands; 162-174 MHz, 406.1-420 MHz, and 1710-1850 MHz.

The 162-174 MHz band is where most of the Department's operations occur. There are approximately 60,000 radios in this band comprised of repeater stations, base stations, mobiles, and portables. The National Interagency Fire Center (NIFC) in Boise, Idaho, bases its primary cache of radio equipment in this band. If this band were to be reallocated, major mission requirements of the Department would not be able to be supported. It is not reasonable to calculate the cost if the Department were to lose this band to reallocation, since there is no alternative.

The Department utilizes the 406.1-420 MHz band to a lesser degree than the 162-174 MHz band; however, it still plays a major part in our activities. NIFC uses portable systems in this band for short-range communications at fire camps and at operation bases at other incidents. Equipment in this band is also used for interconnecting repeaters, base stations, or telephones where wireline or microwave is not cost effective. It is not reasonable to calculate the cost if USDA were to lose this band as they have no alternative.

The Department has over 1,300 microwave sites in 1710-1850 MHz band. The microwave sites are part of backbone systems that tie together the LMR systems of the Forest Service. A reallocation estimate of $130 million is provided that includes all USDA microwave stations in the 1710-1850 MHz band. This estimate is given in 1999 dollars and would cover the move of all stations into a higher frequency band.

Department of Energy

The DOE, as an agency with emergency and incident response responsibilities, has a need to maintain communications capability with other Federal, state, and local government entities in the vicinity of DOE facilities, and in certain situations nationwide. The Department's Nuclear Emergency Search Team (NEST) responds to national and worldwide incidents that usually involve Federal, state, and local public safety entities. The Transportation Safeguards Division (TSD) provides communications nationally for escort teams that require quick response communications to local public safety entities. NEST and TSD intercommunication with communications elements of other public safety entities are restricted by different frequency bands used by Federal, state, and local services and the lack of nationally accepted mutual aid channels. Currently, DOE has approximately 300 frequency assignments issued as co-licenses under Part 90 of the FCC Rules for fire, emergency medical, law enforcement, special emergency, and public safety mutual aid operations in the bands 150-159.4 MHz, 453-458.995 MHz, and 460-468.17 MHz. Most of the Department's Part 90 authorizations are in areas around DOE sites and laboratories. Needs for information sharing are expanding as technology builds an avenue for collection and intercommunications between parties having the necessary responsibilities and expertise for various emergencies. As an example, the technological capabilities of DOE's Lawrence Livermore National Laboratories are being partnered with the FBI to counter emerging threats to national security and public safety. DOE is continuing to strengthen existing methods and forging new avenues for sharing mobile based information, particularly information applicable to nuclear and energy emergencies. Some examples of specific cases where DOE is sharing radio communication systems are given in Appendix E.

Department of the Treasury

Approximately 93 percent of Treasury's business is conducted on equipment operating in the two Federal LMR bands: 162 – 174 MHz (VHF); and 406.1 – 420 MHz (UHF)). The Treasury strategic plan calls for using the VHF band to satisfy nationwide or wide-area requirements and the UHF band to satisfy local area or campus communications requirements. NTIA has mandated all Federal users of these bands to use equipment operating on a 12.5 kHz channel effective 2005 and 2008, respectively.

Treasury is implementing a nationwide digital narrowband LMR system, called the Integrated Treasury Network (ITN). The ITN will provide Treasury bureaus nationwide coverage through a LMR system which will consist of both trunked and conventional VHF digital narrowband equipment. The ITN will provide over-the-air-rekeying and over-the-air-programming capabilities to Treasury agents and officers thereby saving millions in time and manpower costs. Total estimated cost to study, design, build-out, operate and maintain the ITN through 2005 is about $486 million. Treasury believes that the ITN will provide low-cost, low-cost variability and high benefit for Treasury users. Additionally, the ITN will be based on digital technical standards that address common bureau requirements and realizes management and resource efficiencies through consolidation, sharing, centralization, and targeted use of commercial services. The ITN provides the flexibility to support bureau unique mission-critical law enforcement and protective requirements. It not only accommodates increased interoperability among Treasury bureaus, but also allows for interconnect with DOJ's wireless network and other Federal Government and state and local public safety entities. Treasury is seeking to have ITN fully implemented by December 31, 2004, to successfully meet NTIA's narrowband mandate.

The VHF and UHF LMR bands are widely used and are essential to the successful accomplishment of Treasury's many varied missions. Treasury is engaging in negotiations with several vendors to provide not only LMR equipment, but body-worn transmitters and receivers, tactical receivers, vehicle and package tracking transmitters and receivers, and video control equipment in the

VHF and UHF bands. These systems will probably be synthesized which will allow the equipment to be tuned to other frequencies, but the tuning range will be limited. Consequently, the reallocation of any portion of either the VHF or UHF LMR bands would make the remaining portion that much more congested. Any reallocation of either band, especially the VHF band, would have a devastating effect on Treasury's bureaus and negatively impact their ability to carry out their critical spectrum dependent missions and should be avoided at all costs.

Finally, Treasury has incurred many millions of dollars in costs for developing technical studies, issuing request for information and proposals, and purchasing equipment in order to comply with OBRA-93 and BBA-97 mandates and move the current systems from the two bands (216-220 MHz and 1710-1755 MHz) affecting Treasury systems. The bands being investigated to replace these two bands are the VHF LMR band and the 7/8 GHz band, respectively. Any effort to reallocate these other portions of the Federal spectrum will have a detrimental effect on Treasury's strategic and capital planning efforts to provide secure, effective, and efficient communications support to the Department and implement a nationwide wireless solution to consolidate bureau systems, reduce operations and maintenance cost, and expand the digital over-the-air rekeying and reprogramming essential for secure, seamless communications support to the dedicated Treasury officers and agents in the field.

Department of the Interior

The DOI uses LMR to support diverse missions in six major bureaus. Because of land dispersion, inherent public safety missions, the DOI bureaus must rely on LMR to accomplish these missions. DOI requires accessible LMR spectrum because of the amount of public safety activities coinciding with the bureau missions. The available spectrum for these operations exists in the VHF (162-174 MHz) and UHF (406.1-420 MHz) bands.

The following describes the bureau missions and requirements for LMR.

National Park Service (NPS). The NPS preserves the unimpaired natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of present and future generations. The National Park System encompasses approximately 80.7 million acres. The NPS administers three hundred plus areas in the system. There are three principal categories used in classification; namely, natural areas, historical areas, and recreational areas. The use of the national parks by over 250 million visitors annually makes the NPS rely heavily on LMR for reliable communications. LMR communications in the NPS support recreation management, law enforcement, and incident support.

Bureau of Land Management (BLM). The BLM administers 264 million acres of America's public lands, located primarily in 12 western states. The BLM sustains the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations. The BLM requires LMR to support law enforcement operations, wildland firefighting, and recreation.

Fish and Wildlife Service (FWS). The FWS is the only agency of the U.S. Government whose primary responsibility is fish, wildlife, and plant conservation. The Service helps protect a healthy environment for people, fish and wildlife, and helps Americans conserve and enjoy the outdoors and our living treasures. The Service's major responsibilities are monitoring and preserving migratory birds, endangered species, certain marine mammals, and freshwater and anadromous fish. The FWS uses LMR to support these preservation efforts in the areas of law enforcement, wildlife tracking and incident events.

Bureau of Indian Affairs (BIA). The BIA's mission is to enhance the quality of life, promote economic opportunity, and carry out the responsibility to protect the assets and improve the trust of American Indians, Indian tribes and Alaskan Natives. BIA requires LMR for support of law enforcement activities, incident events and tribal lands management.

Bureau of Reclamation (BOR). The mission of the BOR is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. BOR needs LMR to support law enforcement, hydrological operations and incident management.

United States Geological Survey (USGS). The USGS serves the nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. The USGS requires LMR for environmental monitoring, incident reporting, and support and field operations management.

The DOI plans to invest approximately 250 million dollars to narrowband radios in the VHF band by the year 2005. The Department's narrowband implementation strategy consists of a systematic evaluation of the baseline radio infrastructure to identify areas where sharing provides the best fit to support the mission requirement. The departmental strategy puts priority for funding radio programs in the following manner:

1. Public safety- law enforcement and fire-fighting activities;
2. Environmental monitoring activities;
3. Telemetry/wildlife operations; and
4. Other operations.

LMR systems were analyzed in terms of priority, location, cost, and redundancy. This process identified cost savings to make maximum use of infrastructure resources available to all bureaus in the narrowband transition process. The thorough analysis of initiatives like radio sharing, system engineering to match missions, independent contractor evaluations of infrastructure, commercial alternatives and senior level management involvement contribute to the vision of a "lean and mean" departmental radio infrastructure by the year 2005. The amount of money and time DOI spent to plan and engineer this effort will be wasted if the current LMR bands are reallocated. The reallocation will increase cost, disrupts current public safety communications efforts, and severely limits the ability of the Department to execute daily operational missions.

