NTIA TM 97-339

ASSESSMENT OF THE EXPANSION OF THE EARTH EXPLORATION-SATELLITE SERVICE IN THE 8025-8400 MHz RANGE

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NTIA TM 97-339

ASSESSMENT OF THE EXPANSION OF THE EARTH EXPLORATION-SATELLITE SERVICE IN THE 8025-8400 MHz RANGE

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EXECUTIVE SUMMARY

This report contains the results of an NTIA study concerning the use of the Earth exploration-satellite service (EESS) in the frequency range 8025-8400 MHz for Government, non-Government and international operations. The intent of this report was to compile the current and proposed, national and international, spectrum usage in the 8025-8400 MHz frequency range (including the lower adjacent-band, 7900-8025 MHz, and the upper adjacent-band, 8400-8450 MHz), to identify potential sharing issues, and summarize some options available to alleviate the interference interaction that might occur. This report is intended to be a resource document for examining specific EESS issues within the frequency range of 8025-8400 MHz.

The EESS in the 8025-8400 MHz frequency range is expected to increase dramatically in the near future with the increased spectrum requirements of the LANDSAT satellite system, the NASA Earth Observing System (EOS), and systems proposed by four U.S. commercial entities (the AstroVision Incorporated, the Space Imaging LP, the Orbital Sciences Corporation, and the EarthWatch Incorporated). Other Administrations (e.g., France, Japan, Canada, India, Russia, South Africa, and the Ukraine) have or plan to have EESS systems that operate in the 8025-8400 MHz frequency range. Another anticipated change in use of the 8025-8400 MHz range is a result of the reallocation study [Spectrum Reallocation, 95] completed in February 1995. This reallocation study will necessitate moving of certain Government fixed services from the 2 GHz range into the 7/8 GHz range.

United States Government and numerous non-Government entities will launch EESS systems operating in the 8025-8400 MHz frequency range based on the policy directive on remote sensing space capabilities signed by the President (see Appendix-A for the news release from the Commerce News). With the introduction of new and increased use of the EESS systems in that range, harmful interference among the various users of these and adjacent bands may occur. Nine potential interference scenarios involving combinations of EESS earth and space stations, MSS aircraft and FSS earth stations, fixed stations, space research earth stations, and future meteorological-satellite (MetSat) earth and space stations have surfaced. If existing standards and limits are adhered to, the majority of the interactions dealing with known Government services should be manageable.

The planned MetSat use of the 8025-8400 MHz frequency range may require further electromagnetic compatibility analyses between this service and existing services. Further analysis may also be necessary based on the reallocation study of 1995. The use of 30 cm diameter earth stations in the EESS or a large number of relatively small diameter EESS earth stations is a significant sharing issue with respect to terrestrial and other space services. These relatively inexpensive earth station antennas are being investigated for worldwide dissemination and will likely require further study. The 30 cm proposal will not be addressed in this report.

ABSTRACT

This report assesses the expansion of the Earth exploration-satellite service in the 8025-8400 MHz frequency range. The report identifies allocations, standards, regulations and current and planned spectrum usage applicable to this range for Government, non-Government, and international operations. In addition, various potential interference scenarios among the EESS systems and the various other services (operating in this range) are identified.

U.S. Government and non-Government entities will launch Earth exploration-satellite service (EESS) systems in the 8025-8400 MHz frequency range based on the policy directive on remote sensing space capabilities signed by President Clinton (attached in Appendix-A; this policy is dictated by public law, Land Remote Sensing Policy Act of 1992). With the introduction of new and increased use of the EESS systems in that range, the potential for harmful interference exists among the various users of these and adjacent bands. NASA, among other Government agencies, is concerned by Earth exploration-satellite service use in the 8025-8400 MHz frequency range in today's as well as future markets. One method of monitoring the use of the 8025-8400 MHz frequency range by Earth exploration-satellite services is the Space Frequency Coordination Group (SFCG), (September 1994) of which NASA and NOAA are members.

KEY WORDS

8025-8400 MHz BAND
FIXED-SATELLITE SERVICE (FSS)
MOBILE-SATELLITE SERVICE (MSS)
EARTH EXPLORATION-SATELLITE SERVICE (EESS)
METEOROLOGICAL-SATELLITE SERVICE (MetSat)
FIXED SERVICE

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GLOSSARY of TERMS and ACRONYMS

ADEOS	Japanese satellite
AF	Air Force
AR	Army
ARTCC	Air Route Traffic Control Centers
ATC	Air Traffic Control
AVSAT-1	Geostationary satellite of AstroVision
BPSK	Bi-Phase Shift Keying
BW	Authorized Bandwidth
bins	Example: 10 MHz Bins = a list of frequencies 7910-7920, 7920-7930 MHz, etc.
CG	Coast Guard
CDMA	Code Division Multiple Access
CRSS	Commercial Remote Sensing System satellite of the Space Imaging LP
dBi	decibels relative to an isotropic antenna
dBm	decibels relative to a milliwatt
dBW	decibels relative to a Watt
dBW/Hz	decibels relative to a Watt per Hertz
dB(W/m^2)	decibels relative to Watts per meter squared
DISA	Defense Information System Agency
DOC or C	Department of Commerce (defined as C in the GMF)
DoD	Department of Defense
DOE	Department of Energy
DOI or I	Department of Interior (defined as I in the GMF)
DOJ or J	Department of Justice (defined as J in the GMF)
DOT or T	Department of Treasury (defined as T in the GMF)
DSCS	Defense Satellite Communications System satellite
DSN	Deep Space Network
Early Bird	An EarthWatch satellite(s)
EESS	Earth exploration-satellite service
EIRP	equivalent isotropically-radiated power
EOS	Earth Observing System
EOS AM series	EOS satellite crossing the equator southbound at 10:30 am
EOS PM series	EOS satellite crossing the equator northbound at 1:30 pm
EOS CHEM series	EOS satellite named for its measurement of atmospheric chemistry
ENVISAT-1	French satellite
ERS-1, -2	French satellites
ESA	European Space Agency
EYEGLASS	Orbital Science Corp. satellites
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
f_d	Displacement Frequency
FDM	Frequency Division Multiplex
FDMA	Frequency Division Multiple Access
FDM/FM	Frequency Division Multiplex/Frequency Modulation
FLTSATCOM	Fleet Satellite Communications
FSS/MSS	Fixed-Satellite Service/Mobile-Satellite Service
GEO satellite	Geostationary satellite
GMF	Government Master File
GREENSAT-1	South African satellite
GREENSENSE	South African satellite
IDCSP	Initial Defense Communications Satellite Program
I/N	Interference-to-Noise Ratio
IPO	Integrated Program Office
IRAC	Interdepartment Radio Advisory Committee
IRS-1A, 1B, 1C	India satellites
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union-Radiocommunications Sector
ITU-R IS.###	ITU-R Inter-Service Sharing and Compatibility Series

GLOSSARY of TERMS and ACRONYMS (continued)

ITU-R SA.###	ITU-R Space Applications Series
JERS-1	Japanese satellite
JPL	Jet Propulsion Laboratory
LEASAT	low Earth satellite system owned by DOC/NOAA
LEO satellite	Low Earth Orbiting satellite
LANDSAT-4, -5, -6	DOC/NOAA satellites
LANDSAT-7	NOAA/NASA/AF satellite
LOS	Line Of Sight
Mbps	Megabits per second
METOP	Meteorological Operational Satellite
MetSat	Meteorological-Satellite
Mchip	Megachip
MOS-1, 1B	Japanese satellites
MSS	Mobile-Satellite Service
N	Navy
NASA	National Aeronautics and Space Administration
NATO	North American Treaty Organization
NOAA	National Oceanic and Atmospheric Administration
NPOES	National Polar Orbiting Operational Environmental Satellite
NSF	National Science Foundation
NTIA	National Telecommunications and Information Administration
OQPSK	Off-set Quadrature-Phase Shift Keying
OSC	Orbital Sciences Corporation
PFD	Power Flux Density
POEM 1	French satellite
ppm	Parts per million
PSK	Phase Shift Keying
QPSK	Quadrature-Phase Shift Keying
RADARSAT-1A	Canadian satellite
RCL	Radar Communications Link
REC	Recommendation associated with SFCG
RF	Radio frequency
RR	Radio Regulations
SFCG	Space Frequency Coordination Group
SITCH	Ukrainian satellite
SQPSK	Staggered Quadrature-Phase Shift Keying
SPEKTR-R	Russian satellite
SPD	Spectral Power Density
SPOT 1-6	French satellites
SPS	Spectrum Planning Subcommittee
SRA	Spectrum Resource Assessments
SRV	Spectrum Resource file
SSIPR	Russian satellites
SSMA	Spread Spectrum Multiple Access
TDRSS	Tracking and Data Relay Satellite System
TT&C	Tracking, Telemetery and Control
TVA	Tennessee Valley Authority
US & P	United States and Possessions
VA	Department of Veterans Affairs
WARC	World Administrative Radio Conference
WRC	World Radiocommunication Conference
X-Band	bands of 8,000-12,000 Mhz
XXM	French/European Space Agency satellite

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SECTION 1

INTRODUCTION

BACKGROUND

The National Telecommunications and Information Administration (NTIA) is responsible for managing the Federal Government's use of the radio frequency spectrum. NTIA's responsibility includes establishing policies concerning spectrum assignment, allocation and use, and providing various departments and agencies with guidance to ensure that their conduct of telecommunications activities is consistent with these policies [NTIA Manual, 1996]. In support of these requirements, NTIA has undertaken a number of spectrum assessments. The objectives of these studies are to assess spectrum utilization, identify existing and/or potential compatibility problems among the telecommunications systems that belong to various departments and agencies, provide recommendations for resolving any compatibility conflicts that may exist in the use of the radio frequency spectrum, and recommend changes to promote spectrum efficiency and improve spectrum management procedures.

On March 10, 1994, the President issued his policy directive on remote sensing space capabilities (see Appendix-A) which was spurred by Public Law 102-555, the Land Remote Sensing Policy Act of 1992 [Sensing Act of 1992]. This Sensing Act of 1992 was a rewrite of the Land Remote Sensing Communications Act of 1984 (referred to as the Act of 1984). The Sensing Act of 1992 was intended to promote the U.S. leadership in land remote sensing; however, commercial vendors still maintained the requirement to receive a license to operate from the National Oceanic and Atmospheric Administration, Department of Commerce (NOAA/DOC). In 1987, based on the previous Act of 1984, NOAA published its licensing regulations[1] that set forth procedures for submission and Government review of any applications to operate land remote sensing systems under the Land Remote Sensing Communication Act of 1984. When Congress passed the Sensing Act of 1992, it made several revisions to the licensing procedures to stimulate commercial interest.

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[1] Licensing requests by U.S. firms to operate private remote sensing space systems are reviewed on case-by-case basis by the Department of Commerce in accordance with the Sensing Act of '92. Once the license to operate has been granted, the application still needs to receive a license to radiate issued by the FCC (the authority to construct, launch, and operate a commercial remote-sensing satellite system). NOAA is considering updating its 1987 regulations to reflect statutory changes, intervening events, and recent licensing experiences and to ensure that the Government's oversight is simple, transparent, and predictable.

The President's directive provides data continuity for the LANDSAT program, establishes a new national land remote sensing policy, and establishes partnerships in technology between the Government and commercial non-Government entities. Based on this Act and the policy directive, numerous commercial non-Government entities are expected to operate Earth Exploration-Satellite Service (EESS) systems in the 8025-8400 MHz range.

In 1984, NTIA performed a spectrum assessment of the 7125-8500 MHz frequency range [Crandall, 1984]. That study showed the majority of frequency assignments were for high-capacity fixed-microwave communications with little growth anticipated. However, the reallocation study [Spectrum Reallocation, 95] indicated the necessity for accommodating another service in the 2 GHz range and moving some Government agencies from the 2 GHz range into the 7/8 GHz range. The 1984 study also pointed out that this frequency range supports various space radiocommunications. In 1984, the principal users of space radiocommunications were the Defense Satellite Communications System (DSCS) and the Fleet Satellite Communications (FLTSATCOM) system. DSCS operates in the fixed-satellite service (FSS), mobile-satellite service (MSS), and also operates in the tracking, telemetery, and control (TT&C) mode. FLTSATCOM series satellite networks do not have any operations in the 8025-8400 MHz range but operate in the FSS or the TT&C modes on discrete frequencies in the lower adjacent-band (there is no FLTSATCOM MSS operations in the lower adjacent-band).

This spectrum use study, although different in frequency range, updates portions of that 1984 study and summarizes the planned operations of the EESS. Nationally, within the frequency range 7900-8450 MHz, there are six services allocated:

- fixed-satellite (Earth-to-space) service (FSS),
- mobile-satellite (Earth-to-space) service (MSS),
- meteorological-satellite (Earth-to-space) service (MetSat),
- Earth exploration-satellite (space-to-Earth) service (EESS),
- fixed service, and
- space research (space-to-Earth) (deep space only) service.

The use of the band 8025-8400 MHz for the Government and non-Government operations for the EESS is expected to increase in the near term with the signing of the Land Remote Sensing Policy Act of 1992. With the President's release of the policy on remote sensing space capabilities (attached in Appendix-A), it is expected that in the future numerous U.S. non-Government commercial entities will launch EESS systems that will operate in the 8025-8400 MHz band. Other Administrations including France, Japan, Canada, India, Russia, South Africa and the Ukraine have or plan to have EESS systems that will operate in the 8025-

8400 MHz band. Some of these foreign systems will downlink data to earth stations within the United States or nearby countries. With the introduction of new and increased use of the EESS systems in this band, the potential for increased interference among the various users of these and adjacent bands must be evaluated. Due to the concerns with introducing new EESS systems into the 8025-8400 MHz, the National Aeronautics and Space Administration (NASA) scheduled several workshops in the summer of 1994 [X-Band II, 1994] and again in summer 1995 [X-Band III, 1995] to address a variety of significant issues in the band. The reports developed in these workshops, especially the reports generated in the 1995 meeting, contain a variety of useful and pertinent facts that document an understanding of the spectrum requirement for this frequency range.

Because of the expectations of a considerable increase in spectrum requests associated with introducing EESS into this band and requirements for coordination nationally and internationally, it was decided to undertake an assessment of the expanded use of the EESS bands. This information would then be available as resource information to support specific evaluations of spectrum usage issues.

Objective

The objectives of this effort are to: 1) compile the current (including international) and proposed spectrum usage of the 8025-8400 MHz frequency range (including the lower adjacent-band, 7900-8025 MHz, and the upper adjacent-band, 8400-8450 MHz); 2) identify potential sharing issues (inter- and intra-service level); and 3) summarize the options to alleviate interference interactions that may occur.

Approach

The following approach was taken to meet the objectives of this task.

1. Information on current and proposed spectrum usage, both national and international, was compiled from the Government Master File (GMF), Spectrum Review File (SRV), NASA workshop documents, and International Telecommunication Union (ITU) documentation for the 7900-8450 MHz range. The technical standards, regulations, procedures and proposed recommendations for the 7900-8450 MHz range were obtained by reviewing the following:
    - the NTIA Manual,

- the ITU Radio Regulations (RR),
- the final WRC-95 proposal report entitled, "ITU Radiocommunication Sector-Conference Preparatory Meeting For WRC-95 & WRC-97," [ITU Conf.Prep, 1995],
- the Space Frequency Coordination Group (SFCG)[2] minutes,
- Recommendations 14-3 (included as Appendix-B, pages B-2 & B-3) [SFCG REC 14-3], and
- the NASA\NOAA SFCG Recommendations 14- (included as Appendix B, pages B-4 through B-6) [NASA SFCG draft REC 14-].

2. The services operating in these frequency ranges were examined in all combinations to determine if a combination constituted a potential interference scenario.

3. These scenarios were further investigated along with the applicable standards and regulations to appraise the potential for interference.

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2 The SFCG was established after WARC 1979 in order to provide a less formal and more flexible environment, as compared to the official organs of the ITU, for the solution of frequency management issues in the areas of Space Research, Space Operations, Earth Exploration-Satellite, and Meteorological-Satellite services (including radio astronomy) encountered by member space agencies. The member agencies are: Australia (ASO), Austria (ASA), France (CNES), Argentina (CONAE), Germany (DLR), Canada (ISC & CSA), United Kingdom (BNSC), Europe (ESA & EUMETSAT), Brazil (INPE), Spain INSA), India (ISRO), Russia (RAS & RSA), China (CAST), Japan (ISAS & NASDA), USA (NASA & NOAA), Netherlands (NIVR), Sweden (SBSA & SSC), Belgium (SPPS), Italy (Telespazio), Ukraine (USA), and Taiwan (NSA).

SECTION 2

RULES AND REGULATIONS

INTRODUCTION

Radiocommunications systems operating in the 7900-8450 MHz frequency range are governed by various rules and regulations. National and international allocations rules affect usage in the bands. Another aspect affecting usage is the technical standards and procedures, both national and international.

NATIONAL ALLOCATION RULES

Nationally, the 7900-8450 MHz frequency range is allocated to the fixed, fixed-satellite, mobile-satellite, Earth exploration-satellite, meteorological-satellite, and space research services. This frequency range is composed of five allocated bands as shown in TABLE 2-1.

The band 7900-8025 MHz is allocated to Government fixed- and mobile-satellite (Earth-to-space) services on a shared primary basis. The Government fixed service is allocated on a secondary basis in this band. Footnote G117 specifies that the Government fixed-satellite and mobile-satellite services are limited to military systems. There are no allocations for non-Government users in this band.

The three bands between 8025-8400 MHz are allocated to Government Earth exploration-satellite (space-to-Earth), fixed-satellite (Earth-to-space), and fixed services on a shared primary basis. Footnote US258 specifies that the non-Government Earth exploration-satellite (space-to-Earth) service is allocated on a primary basis with authorizations subject to a case-by-case electromagnetic compatibility analysis. The Government mobile-satellite (Earth-to-space) service is allocated in these bands on a secondary basis; however, there are no airborne transmissions allowed. Footnote G117 specifies that the Government fixed-satellite and mobile-satellite services are limited to military systems. In addition, in the 8175-8215 MHz band the Government meteorological-satellite (Earth-to-space) service shares allocation on a primary basis and the provisions of footnote G104 apply to this band.

The band 8400-8450 MHz is allocated to Government fixed and space research (space-to-Earth) (deep space only) services on a shared primary basis. There are no allocations for non-Government users in this band.

TABLE 2-1
NATIONAL ALLOCATION IN THE 7900-8450 MHz BAND

Band MHz	Government Allocation	Non-Government Allocation
7900-8025	FIXED-SATELLITE (Earth-to-space) MOBILE-SATELLITE (Earth-to-space) Fixed G117	
8025-8175	EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED-SATELLITE (Earth-to-space) FIXED Mobile-Satellite (Earth-to-space) (No Airborne Transmissions) US258 G117	US258
8175-8215	EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED-SATELLITE (Earth-to-space) FIXED METEOROLOGICAL-SATELLITE (Earth-to-space) Mobile-Satellite (Earth-to-space) (No Airborne Transmissions) US258 G104 G117	US258
8215-8400	EARTH EXPLORATION-SATELLITE (space-to-Earth) FIXED-SATELLITE (Earth-to-space) FIXED Mobile-Satellite (Earth-to-space) (No Airborne Transmissions) US258 G117	US258
8400-8450	FIXED SPACE RESEARCH (space-to-Earth) (Deep Space only)	

G104 In the bands 7450-7550 and 8175-8215 MHz, it is agreed that although the military space radio communication systems, which include earth stations near the proposed meteorological-satellite installations will precede the meteorological-satellite installations, engineering adjustments to either the military or the meteorological-satellite system or both will be made as mutually required to assure compatible operations of the systems concerned.

G117 In the bands 7250-7750 and 7900-8400 MHz and 20.2-21.2, 30-31, 39.5-40.5, 43.5-45.5 and 50.4-51.4 GHz the Government fixed-satellite and mobile-satellite services are limited to military systems.