The Department has numerous microwave sites in the 1710-1850 MHz band. DOI operates fixed microwave links in this band for a variety of functions including: control of LMR 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. The DOI estimated the direct dollar costs associated with implementing reallocation in this band to be in the range of $8-13 million. The BOR has exemptions for frequencies for power generation. The BOR must continue to have the exemption to operate in this band.

Reallocating either the 162-174 MHz or the 406.1- 420 MHz band will potentially have a catastrophic effect on the conduct of DOI management of its natural resource programs using radio communication to accomplish its missions.

IMPACT OF FUTURE SPECTRUM REALLOCATION ON DEPARTMENT OF DEFENSE USE OF THE SPECTRUM

Introduction

NDAA-2000 directs NTIA to assess Congressionally-directed reallocation of spectrum from Federal to private-sector use mandated in Title VI of OBRA-93 and Title III of BBA-97. In response to these previous reallocation actions, the DoD submitted two reports, *Spectrum Reallocation Cost Impacts: OBRA-93*, dated 11 September 1998, and *Spectrum Reallocation Impacts: DoD Response to Office and Management and Budget*, dated 15 May 1998. Both of these reports provide the operational, cost concerns, and the potential impacts of further reallocation. These operational assessments, cost estimates, and concerns are still valid and remain relevant. Information taken from these two reports is provided in Appendix F to reiterate the key points on operational impacts and future spectrum reallocation actions.

The DoD's greatest concern is the operational impacts for today and in the foreseeable future that will result from spectrum reallocation. The DoD is confronted by very complex challenges and assessing these challenges is not a simple process. DoD continues to investigate methods to address, assess, and solve the spectrum challenges to support the "Warfighter."

The DoD's ability to collect, process, and disseminate an uninterrupted flow of information is dependent on assured access to the radio frequency spectrum and will be far more critical to the military in the United States and its Possessions, and worldwide in the future than it is today.

SECTION V
RECENT REALLOCATION ACTIONS OF THE FEDERAL COMMUNICATIONS COMMISSION

INTRODUCTION

The FCC's actions are broad-based approach to promoting efficient use of spectrum, thereby increasing the availability of spectrum for new technologies and services. Discussed in this section is one aspect of the FCC's spectrum planning program -- its efforts during the past decade to reallocate significant amounts of spectrum from existing non-Federal government and Federal Government users to new technologies and services under two of its own initiatives and two statutory directives. The FCC began this program in 1992 with its Emerging Technologies proceeding, and later identified additional spectrum that could be reclaimed and reallocated as television broadcasting stations transitioned to DTV. Spectrum transferred from the Federal Government under OBRA-93 and BBA-97 has supported these FCC's efforts. In total, 590 MHz of spectrum is being reallocated under this recent reallocation program, with 343 MHz being reallocated among non-Federal government uses and 247 MHz being transferred from Federal Government to non-Federal government use under OBRA-93 and BBA-97. Since beginning this recent program, the FCC has reallocated 273 MHz of both non-Federal government and Federal Government spectrum to new technologies and services; 363 MHz of spectrum will be reallocated as part of several ongoing and planned proceedings; and 40 MHz of spectrum is being held in reserve.

Much of the spectrum identified for this recent reallocation program is located in bands below 3 GHz, which is suitable for a wide range of technologies and services. There are numerous considerations associated with many of the bands that will affect their availability and suitability for new services. Much of the available spectrum is subject to statutory requirements that it be reallocated and auctioned by specific dates. In addition, the spectrum identified under OBRA-93 and BBA-97 for transfer from Federal Government to non-Federal government use is being made available over a period of time. Portions of the transfer spectrum were not available for new uses until 1999, and other portions will not be available until after the year 2000. Some, possibly all, of the 698-746 MHz band now used by the Television Broadcasting Service may not be available for a long period of time. In many of the transferred bands, new services will be required to protect existing Government operations that will continue to operate after the bands are otherwise transferred, and some bands will be mixed use or shared on an ongoing basis between Federal Government and non-Federal government users. Access to some bands will require that new service licensees pay the relocation costs of incumbent Federal Government users.

PLANS FOR SPECTRUM AVAILABILITY

The spectrum recently identified for reallocation under two major FCC initiatives— the Emerging Technologies proceeding and the television broadcasting transition to DTV— demonstrates the benefits that result from efficient use of non-Federal government spectrum. Recent contributions of Federal Government spectrum under OBRA-93 and BBA-97 have assisted the FCC's efforts to increase the availability of spectrum for new technology and services. As discussed below, the reallocation and assignment of spectrum identified by these sources will occur over an extended period of time, allowing for an orderly transition from existing to new services.

Emerging Technologies Spectrum

The FCC in 1992 reallocated 220 MHz in the frequency bands 1.85-1.99 GHz, 2.11-2.15 GHz, and 2.16-2.20 GHz to fixed and mobile services for use with new technologies. The FCC generally required that new entrants be responsible for relocating incumbent users to comparable facilities at higher frequency bands, except in the limited cases where sharing was not feasible. The sharing and relocation procedures were intended to prevent unnecessary disruption and to minimize economic impact to incumbent services. Relocation procedures allow for the spectrum use to transition over a period of years to the new services.

The FCC has reallocated 175 MHz of spectrum for emerging technologies.

- 120 MHz at 1.85-1.91 GHz and 1.93-1.99 GHz allocated for licensed PCS, which was assigned by competitive bidding;
- 20 MHz at 1.91-1.93 GHz designated for unlicensed PCS;
- 35 MHz at 2165-2200 MHz allocated for MSS.

The FCC has proposed to allocate 40 MHz at 2110-2150 MHz for fixed and mobile services, and 5 MHz at 2160-2165 MHz remains available. As discussed further below, in its 1999 Policy Statement the FCC stated its intention to designate both of these bands for advanced mobile and fixed wireless service.

Omnibus Budget Reconciliation Act of 1993 (OBRA-93)

OBRA-93 authorized the reallocation for non-Federal government use of not less than 200 MHz of spectrum under 5 GHz, of which not less than 100 MHz would be below 3 GHz. This spectrum was to be taken from spectrum allocated for the primary use of the Federal Government. The FCC was to allocate 50 MHz of the transfer spectrum within 18 months of the issuance of the Secretary of Commerce's report identifying the transfer spectrum. OBRA-93 directed the FCC to submit to the

President and Congress a plan for the remaining 185 MHz of spectrum. As further directed by OBRA-93, the FCC's plan was to reserve a significant portion of the transfer spectrum for later use and allocate at least 80 MHz of the remainder of the available spectrum gradually over the next 10 years.

Pursuant to OBRA-93, the Secretary of Commerce identified 235 MHz of spectrum for transfer for non-Federal government use. Under the requirements of Title VI of OBRA-93, the Secretary identified and recommended for reallocation bands of frequencies that were the most likely to have the greatest potential for productive uses and public benefits under the 1934 Communications Act if allocated for non-Federal use. As mentioned earlier, the following factors were specified in Section 113 of Title VI of OBRA-93 and were used to address the public benefits of reallocating Federal Government spectrum: a) the extent to which equipment is or will be available that is capable of utilizing the band; b) the proximity of frequencies that are already assigned for commercial or other non-Federal use; c) the extent to which, in general, commercial users could share the frequency with amateur radio licensees; and d) the activities of foreign government in making frequencies available for experimentation or commercial assignments in order to support domestic manufactures of equipment.

OBRA-93 also authorized the FCC, for the first time, to assign licenses by competitive bidding. It also required the FCC to license within five (5) years, in accordance with the competitive bidding provisions of Section 309(j) of the Communications Act, at least 10 MHz of the reallocated spectrum.

As directed by OBRA-93, in 1996 the FCC submitted to Congress a plan for the remaining 185 MHz of spectrum. The 1996 plan placed in reserve 65 MHz at 1390-1400 MHz, 1427-1432 MHz, 1670-1675 MHz, and 1710-1755 MHz, which would not be assigned until 2006. In 2000, the FCC allocated 8 MHz of reserve spectrum at 1395-1400 MHz and 1429-1432 MHz for wireless medical telemetry devices, thereby reducing the reserve. As discussed below, the FCC further modified the spectrum reserve bands in its 1999 Policy Statement. The FCC's plans for the OBRA-93 spectrum were further modified as a result of two additional events. BBA-97 advanced the availability of the 1710-1755 MHz band. In 1999, the NTIA, on behalf of the President, reclaimed the 50 MHz at 4635-4685 MHz, half of which the FCC had allocated for General Wireless Communications Service (GWCS) but subsequently rescinded, and substituted 50 MHz at 4940-4990 MHz. The FCC has allocated 98 MHz of the spectrum transferred under OBRA-93 and proposed the allocation of 50 MHz of spectrum.

The reallocated spectrum transferred under OBRA-93 includes:

- 8 MHz at 1395-1400 MHz and 1429-1432 MHz for WMTS.
- 5 MHz at 2305-2310 MHz allocated to WCS, part of a total 30 MHz for this service, which amateur radio service upgraded to primary.
- 15 MHz at 2402-2417 MHz band continued to be allocated for unlicensed devices operating under Part 15 of the Commission's Rules and amateur service allocation upgraded to primary.