US258 In the band 8025-8400 MHz, the non-Government earth exploration-satellite service (space-to-Earth) is allocated on a primary basis. Authorizations are subject to a case-by-case electromagnetic compatibility analysis.

INTERNATIONAL ALLOCATION RULES

Internationally, the 7900-8450 MHz frequency range is allocated to fixed, mobile, fixed-satellite, mobile-satellite, Earth exploration-satellite, meteorological-satellite, and space research services. This frequency range is composed of five allocated bands as shown in TABLE 2-2.

The 7900-8025 MHz band is allocated worldwide to the fixed, mobile, and fixed satellite (Earth-to-space) services on a shared primary basis. Footnote S5.461 (812)[3] specifies that the mobile-satellite (Earth-to-space) service may use this band but is subject to agreement under the procedures set forth in Article 14/No.S9.21 of the ITU Radio Regulations.

In Regions 1 and 3 (the Eastern Hemisphere), the 8025-8400 MHz band is allocated to fixed, mobile, and fixed-satellite (Earth-to-space) services on a primary basis. The Earth exploration-satellite (space-to-Earth) service is allocated on a secondary basis with limits placed on the power flux-density as specified in Article S21, Table S21-4, of ITU Radio Regulation per footnote S5.462 (813). Footnote S5.464 (815) specifies for certain countries (see TABLE 2-2 for countries), that the Earth exploration-satellite (space-to-Earth) service can be used on a primary basis subject to agreement under the procedures set forth in Article 14/No.S9.21 of the ITU Radio Regulations. In addition, in the 8175-8215 MHz band the meteorological-satellite (Earth-to-space) service shares allocation status on a primary basis.

Region 2 is the same as Regions 1 and 3 in the 8025-8400 MHz band except that EESS has primary allocation status and the footnotes are different. Footnotes S5.462 (813) and S5.464 (815) are not present and footnote S5.463 (814) under the mobile allocation specifies that aircraft stations in the mobile service are not permitted to transmit in this region.

The 8400-8500 MHz band is allocated worldwide to the fixed, mobile (except aeronautical mobile), and space research (space-to-Earth) services on a primary basis. The space research service in the band 8400-8450 MHz is limited to deep space only, per footnote S5.465 (816). In certain countries (see TABLE 2-2 for countries) the space research service is allocated on a secondary basis per footnote S5.466 (817). In the United Kingdom, the band 8400-8500 MHz is allocated to space research and radiolocation services on a primary basis per footnote S5.467 (818).

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3 The international footnotes in this report will appear similar to S5.461 (812). The "S" notes are from the *Radio Regulations*, International Telecommunication Union, Geneva, 1996. The number(s) inside the parenthesis are the old international footnotes.

TABLE 2-2
INTERNATIONAL ALLOCATIONS IN THE 7900-8450 MHz BAND

Region 1 Allocations	Region 2 Allocations	Region 3 Allocations
7900-8025 MHz FIXED FIXED-SATELLITE (Earth-to-space) MOBILE S5.461(812)		
8025-8175 MHz FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (space-to-Earth) S5.462 (813) S5.464 (815)	8025-8175 MHz FIXED FIXED-SATELLITE (Earth-to-space) EARTH EXPLORATION-SATELLITE (space-to-Earth) MOBILE S5.463 (814)	8025-8175 MHz FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (space-to-Earth) S5.462 (813) S5.464 (815)
8175-8215 MHz FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (space-to-Earth) S5.462 (813) S5.464 (815)	8175-8215 MHz FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) EARTH EXPLORATION-SATELLITE (space-to-Earth) MOBILE S5.463 (814)	8175-8215 MHz FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (space-to-Earth) S5.462 (813) S5.464 (815)
8215-8400 MHz FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (space-to-Earth) S5.462 (813) S5.464 (815)	8215-8400 MHz FIXED FIXED-SATELLITE (Earth-to-space) EARTH EXPLORATION-SATELLITE (space-to-Earth) MOBILE S5.463 (814)	8215-8400 MHz FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (space-to-Earth) S5.462 (813) S5.464 (815)
8400-8450 MHz FIXED MOBILE except aeronautical mobile SPACE RESEARCH (space-to-Earth) S5.465 (816) S5.466 (817) S5.467 (818)		

S5.461 *Additional allocation:* the bands 7250-7375 MHz (space-to-Earth) and 7900-8025 MHz (Earth-to-space) are also allocated to the mobile-satellite service on a primary basis, subject to agreement obtained under Article **14**/No.**S9.21**.

S5.462 In the band 8025-8400 MHz, the power flux-density limits specified in Article **S21**, Table **S21-4**, shall apply in Regions 1 & 3 to the earth exploration-satellite service.

S5.463 In Region 2, aircraft stations are not permitted to transmit in the band 8025-8400 MHz.

S5.464 *Different category of service:* in Bangladesh, Benin, Burkina Faso, Cameroon, China, the Central African Republic, Cote d'Ivoire, Egypt, France, Guinea, India, the Islamic Republic of Iran, Italy, Japan, Libya, Mali, Niger, Pakistan, Senegal, Somalia, Sudan, Sweden, Tanzania, Zaire and Zambia, the allocation of the band 8025-8400 MHz to the Earth exploration-satellite service (space-to-Earth) is on a primary basis, subject to agreement obtained under Article **14**/No.**S9.21**.

S5.465 In the space research service, the use of the band 8400-8450 MHz is limited to deep space.

S5.466 *Different category of service:* in Belgium, Israel, Luxembourg, Malaysia, Singapore and Sri Landka, the allocation of the band 8400-8500 MHz to the space research service is on a secondary basis (see No.**S5.32**).

S5.467 *Alternative allocation:* in the United Kingdom, the band 8400-8500 MHz is allocated to the radiolocation and space research services on a primary basis.

TECHNICAL STANDARDS AND PROCEDURES

As with national and international allocations rules and procedures, systems operating within the 7900-8450 MHz frequency range are also subject to and governed by national and international technical standards and procedures.

National

The spectrum standards for Government systems operating within the 7900-8450 MHz frequency range are given in Chapter 5 and procedures in Chapter 8 of the NTIA Manual. Sections 5.1, 5.4.2, and 5.7 specify limits of frequency tolerance and unwanted emissions for Federal Government services employing point-to-point equipments (fixed and transportable), earth stations, and space stations operating between 1710 MHz and 15.35 GHz as of January 1, 1994. The transmitter frequency tolerance standards for transmitting stations in the 7900-8450 MHz band are as follows:

Station Type	Frequency Tolerance ppm (parts per million)
Fixed Stations	
power $\leq$ 100 watts	50
power $>$ 100 watts	10
Earth Station	20
Space Station	20

The level of unwanted emissions for fixed service stations are listed in Section 5.4.2.

For fixed service - The average power of any emission on any frequency removed from the center of the authorized bandwidth[4] (BW) by a displacement frequency (f_d) in kHz shall be attenuated below the mean output power in watts of the transmitter in accordance with the following schedule:

a) For transmitters other than those employing digital modulation techniques:

[4] NTIA Manual defines the term "authorized bandwidth" as the necessary bandwidth (bandwidth required for the transmission and reception of intelligence) and does not include allowance for transmitter drift of Doppler shift.

f_d in kHz	Attenuation in dB
50% BW < $f_d \leq$ 100% BW	25
100% BW < $f_d \leq$ 250% BW	35
f_d > 250% BW	43 + $10\log_{10}$ (mean output power in Watts) or 43 Whichever is the greater attenuation. Attenuation greater than 80 dB is not required.

b) For transmitters employing digital modulation techniques:[5]

In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent, up to and including 250 percent, of the authorized bandwidth as specified by the following equation but at least 50 dB of attenuation:

$$A = 35 + 0.8\,(\% - 50) + 10\log_{10}BW$$

where:
A = attenuation (in decibels) below the mean output power level,
BW = authorized bandwidth in MHz,
% = percent of the authorized BW removed from the assigned frequency.

Attenuation greater than 80 dB is not required.

In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth:

At least:
43 + $10\log_{10}$(mean output power in watts) decibels
or
80 decibels,
whichever is the lesser attenuation

5 It is recognized that relatively narrowband digital radio systems may be unduly restricted by this standard. Work is in progress to define appropriate limitations for such narrowband systems. This standard will be modified in accordance with the findings and experience with such narrowband systems.

A measurement method or procedure for measuring the unwanted emissions is outlined following the standard.

The standard requires that received unwanted signals shall be attenuated at least 60 dB relative to the receiver sensitivity at the center of the passband. A method of measurement of the suppression of unwanted emission is presented in the NTIA Manual, Section 5.4.2.B.2.

The receiver selectivity is the degree to which a receiver is able to discriminate against the effects of undesired signals primarily outside the authorized emission bandwidth that arrive at its RF input terminals. The -3 dB receiver bandwidth should be commensurate with the authorized emission bandwidth plus twice the frequency tolerance of the transmitter specified above. The -60 dB receiver bandwidth shall not exceed five times the -3 dB receiver bandwidth.

The noise figure of a receiver is the ratio expressed in dB of the output noise power to the portion of noise power attributable to thermal noise in the input termination at 290 Kelvin. The receiver noise figure including any pre-amplifier should be 12 dB or less for frequencies between 4.4 GHz to 10.0 GHz.

The antenna radiation pattern is the relative power gain as a function of direction for specified polarizations. Directional antennas shall meet the performance standards as indicated:

Frequency Band (GHz)	Maximum beamwidth 3 dB point	Minimum suppression at angle in degrees from center line of main beam (dB)						
		5°-10°	10°-15°	15°-20°	20°-30°	30°-100°	100°-140°	140°-180°
7.125-8.5	2.5°	19	23	28	30	34	35	43

The level of unwanted emissions for earth stations and space stations are listed in Section 5.7.1 of the NTIA Manual.

For earth stations and space stations in the space services - These standards shall be equalled or exceeded in space systems initially submitted for a System Review by the Spectrum Planning Subcommittee (SPS)[6] as of January 1, 1985.

6 The SPS will be responsible to the (IRAC) for carrying out those functions given in mission bylaws that relate to planning for the use of the electromagnetic spectrum in the National interest to include the apportionment of spectrum space for the support of established or anticipated radio service as well as the apportionment of spectrum space between or among Government and non-Government activities.

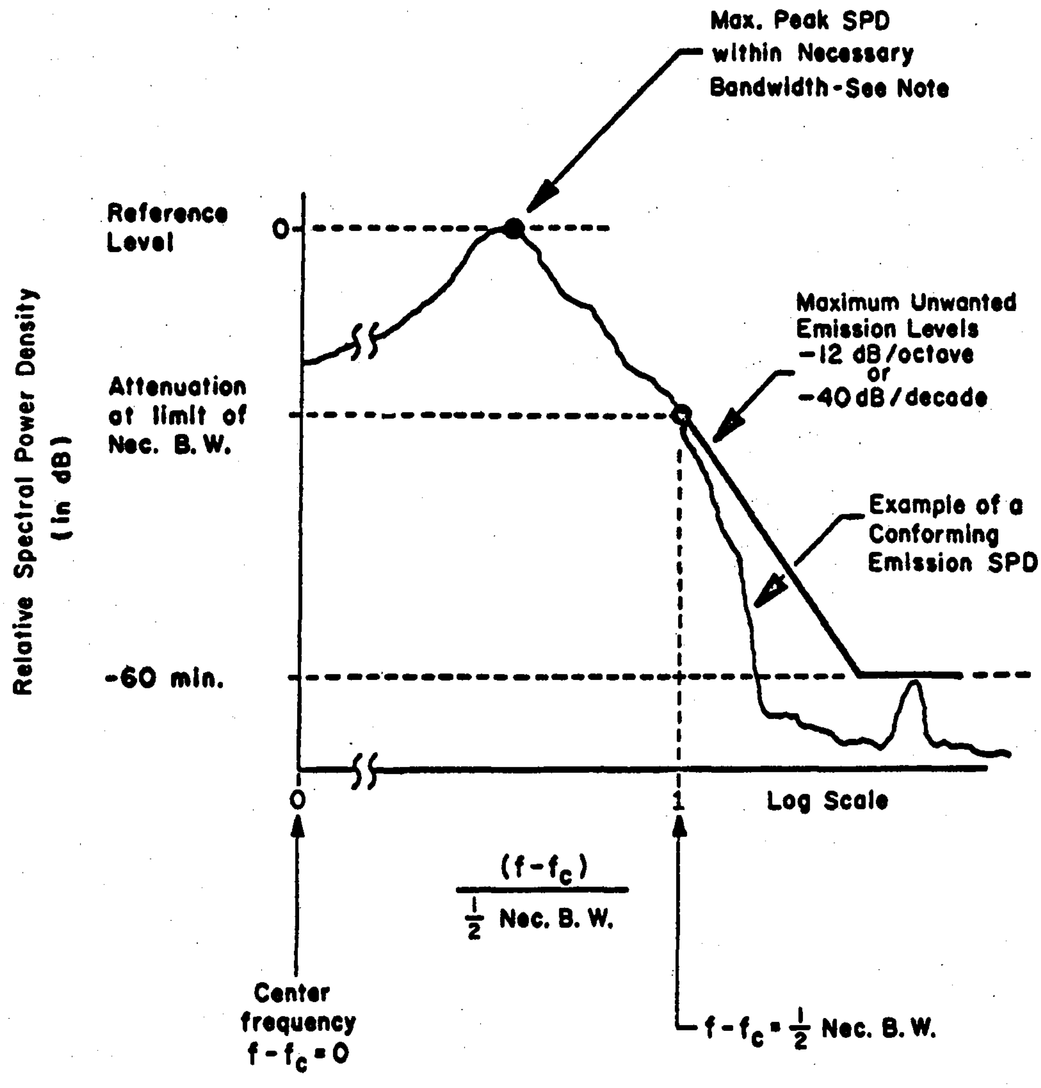
The requirements in this standard specify the upper bounds on unwanted emissions from earth and space stations associated with the space services. The unwanted emissions standard promotes electromagnetic compatibility among space systems and between space systems and systems of other services sharing the spectrum. These requirements are applicable to U.S. Government space systems including associated earth terminals operating in all portions of the spectrum allocated to the space services above 1 GHz. Figure 2-1 shows these requirements which simplify the planning and evaluation of systems by limiting the envelope of the emitted spectrum to maximum spectral power density (SPD) levels below a given value.

NTIA Manual, Section 8.2.32, specifies that in order to control space stations emissions, frequency authorization will only be given to space stations that have the ability to turn on and turn off (space stations that have immediate cessation capability via telecommand).

NTIA Manual, Section 8.2.33, specifies that the selection of sites and frequencies for earth and terrestrial stations operating in shared frequency bands above 1 GHz, shall be selected to the extent practicable in areas where the surrounding terrain and existing frequency usage are such as to minimize the possibility of harmful interference between sharing services.

NTIA Manual, Section 8.2.34, Paragraph 2, specifies the power and direction of maximum radiation of stations in the fixed or mobile service in the bands between 8025 and 8400 MHz that share the allocations with space radiocommunications on an equal rights basis, the power delivered by a transmitter to the antenna of that fixed station shall not exceed 13 dBW. The maximum EIRP of a station within the fixed or mobile service shall not exceed 55 dBW.

NTIA Manual, Section 8.2.34, Paragraph 3, specifies the power and direction of maximum radiation of stations in the fixed or mobile service in the bands between 8025 and 8400 MHz that share the allocations with space radiocommunications on an equal rights basis, as far as practicable, the sites for transmitting stations, in the fixed service, employing maximum values of EIRP exceeding 35 dBW in the frequency bands between 8025 and 8400 MHz, shall be selected so that the direction of maximum radiation of any antenna will be at least 2° away from the geostationary satellite orbit. Where this is impractical, the maximum EIRP of a station in the fixed or mobile service shall not exceed 47 dBW in any direction within 0.5° or 47 dBW to 55 dBW, on a linear decibel scale (8 dB per degree), between 0.5° and 1.5° of the geostationary satellite orbit.



NOTE: This sample signal spectrum was chosen to emphasize that the reference level is determined by peak SPD wherever it occurs within the necessary bandwidth. The peak does not necessarily occur at the center frequency or the carrier frequency.

Figure 2-1. Maximum Unwanted Emission Levels for Space Services.

NTIA Manual, Section 8.2.35, specifies the power and direction of maximum radiation of earth stations in the band 7900-8400 MHz that share the allocation with the fixed or mobile service on an equal basis, the EIRP of earth stations in any direction toward the horizon shall not exceed the following limits:

- 40 dBW in any 4 kHz band for $\Theta \leq 0°$,
- $40 + 3(\Theta)$ dBW in any 4 kHz band for $0° < \Theta \leq 5°$,
- for angles of elevation of the horizon above 5°, there is no limit,
- earth station antennas for services, other than the space research service, shall not be employed at elevations angles of less than 3° measured from the horizontal plane to the direction of maximum radiation,
- earth station antennas for the space research service shall not be employed at elevation angles measured from the horizontal plane to the direction of maximum radiation for less the 5° for the near-earth operations nor less than 10° for deep space operations.

NTIA Manual, Section 8.2.36, specifies the power flux density limits at the Earth's surface from space stations and at the geostationary satellite orbit as is shown in TABLE 2-3 and 2-4, respectively.

TABLE 2-3
POWER FLUX DENSITY LIMITS AT THE EARTH'S SURFACE FROM SPACE STATIONS SHARING WITH THE FIXED & MOBILE SERVICES

Frequency Band (MHz)	Space Radio-communication Service	Angle of arrival (δ) above the horizontal plane in degrees		
		0° - 5°	5° - 25°	25° - 90°
8025-8400	Earth Exploration-satellite	-150 dBW/m^2/4 kHz	$-150 + 0.5(\delta-5)$ dBW/m^2/4 kHz	-140 dBW/m^2/4 kHz
8400-8450	Space Research			

TABLE 2-4
POWER FLUX DENSITY LIMITS AT THE GEOSTATIONARY ORBIT FROM SPACE STATIONS USING NON-GEOSTATIONARY ORBITS

Frequency Band (MHz)	Space Radio-communication Service	Angle of arrival (δ) above the horizontal plane in degrees
8025-8400	Earth Exploration-Satellite	-174 dBW/m^2/4 kHz

NTIA Manual, Section 8.2.38, Paragraph (1), specifies that station keeping of space stations on geostationary satellites shall have the capability of maintaining their positions within the tolerance specified.

NTIA Manual, Section 8.2.38, Paragraph (2), specifies that space stations on board geostationary satellites which use frequency bands allocated to the fixed-satellite service:

a) shall have the capability of maintaining their position with $\pm 0.1°$ of the longitude of their normal position;
b) shall maintain their positions with $\pm 0.1°$ of longitude of their normal positions; but,
c) experimental stations on board geostationary satellites do not need to comply with either a) or b) above, but shall maintain their positions with $\pm 0.5°$ of the longitude of their normal positions;
d) however, space stations do not need to comply with b) or c) above, as appropriate, as long as the satellite network to which the space station belongs does not cause unacceptable interference to any other satellite network whose space station complies with the limits given in b) and c) above.

NTIA Manual, Section 8.2.38, Paragraph (3), specifies that space stations on board geostationary satellites which do not use any frequency band allocated to the fixed-satellite service:

a) shall have the capability of maintaining their position within $\pm 0.5°$ of the longitude of their normal position;
b) shall maintain their positions within $\pm 0.5°$ of the longitude of their normal positions; but,
c) need not comply with b) above as long as the satellite network to which the space station belongs does not cause unacceptable interference to any other satellite network whose space station complies with the limits given in b) above.

NTIA Manual, Section 8.2.39, Paragraph (1), specifies accuracy of antennas on geostationary satellites, the point direction of the maximum radiation of any earthward beam of antennas (intended for less then earth coverage) on geostationary satellites shall be capable of being maintained within:

a) 10% of the half-power beamwidth relative to nominal pointing direction; or
b) 0.3° relative to the nominal pointing direction, whichever is greater.

NTIA Manual, Section 8.2.39, Paragraph (2), specifies accuracy of antennas on geostationary satellites, in the event that an antenna beamwidth is not rotationally symmetrical about the axis of maximum radiation, the tolerance in any plane containing this axis shall be related to the half power beamwidth in that plane.

NTIA Manual, Section 8.2.39, Paragraph (3), specifies accuracy of antennas on geostationary satellites, that this accuracy shall be maintained only if it is required to avoid unacceptable interference to other systems.

NTIA Manual, Section 8.2.43, specifies that frequency assignments to transportable earth stations in the 8025-8400 MHz band are temporary and renewable with an expiration date not to exceed five years.

International

The technical standards for rules and regulations in the ITU Radio Regulations (RR) that apply in the 8025-8400 MHz range include Articles, Appendices, and Recommendations (those recommendations are strictly what the international community feels comfortable recommending to the ITU; they are not binding on individual countries):

- Article 8 (Frequency Allocations) [new Article S5],
- Articles 11 and 13 (for coordinating the notification and registration of frequencies) and Article 14 (procedure for administrative agreement) [new Article S9 and S11],
- Articles 27, 28, and 29 (provisions relating to specific services) [new Article S21 and Article S22 encompass these three articles],
- Appendices 3 and 4 (notices and advanced publication) [new Annex 2A and 2B of Appendix S4],
- Appendices 7 and 8[7] (tolerances and spurious emission levels) [new Appendix S2 and Appendix S3, respectively],
- Appendices 28 and 29 (methods to determine coordination areas) [new Appendix S7 and Appendix S8, respectively], and
- ITU-R Inter-Service Coordination Recommendations (ITU-R IS.847-1, IS.848-1, and IS.849-1 [ITU-R IS, 1994]).

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7 Study Group 1/3 has been tasked to rewrite Recommendation 329-6 which is the basis for the spurious emission limits reported in Appendix 8. The *Draft Revision Of Recommendation ITU-R SM.329-6, SPURIOUS EMISSIONS,* (Question 55/1), Document 1/31-E, dated Santa Rosa, CA, 30 October 1996, has recently been obtained such that this rewrite can receive Study Group 1 approval prior to the WRC 97. One purpose of the rewrite is to develop standardized satellite spurious emission limits.

Also, one needs to be aware of several recommendations relating to Earth exploration-satellite and meteorological-satellite issues that are currently used on an international basis to avoid interference; Recommendation ITU-R SA.515-2, SA.516-1, SA.578, SA.609-1, SA.1020, SA.1021, SA.1022, SA.1023, SA.1025, SA.1026, and SA.1027 [ITU-R SA, 1994]. This is a listing of those recommendations concerning EESS and MetSat:

•Recommendation ITU-R IS.847-1 entitled, *Determination Of The Coordination Area Of An Earth Station Operating With A Geostationary Space Station And Using The Same Frequency Band As A System In A Terrestrial Service.*

•Recommendation ITU-R IS.848-1 entitled, *Determination Of The Coordination Area Of A Transmitting Earth Station Using The Same Frequency Band As Receiving Earth Stations In Bidirectionally Allocated Frequency Bands;*

•Recommendation ITU-R IS.849-1 entitled, *Determination Of The Coordination Area For Earth Stations Operating With Non-Geostationary Spacecraft In Bands Shared With Terrestrial Services;*

•Recommendation ITU-R SA.515-2 entitled, *Frequency Bands And Bandwidths Used For Satellite Passive Sensing;*

•Recommendation ITU-R SA.516-1 entitled, *Feasibility Of Sharing Between Active Sensors Used On Earth Exploration And Meteorological Satellites And The Radiolocation Service;*

•Recommendation ITU-R SA.609-1 entitled, *Protection Criteria for Telecommunication Links for Manned and Unmanned Near-Earth Research Satellites;*

•Recommendation ITU-R SA.1020 entitled, *Hypothetical Reference System For The Earth Exploration-Satellite And Meteorological-Satellite Services;*

•Recommendation ITU-R SA.1021 entitled, *Methodology For Determining Performance Objectives For Systems In The Earth Exploration-Satellite And Meteorological-Satellite Services;*

•Recommendation ITU-R SA.1022 entitled, *Methodology For Determining Interference Criteria For Systems In the Earth Exploration-Satellite And Meteorological-Satellite Services;*

•Recommendation ITU-R SA.1023 entitled, *Methodology For Determining Sharing And Coordinations Criteria For Systems In The Earth Exploration-Satellite And Meteorological-Satellite Services;*

•Recommendation ITU-R SA.1025 entitled, *Performance Criteria For Space-To-Earth Data Transmission Systems Operating In The Earth Exploration-Satellite And Meteorological-Satellite Services Using Satellites In Low-Earth Orbit;*

•Recommendation ITU-R SA.1026 entitled, *Interference Criteria For Space-To-Earth Data Transmission Systems Operating In The Earth Exploration-Satellite And Meteorological-Satellite Services Using Satellites In Low-Earth Orbit;*

•Recommendation ITU-R SA.1027 entitled, *Sharing And Coordination Criteria For Space-To-Earth Data Transmission Systems Operating In The Earth Exploration-Satellite And Meteorological-Satellite Services Using Satellites In Low-Earth Orbit;*

Recommendation ITU-R SA.1157 entitled, *Protection Criteria For Deep-Space Research* recommends (in part) that protection criteria for deep space research earth stations be established at -220.9 dB(W/Hz) in the bands near 8 GHz (see TABLE 2-5). This PFD recommendation applies to non-deep space service transmissions that occur in the 8400-8450 MHz band. Recommendation ITU-R SA.1157 [ITU-R SA, 95] is the standard for the permissible interference interactions. Recommendation ITU-R SA.1157 summarizes and gives details on the allowable interference power spectral density and power flux density to protect the deep space earth station receptions.

TABLE 2-5
DEEP SPACE 8 GHz INTERFERENCE LEVELS

Frequency Band (MHz)	Maximum allowable interference power spectral density (dB(W/Hz))	Maximum allowable interference power spectral flux density (dB(W/m^2 -Hz))
8400-8450 MHz	-220.9	-255.1
The -220.9 value applies at the deep space Earth station receiver input terminals. The -255.1 value applies to the aperture of 70 meter diameter reflector earth station antennas which have approximately 70% area efficiency in the downlink band of 8400-8450 MHz.		

TABLE 2-6 gives a brief overview of the potential interference paths involved with the EESS. This table also indicates the standard(s) that are applicable to each of the potential interference cases and the number in parentheses gives the potential interference case as provided in Section 4 (this table is repeated in Section 4 for the convenience of the reader).

TABLE 2-6 (repeated in Section 4 for ease of reading)
APPLICABILITY OF INTERNATIONAL RULES, REGULATIONS AND RECOMMENDATIONS CONCERNING COMPATIBILITY WITH EESS

Victim / Source	FIXED	FSS/MSS ↑ in GEO orbit	EESS ↓ in GEO orbit	EESS ↓ in LEO orbit	SPACE RESEARCH ↓ (earth stations)	METSAT ↑ in GEO orbit	METSAT ↑ in LEO orbit
FIXED			Rec.IS.849[8]	Rec.IS.849[8]			
FSS/MSS ↑			Appendix 29, Case 2 and Rec.IS.848	Rec.IS.849[9]			
MSS ↑ Airborne			Rec.SM.329[10]	Rec.SM.329[10]			
EESS ↓ in GEO orbit	Article 28, (RR 2569)	Appendix 29, Case 2	Appendix 29, Case 1	Article 28,[11] (RR 2569)	Rec.SM.329[10]	Appendix 29, Case 2	(simulation[12])
EESS ↓ in LEO orbit	Article 28, (RR 2569)	Article 29, (RR 2613), (RR 2631)	Article 28,[11] (RR 2569)	Article 28,[11] (RR 2569)	Rec.SM.329[10]	(simulation[12])	(simulation[12])
METSAT ↑ in GEO orbit			Appendix 29, Case 2 and Rec.IS.848	Rec.IS.849[13]			
METSAT ↑ in LEO orbit			Rec.IS.847[14]	Rec.IS.849[13]			

Note: ↑ indicates satellite uplink. ↓ indicates satellite downlink.

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8 There is no ITU-R recommendation that covers this type of interaction. However, ITU-R IS.849 might be adapted to this potential interference case by treating the FSS/MSS uplink earth station as a terrestrial station.

9 There is no ITU-R recommendation that covers this type of interaction. However, ITU-R IS.849 might be adapted to this potential interference case by treating the FSS/MSS uplink earth station as a terrestrial station.

10 The out-of-band emissions that may be associated with unwanted emissions will not be discussed in this report (see footnote 6, page 16 for re-write details on Appendix 8 as the "Draft Revision of Recommendation ITU-R SM.329-6"). Also, see page 18 for in-band space research criteria.

11 Article 28 (RR 2569) might be adapted to this potential interference case by treating the victims earth stations in either the GEO or LEO case as terrestrial stations

12 Rules or regulations applicable to these cases were not identified during this study; however, if the interference potential requires analysis, there are models similar to FlySat (see Section 3, page 37) that might be used for sharing analysis.

13 There is no ITU-R recommendation that covers this type of interaction. However, ITU-R IS.849 might be adapted to this potential interference case by treating the MetSat uplink earth station as a terrestrial station.

14 There is no ITU-R recommendation that covers this type of interaction. However, ITU-R IS.847 might be adapted to this potential interference case by treating the MetSat uplink earth station as a terrestrial station.

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SECTION 3

SPECTRUM USAGE OF THE 7900-8450 MHz FREQUENCY RANGE

BAND USAGE

Statistics Concerning the 7900-8450 MHz Frequency Range Usage in the United States

TABLE 3-1 shows the current overall summary of frequency assignments in the 7900-8450 MHz range extracted from the GMF (June 1996). The quantities shown are obtained by a computer count of the number of occurrences of assignments in the GMF over the frequency range of interest. It should be noted that DoD users account for approximately 57% of the assigned frequencies in the 7900-8450 MHz frequency range. Figures 3-1 and 3-2 show the distribution of discrete assignments in the 7900-8450 MHz frequency range and the distribution of tuneable assignments[15] in the 7900-8450 MHz frequency range. It should be noted that the frequency range bins in Figure 3-2 were defined such that the lower range is the start of each tuneable assignment and the higher range is the upper limit of each assignment. Also, it should be noted that the frequency range of 8040-8120 MHz has 153 tuneable entries (e.g., band assignments). Of these 153 assignments, 95% are DoD DSCS transportable backbone fixed-satellite earth station records with the other 5% being specialized equipment assignments used for the testing/checkout of the DSCS satellites.

The usage in the sub-bands that make-up the 7900-8450 MHz range are also shown in separate tables for the five frequency bands of 7900-8025 MHz, 8025-8175 MHz, 8175-8215 MHz, 8215-8400 MHz and 8400-8450 MHz. Again, the quantities shown are obtained by a computer count of the number of frequency assignments in the GMF over the frequency range of interest. Some frequency assignments have multiple station class entries.

The 7900-8025 MHz band is predominantly used for Government fixed and fixed-satellite (Earth-to-space) service operations (approximately 32% and 22%, respectively, of the frequency assignment counts as shown in TABLE 3-2). Applications include DSCS III

[15] A tuneable assignment (also referred to as a band assignment) conveys the authorization to operate the equipment on any frequency within the assigned band.

TABLE 3-1

SUMMARY OF THE FREQUENCY ASSIGNMENTS IN THE 7900-8450 MHz BAND

as of June 1996

SERVICE	AF	AR	C	CG	DOE	FAA	I	J	N	NASA	NG	NSF	TVA	VA	Others*	TOTALS	PERCENTAGE
FIXED-SATELLITE (Earth-to-space)	306	246							143						33	728	20.1%
MOBILE-SATELLITE (Earth-to-space)	1															1	0.0%
FIXED	228	193	23	27	340	866	28	61	273	40		1	61	6	35	2182	60.2%
AERONAUTICAL MOBILE-SATELLITE (Earth-to-space)	5								2							7	0.2%
EARTH EXPLORATION-SATELLITE (space-to-Earth)			2							1						3	0.1%
METEOROLOGICAL-SATELLITE (Earth-to-space)																--	0.0%
SPACE RESEARCH (Deep Space) (space-to-Earth)										14						14	0.4%
NO SERVICE o Experimental	663	7							7	6	8					691	19.0%
TOTALS	1203	446	25	27	340	866	28	61	425	61	8	1	61	6	68	3613	
PERCENTAGE	33.3%	12.3%	0.7%	0.7%	9.4%	23.9%	0.8%	1.7%	11.7%	1.7%	0.2%	0.0%	1.7%	0.2%	2.0%		100.0%

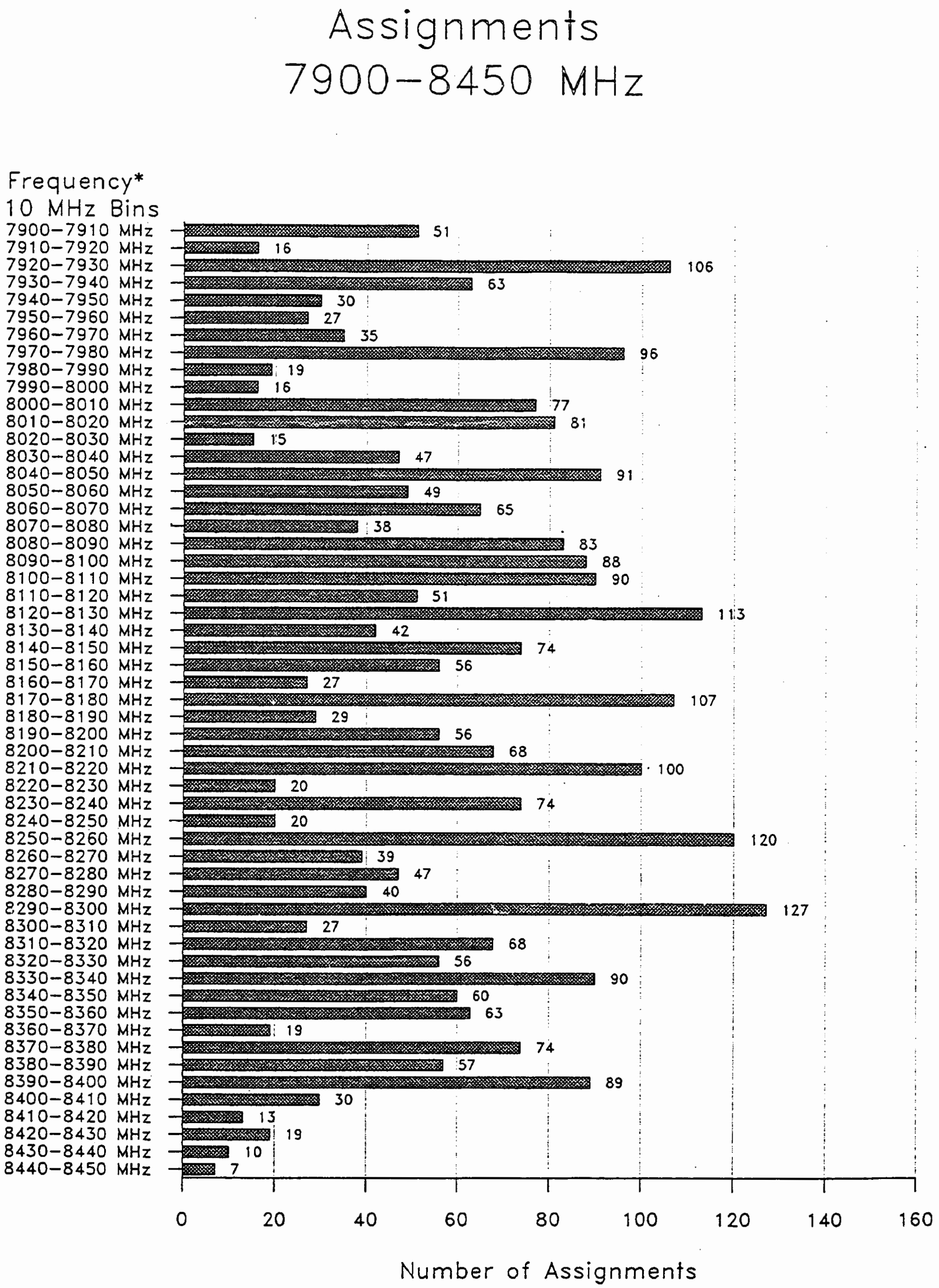
Agencies or Administrations

AF - Department of the Air Force
AR - Department of the Army
C - Commerce Department
CG - Coast Guard
DOE - Department of Energy
FAA - Federal Aviation Administration
TVA - Tennessee Valley Authority

Agencies or Administrations

I - Department of Interior
J - Department of Justice
N - Department of the Navy
NASA - National Aeronautics and Space Administration
NG - Non-Government entities provided by the Federal Communications Commission
NSF - National Science Foundation
VA - Department of Veterans Affairs

* *(Others) Other agencies having a few fixed and fixed-satellite assignments.*



*Lower limit is inclusive, upper limit is not.

Figure 3-1. Distribution of all discrete Government assignment records, by frequency, in the 7900-8450 MHz range (as of June 1995).