- 50 MHz at 3650-3700 MHz for fixed and mobile (except aeronautical) services.

The spectrum proposed for reallocation includes 50 MHz at 4940-4990 MHz band for the GWCS, a new flexible fixed/mobile service, for assignment by auction.

As discussed below, in its 1999 Policy Statement the FCC stated its intentions for the remaining 57 MHz of spectrum transferred under OBRA-93 for non-Federal government use.

Balanced Budget Act of 1997 (BBA-97)

Whereas OBRA-93 focused on the transfer of spectrum from Federal Government to non-Federal government use, BBA-97 emphasized the FCC's role to reallocate non-Federal government spectrum for new services and technologies and to assign it by auction. BBA-97 identified certain non-Federal government bands for reallocation and auction and specified that an additional 20 MHz below 3 GHz would be transferred from Federal Government to non-Federal government use and assigned by auctions. BBA-97 also expanded the scope of the FCC's auction authority, although it excluded some services such as public safety radio services.

Auction of 55 MHz of non-Federal government spectrum**:** BBA-97 directed the FCC to reallocate 55 MHz of non-Federal government spectrum and to assign it by auction no later than September 30, 2002. It further directed that this spectrum include the 2110-2150 MHz band already identified for reallocation under the Emerging Technologies proceeding and 15 MHz from within the 1990-2110 MHz band. The President was given the option to identify 15 MHz for auction from alternative spectrum if the Administration determined that the spectrum from the designated band was needed to protect incumbent Federal Government systems from interference and that allocation of other spectrum would better serve the public interest and could reasonably be expected to produce comparable auction revenues.

The President, through NTIA, exercised the option to propose alternative spectrum that could be assigned by auction. The suggested alternative bands are: (1) 944-960 MHz, which is currently used by the broadcasting service and fixed service; (2) 1390-1400 MHz, 1427-1432 MHz and 1670-1675 MHz, which were transferred to the FCC pursuant to OBRA-93; (3) 2500-2690 MHz, which is currently used by the MDS, Instructional Television Fixed Service, and fixed service; and (4) 3650-3700 MHz, which was transferred to the FCC pursuant to OBRA-93. The FCC noted in its 1999 Policy Statement that although the OBRA-93 bands may be auctioned as substitutes for the 15 MHz within the 1990-2110 MHz, they would not provide additional spectrum for new uses beyond the allocations already made, proposed or planned by the FCC. In considering the other suggested bands, the FCC noted that both 944-960 MHz and 2500-2690 MHz are already used extensively for existing non-Federal government services, which would limit the opportunities for licensing new services on these frequencies.

***Reclaimed television channels*:** BBA-97 required that, as licenses for analog television service expire in the transition to DTV service, the FCC is to reclaim and reorganize the vacated spectrum (108 MHz) for assignment by auction in most cases. In its DTV proceeding, the FCC provided that the transition from analog to DTV service would result in the early recovery of 60 MHz at 746-806 MHz and the later recovery of 48 MHz at 698-746 MHz at the end of the transition. BBA-97 provides that licensees may continue to use spectrum for analog television service until December 31, 2006, and the FCC must extend license terms beyond that date under certain circumstances. BBA-97 also provides that licenses for new services occupying spectrum reclaimed as the licenses for analog television service expire shall be assigned by auction by September 30, 2002. BBA-97 directed the FCC to designate, no later than January 1, 1998, 24 MHz at 746-806 MHz for exclusive use by public safety services, which would not be assigned by auction. The remaining 36 MHz of spectrum at 746-806 MHz is to be made available for commercial services for assignment by auction.

***Transfer of Federal Government Spectrum*:** As required by BBA-97, in 1998 the Secretary of Commerce released a report identifying 20 MHz of spectrum to transfer from Federal Government to non-Federal government use. Six frequency bands—139-140.5 MHz, 141.5-143 MHz, 216-220 MHz, 1385-1390 MHz, 1432-1435 MHz, and 2385-2390 MHz—were designated. As specified earlier, Title III of BBA-97 specified criteria to be used in identifying spectrum for reallocation which consisted of two overriding factors: (1) the impact on the Federal agencies, in terms of mission, costs, and potential reduction of services to the public, and (2) the benefits expected to be realized by the public. Title X of NDAA-2000 reduced the amount of spectrum to transfer under BBA-97, by retaining for exclusive Federal Government use 3 MHz at 138-144 MHz and 5 MHz at 1385-1390 MHz. This action effectively reduced the amount of transfer spectrum under BBA-97 to 12 MHz at 216-220 MHz, 1432-1435 MHz, and 2385-2390 MHz bands.

BBA-97 also accelerated the availability of the 1710-1755 MHz band, which had been identified for transfer to non-Federal government use under OBRA-93. This band had been scheduled for transfer to non-Federal government use in the 25 largest cities in January 1999 and in all other locations in January 2004. BBA-97 requires this spectrum to be assigned for commercial use by competitive bidding, with the auction to commence after January 1, 2001.

***FCC actions pursuant to BBA-97*:** As required by BBA-97, in 1999 the FCC reported to the President and Congress its plans for the spectrum transferred from Federal Government to non-Federal government use under both OBRA-93 and BBA-97. The FCC has reallocated 60 MHz of spectrum pursuant to BBA-97.

- 24 MHz at 764-776 MHz and 794-806 MHz, which is recaptured television broadcast spectrum, for fixed and land mobile services and designated for public safety use;
- 36 MHz at 746-764 MHz and 776-794 MHz, which is recaptured television broadcast spectrum, for fixed, mobile and broadcasting services.

As discussed below, in its 1999 Policy Statement, the FCC stated its plans for the 12 MHz of spectrum transferred under BBA-97 and the additional 15 MHz of spectrum to be reallocated and made available for auction pursuant to BBA-97.

Strom Thurmond National Defense Authorization Act for Fiscal Year 1999

FCC planning for reallocating Government transfer spectrum is significantly affected by the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 (Thurmond Act).[1] This Act requires auction-winning licensees in certain spectrum to compensate Federal entities for their relocation costs. The Thurmond Act applies to the 12 MHz of spectrum designated for transfer to the FCC under BBA-97, as modified by NDAA-2000, and to the 1710-1755 MHz band, identified for transfer under OBRA-93. The relocation costs of Government stations must enter into the calculation of the value of the transfer spectrum bands in considering reallocation options. NTIA will receive reports from Government agencies of the marginal costs of relocation, and the FCC, with the cooperation of NTIA, will notify potential bidders of the estimated relocation costs.

Policy Statement on Reallocation of Spectrum (1999)

The FCC's 1999 Policy Statement[2] addressed the spectrum remaining from frequency bands that were to be made available under the spectrum recovery efforts of the past decade that are described above. Much of this spectrum is located in bands below 3 GHz and is suitable for a wide range of emerging technologies and services, including mobile services. In addition, there are frequency blocks of varying size within this spectrum that can accommodate the differing needs of the variety of new services now seeking allocations. In developing a spectrum plan for the new millennium, the FCC took into consideration the statutory requirements for reallocating and auctioning the available spectrum, the statutory requirement that we maintain a reserve of spectrum for future uses, the availability and suitability considerations associated with each of the bands, our spectrum policy goals as discussed in Section II of this report, and the various identified needs for new spectrum.

The FCC stated its policies, consistent with the auction requirements of the OBRA-93 and BBA-97, to allocate a major portion of the available spectrum for services in which licenses will be assigned by competitive bidding and to make the allocations as flexible as possible, recognizing the technical parameters required to address interference issues. Specifically, the FCC stated that it will consider allocating:

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1 The Strom Thurmond National Defense Authorization Act for 1999, Public Law No. 105-261, 112 Stat. 1920.

2 The FCC Statement Policy, *Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millennium*, (November 18, 1999).

- 90 MHz to establish a new AMFCS, a new flexible use service that could be used for future "third generation" mobile service; considering 50 MHz at 1710-1755 MHz and 2160-2165 MHz, plus 40 MHz at 2110-2150 MHz;
- 10 MHz to establish a new Land Mobile Communications Service that makes use of spectrum efficient radio technologies; considering 1390-1395 MHz, 1427-1429 MHz, and 1432-1435 MHz;
- 48 MHz at 698-746 MHz (existing TV channels 52-59) for fixed, mobile and new broadcast services;
- an additional 10 MHz for fixed and mobile service; considering 1670-1675 MHz and 2385-2390 MHz.