DISTRIBUTION OF TUNEABLE ASSIGNMENTS IN THE 7900-8450 MHz BAND

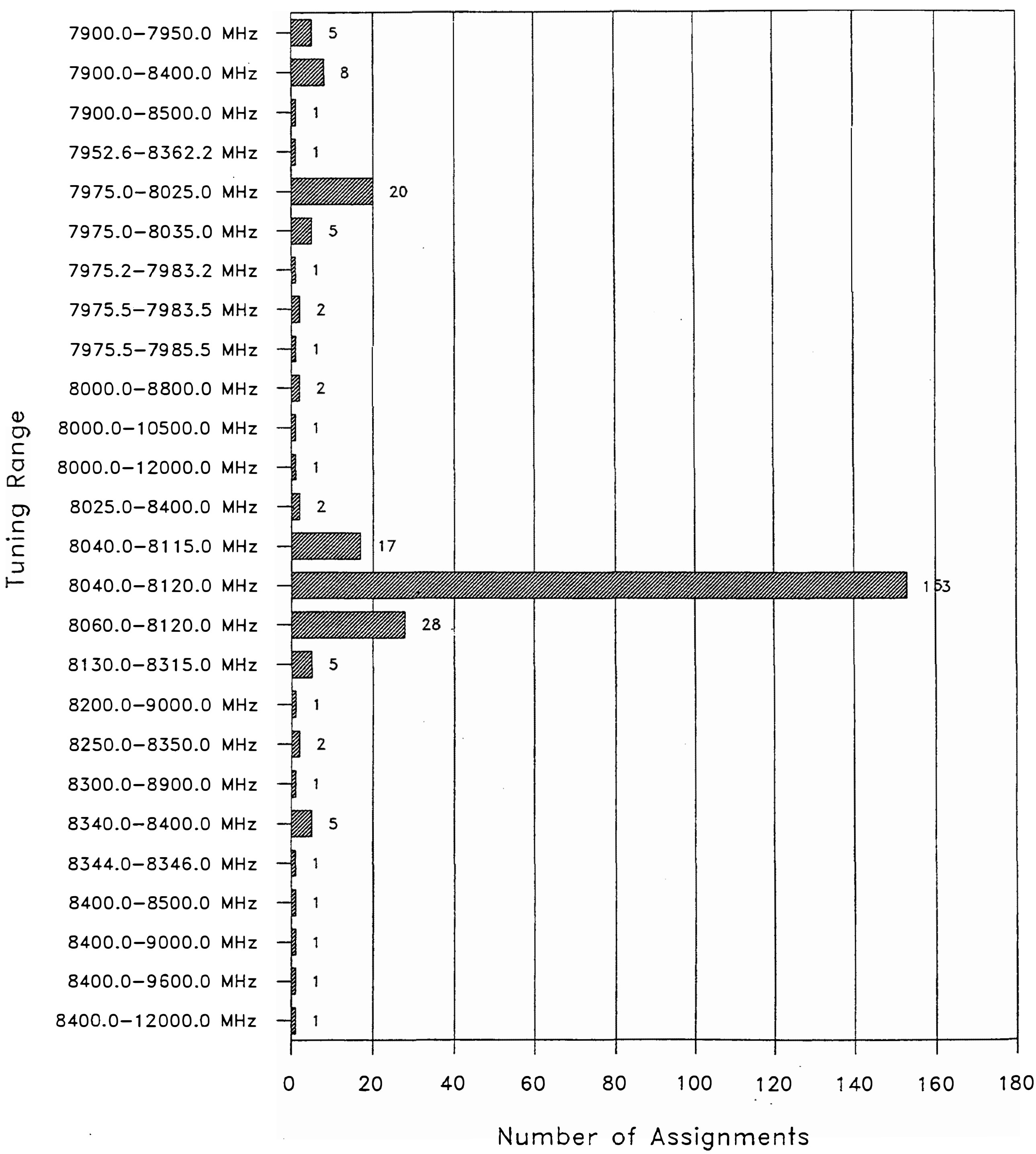


TABLE 3-2
SUMMARY OF FREQUENCY ASSIGNMENTS IN THE 7900-8025 MHz BAND
as of June 1996

SERVICE	AF	AR	C	CG	DOE	FAA	I	N	NASA	NG	TVA	Others*	TOTALS	PERCENTAGE
FIXED-SATELLITE (Earth-to-space)	74	23						45				11	153	22.2%
MOBILE-SATELLITE (Earth-to-space)	1												1	0.1%
FIXED	53	42	7	2	12	23	1	57	10		8	2	217	31.5%
AERONAUTICAL MOBILE-SATELLITE (Earth-to-space)	5							2					7	1.0%
NO SERVICE o Experimental	304							3		3			310	45.1%
TOTALS	437	65	7	2	12	23	1	107	10	3	8	13	688	
PERCENTAGE	63.5%	9.4%	1.0%	0.3%	1.7%	3.3%	0.1%	15.6%	1.5%	0.4%	1.2%	1.9%		100.0%

Agencies or Administrations

AF - Department of the Air Force
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C - Commerce Department
CG - Coast Guard
DOE - Department of Energy

Agencies or Administrations

FAA - Federal Aviation Administration
I - Department of Interior
N - Department of the Navy
NASA - National Aeronautics and Space Administration
NG - Non-Government entities provided by the Federal Communications Commission
TVA - Tennessee Valley Authority

* *(Others) Other agencies having a few fixed and fixed-satellite assignments.*

satellites[16], FLTSATCOM satellites[17] and a number of DoD, FAA, NASA and DOE medium-to-high capacity microwave point-to-point networks used mainly for video and data relay systems.

The three bands which compose the 8025-8400 MHz frequency range are used for Government fixed and fixed-satellite (Earth-to-space) service operations. Applications include DSCS III satellites[18], Government medium-to-high capacity LOS fixed service operations including law enforcement networks, backbone networks, video relay, data relay, remote data transmissions in support of aviation and control links for various power, land, water, energy management systems and timing distribution signals. There is only slight use of the Earth exploration-satellite service by two agencies (NASA and Commerce) with no non-Government entities using any frequencies within this band. In the band 8025-8175 MHz, the predominant frequency assignment counts are for the fixed and fixed-satellite services which use approximately 62% and 38%, respectively, as shown in TABLE 3-3. In the band 8175-8215 MHz band, the predominant frequency assignment counts are the fixed and fixed-satellite services which use approximately 89% and 8%, respectively, as shown in TABLE 3-4. In the band 8215-8400 MHz band, the predominant frequency assignment counts are for the fixed, experimental and fixed-satellite services which use approximately 79%, 12% and 9%, respectively, as shown in TABLE 3-5. (Note: There are currently no MetSat operations in the 8215-8400 MHz band.)

The 8400-8450 MHz band is used for Government medium-to-high capacity LOS fixed service operations (approximately 68% of the frequency assignment counts as shown in TABLE 3-6). Applications include short-haul law enforcement networks, video relay, and data relay. The current use of the space research (space-to-Earth) (deep space) service is for receiving earth stations at Goldstone, CA.

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16 DSCS III satellite earth station uses uplink frequencies in the 7900-8400 MHz frequency range. DSCS III (A1-B7) has channels 1 through 6 which employ the frequency ranges of 7975-8035, 8060-8120, 8145-8230, 8255-8315, 8340-8400, and 7900-7950 MHz respectively. DSCS III B8-B14 has channels 1 through 6 which employ the frequency ranges of 7975-8025, 8040-8115, 8130-8215, 8230-8315, 8340-8400, and 7900-7950 MHz respectively. The DSCS follow-on, USGCSS Phase 4, will not be studied because it will have uplink and downlink frequencies in the 2 GHz and 20/45 GHz ranges.

17 FLTSATCOM satellite earth station terminals use two uplink frequencies: 7994 and 7995 MHz The 7995 MHz is rebroadcast in the 235-322 MHz fleet broadcast channels (space-to-Earth). These satellite terminals utilize spread spectrum modulation techniques.

18 See footnote 16, above.

TABLE 3-3
SUMMARY OF FREQUENCY ASSIGNMENTS IN THE 8025-8175 MHz BAND
as of June 1996

SERVICE	AF	AR	C	CG	DOE	FAA	I	J	N	NASA	TVA	VA	Others*	TOTALS	PERCENTAGE
FIXED-SATELLITE (Earth-to-space)	180	188							77				10	455	37.5%
MOBILE-SATELLITE (Earth-to-space)														---	
FIXED	77	63	3	5	113	317	17	22	91	13	28	2	3	754	62.1%
EARTH EXPLORATION-SATELLITE (space-to-Earth)										1				1	0.1%
NO SERVICE o **Experimental**			3						1					4	0.3%
TOTALS	257	251	6	5	113	317	17	22	169	14	28	2	13	1214	
PERCENTAGE	21.2%	20.7%	0.5%	0.4%	9.3%	26.1%	1.4%	1.8%	13.9%	1.2%	2.2%	0.2%	1.1%		100.0%

Agencies or Administrations

AF - Department of the Air Force
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C - Commerce Department
CG - Coast Guard
DOE - Department of Energy
FAA - Federal Aviation Administration

Agencies or Administrations

I - Department of Interior
J - Department of Justice
N - Department of the Navy
NASA - National Aeronautics and Space Administration
TVA - Tennessee Valley Authority
VA - Department of Veterans Affairs

* *(Others) Other agencies having a few fixed and fixed-satellite assignments.*

TABLE 3-4
SUMMARY OF FREQUENCY ASSIGNMENTS IN THE 8175-8215 MHz BAND
as of June 1996

SERVICE	AF	AR	C	CG	DOE	FAA	I	J	N	NASA	TVA	VA	Others*	TOTALS	PERCENTAGE
FIXED-SATELLITE (Earth-to-space)	5	8							5				5	23	8.3%
MOBILE-SATELLITE (Earth-to-space)														--	
FIXED	20	20	3	3	50	106	6	6	25	1	2	2	4	248	89.2%
EARTH EXPLORATION-SATELLITE (space-to-Earth)			1											1	0.3%
NO SERVICE o Experimental	1		2						1	2				6	2.2%
TOTALS	26	28	6	3	50	106	6	6	31	3	2	2	9	278	
PERCENTAGE	9.4%	10.1%	2.2%	1.1%	18.0%	38.1%	2.2%	2.2%	11.2%	1.1%	0.7%	0.7%	3.0%		100.0%

Agencies or Administrations

AF - Department of the Air Force
AR - Department of the Army
C - Commerce Department
CG - Coast Guard
DOE - Department of Energy
FAA - Federal Aviation Administration

Agencies or Administrations

I - Department of Interior
J - Department of Justice
N - Department of the Navy
NASA - National Aeronautics and Space Administration
VA - Department of Veterans Affairs
TVA - Tennessee Valley Authority

* *(Others) Other agencies having a few fixed and fixed-satellite assignments.*

TABLE 3-5
SUMMARY OF FREQUENCY ASSIGNMENTS IN THE 8215-8400 MHz BAND
as of June 1996

SERVICE	AF	AR	C	CG	DOE	FAA	I	J	N	NASA	NSF	TVA	VA	Others*	TOTALS	PERCENTAGE
FIXED-SATELLITE (Earth-to-space)	47	27							16					7	97	8.6%
MOBILE-SATELLITE (Earth-to-space)															--	
FIXED	70	66	10	16	160	415	4	16	92		1	20	1	4	891	78.9%
EARTH EXPLORATION-SATELLITE (space-to-Earth)			1												1	0.1%
NO SERVICE o Experimental	134		2						2	1					139	12.4%
TOTALS	251	93	13	16	160	415	4	16	110	17	1	20	1	11	1128	
PERCENTAGE	22.2%	8.3%	1.1%	1.4%	14.2%	36.8%	0.4%	1.4%	9.7%	1.5%	0.1%	1.8%	0.1%	1.0%		100.0%

Agencies or Administrations

AF - Department of the Air Force
AR - Department of the Army
C - Commerce Department
CG - Coast Guard
FAA - Federal Aviation Administration
DOE - Department of Energy

Agencies or Administrations

J - Department of Justice
N - Department of the Navy
NASA - National Aeronautics and Space Administration
TVA - Tennessee Valley Authority
VA - Department of Veterans Affairs

* *(Others) Other agencies having a few fixed and fixed-satellite assignments.*

TABLE 3-6
SUMMARY OF FREQUENCY ASSIGNMENTS IN THE 8400-8450 MHz BAND
as of June 1996

SERVICE	AF	AR	CG	DOE	FAA	J	N	NASA	NG	T	TVA	Others*	TOTALS	PERCENTAGE
FIXED	8	2	1	5	5	17	8			20	3	1	70	68.6%
SPACE RESEARCH (space-to-Earth)								14					14	13.7%
NO SERVICE o Experimental	10							3	5				18	17.7%
TOTALS	18	2	1	5	5	17	8	17	5	20	3	1	102	
PERCENTAGE	17.7%	2.0%	1.0%	4.9%	4.9%	16.7%	7.8%	16.7%	4.9%	19.5%	2.9%	1.0%		100.0%

Agencies or Administrations
AF - Department of the Air Force
AR - Department of the Army
CG - Coast Guard
DOE - Department of Energy
FAA - Federal Aviation Administration
T - Department of Transportation

Agencies or Administrations
I - Department of Interior
J - Department of Justice
N - Department of the Navy
NASA - National Aeronautics and Space Administration
NG - Non-Government entities provided by the Federal Communications Commission
TVA - Tennessee Valley Authority

* *(Others) Other agencies having a few fixed and fixed-satellite assignments.*

National and International Usage of the 8025-8400 MHz Frequency Range for Earth Exploration-Satellite Service

The frequency range 8025-8400 MHz is allocated on a shared basis to the Earth exploration-satellite (space-to-Earth) service and the Government has expressed interest in this range to downlink data from Earth sensing satellites. This frequency range is also very attractive to non-Government entities (commercial providers) to provide saleable Earth sensing data. With that in mind, NASA convened several X-Band Workshops in the summers of 1994 and 1995 at Goddard Space Flight Center, Greenbelt, MD and Vandenberg Air Force Base in Lompoc, CA. These X-band workshops considered what options were available and what direction the U.S. Government and the non-Government commercial entities should take to resolve the issues, both on a national and international scale.

There are three Government agencies that operate or plan to operate EESS systems in the 8025-8400 MHz range; those agencies are Air Force, Commerce (NOAA), and NASA (JPL). There are several known U.S. non-Government commercial ventures[19] that plan to operate EESS systems in the 8025-8400 MHz frequency range; those entities are AstroVision Company, Space Imaging L.P., Orbital Sciences Corporation (OSC), EarthWatch Corporation, Resource 21[20], and Motorola[21] (see Major Systems for further information). TABLE 3-7 summarizes the planned and current Earth exploration-satellite systems spectrum usage as of

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19 License to operate requests by U.S. firms for private remote sensing space systems are reviewed on a case-by-case basis by the Department of Commerce in accordance with the Sensing Act of '92. There are several U.S entities that received a license to operate under this Act:
- EarthWatch (two satellites) Early Bird (issued 1/4/1993) and Quick Bird (issued 9/2/1994),
- EOSAT (issued 6/17/1993, lost with the LANDSAT-6 see Appendix B),
- Space Imaging L.P., CRSS (formally Lockheed, issued 4/22/1994),
- Orbital Science Corp. (two satellite) OrbView (issued 5/5/1994) and SeaStar (issued 7/1/1994),
- AstroVision AVSAT-1 (issued 1/23/1995),
- GDE Systems Imaging (issued 7/14/1995, as of April'96, this consortium is led by Resource 21), and
- Motorola (issued 8/1/1995).

These licenses were issued by the NOAA/DOC National Environmental, Satellite, Data, and Information Service, Office of System Development per the Sensing Act of '92.

20 Resource 21 developmental partners are Agrium, US; Boeing Commercial Space Company; Farmland Industries; GDE Systems; Institute for Technology Development; and Pioneer Hi-Bred International.

21 This spectrum is in support of prospective remote Earth sensing technology which is currently inactive. Should any potential spectrum conflicts or spectrum management issues be identified, Motorola will coordinate with concerned parties prior to activation per memo, May 1, 1996, from Motorola, Chandler, AZ (on file at NTIA).

TABLE 3-7
PLANNED/CURRENT INTERNATIONAL USE OF THE 8025-8400 MHz FREQUENCY RANGE FOR EESS SYSTEMS

Satellite	Administration	Apogee (km)	Perigee (km)	Inclin. (degrees)	Service Area	Latitude (degrees)	Longitude (degrees)	Frequency Range @ 8 GHz Lower (MHz)	Upper (MHz)	Launch Date
ADEOS	Japan	979	979	98.6	Global Coverage			8124.40 8243.40 8324.40	8175.60 8256.60 8375.60	Aug.17, 1996
AVSAT-1* (AstroVision)	USA (Commercial)	Geostationary at 92°			CONUS South Central Utah			8215.00	8230.00	Apr.1, 1996
CLARK	USA	475	475	97.3	Kiruna Fairbanks, AK Longmont, CO	67.9 64.9 40.1	21.1 -147.7 -105.1	8305.00	8340.00	Oct. 1996
CRSS-1a* (Space Imag.)	USA (Commercial)	680	680	98.1	Santa Cruz, CA Mariette, GA	37.15 33.9	-122.2 -89.5	8025.00 8344.97	8345.00 8345.03	Dec.1, 1996
CRSS-1b* (Space Imag.)	USA (Commercial)	680	680	98.1	Santa Cruz, CA Mariette, GA	37.15 33.9	-122.2 -89.5	8025.00 8344.97	8345.00 8345.03	Dec.1, 1996
EarthWatch- 1A & 1B (2 satellites #)	USA (Commercial)	600	600	52.0	Longmont, CO Italy & Japan USA	40.1	-105.1	8027.90 8105.00	8032.10 8260.00	Feb.1, 1998
EarthWatch- 2A & 2B (2 satellites #)	USA (Commercial)	468	468	97.3	Scandanavia Fairbanks, AK Longmont, CO	 64.9 40,1	 -147.7 -105.1	8305.00	8340.00	Jan. 2001
ENVISAT-1*	France (ESA)	468	468	97.3	Global Coverage			8061.50 8161.50 8261.50	8138.50 8238.50 8338.50	Mid. 1999
EOS AM (3 satellites)	USA (NASA)	714	697	98.2	Global Coverage			8182.50 8062.50 8025.00	8242.50 8362.50 8400.00	Jun.1, 1998 Jun.1, 2004 Jun.1, 2010
EOS PM* (3 satellite)	USA (NASA)	705	705	98.2	Global Coverage					Dec.1, 2000 Dec.1, 2006 Dec.1, 2012

Information obtained from the USWP 7C/63 Rev.1 - (3 June '96)

TABLE 3-7 (continued)
PLANNED/CURRENT INTERNATIONAL USE OF THE 8025-8400 MHz FREQUENCY RANGE FOR EESS SYSTEMS

Satellite	Administration	Apogee (km)	Perigee (km)	Inclin. (degrees)	Service Area	Lat. (degrees)	Long. (degrees)	Frequency Range @ 8 GHz Lower (MHz)	Upper (MHz)	Launch Date
EOS CHEM* (3 satellite)	USA (NASA)	705	705	98.2	Global Coverage					Dec.1, 2002 Dec.1, 2008 Dec.1, 2014
ERS-1	France (ESA)	785	785	98.5	Kiruna Fucino Maspalomas Prince Albert Fairbanks, AL Esrange McMurdo	62.9 42.0 27.8 53.2 65.0 67.9 -77.9	21.1 13.6 -15.4 -105.9 -147.5 21.0 166.7	8028.00 8100.00	8052.00 8180.00	Jul.1, 1991
ERS-2*	France (ESA)	785	785	98.5	Kiruna Fucino Maspalomas Prince Albert Fairbanks, AL Esrange McMurdo	62.9 42.0 27.8 53.2 65.0 67.9 -77.9	21.1 13.6 -15.4 -105.9 -147.5 21.0 166.7	8028.00 8100.00	8052.00 8180.00	Jan.1, 1995
EYEGLASS1* (OSC) (3 satellites)	USA (Commercial)	710	710	98.2	Global Coverage			8025.00	8325.00	Late 1996
GREENSAT-1 (ex GROENSAT-TP1)	South Africa	480	440	72.0	South Africa			8100.00 (100 MHz bandwidth)	8300.00	Nov. 1995
GREENSENCE (3 satellite)	South Africa	613	613	97.8	Global Coverage			8100.00 8200.00	8200.00 8300.00	Jan., 1997
IRS-1A	India	919	890	99.0	India			8249.75 8305.60	8250.25 8326.40	March, 1988
IRS-1B	India	900	900	99.0	India			8249.75 8305.60	8250.25 8326.40	Aug.29, 1991
IRS-1C	India	817	817	98.7	India			8107.50 8254.75 8328.75	8192.50 8255.25 8371.25	Jun.30, 1993
JERS-1	Japan	568	568	98.0	Global Coverage			8124.20 8324.20	8175.50 8375.50	Feb.11, 1992

Information obtained from the USWP 7C/63 Rev.1 - (3 June '96)

TABLE 3-7 (continued)
PLANNED/CURRENT INTERNATIONAL USE OF THE 8025-8400 MHz FREQUENCY RANGE FOR EESS SYSTEMS

Satellite	Administration	Apogee (km)	Perigee (km)	Inclin. (degrees)	Service Area	Lat. (degrees)	Long. (degrees)	Frequency Range @ 8 GHz Lower (MHz)	Upper (MHz)	Launch Date
JERS-1	Japan	568	568	98.0	Global Coverage			8124.20 8324.20	8175.50 8375.50	Feb.11, 1992
LANDSAT-4 (not funct'ing)	USA (NOAA-DOC)	704	686	98.0	Norman, OK Other global sites	35.1	-97.6	8127.50	8297.50	Jul.16, 1982
LANDSAT-5*	USA (NOAA-DOC)	720	698	98.2	Norman, OK Other global sites	35.1	-97.6	8127.50	8297.50	Mar.1, 1984
LANDSAT-6	USA (NOAA-DOC)				See Appendix-B					Oct.5, 1993
LANDSAT-7*	USA (DOC/NASA)	707	705	98.2	Sioux Falls, SD Other global sites	43.6	-96.6	8027.50 8157.50 8287.50	8137.50 8267.50 8397.50	Jan.1, 1998
MOS-1	Japan	909	909	99.0	Katsuuraa Masuda Okinawa Hatoyama Esrange Several DCP ESs	35.3 30.5 26.5 36.0 67.9	140.3 131.0 127.9 139.3 21.0	8144.00 8344.00	8156.00 8356.00	Feb.19, 1987
MOS-1B	Japan	909	909	99.0	Global Coverage			8144.00 8344.00	8156.00 8356.00	Feb.2, 1990
METOP-1	France (ESA)	800	800	98.6	Global Coverage			8061.50 8161.50 8261.50	8138.50 8238.50 8338.50	2001
ORBVIEW 1, 2, 3 (3 satellites)	USA (Commercial)	460	460	97.0	Global Coverage			8025.00	8325.00	Dec., 1997