Spectrum reserve: Consistent with OBRA-93's requirements, the FCC's plan maintained a portion of the spectrum as a reserve for future use after the year 2006. In order to provide the most appropriate frequency bands to meet existing needs, the FCC will require use of all of the frequency bands it had included in the spectrum reserve required under OBRA-93. Thus, the FCC replaced the prior spectrum reserve with a new reserve of 40 MHz in three frequency bands at 2300-2305 MHz, 2400-2402 MHz, and 2417-2450 MHz. In so doing, the FCC made the following observations about the new reserve spectrum. The 5 MHz at 2300-2305 MHz has generally been transferred from Government use, but any operations in this band would be subject to significant constraints in order to protect the reception of signals from the Government's DSN that will remain in the band. The 35 MHz at 2400-2402 MHz and 2417-2450 MHz are currently used by ISM equipment and very low power radio devices. This existing use restricts the availability of the bands for new services given current sharing techniques. In view of these considerations relating to existing uses, the FCC concluded that it was reasonable to reserve the 2300-2305 MHz, 2400-2402 MHz, and 2417-2450 MHz bands until a future time, when new technology or other changes may increase the opportunities for new operations in these bands.

APPENDIX A

TEXT OF TITLE X, SUBTITLE G, SECTION 1062, OF THE NATIONAL DEFENSE AUTHORIZATION ACT FOR Fiscal Year 2000 (S1059)

SEC. 1062. ASSESSMENT OF ELECTROMAGNETIC SPECTRUM REALLOCATION.

(a) ASSESSMENT REQUIRED- Part C of the National Telecommunications and Information Administration Organization Act is amended by adding after section 155 the following new section:

SEC. 156. ASSESSMENT OF ELECTROMAGNETIC SPECTRUM REALLOCATION.

(a) REVIEW AND ASSESSMENT OF ELECTROMAGNETIC SPECTRUM REALLOCATION-

(1) REVIEW AND ASSESSMENT REQUIRED-The Secretary of Commerce, acting through the Assistant Secretary and in coordination with the Chairman of the Federal Communications Commission, shall convene an interagency review and assessment of--

(A) the progress made in implementation of national spectrum planning;

(B) the reallocation of Federal Government spectrum to non-Federal use, in accordance with the amendments made by title VI of the Omnibus Budget Reconciliation Act 1993 (Public Law 103-66; 107 Stat. 379) and title III of the Balanced Budget Act of 1997 (Public Law 105-33; 111 Stat. 258); and

(C) the implications for such reallocations to the affected Federal executive agencies.

(2) COORDINATION-The assessment shall be conducted in coordination with affected Federal executive agencies through the Interdepartmental Radio Advisory Committee.

(3) COOPERATION AND ASSISTANCE-Affected Federal executive agencies shall cooperate with the Assistant Secretary in the conduct of the review and assessment and furnish the Assistant Secretary with such information, support, and assistance, not inconsistent with law, as the Assistant Secretary may consider necessary in the performance of the review and assessment.

(4) ATTENTION TO PARTICULAR SUBJECTS REQUIRED-In the conduct of the review and assessment, particular attention shall be given to–

(A) the effect on critical military and intelligence capabilities, civil space programs, and other Federal Government systems used to protect public safety of the reallocated spectrum described in paragraph (1)(B) of this subsection;

(B) the anticipated impact on critical military and intelligence capabilities, future military and intelligence operational requirements, national defense modernization programs, and civil space programs, and other Federal Government systems used to protect public safety, of future potential reallocations to non-Federal use of bands of the electromagnetic spectrum that are currently allocated for use by the Federal Government; and

(C) future spectrum requirements of agencies in the Federal Government.

(b) SUBMISSION OF REPORT-The Secretary of Commerce, in coordination with the heads of the affected Federal executive agencies, and the Chairman of the Federal Communications Commission shall submit to the President, the Committee on Armed Services and the Committee on Commerce, Science, and Transportation of the Senate, and the Committee on Armed Services, the Committee on Commerce, and the Committee on Science of the House of Representatives, not later than October 1, 2000, a report providing the results of the assessment required by subsection (a).

(c) SURRENDER OF DEPARTMENT OF DEFENSE SPECTRUM-

(1) IN GENERAL-If, in order to make available for other use a band of frequencies of which it is a primary user, the Department of Defense is required to surrender use of such band of frequencies, the Department shall not surrender use of such band of frequencies until–

(A) the National Telecommunications and Information Administration, in consultation with the Federal Communications Commission, identifies and makes available to the Department for its primary use, if necessary, an alternative band or bands of frequencies as a replacement for the band to be so surrendered; and

(B) the Secretary of Commerce, the Secretary of Defense, and the Chairman of the Joint Chiefs of Staff jointly certify to the Committee on Armed Services and the Committee on Commerce, Science, and Transportation of the Senate, and the Committee on Armed Services and the Committee on Commerce of the House of Representatives, that such alternative band or bands provides comparable technical characteristics to restore essential military capability that will be lost as a result of the band of frequencies to be so surrendered.

(2) EXCEPTION-Paragraph (1) shall not apply to a band of frequencies that has been identified for reallocation in accordance with title VI of the Omnibus Budget Reconciliation Act of 1993 (Public Law 103-66; 107 Stat. 379) and title III of the Balanced Budget Act of 1997 (Public Law 105-33, 111 Stat. 258), other than a band of frequencies that is reclaimed pursuant to subsection (c).

(d) REASSIGNMENT TO FEDERAL GOVERNMENT FOR USE BY DEPARTMENT OF DEFENSE OF CERTAIN FREQUENCY SPECTRUM RECOMMENDED FOR REALLOCATION-

(1) Notwithstanding any provision of the National Telecommunications and Information Administration Organization Act or the Balanced Budget Act of 1997, the President shall reclaim for exclusive Federal Government use on a primary basis by the Department of Defense--

(A) the bands of frequencies aggregating 3 megahertz located between 138 and 144 megahertz that were recommended for reallocation in the second reallocation report under section 113(a) of that Act; and

(B) the band of frequency aggregating 5 megahertz located between 1385 megahertz and 1390 megahertz, inclusive, that was so recommended for reallocation.

(2) Section 113(b)(3)(A) of the National Telecommunications and Information Administration Organization Act (47 U.S.C. 923(b)(3)(A)) is amended by striking 20 megahertz and inserting 12 megahertz.

APPENDIX B

DEPUTY SECRETARY OF DEFENSE

1010 DEFENSE PENTAGON
WASHINGTON, DC 20301-1010

DEC 1 0 1998

Honorable Floyd Spence
Chairman
Committee on National Security
House of Representatives
Washington, DC 20515-6035

Dear Mr. Chairman:

The purpose of this letter is to provide your committee with the report on Department of Defense (DoD) Spectrum Reallocation Cost Impacts. Submission of this report is in response to the Section 1064 of the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 report (Public Law 105-261).

Title VI of the Omnibus Budget Reconciliation Act of 1993 (OBRA-93, Public Law 103-66) resulted in the identification for reallocation of at least 200 MHz of federal spectrum. Title III of the Balanced Budget Act of 1997 (BBA-97, Public Law 105-33) resulted in the identification for reallocation of an additional 20 MHz of federal spectrum. This report contains the results of our review of the identified frequency bands to determine the specific operational and cost impacts that will be caused by OBRA-93 reallocations. Also enclosed is the Spectrum Reallocation Impacts: DoD Response to the Office of Management and Budget, 15 May 1998. This report contains operational and cost impacts that will be caused by BBA-97 reallocations. Additional costs that would be incurred by classified programs, due to these reallocations, are not included in these reports. A classified report will be submitted under separate cover.

As you can see from the report, OBRA-93 will cost the Defense Department as much as $2.3 billion. In the current capped funding environment, those reallocation costs directly threaten the readiness of our forces. We stand ready to do our part and make the changes necessary to make more efficient use of the spectrum. However, we cannot make changes that negatively impact national security in the present or that limit our flexibility to make use of the spectrum to protect national security in the future.

Sincerely,

John J. Hamre

Enclosures

cc:
Honorable Ike Skelton
Ranking Democrat

Spectrum Reallocation Cost Impacts:
OBRA-93

CAVEAT: This report does not include additional costs that would be incurred by classified and/or special access programs. The information contained herein is unclassified only.

The Joint Chiefs of Staff have provided military planners with an operationally based template for the evolution of the Armed Forces over the next several years (Joint Vision 2010). Based on this emerging framework, future operational concepts will require improved command, control, and intelligence. The ability to collect, process, and disseminate an uninterrupted flow of information, while exploiting or denying the enemy's ability to do the same, is paramount to the success of these new strategies. Assured access to the radio frequency (RF) spectrum will thus be at least as critical to the military in the future as it is today.

Although many individuals and organizations use the spectrum, the military faces unique challenges in its spectrum Operations. Military communications-electronics systems perform a wide variety of functions. Many of these functions must be performed simultaneously on small platforms or by units in close proximately to one another. Military aircraft, for example, perform voice communications, radionavigation, and radar surveillance operations. They also have uniquely military requirements such as sustaining multiple radar tracks of hostile, forces, launching and controlling weapons, conducting data communications and/or relay with cooperating units, jamming hostile sensors, and performing counter-countermeasures when necessary. Successfully performing all of these spectrum dependent functions, in the face of active attempts by hostile forces to jam and disrupt their operation, demands various control measures that in turn require sufficient spectrum to be effective. Limiting the tuning capability of military systems by decreasing their available spectrum inherently increases their vulnerability to hostile attack and self-induced interference.