Information obtained from the USWP 7C/63 Rev.1 - (3 June '96)

TABLE 3-7 (continued)
PLANNED/CURRENT INTERNATIONAL USE OF THE 8025-8400 MHz FREQUENCY RANGE FOR EESS SYSTEMS

Satellite	Administration	Apogee (km)	Perigee (km)	Inclin. (degrees)	Service Area	Lat. (degrees)	Long. (degrees)	Frequency Range @ 8 GHz Lower (MHz)	Upper (MHz)	Launch Date
RADARSAT-1	Canada	820	795	98.7	Gatineau, CAN Prince Albert, CAN Fairbanks, AL McMurdo Other global sites	45.6 53.3 65.0 -77.9	-75.8 -105.9 -147.5 166.6	8075.00 8200.00	8135.00 8260.00	Nov.4, 1995
SITCH	Ukraine	650	650	98.0	Global Coverage			8025.00	8400.00	Jul.1, 1997
SPEKTR-R	Russia	78,000	2000	65.0	Region 1 & 2 Evpatoriiya Ussuriisk	 45.3 44.0	 33.2 131.75	8128.00	8256.00	Dec.30, 1993
SPOT-1	France	822	822	98.7	Global Coverage			8200.50 8306.75	8305.50 8307.25	Feb.22, 1986
SPOT-2	France	822	822	98.7	Global Coverage			8200.50 8306.75	8305.50 8307.25	Jan.21, 1990
SPOT-3	France	822	822	98.7	Aussaguel Kourou Kiruna Greenbelt, MD Fairbanks, AL Other global sites	43.4 5.1 62.9 39.0 65.0	1.5 -52.6 21.1 -76.9 -147.5	8200.50 8306.75	8305.50 8307.25	Aug.26, 1993
SPOT-4	France	822	822	98.7	Aussaguel Kourou Kiruna Other global sites	43.4 5.1 62.9	1.5 -52.6 21.1	8200.50 8306.75	8305.50 8307.25	Jan.31, 1995
SPOT-5a	France	822	822	98.7	Aussaguel Kourou Kiruna Other global sites	43.4 5.1 62.9	1.5 -52.6 21.1	8200.50 8306.75	8305.50 8307.25	Jan.31, 1996

Information obtained from the USWP 7C/63 Rev.1 - (3 June '96)

TABLE 3-7 (continued)
PLANNED/CURRENT INTERNATIONAL USE OF THE 8025-8400 MHz FREQUENCY RANGE FOR EESS SYSTEMS

Satellite	Administration	Apogee (km)	Perigee (km)	Inclin. (degrees)	Service Area	Lat. (degrees)	Long. (degrees)	Frequency Range @ 8 GHz Lower (MHz)	Upper (MHz)	Launch Date
SPOT-5b	France	822	822	98.7	Aussaguel Kourou Kiruna Kerquelen St. Pierre	43.4 5.1 62.9 -51.8 46.8	1.5 -52.6 21.1 69.1 -56.3	8200.50 8306.75	8305.50 8307.25	Jan.31, 1998
SSIPR (2 satellite)	Russia	650	650	98.0	Russian Territory Germany Poland Czechoslovakia Hungray Romania Bulgaria Mongolia Viet Nam Cuba			8025.00 8044.00 8112.00 8240.00	8185.00 8084.00 8272.00 8400.00	Oct.10, 1992
XMM*	France (ESA)							8025.00	8400.00	

Information obtained from the USWP 7C/63 Rev.1 - (3 June '96)

* These systems have not registered with the ITU as of June 1, 1994.

WorldView will hold 44% interest in EarthWatch; the remaining 56% will be held by Ball Corp's Aerospace & Communication Group.

July 1995.[22] The frequency range 8025-8400 MHz is of critical importance because these bands are the only primary allocation suitable for wideband Earth exploration-satellite (space-to-Earth) service use below 65 GHz.[23] A number of foreign entities (see TABLE 3-7) have or plan to have operational satellites within the frequency range 8025-8400 MHz. Several items in the 1995 X-band workshop at Vandenburg Air Force Base, CA in June 1995 are important references. Many of these references were analyzed and presented by NASA JPL, NASA Headquarters or private contractors for NASA. Those analyses are included in the X-band workshop III minutes [X-Band III, 95]. Titles of the analyses are:

Interference from LANDSAT-7 to the Deep Space Network (DSN);

Interference between EESS in the band 8025-8400 MHz;

Interference from NASA's EOS AM-1 to the DSN;

Efficient Modulation Method Study - A Comparison of Modulation Schemes;

Use of Pulse Shaping for Spectrum Control;

FlySat Interference Simulation Software (FlySat); and

Impact of Data Asymmetry on EOS PM Design

TABLE 3-7 also shows Administrations that operate or plan to operate EESS systems in the 8025-8400 MHz frequency range; those administration are: Canada, France, India, Japan, Russia, South Africa, and Ukraine. Figure 3-3 shows what frequency range or discrete frequencies the operational and planned satellite systems will use. Note that the NASA's EOS-AM 3rd satellite, and Ukraine's SITCH satellite are planning to use the entire frequency range. Figure 3-4 shows the operational life of satellites and when the satellites were launched or will be launched. Satellites operating in the frequency range of 8025-8400 MHz, launched prior

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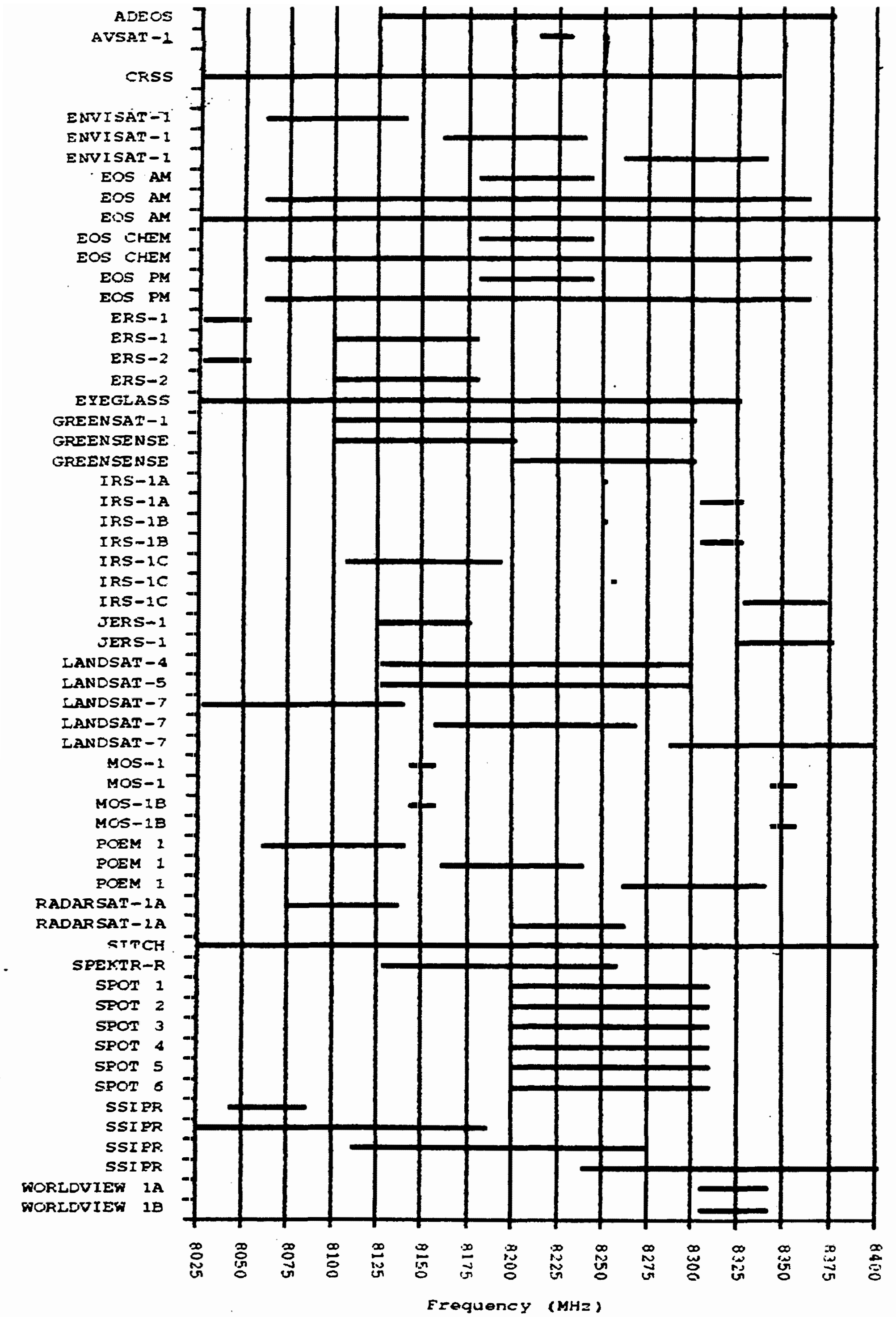
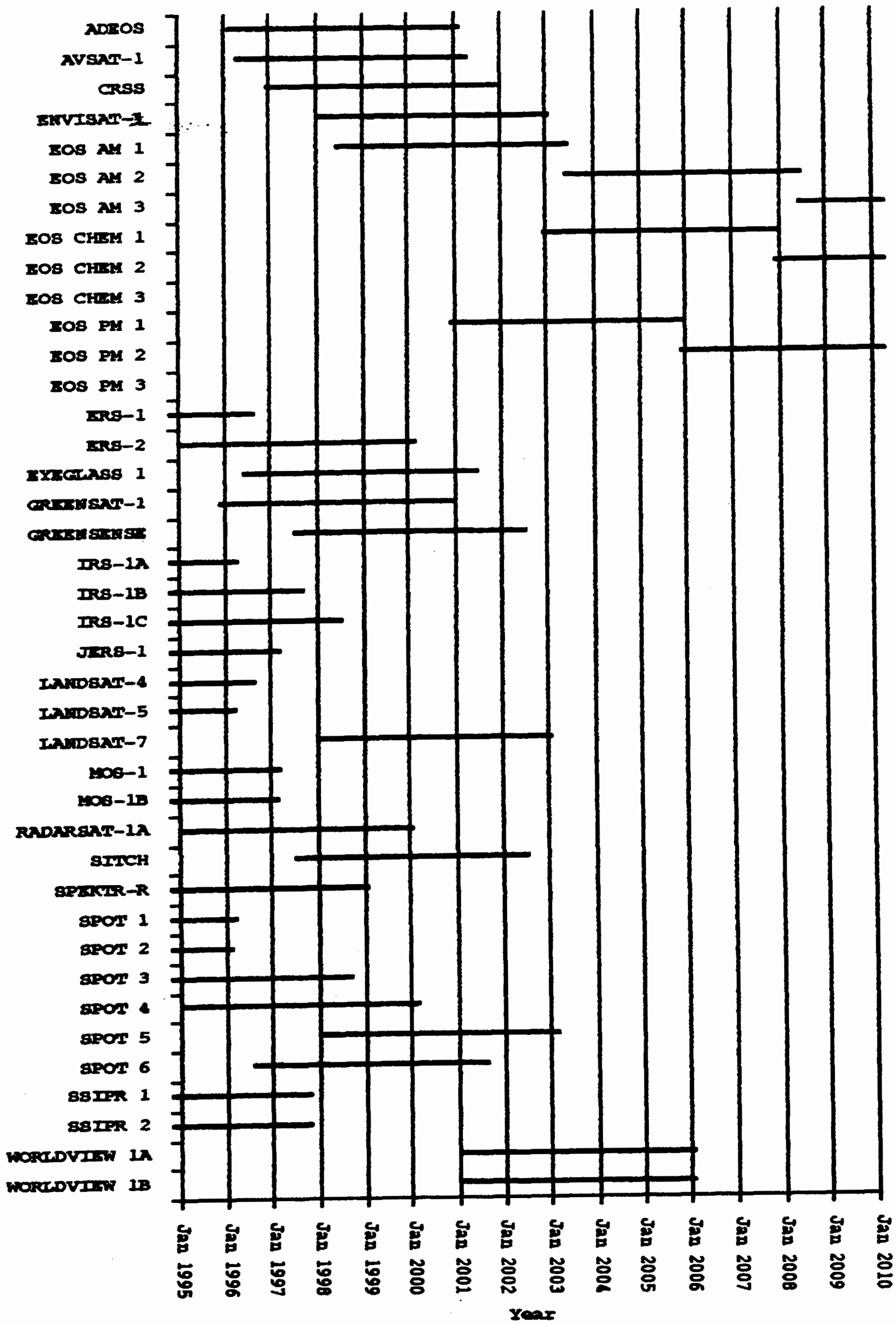
22 Based on the Computer Science Corporation presentation at the NASA's X-Band Workshop III, June 1995.

23 Letter of June 21, 1994, from NASA Headquarters, Office of Associate Administrator for Space Communications, Subject: *Spectrum Management Workshop II on the 8025-8400 MHz Band (on file at NTIA).*



Information obtained from the X-Band Workshop III (June'95) - presented by Douglas N. Boyd/CSC

Figure 3-3. EESS Systems as a function of spectrum usage for the frequency range 8025-8400 MHz.



Information obtained from the X-Band Workshop III (June'95) - presented by Douglas N. Boyd/CSC

Figure 3-4. EESS Systems as a function of operational life.

to June 1995, include: ERS-1, IRS-1A, IRS-1B, IRS-1C, JERS-1, LANDSAT-4 & -5, MOS-1, MOS-1B, SPEKTR-R, SPOT 2, SPOT-3, SSIPR 1, and SSIPR 2.

MAJOR SYSTEMS

Military Satellite Communications Systems

The DoD currently uses the 7900-8400 MHz range for DSCS (FSS and MSS) and FLTSATCOM (FSS) systems to provide communications for the military services. These two military satellite systems provide unique and complementary communications capability to the U.S. Armed Forces within the United States and around the world. These systems with their normal orbital deployment location are summarized in TABLE 3-8. The frequency range of 7900-8400 MHz continues to be used extensively for military space systems around the world by various countries.

Defense Satellite Communications System (DSCS). The DSCS system is a DoD satellite communications system providing worldwide coverage. The satellite system includes the space segment, fixed earth stations, transportable earth stations, and mobile earth stations on board ships and aircraft. The satellite system satisfies a number of communication requirements: 1) command and control, 2) crises management, 3) intelligence, 4) early warning detection, 5) data relay, 6) treaty monitoring and surveillance information, 7) diplomatic traffic, and 8) secure voice and high-data-rate communications.

DSCS research and development began in 1962 with the Initial Defense Communications Satellite Program (IDCSP). The IDSCP satellite was launched in 1966. The space segment continued with the launch of the DSCS-II satellites in 1971. These satellites had the capability to use frequencies in the range of 7900-8400 MHz. Sixteen DSCS-II satellites have been launched since 1971; however, four of the sixteen never made it to the geostationary-satellite orbit due to launch failures. There are no longer any operational DSCS-II satellites.

The DSCS-III satellites (or third-generation DSCS satellites) have a 10-year lifespan. There are nine DSCS III satellites in geostationary orbit located at 12°W, 42.5°W, 52.5°W, 57°E, 60°E, 130°W, 135°W, 175°W, and 180° that have the capability to use frequencies in the range of 7900-8400 MHz with bandwidths ranging from approximately 100 kHz to 15 MHz for Frequency Division Multiple Access (FDMA) and a maximum of 40 MHz for Spread Spectrum Multiple Access (SSMA).

TABLE 3-8
DSCS AND FLTSATCOM GEOSTATIONARY SATELLITES UTILIZING THE 7900-8400 MHz FREQUENCY RANGE

as of June 1996

Nomenclature	Frequencies (MHz)	FSS/MSS	Satellite Longitude
DSCS III	7900-8400	FSS/MSS	57°E
DSCS III	│	│	180°
DSCS III	│	│	12°W
DSCS III	│	│	42.5°W
DSCS III	│	│	52.5°W
DSCS III	│	│	60°E
DSCS III	│	│	130°W
DSCS III	│	│	135°W
DSCS III	↓	↓	175°W
FLTSATCOM	7994[24],7995[25]	FSS	23°W
FLTSATCOM	│	│	15°W
FLTSATCOM	│	│	100°W
FLTSATCOM	│	│	172°E
FLTSATCOM-C	│	│	15°W
FLTSATCOM-C	│	│	23°W
FLTSATCOM-C	│	│	75°E
FLTSATCOM-C	│	│	105°W
FLTSATCOM-C	│	│	177°W
FLTSATCOM-C	↓	↓	172°E

24 The use of 7994 MHz is considered telecommand only to provide communications capability to link command centers ashore.

25 The use of 7995 MHz is considered FSS only.

DCSC III space stations operate with multiple-beam antennas, Earth-coverage horn antennas, and a gimballed-dish antenna. The DSCS III , A1-B7 uplink earth terminals have channels 1 through 6 which employ the frequency ranges of 7975-8035, 8060-8120, 8145-8230, 8255-8315, 8340-8400, and 7900-7950 MHz, respectively. DSCS III A1-B7 terminals have the capability to transmit in a spread spectrum mode in the frequency range 7975-8035 MHz (channel-1). DSCS III B8-B14 uplink earth terminals have channels 1 through 6 which employ the frequency ranges of 7975-8025, 8040-8115, 8130-8215, 8230-8315, 8340-8400, and 7900-7950 MHz, respectively. Earth terminal transmitter bandwidths are from 100 kHz through 15 MHz for FDMA modulation schemes and use up to a maximum of 40 MHz for spread spectrum modulation schemes. The DSCS earth terminals employ parabolic dish antennas of 2.4 m. (8 ft.), 6.1 m. (20 ft.), 11.6 m. (38 ft.), and 18.3 m. (60 ft.) in diameter. The main beam gain for each of these antennas is 44 dBi, 52 dBi, 57 dBi, and 61 dBi, respectively (see TABLE 3-9).

Fleet Satellite Communications (FLTSATCOM) System. The FLTSATCOM system provides unique and complementary communications capability to the U.S. Armed Forces within the United States and around the World. The FLTSATCOM system provides communications capability to link
command centers ashore (using the 7/8 GHz range) with commanders afloat (using the 235-322 MHz UHF band) for tactical purposes.

Presently, there are four FLTSATCOM satellites in orbit. These satellites use discrete frequencies of 7994 and 7995 MHz with bandwidths of 15 MHz in the range of 7900-8400 MHz. The current FLTSATCOM satellites have the ability to transmit in a spread spectrum mode. The FLTSATCOM satellites are geostationary satellites located at 15°W, 23°W, 100°W, and 172°E. The FLTSATCOM-C satellite system essentially replaces the four original ITU registered FLTSATCOM satellites (23°W, 72°E, 172°E, and 100°W) and four original ITU registered FLTSATCOM-A satellites (15°W, 77°E, 177°W, and 105°W). Two additional FLTSATCOM-C positions are being considered for in-orbit reserve satellites at 29°E and 145°W. Typical earth stations are located in Norfolk, VA; Wahiawa, HI; Finegayan, Guam; Moffett Field, CA.