Technologically superior equipment has been critical to our past combat success. We must maintain this edge even as we face the wider range of threats our technologically advanced adversaries will employ. Many recent developments in military technology, including anti-stealth and portable mine detection radars, integrated aircraft avionics, and secure, high capacity communications, require greater spectrum access rather than less. In the case of the highly mobile, and often life threatening operations of the military, there simply are no alternatives to using the spectrum.

In light of its increasing information requirements, DoD continues to participate in, and often leads efforts to develop spectrum efficient methods and technologies. Long-term goals include the development of technologies such as adaptive, software-driven equipment and advanced spectrum management techniques. Mid-term initiatives include a multi-layer national technology thrust in aerospace communications efficiency, with immediate emphasis on developing and implementing new, efficient modulation techniques. However, technology advances and their implementation in military systems, doctrine, and training cannot occur overnight. It is imperative that we devise and adhere to an orderly transition from legacy technologies and methods to those of tomorrow. An orderly transition is critical if we are to sustain the military readiness and superiority required for the broad range of deterrent, conflict prevention, and peacetime activities that we will face in the foreseeable future.

Preserving access to the spectrum resources required by today's military is a prerequisite for the transitions to follow.

As illustrated in the table below, military access to the spectrum is being increasingly constrained in the face of increasing requirements. Many of the military technology advantages employed today and planned for tomorrow rely heavily on access to specific portions of the electromagnetic spectrum. Unfortunately, the same spectrum, that below five to six GHz, is of great value to both military and commercial applications. In fact, over 90 percent of DoD's permanent frequency assignments are registered in bands below 3 GHz.

Spectrum Constraints Imposed by Recent and Planned Reallocations

Band Affected (MHz)	OBRA-93, Title VI	BBA-97, Title III	MHz Reallocated	Reallocation Status
138-144		139-140.5	1.5	Mixed
		141.5-143	1.5	Mixed
216-220		216-220	4	Mixed
1350-1400		1385-1390	5	Exclusive
	1390-1400		10	Exclusive
1427-1435	1427-1432		5	Exclusive
		1432-1435	3	Mixed
1670-1690	1670-1675		5	Mixed
1710-1850	1710-1755		45	Mixed
2300-2310	2300-2310		10	Exclusive
2310-2390		2385-2390	5	Exclusive
2390-2450	2390-2417		27	Exclusive
	2417-2450		33	Mixed
3600-3700	3650-3700		50	Mixed
4500-4800	4635-4685		50	Exclusive
Total MHz Reallocated	235	20	255	

One of the DoD's major concerns is the unnecessarily rapid rate at which the reallocation process is conducted. The report to Congress for Title VI of the Omnibus Budget Reconciliation Act (OBRA-93) was submitted after 18 months of analysis and negotiation. The Balanced Budget Act of 1997 (BBA-97) was signed into law on 8 August 1997, with NTIA's report due to Congress in six months (delivered 8 February). NTIA made its first spectrum band selection for BBA-97 during the second week of September 1997 and requested impacts and cost analysis by 30 November 1997. Selected bands were changed several times over the following months, and the final decision on band selection was not made until early January 1998. The DoD, as primary user of these bands, will experience major cost impacts and impairments to critical missions because of these reallocations.

This report summarizes spectrum identified for reallocation as a result of OBRA-93. In this report, we considered the following:

- Current missions and functions performed in each band
- Primary systems in each band and their estimated operational lifetimes
- Estimates of the costs associated with the reallocations
- Details regarding the cost drivers associated with each of the estimates
- The nature and severity of anticipated operational impacts
- The primary sites affected by the reallocation and an assessment of the impact for those sites

A copy of a separate report on the impact of the spectrum identified for reallocation by BBA-97 is enclosed.[1]

The DoD's greatest concern is the operational impacts that will result from spectrum reallocations. The impacts discussed in this report are in the context a National Defense posture that will remain unchanged for the foreseeable future. This posture requires that our forces receive adequate training and be prepared for short notice deployment to regional hotspots throughout the world. There is also a continuing requirement for non-combat operations worldwide as the military continues to participate in a broad range of deterrent, conflict prevention, and peacekeeping activities. No medium other than the RF spectrum can support the DoD's attendant mobility and flexibility requirements. Critical missions and operations affected by reallocations include precision strike test, training operations, and aeronautical telemetry operations that support flight testing of aircraft, spacecraft, and missiles at major military test ranges and facilities.

The NTIA intended to provide the means to continue some of DoD's critical operations by reallocating some of the spectrum on a 'Mixed Use' basis and allowing selected protection zones where military use of the spectrum will be permitted to continue. The DoD is concerned that these zones will not provide sufficient

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1 Spectrum Reallocation Impacts: DoD Response to the Office of Management and Budget, 15 May 98

protection nor prevent electromagnetic interference (EMI) between Federal and non-Federal operations. For example, the DoD's airborne tactical communications are not protected by the zones identified for the 139-140 -140.5 and 141.5-143 MHz bands reallocated by BRA-97. In fact, in some cases, a single protection zone is proposed for multiple sites that are geographically separated by a distance greater than the diameter of the protection zone.

Of additional concern to the DoD is the cost of implementing OBRA-93 and BBA-97 reallocations. Although analysis is ongoing, estimates to date clearly show that the costs will be substantial. Both low and high costs estimates from both reports are presented herein, along with identification of the uncertainties and expected conditions that will strongly influence the ultimate cost. The low and high estimates of OBRA-93 reallocation costs are $247.2 million and

$1,240.2 million, respectively. The OBRA-93 reallocation costs are based on information provided to NTIA as part of the OBRA-93 band selections process.

Our report to OMB estimated the BBA-97 reallocation costs to range from a low of $436 million to a high of $2,518 million. The total estimated cost of both reallocation is between

$556.3 million and $2,271.7 million. The high cost estimate associated with the frequency band between 1385-1390 MHz was decreased by approximately $449 million. Frequency band

2390-2450 MHz was increased by approximately $12 million and the frequency band between 1710-1755 MHz was increased by $7 million. This results in a decrease from $2,518 million to 2271.7M). These totals, identified below, take into account the combined updated costs of both reallocations and include the effect of reallocating bands for BBA-97 that are adjacent to those reallocated by OBRA-93.

Reallocation costs from both reports are not cumulative in some cases. As an example, OBRA-93 reallocated 1390 -1400 MHz and BBA-97 reallocated 1385-1390 MHz. Radar operating in those bands require filters which cost the same, whether it is a 10 MHz or 15 MHz filter. The filter costs are reflected in each report, but the combined cost is not cumulative, and is collectively reflected in this table only once.

An estimated low cost/high cost approach was employed to account for the system complexities and technical., policy, and doctrinal uncertainties associated with constraining the operation of systems that support critical functions. These functions include continental air defense, tactical radio relay, missile telecommand and guidance, and aeronautical flight-testing. The low cost/high cost estimate accommodates the uncertainties involved for cases where reducing the frequency availability would have an unknown impact on operational readiness. That is, if the missions can still be accomplished with the reduced-spectrum capability, the low cost estimate will be realized. If, on the other hand, the mission would be compromised by the reduced-spectrum capability, the estimated high cost would be required to develop other means to accomplish the mission. The same basic rationale applies to all bands and equipment included in this report.

Specific details describing individual system complexities and uncertainties regarding operational impacts are provided in the discussion that follows. Low-cost estimates generally consist of modifications to existing equipment to facilitate their operation in the remaining spectrum. High

ESTIMATED TOTAL COST IMPACTS DUE TO OBRA-93 AND BBA-97

OBRA-93, Title VI	BBA-97 Title III	Reallocation Costs ($M)
	139 - 140.5	80 - 1,000
	141.5 - 143	
	216 - 220	0.37 - 1
	1385 - 1390	185.6 - 682.4
1390 - 1400		
1427 - 1432		
		67 - 170
1670 - 1675	1432 - 1435	
1710 - 1755		0
2300 - 2310		38.4 - 138.4
2390 - 2417		0
2417 - 2450	2385 - 2390	120.2 - 215
3650 - 3700		51.1
4635 - 4685		13.7
Total Reallocation Costs ($M)		556.3 - 2271.7

cost estimates generally consist of major equipment modifications or development of new, replacement systems that operate in an alternative frequency band. It should be noted, however, that numerous factors such as the physics of propagation, the density of current spectrum, users and concern regarding possible future reallocations make it extremely difficult for the DoD to gain access to alternative spectrum.

The OMB requested that the DoD provide a description of the conditions, actions, regulations, or policies that would need to occur or be in place in order for DoD to realize the lowest cost impacts.[2] Obviously, both cost and operational impacts would be reduced if some or all of the planned spectrum reallocations were rescinded. Likewise, full reimbursement of the c cost incurred as a result of OBRA-03 and BBA-97 would negate reallocation costs to the DoD, provided adequate alternative spectrum was available.