North Atlantic Treaty Organization (NATO) System. The NATO communications satellite system will employ two satellites in geostationary orbit with the capability to use frequencies in the range of 8025-8400 MHz [and have bandwidths of 277 kHz through 2 MHz and the ability to transmit in a spread spectrum mode]. The satellites have transmit power in the range of 60-65 dBm. The earth terminal antennas are parabolic dishes of 21 meters in size with 61 dBi gain. Of the two satellites only the NATO SATCOM IV network located in orbit at 17.8°W is currently operational. The second satellite, NATO SATCOM IIIB network (proposed orbit of 60°W) is in the coordination phase.

TABLE 3-9
LARGE, MEDIUM, SMALL, AND SPREAD SPECTRUM DSCS EARTH TERMINAL CHARACTERISTICS
as of June 1996

DSCS Earth-Station Terminal Characteristics[26]	
Large Terminal Transmitter Characteristics	
Nomenclature	AN/FSC-78
Deployment / Function	Worldwide/Strategic and Tactical Gateway
Uplink Frequency Range	7900-8400 MHz
Modulation Type / Technique	BPSK, OQPSK, & Spread Spectrum / FDMA
Modes of Operation	Digital Voice & Data
Emission Bandwidth *(Typical)*	6 MHz
Baseband Data Rate *(Typical)*	2 times T1 (1.544 Mbps)
Power Level *(Typical)*	32 dBm
Antenna Size & Type	18.3 Meters (60 ft.) parabolic reflector
Antenna Gain	61 dBi
Medium Terminal Transmitter Characteristics	
Nomenclature	AN/GSC-39 & AN/GSC-52 & AN/MSC-73
Deployment / Function	Worldwide/Strategic & Tactical Gateway
Uplink Frequency Range	7900-8400 MHz
Modulation Type / Technique	BPSK & OQPSK / FDMA
Modes of Operation	Digital Voice & Data
Emission Bandwidth *(Typical)*	6 MHz
Baseband Data Rate *(Typical)*	2 times T1 (1.544 Mbps)
Power Level *(Typical)*	33 dBm
Antenna Size & Type	11.6 meters (38 ft.) parabolic reflector
Antenna Gain	57 dBi
Small Terminal Transmitter Characteristics	
Nomenclature	AN/TSC-85B,-93A,-93B,-94B,-100A *(Tactical)* AN/TSC-86,-90 (Strategic)
Deployment / Function	Worldwide / Strategic & Tactical
Uplink Frequency Range	7900-8400 MHz
Modulation Type / Technique	BPSK & OQPSK / FDMA
Modes of Operation	Digital Voice & Data
Emission Bandwidth *(Typical)*	25 kHz through 9.8 MHz
Baseband Data Rate *(Typical)*	16 kbps through 4.9 Mbps
Power Level *(Typical)*	47 dBm - 2.4 meters dish terminal 37 dBm - 7 meters dish terminal
Antenna Size & Type	2.4 m. (8 ft.) or 6.1 m. (20 ft.) parabolic reflector
Antenna Gain	44 dBi or 52 dBi
Terminal Transmitter Characteristics Employing Spread Spectrum Modulation	
Nomenclature *(at certain locations only)*	AN/FSC-78 & AN/GSC-52 & AN/GSC-39 S.S. multi-access - AN/GSC-49
Deployment	Fixed sites Worldwide
Uplink Frequencies	8002.7 MHz & 8013.0 MHz
Modulation Type / Technique	BPSK & OQPSK / CDMA
Emission Bandwidth	40 MHz (40 Mchip code rate) 10 MHz (10 Mchip code rate)
Power Level	53 dBm - 6.1 meters dish terminal
Antenna Size & Type	6.1 meters (20 ft.) parabolic reflector
Antenna Gain	52 dBi

[26] The information on DCSC was taken from the DISA briefing to the X-Band Workshop in July 1994 and was not intended to be all inclusive and respesents typical characteristics.

DoD Earth Terminals

The DSCS II and III system operates with fixed and transportable earth stations and with mobile terminals on board aircraft and ships. A number of earth terminals are available for DSCS use throughout the U.S. as is seen in Figure 3-5 (the earth station locations may not be all inclusive). The DSCS satellites can operate fixed and transportable sites with either large, medium, small or spread spectrum earth terminals as shown in Figures 3-6 through 3-9. Note the large earth terminals include the NATO and FLTSATCOM earth terminals. It should be noted that ship and aircraft earth stations are smaller than the small fixed/transportable terminals and are not included in TABLE 3-9 or Figures 3-8 through 3-9. The listing of the most typical DSCS and FLTSATCOM earth terminals are presented in TABLES 3-9 and 3-10.

DOC/NOAA Space Systems

LANDSAT System. LANDSAT-4 and -5 satellites were launched in July 1982 and March 1984, respectively, for medium and large scale mapping. The LANDSAT-4 satellite has ceased providing useful imagery. LANDSAT-5 uses the 8127.5-8297.5 MHz frequency range with transmissions using 170 MHz of bandwidth. The LANDSAT-5 satellite is in a sun-synchronous inclined orbit with orbital height of 705 km at 98.2 degrees. The downlink locations for the satellite are shown on TABLE 3-7 under Service Areas with the operations ground station at Norman, OK. The satellite antennas have righthand circular polarization with Earth coverage. The LANDSAT-5 EIRP is 44 dBm. LANDSAT-6 did not achieve proper orbit. A failure review board determined this was due to a ruptured hydrazine manifold. As a consequence, there was a failure to maintain attitude control during apogee burn. This failure caused the spacecraft to tumble during that burn and not accumulate sufficient energy to attain orbit.

LANDSAT-7 is a remote-sensing system being developed by NOAA(DOC)/NASA[27] and is planned to have downlink capabilities in the 8025-8400 MHz frequency range. The NOAA/NASA plan is to launch a single satellite in polar orbit in 1998. LANDSAT-7 will use three RF channels 165 MHz wide for data downlink; 1) 8000-8165 MHz centered on 8082.5 MHz, 2) 8130-8295

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27 NOAA presented a briefing at the NASA X-Band Workshop in which they said a program merge between NASA and NOAA should be active by the end of 1995/96.

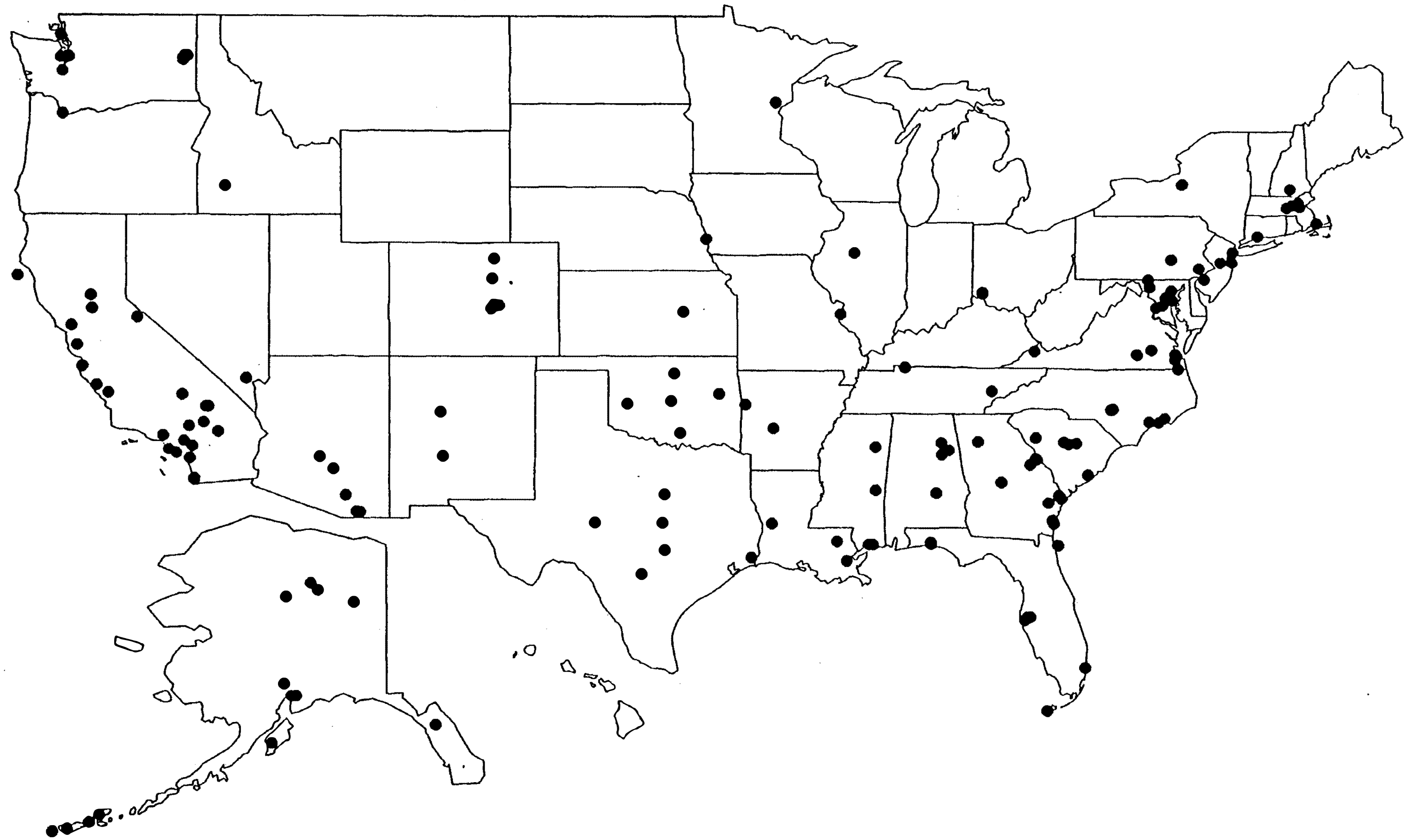

Figure 3-5. DSCS earth terminal locations in the U.S. for all antenna sizes. (June 1995)

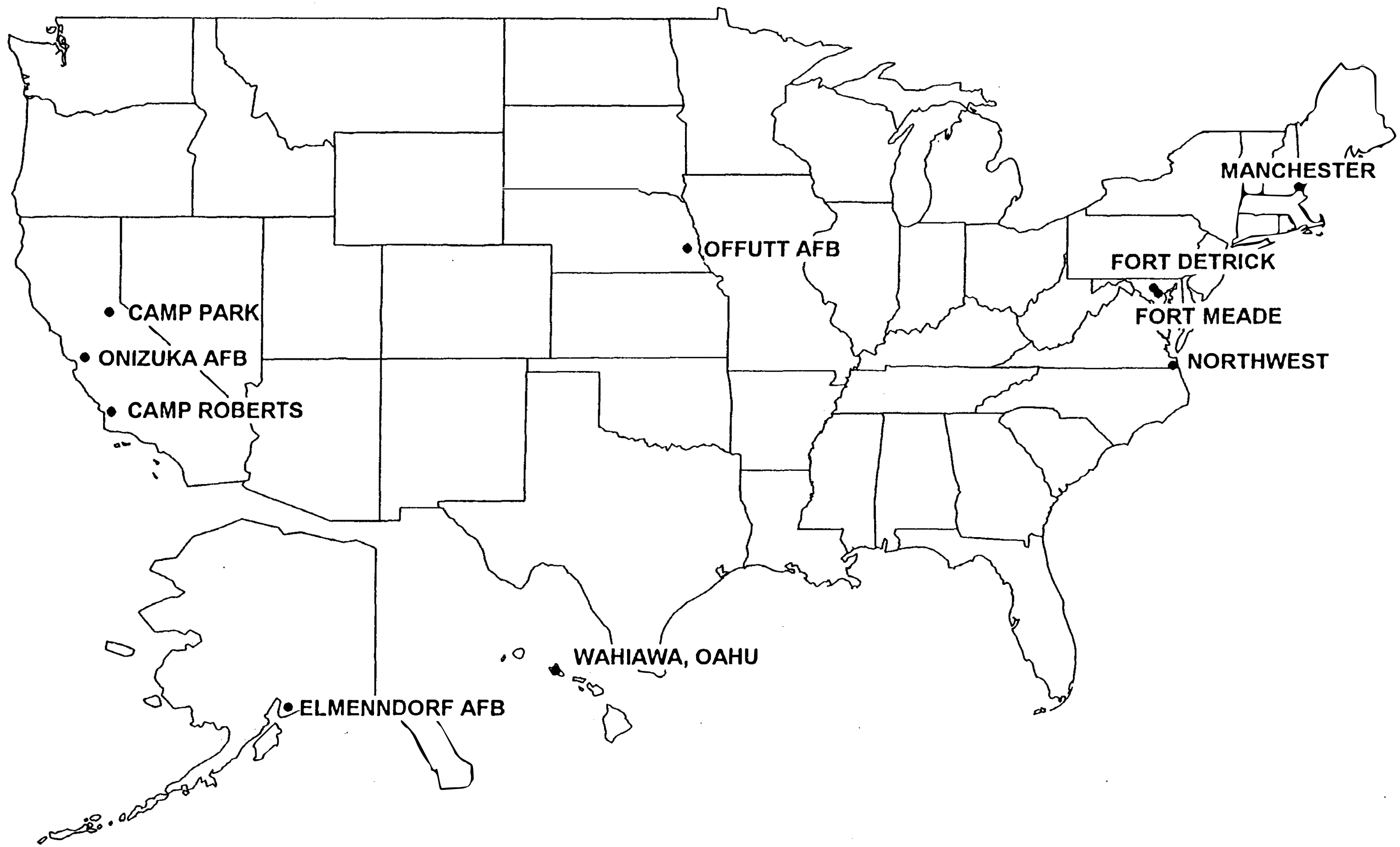

Figure 3-6. Large DSCS Earth terminal locations using approximately 18.3 meters (60 ft.) dish size. (June 1995)

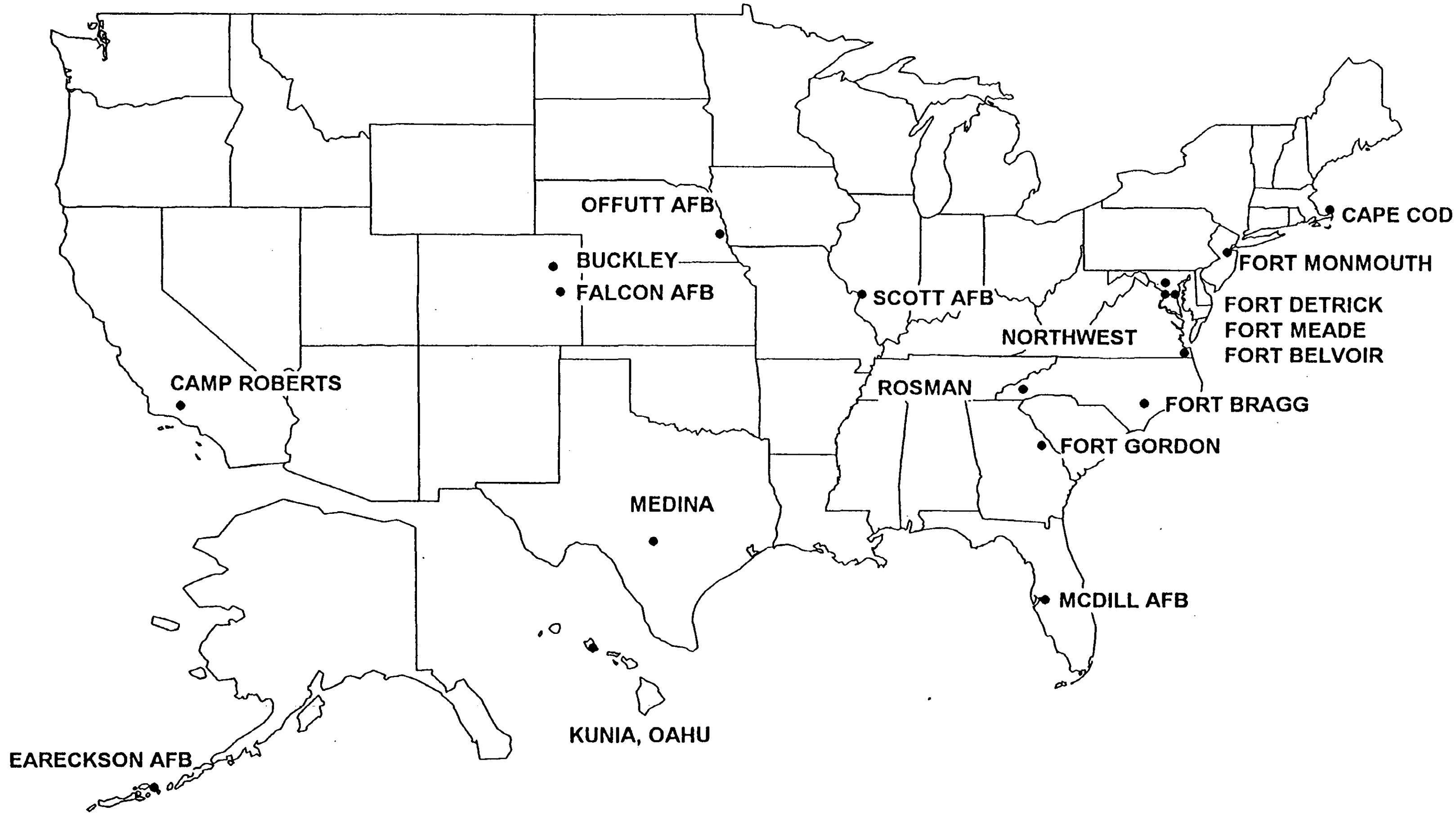

Figure 3-7. Medium DSCS Earth terminal locations using approximately 11.6 meters (40 ft.) dish size. (June 1995)

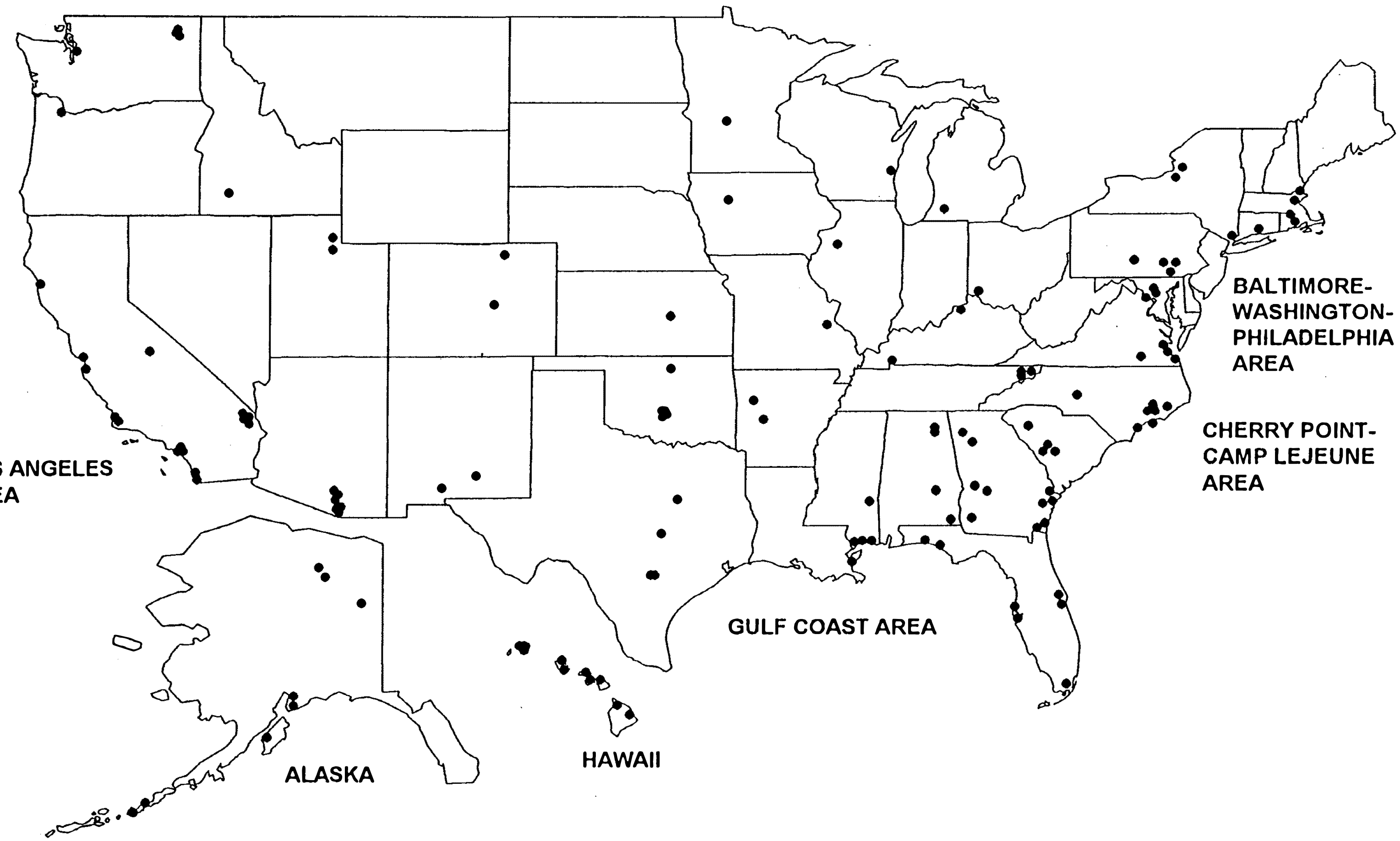

Figure 3-8. Small DSCS Earth terminal locations using either 2.4 or 6.1 meters (8 or 20 ft.) dish size. (June 1995)