The OMB memorandum also requested that the DoD identify any additional legislative or regulatory actions that could reduce cost of operational impacts to DoD. The DoD believes the following are actions that should be taken in this regard:

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[2] OMB memorandum, Impact of Spectrum Auctions of the Department of Defense, 5 March 1998

- A footnote should be included in the National Table of Allocations authorizing use of the 1385-1400 MHz band by the Commander in Chief of the North American Defense (CINCNORAD) radar assets during a national defense situation, as determined by a CINCNORAD

- Sufficient time and funds should be provided to conduct a thorough analysis of reallocation alternatives prior to drafting future spectrum reallocation legislation.

Solutions to the challenges arising from the impacts of spectrum reallocations are being aggressively pursued, and the DoD is expending significant resources to project its spectrum needs for the future. These are formidable tasks, however, since they included not only a determination of future operational scenarios and corresponding information requirements but also an informed estimate of the types and extent of future technology development. Completing such complex tasks will require time, as will migrating to any future spectrum management techniques and advanced technologies. The Defense Department requires adequate spectrum access to support National Defense mission in the interim. Measures that would help to mitigate the impacts of spectrum reallocations and assure adequate spectrum availability include:

- Reimbursing the full cost incurred to migrate from the one frequency band to another

- Implementing and enforcing equipment (transmitter and receiver) standards for spectrum users.

It is certain that advancements in technology and spectrum management techniques will enable more to be done with a given amount of spectrum. However, the demand for increased information capacity and the spectrum the support it has historically outpaced technological developments. Thus, the only long-term way to make adequate spectrum available for Government and non-Government needs is to develop technologies and practices that address the issue of sharing spectrum, Compatible spectrum sharing will not just happen. Apportioning the limited spectrum resource in the best interests of the American people requires the formation of a National Spectrum Plan to establish and protect our national priorities. This National Spectrum Plan should address the following:

- Whether spectrum used by National Security systems should be exempt from reallocation
- Whether a moratorium on reallocation of spectrum used by DoD should be pursued
- If reallocation of spectrum not highly valued by the civil sector should be rescinded
- Identification of and guaranteed access to alternative spectrum displaced DoD users can be achieved.

APPENDIX C

EXTRACTS FROM NTIA SPECTRUM REALLOCATION FINAL REPORT (February 1995)

SECTION 5: SPECTRUM REALLOCATION FINAL PLAN

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. Taking into consideration the FCC Report, and the comments by the public and the Federal agencies on the Preliminary Report, a final spectrum reallocation plan was developed (*See* Table 5-1).

In complying with the 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 acquisition 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.

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 MHz Band** 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 MHz and 5850 - 5925 MHz Bands Expanded non-Federal use of the these bands 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 cities and is further subject to timely reimbursement of Federal costs, including reimbursement directly from the private sector. See Section 4 for details.

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 Spectrum Reallocation Final Report for the 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 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. 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 of the Spectrum Reallocation Final Report).

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 Cost ($Million)
Agriculture	Replace 580 Forest Service fixed microwave links.	48
Army	Change frequencies and realign 260 Corps of Engineers fixed microwave links. 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. Replace 90 INS fixed microwave links. 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. Redesign integrated instrumentation systems.	60 [b]
Transportation	Replace 150 FAA and Coast Guard fixed microwave links. Redesign software for 44 joint FAA/AF air traffic control radars (ARSR-4). 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 D

EXTRACTS FROM THE SPECTRUM REALLOCATION REPORT
(February 1998)

SECTION 4: SPECTRUM REALLOCATION PLAN

OVERVIEW OF REALLOCATED BANDS

The radio spectrum allocated for Federal use, especially in the bands below 3 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. Significant impediments 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 requirements and band selection criterion of Title III of the BBA 97, this spectrum reallocation plan establishes a reasonable balance between the spectrum needs of non-Federal users and those of the Federal Government. The effective implementation of this spectrum reallocation plan is contingent upon the availability of funds either through the agency appropriations process or reimbursement from the private sector.

Several bands identified for reallocation are adjacent to bands that will continue to be used for high-powered or sensitive Federal operations. In order to reduce the potential for mutual interference, industry established transmitter and receiver standards are essential.

139-140.5 and 141.5-143 MHz Bands

These band segments are part of the 138-144 MHz band that is used primarily by the military services to establish communications for both tactical and non-tactical use. This includes: tactical air-to-air and air-to-ground communications; air traffic control; non-tactical intra-base ground-to-ground communications; LMR nets; and trunking systems. This reallocation strategy will minimize the impact to the Federal Government and will provide a transmit and receive separation, maximizing its usefulness for commercial applications. This band has a great deal of potential for a wide variety of new non-Federal fixed and mobile wireless communications services. Reallocating this band in 2008 will allow sufficient time to re-engineer radio systems operating in the band. This date also coincides with the established schedule for Federal conversion to narrowband technology in this band. Federal operations will be protected indefinitely at the sites listed in Table 3-1. DoD has raised concerns about the need to include additional military sites in this band. NTIA and DoD will assess the need to include additional

TABLE 4-1: SPECTRUM REALLOCATION PLAN

Bands Identified for Reallocation	Reallocation Status	Reallocation Schedule [4]
139-140.5 and 141.5-143 MHz	Mixed	January 2008
216-220 MHz [1]	Mixed	January 2002
1385-1390 MHz [2]	Exclusive	January 1999
1432-1435 MHz	Mixed	January 1999
2385-2390 MHz [3]	Exclusive	January 2005

1) The SPASUR radar system (transmit frequency of 216.98 MHz and receive frequencies of 216.965-216.995 MHz), located in the Southern part of the United States will continue to be protected indefinitely.

2) Military airborne operations at the sites listed in Table 3-3 will be continued for 9 years after the scheduled reallocation date.

3) Military and commercial airborne operations at the sites listed in Table 3-6 will be continued for 2 years after the scheduled reallocation date.

4) The spectrum will be auctioned prior to 2002, in accordance with the Balanced Budget Act of 1997.

sites and work with the FCC during the reallocation process to insure that disruption to critical military operations is minimized.

216-220 MHz Band

This band is used for a space surveillance bistatic radar system, and various low power applications which include: telemetry for monitoring seismic activity and wildlife, hands free communication between firefighters wearing hazardous environment suits, and audio collection devices. The band has potential for new non-Federal fixed and mobile communications services. This band could also be used as an expansion to the existing non-Federal services. The band is to be reallocated on a mixed-use basis with a scheduled availability date of January 1, 2002. The space surveillance radar located at three transmitter sites and six receiver sites listed in Table 3-2 will be protected indefinitely.

1385-1390 MHz Band

This band segment is part of the 1215-1400 MHz band that is used by the Federal Government for long-range radars, aeronautical telemetry systems, and tactical radio relay systems. In weighing the cost and operational impact to the Federal Government with the potential public benefit, reallocation of the 1385-1390 MHz segment for non-Federal use establishes a reasonable balance. This band is adjacent to the 1390-1400 MHz band previously identified for reallocation under OBRA 93, creating a contiguous block of spectrum 15 MHz wide. This band can also be combined with spectrum in the 1427-1435 MHz band (also scheduled for reallocation) to create a pair of bands with adequate transmit and receive separation. In order to realize the full public benefit of this band, the reallocation availability date will be scheduled to coincide with that of the 1390-1400 MHz and 1427-1435 MHz bands, which is January 1, 1999. To reduce the impact on important Federal and university radio astronomy operations, reallocation of this band for airborne or space-to-Earth links must be avoided. High-powered FAA and DoD radars will continue to operate in the lower adjacent band and will require that filters be installed on radar transmitters. In addition, adopting adequate regulatory or industry receiver standards for new non-Federal equipment in this band is essential to assure satisfactory performance of commercial services. Reallocation of the 1385-1390 MHz band must also be accompanied by mandatory transmitter standards to reduce interference to the Nuclear Detonation System. To preserve the investment made by the Federal Government, essential operations will be protected at the sites listed in Table 3-3 for 9 years after the scheduled reallocation date. DoD has raised the issue of radar operations during wartime. NTIA and DoD will work with the FCC during the reallocation process in the 1385-1390 MHz band to insure that wartime emergency considerations will be addressed to maintain national security.

1432-1435 MHz Band

This band is used by the military for tactical radio relay communications, military test range aeronautical telemetry and telecommand, and various types of guided weapon systems. The 1432- 1435 MHz band will be reallocated for non-Federal use on a mixed-use basis. This will preserve the investment made by the Federal Government and permit essential military operations to continue, while making additional spectrum available for the development of commercial and consumer wireless applications. This band is adjacent to the 5 MHz in the 1427-1432 MHz band to be transferred under OBRA 93. This band can also be combined with spectrum in the 1390- 1400 MHz band (also scheduled for reallocation) to create a pair of bands with adequate transmit and receive separation. To realize its full public benefit, the reallocation date of the 1432-1435 MHz band will be January 1, 1999. This date coincides with that of the 1427-1432 MHz and 1390-1400 MHz bands that were previously identified for reallocation under OBRA 93. Essential Federal Government operations and their associated airspace will be protected indefinitely at the sites listed in Table 3-4. DoD has raised concerns about the need to include additional military sites in this band. NTIA and DoD will assess the need to include additional sites and work with the FCC during the reallocation process to insure that disruption to critical military operations is minimized.

2385-2390 MHz Band

This band is used by the Federal Government for aeronautical flight test telemetry and for scientific observations. This band is also used by the commercial aviation industry for flight test telemetry and as designated for telemetry used in conjunction with commercial launch vehicles. Reallocating the 2385-2390 MHz portion of the band establishes a reasonable balance between providing additional spectrum resources for new commercial and consumer applications while reducing the cost and operational impact to the Federal Government. Since the adjacent band will continue to be used by airborne systems it is important that commercial receiver and transmitter standards be established to reduce the potential for mutual interference. Reallocation of this band is scheduled in 2005 to provide a sufficient amount of time for engineering studies and to implement new systems employing more spectrum efficient modulation techniques. To minimize the operational impact on flight test programs that are ongoing or planned to begin in the near future, continued Federal and commercial use of the 2385-2390 MHz band at the sites listed in Table 3-6 will continue for two years after the scheduled reallocation date. To provide protection to the Arecibo planetary radar, airborne and space-to-earth transmissions will be prohibited in Puerto Rico. DoD has raised concerns about the need to include additional military sites in this band. NTIA and DoD will assess the need to include additional sites and work with the FCC during the reallocation process to insure that disruption to critical military operations is minimized.

OVERVIEW OF FEDERAL IMPLEMENTATION COSTS

Every effort has been made to insure that the bands identified in this report meet the Title III band selection criteria. However, the displaced Federal functions resulting from the reallocation must, in most cases, be preserved at a considerable cost to the Federal Government. The Federal agencies maintain that, in order to meet the time constraints of Title III of the BBA 97, it is only possible to provide preliminary reallocation cost estimates and operational impact assessments since accurate data will require extensive cost and engineering analysis. Furthermore, the task of estimating reallocation costs becomes more complex as available spectrum continues to diminish. Table 4-2 summarizes the Federal reallocation costs for each of the affected agencies. Several agencies provided low and high estimates for the reallocation costs associated with the 20 MHz in Table 4-1.

The cost estimates provided by DoD assume that suitable spectrum will be available for relocation such that current equipment can be retuned and that extensive system modification will not be required to operate on new frequencies or to avoid interfering with new commercial users. If

TABLE 4-2: SUMMARY OF PRELIMINARY FEDERAL REALLOCATION COST

Federal Agency	Estimated Reallocation Cost
Department of the Army	$260 million
Department of the Navy	$251 million
Department of the Air Force	$520 million
Federal Aviation Administration	$10 million
Department of Energy	$2.1 million
Department of Interior	$1.76 million
Department of Justice	$7 million
Department of the Treasury	$3.5 million
National Aeronautics and Space Administration	$520,000
United States Information Agency	$100,000
Total	$1.056 billion

replacement of major systems is required, relocation costs could be significantly higher. Individual Federal agencies provided the estimated reallocation cost information shown in Table 4-2 to NTIA. NTIA did not independently verify the cost estimates as part of this study. Furthermore, the Office of Management and Budget has not formally reviewed the estimated costs. Federal agency requests for reallocation will be reviewed as part of the annual budget formulation process. Specific inquiries regarding the reallocation cost estimates should be referred to the originating agency.

APPENDIX E

SOME EXAMPLES OF SPECIFIC CASES WHERE Department of Energy IS SHARING RADIO COMMUNICATION SYSTEMS

1. **<u>Argonne Initiative to Share Illinois Public Safety Mobile Net</u>**

Argonne National Laboratory has joined the Illinois State police trunking system and is using the system for laboratory public safety (e.g., fire and police uses) onsite. The Illinois State system, authorized by the Federal Communications Commission (FCC) is licensed in the 800 MHz band. Argonne is migrating 105 radio units onto a 10-channel Illinois State police trunking system and plans to migrate over another 200 units. This will be the first Department of Energy (DOE) site to enter into this type arrangement to share a system with a public safety entity, and in this case the arrangement provides advantages to both the state and Laboratory. This initiative is important to DOE because it improves interoperability with a state public safety net, and enhances spectrum efficiency with more spectral efficient technology.

2. **<u>Los Alamos National Laboratory Intercommunications with Fire/Police</u>**

Los Alamos National Laboratory, *co-located* with the town of Los Alamos approximately 35 miles northwest of Santa Fe, occupies 43 square miles of land in Northern New Mexico. The Laboratory was born as part of the Manhattan Project to create the first atomic weapons during World War II. National security remains the central part of Los Alamos' mission, their scientific expertise is very broad and ranges from innovative biological search to modeling global climate, and from novel methods for examining material properties to helping explore the outer reaches of the solar system. The Los Alamos National Laboratory Federal trunking system accommodates the county fire and medical emergency services which are a shared resource between the Laboratory and the City of Los Alamos. They are transitioning and expanding their radio trunking system to narrowband digital operations and will be providing access to the Los Alamos City Police Department. This will position all the laboratory and county public safety services on the same radio system.

3. **<u>Lawrence Livermore National Laboratory (LLNL) Intercommunications</u>**

Lawrence Livermore National Laboratory (LLNL) mission is to apply science and technology in the national interest, with a focus on global security, global ecology, bioscience, and technology exchange. Laboratory employees are working with industrial and academic partners to increase national economic competitiveness and improve science education. The Laboratory's mission is dynamic and has changed over the years to meet new national needs. The Laboratory is heavily involved with local public safety communications. The laboratory emergency operations center provides mutual aid dispatch services for Alameda County over the county’s 800 MHz trunked system and for the tri-valley area using the City of Livermore's 800 MHz trunked system. LLNL has its own 400 MHz Federal state of the art digital radio trunking system. Already the system has expand to the San Joaquin Valley to provide service to the U.S. DoD Logistics Agency. Plans are underway to add Lawrence Berkeley Laboratory and the Stanford Linear Accelerator Center, and inquiries to join the system have come from a number of Federal agencies in the bay area including the Golden Gate National Recreation Area who now manage the property formerly known as the Presidio of San Francisco.

4. Oak Ridge Operations Trunking System Planning Improved Intercommunication with State and Local Public Safety

Oak Ridge Operations is very diverse, with major national programs in energy research, national defense, re-industrialization, and environmental cleanup. Operations are based in Oak Ridge, Tennessee, and are responsible for managing programs and facilities in five states. However, these programs are performed at three major DOE facilities located on the 35,252-acre Oak Ridge Reservation. Oak Ridge is expanding their overloaded radio trunking system with a new narrowband high capacity system and expanded coverage area. The improved system will also correct a previous problem where local police were unable to communicate with Oak Ridge security personnel during emergencies.

5. Waste Isolation Pilot Plant

The Waste Isolation Pilot Plant (WIPP) is the first underground repository licensed to safely and permanently dispose of transuranic radioactive waste left from the research and production of nuclear weapons. WIPP is located in the Chihuahua desert of Southeastern New Mexico and operates radio communications in conjunction with the Carlsbad Police Department, Eddy County Sheriff's Department, and the Eddy County Fire Department in cooperative agreements to fulfill state requirements related to the transport and storage of nuclear waste. Inter-communications take place on both Federal, and state and local radio channels through Memorandum of Understandings and co-licenses.

6. Strategic Petroleum Reserve

The Strategic Petroleum Reserve was created in wake of the 1973 Arab oil embargo and the Reserve is now at 564 million barrels of oil that equates to about 67 days of net oil imports. The oil is stored in huge caverns created in the salt domes of the Texas and Louisiana Gulf Coast region. Currently, emergency assistance communications have been established using 800 MHz conventional and trunking systems with the Calcasieu Parish Mutual Aid Association, the Louisiana State Police, the Hampshire Fire Department and Neches Mutual Aid Association.

APPENDIX F
DEPARTMENT OF DEFENSE RESPONSE TO TITLE X OF NDAA-2000

The following information taken from the two DoD reports is provided to reiterate the key points on operational impacts and future spectrum reallocation actions:

- DoD's critical missions and operations affected by reallocations include surveillance and control of North American airspace, tactical communications networks, air launched missile control and precision strike test, training operations, and aeronautical telemetry operations that support flight testing of aircraft, spacecraft, and missiles at major military test ranges and facilities.
- DoD's greatest concern is the operational impacts that will result from spectrum reallocation.
- In the case of the highly mobile, and often life threatening military operations, there are no simple alternatives to using the spectrum.
- Technologically superior equipment has been critical to our combat and operational successes.
- An orderly transition from legacy systems to new technologies of tomorrow is imperative to sustain the military readiness and superiority required for the diverse and broad range of military missions that we will face in the foreseeable future.
- Another major concern is the increasingly rapid rate at which reallocations are taking place and the short, limited time to conduct the appropriate analysis and research required to assess and minimize the impacts.
- DoD conducted a band-by-band analysis to identify mission(s) and functions performed, the primary systems used, the estimated operational life of the equipment, the estimated cost and cost drivers associated with reallocation, and the extent of operational impacts caused by reallocation.