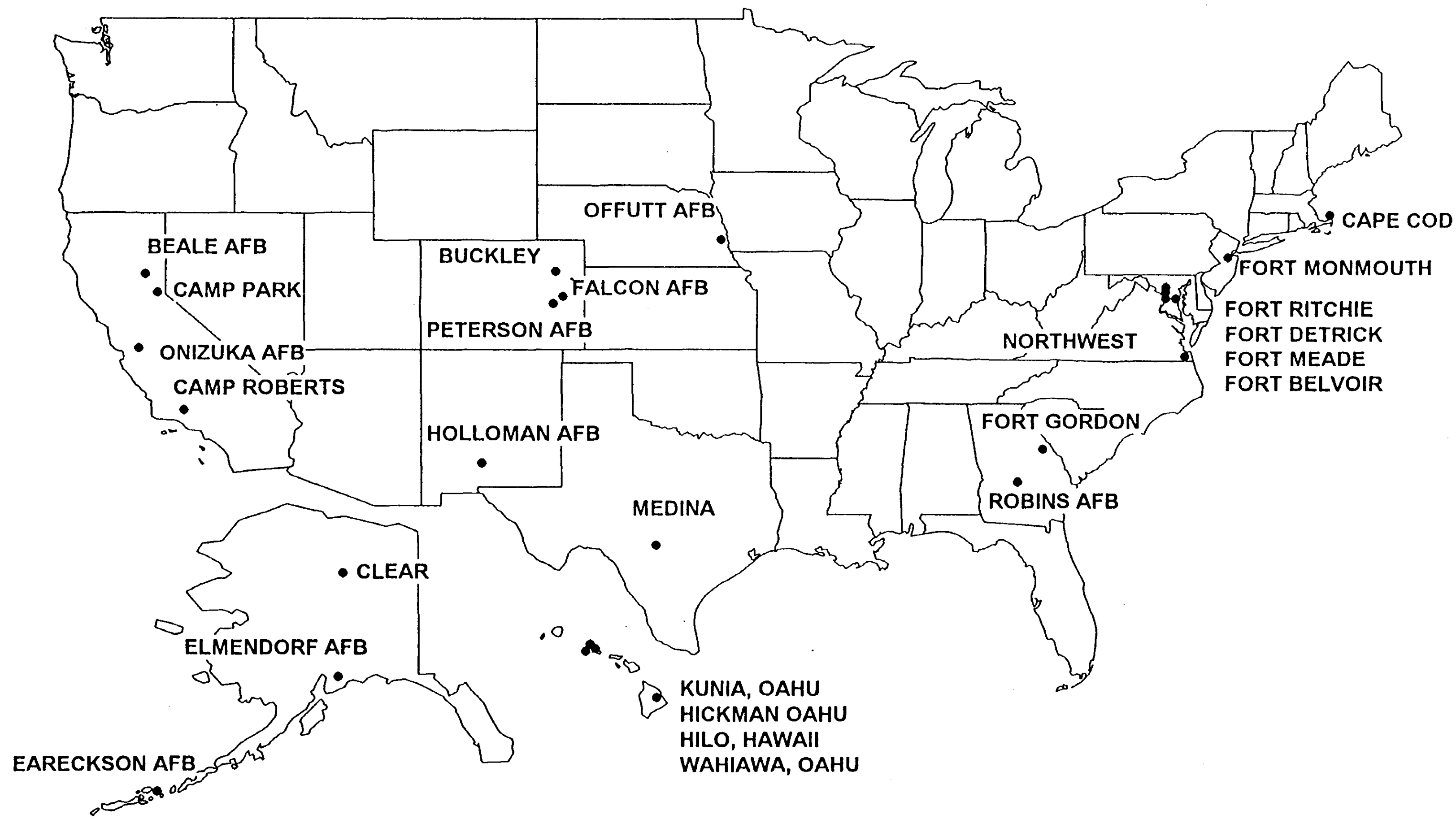

Figure 3-9. DSCS Earth terminal locations using spread spectrum modulation. (June 1995)

TABLE 3-10
FLTSATCOM EARTH TERMINAL CHARACTERISTICS
as of June 1996

General Transmitter Characteristics	
Nomenclature	AN/FSC-79
Deployment / Function	US&P, Italy
Uplink Frequency Range	7980, 7994, 7995 MHz
Modulation Type / Technique	Spread Spectrum / CDMA
Emission Bandwidth *(Typical)*	20 MHz
Baseband Data Rate *(Typical)*	75 bps (7994 MHz) 1200 bps (7995 MHz)
Power Level *(Typical)*	69 dBm
Antenna Size & Type	18.3 Meters (60 ft.) parabolic reflector
Antenna Gain	61 dBi

MHz centered on 8212.5 MHz, and 3) 8250-8425 MHz centered on 8342.5 MHz. Figure 3-10 shows the frequency plan for the LANDSAT-7.[28] The satellite downlink transmissions will use a data rate of 150 Mbps and a balanced QPSK modulation with 75 Mbps on each channel with an RF filter projected to be a 6-pole elliptical type filter. The maximum EIRP expected is 29 dBW. The satellite transmitting antenna will use a 7 degrees beamwidth steerable type antenna (side lobes will be more than 17 dB below the mainbeam gain). The location of downlink earth stations are shown on TABLE 3-7 under Service Areas. Also at the X-Band Workshop III, the Integrated Program Office (IPO) established at DOC/NOAA to develop the converged polar orbiting meteorological satellite series for the Air Force and NOAA introduced the fact that two other satellite systems are planned for launch; Meteorological Operational Satellite (METOP) system intended for launch in the year 2003 and National Polar Orbiting Operational Environmental Satellite (NPOES) system intended for launch in the year 2009. No firm decisions have been made concerning these two satellites. Note: There are plans to seek an allocation for METSATs (downlink) of 100 MHz in the 7750-7900 MHz band.

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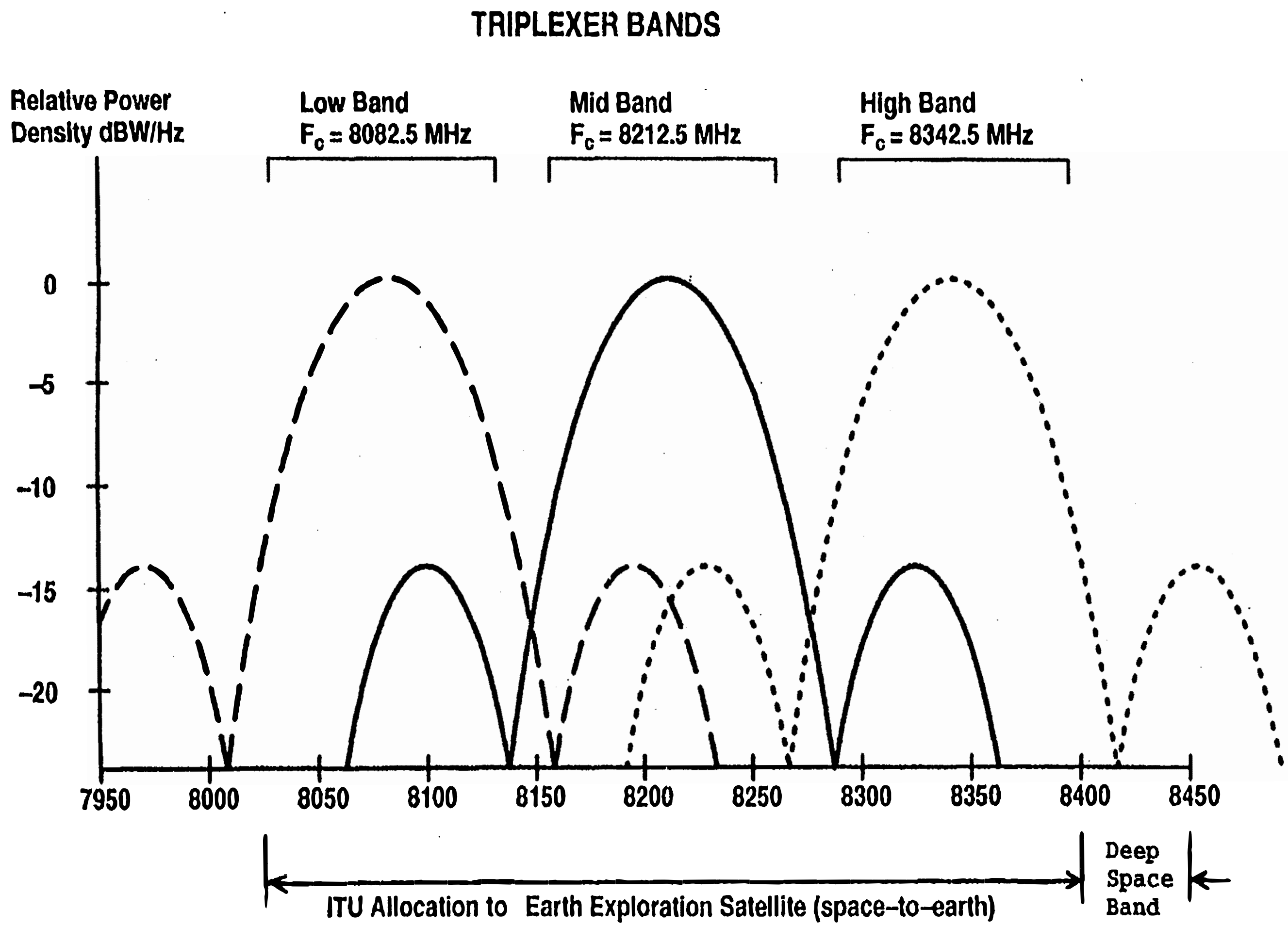
28 The LANDSAT-7 power spectral density received by the deep space network for filtered transmissions was smaller than -12.1 dBW/Hz for discrete components (assuming a data asymmetry of 5%) and was smaller than -63.9 dBW/Hz for continuous components. The analysis, *Interference from LANDSAT-7 to the DSN*, was done for the X-Band Workshop III by J. Hart.



Information obtained from the X-Band Workshop III (June'95) - presented by Lester Riddle

Figure 3-10. LANDSAT-7 space segment 8025-8400 MHz frequency plan.

The LANDSAT-7 system operates in the EESS band (8025-8400 MHz) in the space-to-Earth direction and the deep space network (DSN) operates in the space research (deep space) band (8400-8450 MHz) in the space-to-Earth direction. Due to the out-of-band emissions of LANDSAT-7, the satellite will exceed the DSN requsted protection criteria of -220.9 dBW/Hz (contained in Table 2-5) at the front-end of the DSN receiver.[29]

NASA Satellite Systems

NASA Earth Observation System (EOS). The NASA EOS program plans to launch nine satellites, three each in the AM, PM, and CHEM series, into a 705 km, 98.2 degrees retrograde orbit between 1998 and 2014 (see TABLE 3-7 for exact launch dates). These orbits are characterized by their repeat cycle of 16 days (or 233 orbits) (i.e., the same swath on the ground will be overflown every 16 days). The EOS AM satellites (the name refers to the 10:30 a.m. local time southbound equatorial crossing) are projected to have an operational life of six years. The PM and CHEM satellites are not designed at present (only the first AM satellite is), and are both planned for 1:30 p.m. local time northbound equatorial crossings. The PM series is named for its afternoon equatorial crossing time, while the CHEM series, originally planned for a late afternoon crossing, is named for its emphasis on measurement of atmospheric chemistry. The function of the EOS AM satellite series[30] is the characterization of the terrestrial surface, cloud cover, aerosols, and radiation balance (its morning crossing time was chosen to minimize cloud cover). The function of the EOS PM satellite series will be to measure characteristics of clouds, precipitation, radiative balance, terrestrial snow cover and sea ice, and ocean surface temperature (its afternoon crossing time was chosen for its usefulness in meteorological forecasting). The function of the CHEM satellite series will be to characterize atmospheric chemicals and their transformations into the ocean. The CHEM data are not deemed suitable for most direct broadcast users (direct broadcast mode is discussed in detail several paragraphs later).

This series of NASA EOS satellites will transmit scientific data directly to ground stations using the 8025-8400 MHz frequency range. Two of these series of satellites, the AM and PM,

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29 See *Interference from LANDSAT-7 to the DSN,* in the minutes of the X-Band Workshop III (June'95).

30 A 30 cm. earth station dish size has been proposed. These relatively inexpensive earth station antennas are planned for distribution on a worldwide basis at a large number of locations. Additional information and an interference analysis per location will be required for these operations.

will continuously transmit at a relatively low data rate of 15 Mbps to a world-wide user community. The satellites in all three series will intermittently transmit high rate data (100-300 Mbps) to a few selected ground stations, although for the EOS AM-1 satellite, the high data rate capability will be used only as a back-up in the event of a failure in the NASA Tracking and Data Relay Satellite System (TDRSS) link. The extent of use of the 8025-8400 MHz frequency range by other satellites in the EOS program is yet to be determined, but the instrument data rates of those satellites will be considerably lower, and the 8025-8400 MHz range downlink data rates should also be correspondingly lower.

The EOS AM-1 satellite has three modes of operation; direct broadcast, direct playback, and direct downlink. Only the AM and PM series will include the direct broadcast capability, and none of the CHEM satellites will have the direct broadcast downlink capability. The implementation of these capabilities on satellites after the EOS AM-1 has not yet been determined, although the given data rates and ground station capabilities are reasonable estimates. The EOS AM-1 project will not cause interference to the DSN operations (see analysis in the X-Band Workshop III entitled, *EOS AM-1 Interference*, by B. Tunstall). The three modes of operation are as follows:

1) The direct broadcast mode provides a continuous broadcast of real time scientific data from an EOS AM and PM satellite to any user with a suitable ground station.[31] The direct broadcast data are primarily for local consumption, albeit to a user community distributed worldwide. Normally, the direct broadcast mode should be available at all times; however, if the direct playback mode is required on the EOS AM-1 satellite, the direct broadcast service may be interrupted while the playback mode is transmitting. On later satellites the direct broadcast mode should not be interrupted. The direct broadcast data are a subset of the data stored on board (via a 140 gigabit solid state recorder on the EOS AM-1) for later down-linking (see direct playback mode). The direct broadcast mode will have moderate data rates of approximately 15 Mbps and a modulation type of QPSK. The ground stations to receive satellite transmission from direct broadcast satellites will have approximately 3 meter dishes. There is also the potential that the next-generation of NOAA weather satellites and the NASA EOS PM satellite series will converge in the future (perhaps on the EOS PM-2 satellite).

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31 DoD is concerned about the direct broadcast mode of operation on the EOS or any other EESS system. The effects that a relatively large number of either the Government or non-Government direct broadcast earth stations may have on the sharing of the 8025-8400 MHz range with Government space and terrestrial systems is of concern.

2) The direct playback mode provides the needed and most important capability of the satellite system; down-linking or loading the data stored on-board directly to a few (two to four) specially equipped ground stations. The direct playback mode is the only means of transmitting the onboard recorded data for all but the first satellite (EOS AM-1); for the EOS AM-1 satellite, the direct playback mode serves as a back-up should the prime TDRSS link fail. The direct playback mode will have a modulation type of QPSK. There are two direct playback modes available on the EOS AM-1 satellite, a slightly lower rate of 105 Mbps which allows the direct broadcast mode to continue operation and a higher rate of 150 Mbps which discontinues the direct broadcast mode. The selected ground stations to receive satellite transmission from direct playback mode will have approximately 10 meter dishes. Once downloaded to the ground via direct playback, the scientific data is then forwarded to the EOS data and information system. The direct playback mode takes higher priority than either direct broadcast or direct downlink modes with an effort made to minimize the impact on the direct broadcast mode.

3) The direct downlink mode sends high rate, real time data to a limited number of very specific users. This capability is only planned for the EOS AM-1 satellite system (only the first satellite).

NASA has not yet selected the ground stations which will supply direct playback support to the EOS program. The polar orbits of these satellites makes high latitude stations (e.g., Fairbanks, Alaska; Scandinavia; Antarctica; etc.) particularly effective as they can contact these EOS satellites more often than those of low latitude ground stations.

Terrestrial Point-to-Point Microwave Communications Systems

The FAA, DoD, and DOE are the predominant users of the 7900-8450 MHz frequency range for fixed services from the standpoint of number of frequency assignments. These assignments are for the FAA Radar Communications Link (RCL) networks that provide communications between remote radar sites and associated air traffic control (ATC) sites. The DoD fixed systems provide communications to relay radar, video and voice data for operations and control support, land-line backup and satellite communications support. The DOE fixed systems are used to interconnect the various substations and generators for monitoring and control of their power generation and transmission systems. Other users of fixed systems include the Commerce Department, Coast Guard, Interior Department, Justice Department, NASA, TVA, VA and the National Science Foundation. The geographic distribution of assignments to stations in the fixed service in the 7900-8450 MHz range are represented by

Figure 3-11. The terrestrial systems used by these agencies differ with respect to purpose, information carried, spectrum requirements, and configuration but most of the equipments used are commercial off-the-shelf multichannel (typically 600 channel) FDM/FM radios.