Operational Impacts Assessment

The DoD's greatest concern in both reports is the operational impacts that will result from spectrum reallocations. The impacts discussed in these reports are in the context of a National Defense posture that will remain unchanged for the foreseeable future. This posture requires that our forces receive adequate training and be prepared for short notice deployment to regional hotspots throughout the world. There is also a continuing requirement for non-combat operations worldwide as the military continues to participate in a broad range of deterrent, conflict prevention, peacekeeping activities, and testing and training. All of these operations may differ in scope (i.e., capabilities, duration, systems configurations, spectrum access requirements, and geography); however, what is common to every operational environment is the requirement to have access to the radio frequency spectrum. Virtually, all of these military operations are supported by spectrum dependent systems. Consequently, spectrum reallocation impacts military operational capability. However, past experiences have shown that assessing operational impacts is not a simple process and, furthermore, DoD is confronted with very complex spectrum access challenges. The DoD continues the process of assessing operational impacts from spectrum reallocation and during this process other major concerns and observations have become apparent. In addition to the concerns identified in the reports, DoD faces a major challenge in quantifying operational impacts as noted below.

The DoD reports address equipment limitations and impacts of the reduction in the available military frequencies as a consequence of the reallocation of OBRA-93 and BBA-97. But, assessing the subjective issue of what constitutes an acceptable risk to our national security strategy or what is deemed an acceptable combat loss is very difficult. There is no known direct correlation between the loss of spectrum and a resulting loss of life from actual military combat or test and training operations, (i.e., as an artillery shell with bursting kill radius), nor are there inferences or relationships to mission success. There are no performance or cost matrix standards to assess and measure the situational military operations and potential life threatening combat operations. For example, what is an acceptable risk of not having radar coverage over a particular area? Or, what is the acceptability of failure to detect only a percentage of incoming missiles – is it 1, 10, 100 missiles? How much of a total, comprehensive, tactical information network is adequate? And, what is the acceptable latency of the C3 information or data for information operations that can, or will, put our soldiers, sailors, and airman in harm's way? The trade-offs are complex because the capabilities affect the safety, protection, combat weapons operation, and command, control, and communications of military operations. These responsibilities are not taken lightly. As a matter of precedence and prudence, any impairment to critical military operations and missions requires spectrum access protection.

The process and methodology of assessing the overall operational impact from spectrum reallocation is dynamic and multiple variables cause such an assessment to be very complex and difficult. Each military operation is uniquely situational with a variety of capabilities supported by spectrum dependent systems. Each military operation is unique, with political, infrastructure, and environmental differences that dictate the use of specific spectrum dependent systems. Service and Joint doctrine provide the general operational guidance but cannot cover all conditions and situations. The assessment of an operational situation may vary from being considered satisfactory to being considered as totally unsatisfactory as military conditions and other variables change. Considering only the worse case situations may be unfairly weighted such that the operational impact from any loss of spectrum is unsatisfactory in terms of system capabilities to support and conduct military operations.

A major misconception and flawed assumption is that assessing operational impacts by loss of spectrum is proportionate or has a direct relationship to the operational impact. For example, the perception that a loss of 10 percent of frequency band for the equipment's tuning range relates to a 10 percent loss in operational capability—the loss in operational capability could be much greater. Managing self induced interference from platform configurations and operational situational dynamics adds to the complexity of the relationship. Combining these situation-dependent variables with requirements to maintain guard bands to protect users in adjacent bands and the use of allotment and equipment channeling plans significantly contributes to the complexity of assessing operational impacts due to spectrum loss. Further adding to the complexity, is the fact that these military spectrum-dependent systems perform a wide variety of functions, many of which must be performed simultaneously in relatively close proximity to one another. To summarize, a 10 percent loss in the available spectrum within the tuning range of a piece of equipment or communications electronic system may actually result in a 30-50% loss in overall operational capability.

Almost all current military operations, as well as those in the future, will be joint operations. A joint operation is defined as more than one military service involved in the operations. Each of the Military Departments (MILDEPs) and DoD agencies rely on different capabilities and functions to support the land warfare, air maneuvering, and maritime operations. Based upon these differences in capabilities and functions, the MILDEPs and DoD Agencies have different priorities for various frequency bands. Impacts to military operations must be viewed and assessed in the complete context of joint operations, not as a singular system, equipment function, or capability. The synergy among these functions and capabilities is part of the technological superiority that we maintain for our combat and operational successes. Evaluating the impact to a joint operation due to a decrease in capability caused by the loss of a particular portion of a frequency band is complex and confronted with situational uncertainties.

Modifying existing hardware equipment to conform to imposed spectrum limitations and facilitate operations in the remaining available frequency band has additional logistical implications and operational considerations. The OBRA-93 and BBA-97 spectrum reallocations affected training, testing, and operations in the United States and Possessions only. Modifying hardware equipment to facilitate U.S. operations and training can also affect overseas operations, depending upon where the systems are deployed. If equipment which has been modified to conform to spectrum limitations within the US&P cannot be deployed overseas and operate within available host nation spectrum, then DoD will be forced into a costly scenario; maintain one set of equipment for testing, training, and operations within the US&P and another set of equipment for use outside US&P.

Impact of Potential Future Allocations

Market trends indicate the need for commercial wireless products and services is increasing, both within the United States and internationally. Finding unused bands for new wireless commercial applications is increasingly difficult. Identifying frequency bands, with no or minimal operational impact on the DoD systems is also increasingly complex. Future DoD operational concepts, embraced by Joint Vision 2010 and Joint Vision 2020, require improved command, control, communications, and intelligence. The ability to collect, process, and disseminate an uninterrupted flow of information, while exploiting or denying the enemy's ability to do the same, is paramount to the success of these new concepts. Assured access to the radio frequency spectrum will be far more critical to the military in the future than it is today. DoD continues to study, analyze, and assess the spectrum access challenges in relation to continued support for the "Warfighter."

DoD conducted an analysis based on the electromagnetic access to support the projected information exchange requirements of US Forces through the year 2010 with the intent of gaining an understanding of the long-term trend of DoD's spectrum access needs. Though limited in scope and time, the findings of the analysis are as follows:

- DoD's requirements for spectrum will grow in all spectrum categories over the next decade, irrespective of planned and programmed modernization efforts.

- DoD's spectrum requirements growth occurs in the same congested spectrum bands in which commercial wireless demands are increasing the most rapidly, that is below 3 GHz.

- DoD also projects a growth in requirements for spectrum in bands above 3 GHz. While some of these bands are not as heavily occupied as the lower bands today, they are critical to future warfighting systems.

- Employment of current (pre-JV 2010) warfighting systems and capabilities severely stresses available spectrum resources. Consequently, future spectrum requirements growth and the associated JV 2010 operational concepts will not be fully supportable without advances in spectrum utilization technologies and practices.

- Any loss of spectrum access through reallocation or other means will exacerbate DoD's challenge to meet future warfighting requirements.

Based on these conclusions, it is clear that DoD action is essential to ensure that limitations in spectrum access do not constrain the ability of the Warfighter to perform all missions worldwide. Recommended DoD actions fall into two complementary areas: Improve the utilization of current spectrum allocations and increase DoD electromagnetic spectrum access in consonance with other spectrum users' requirements.

- To improve the utilization of current spectrum allocations, DoD will:

– Pursue advanced technologies that reduce spectrum needs (spectral efficiency), increase spectrum flexibility (systems that can operate in multiple bands), and allow for adaptive spectrum uses ("Smart" radios).

– Pursue changes in the spectrum planning and management processes to allow for much greater intra-DoD sharing and to facilitate the leveraging of emerging technologies.

– Elevate spectrum considerations in the acquisition process. Ensure spectrum utilization trades and alternatives are addressed in the context of overall DoD spectrum use. Ensure spectrum supportability is addressed on a worldwide basis.

- To increase future spectrum access, DoD will:

– Explore policy alternatives to achieve spectrum sharing on a co-equal basis in bands currently unavailable to DoD.

– Initiate coordination processes with other national and international agencies to ensure DoD spectrum access needs are recognized and affirmed.

– Identify and defend access to that spectrum deemed as vital to warfighting requirements.

– Continue to reassess the effectiveness of the proposed initiatives.

A major DoD concern is the increasingly rapid rate at which reallocations are mandated and the extremely short time-frame that is provided to assess and report potential impacts of such reallocations. For example DoD was required to prepare assessment reports in a fairly short time- frame of 18 months for OBRA-93, and six months for BBA-97. Bands initially selected for reallocation were deliberated and changed several times before a final decision was made. Adequate time is necessary to conduct the research and perform appropriate analysis required to identify the operational impacts of spectrum reallocation.