The FAA Radio Communications Links (RCL) Systems. The RCL backbone network is an integrated voice and data transmission system composed of over 1,000 microwave facilities. These facilities are designed by the FAA to provide a cost effective and reliable (99.999% reliability) service between the en-route airborne radars and the Air Route Traffic Control Centers (ARTCC). A number of RCL systems also provide service between these en-route airborne radars and ATC towers. The RCL system carries operational safety-of-life air traffic control voice, data, broadband real-time radar data, and redundant and alternate routing of other air traffic control communication requirements. There are several types of equipment used on these networks (see TABLE 3-11). The RCL systems operate in the 7125-8500 MHz frequency range and only that portion that operates in the 7900-8450 MHz range is of interest. A list of typical system characteristics for the RCL LOS microwave equipments are listed in TABLE 3-11. The radio frequency (RF) power is typically 100 milliwatts. Frequencies used for the RCL systems are selected from FAA-developed frequency assignment plans. The geographic distribution of assignments to stations in the fixed service in the 7900-8450 MHz

TABLE 3-11
TYPICAL CHARACTERISTICS FOR LOS MICROWAVE EQUIPMENTS USING THE 7125-8500 MHz BAND
(as of June 1996)

Modulation	FDM/FM 8 PSK - 45/90 Mbps 16 QAM - 45 Mbps/64 QAM - 135 Mbps
Power Output	-10 to +10 dBW
RF Bandwidth	10 - 45 MHz
Number of Channels	600 Voice or Video
Deviation	200 kHz/channel for FDM, 4 MHz/channel for Video
Receiver Sensitivity	-90 dBm
Antenna Type	Parabolic or Periscope
Antenna Polarization	Horizontal or Vertical
Antenna Gain	40 - 48 dBi

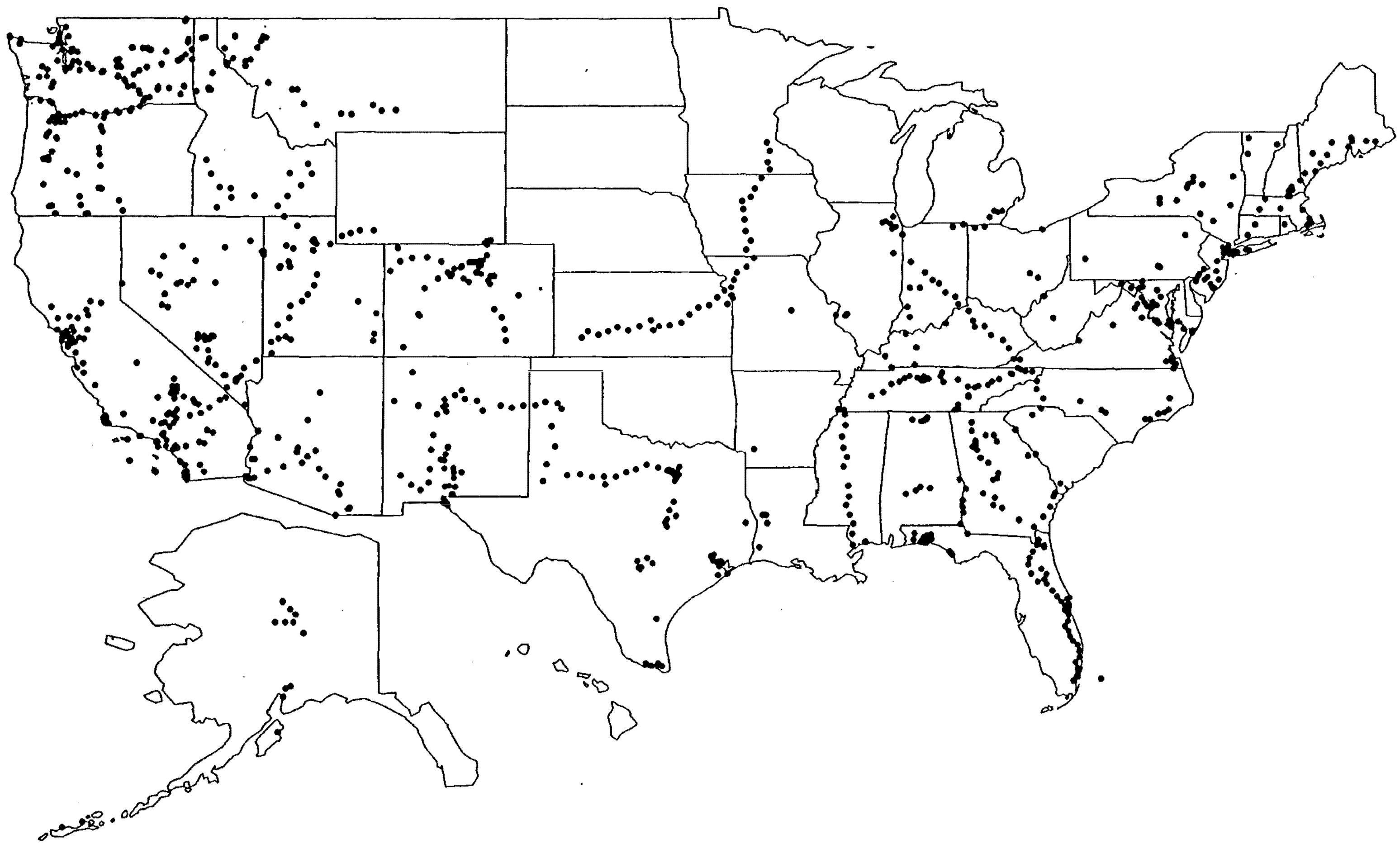

Figure 3-11. Geographic distribution of all assignments in the fixed service in the 7900-8450 MHz range. (June 1996)

range is represented by Figure 3-12. There are currently no RCL frequency assignments in the frequency range 7900-8450 MHz in Alaska.

Military and DOE Terrestrial Systems. The Air Force, Navy, and Army comprise the next largest group of terrestrial users of fixed systems. Department of Energy (DOE) is the third largest user of terrestrial fixed systems. The equipment used for these systems are similar and may be discussed together.

The military fixed point-to-point microwave systems are used to relay radar, video and voice data for operations and control support, land-line backup and satellite communications support. The locations of these fixed networks in and around military bases and test ranges are found in Figure 3-13. The equipments used are typical commercial off-the-shelf analog and digital FDM/FM radios (see TABLE 3-11 for details). There is no formal channelization plan used in the frequency range of 7900-8450 MHz.

The DOE fixed point-to-point microwave systems are used to interconnect the various substations, generators, and users for monitoring and control of their respective power transmission systems (see Figure 3-14). The DOE systems are predominantly 600-channel FDM/FM commercial off-the-shelf equipment. The current digital microwave systems allow capacities up to 2,016 channels. A propagation reliability of 99.9999% is required for each radio hop to meet national power system objectives. Information is telemetered over the system that provides status of the electrical power distribution system. Critical real-time control signals are transmitted over the systems that provide necessary control and protection of high voltage equipment to preserve the stability of the electrical power system.

Because of the number of channels required and the bandwidth necessary to accommodate these channels, operational requirements currently using the 2 GHz band will be relocated to the 7/8 GHz bands using digital, TDM/FM, commercial-off-the-shelf systems. Other alternative transmission media such as fiber optic cable is evaluated but has yet to prove to be cost effective for many cases. This alternative will continue to be evaluated. There are currently no DOE frequency assignments in the frequency range 7900-8450 MHz in Alaska.

Domestic Non-Government Commercial Satellite Systems

AstroVision Incorporated. AstroVision plans to use the 8025-8400 MHz frequency range for a geostationary Earth exploration-satellite, AVSAT-1, whose purpose is for the continuous

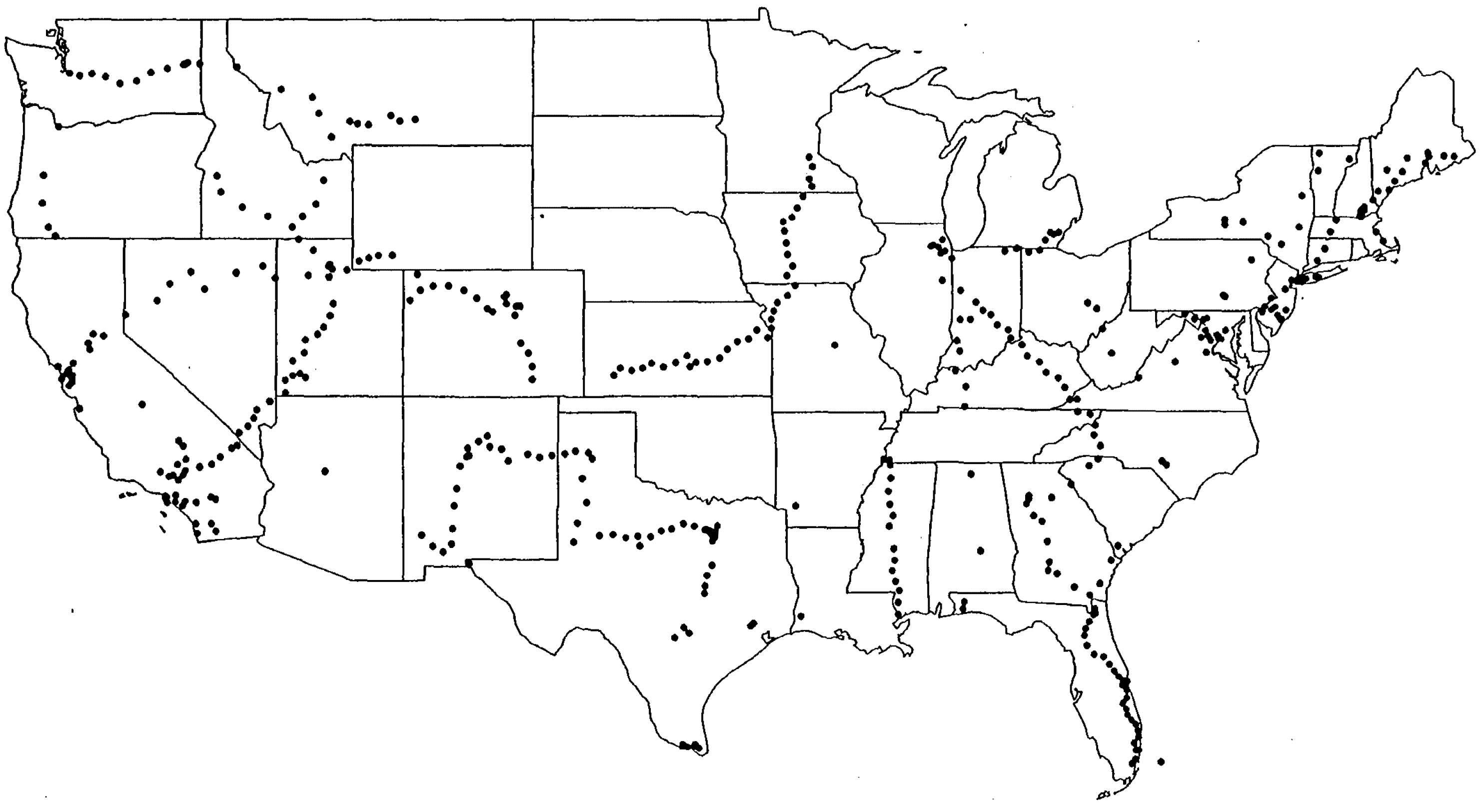

Figure 3-12. Geographic distribution of the FAA assignments in the fixed service in the 7900-8450 MHz range. (June 1996)

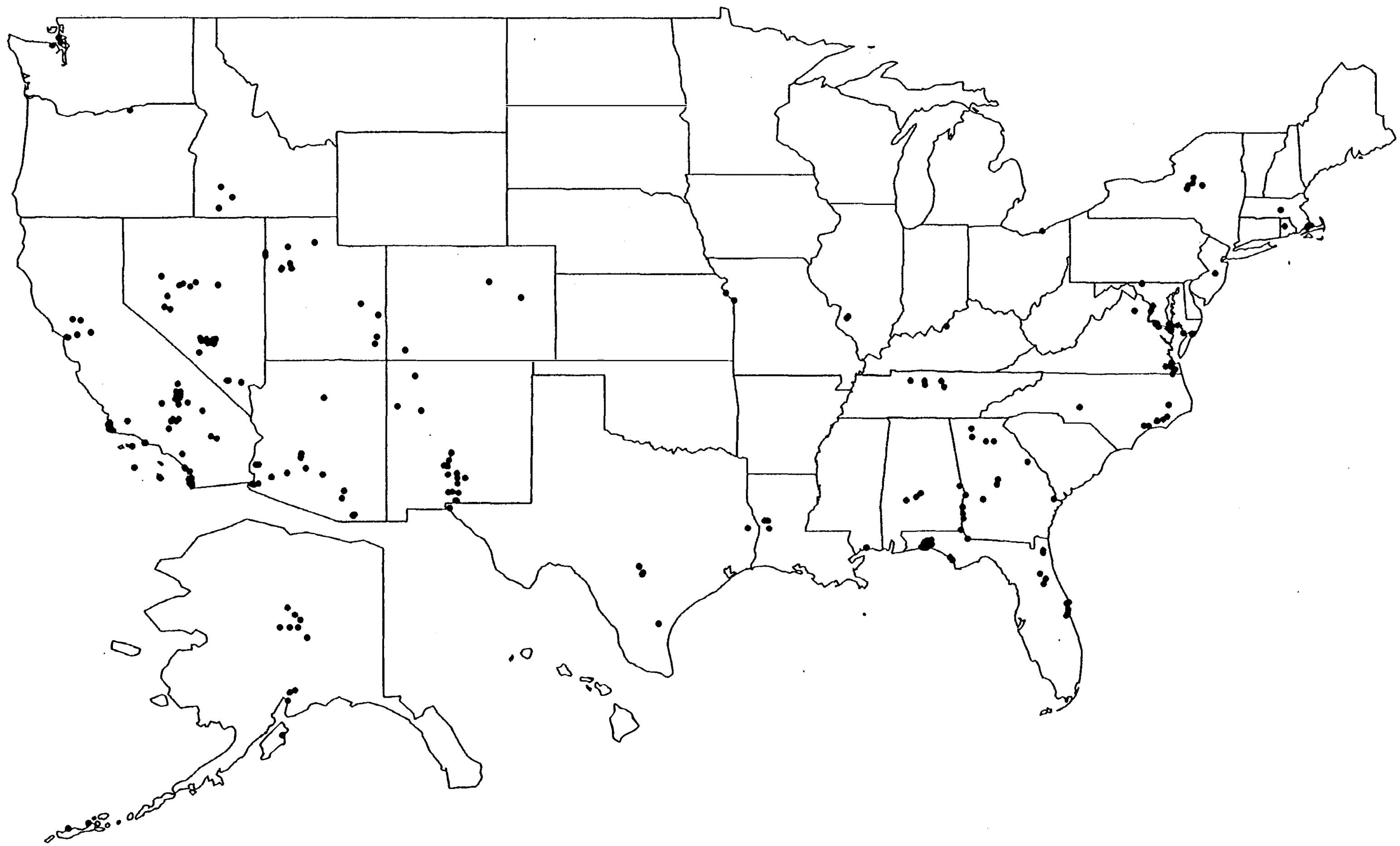

Figure 3-13. Geographic distribution of the DoD assignments in the fixed service in the 7900-8450 MHz range. (June 1996)

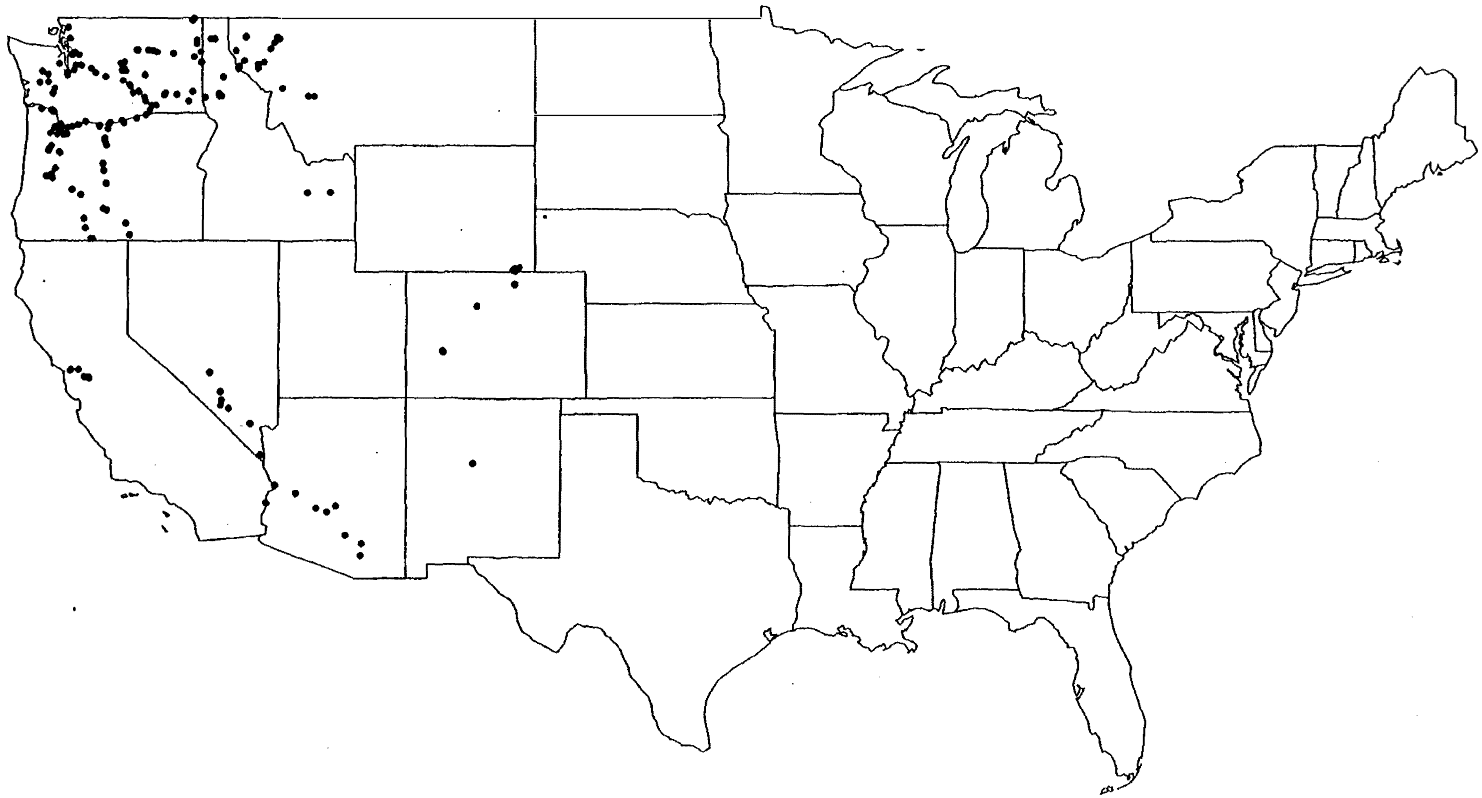

Figure 3-14. Geographic distribution of the DOE assignments in the fixed service in the 7900-8450 MHz range. (June 1996)

monitoring of the Earth's western hemisphere environment at moderate to low spatial resolution.

The AVSAT-1 geostationary satellite is proposed to be at 92° West longitude. The coverage area of the AVSAT-1 satellite is shown in Figure 3-15. The operation at geostationary orbit of this system will utilize a steerable directional antenna and be equipped with a LORAL CXS-800A transmitter and a LORAL CXS-800 receiver. There will be continuous transmissions from AVSAT-1 satellite system to a receiving earth station located in the central part of UT.[32] Other earth station locations are to be determined. The AstroVision Company requested an experimental license from the FCC in March 1994.[33] The downlink frequency range would be 8215-8230 MHz with bandwidth of 15 MHz centered at 8222.5 MHz. The satellite would have a power of 5 watts peak with the antenna footprint being over the entire U.S. The system will transmit digitized Earth exploration and meteorology data to the earth station for interpretation, processing and enhancement, before being distributed for market analysis. The same transmitter will also be used to download satellite payload status information at regular intervals. The downlink spectral power flux density near antenna boresite at the Earth's surface is -199.8 dBW/m^2/4kHz and the contiguous 48 States almost lie within the -6 dB contour (see Figure 3-15).

The uplink frequency range would be 2105-2110 MHz with a bandwidth of 5 MHz[34] and a power of 5 watts peak, but because of the uplink frequency range it will not be addressed in this report.

Space Imaging Limited Partnership (LP). Space Imaging LP plans to use the 8025-8400 MHz frequency range for high resolution (1 meter) mapping from two identical satellite

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32 An *APPLICATION FOR NEW OR MODIFIED RADIO STATION AUTHORIZATION UNDER PART 5 OF FCC RULES - EXPERIMENTAL RADIO SERVICE (OTHER THAN BROADCAST)*, FCC Form 442, was submitted by AstroVision, Inc., on March 17, 1994. The FCC determines whether the proposed operations are electromagnetically compatible with other operations in the band and whether any operational or technical requirements that need to be imposed (license to radiate). Licensing requests by U.S. firms to operate private remote sensing space systems are reviewed on case-by-case basis by the Department of Commerce in accordance with the Sensing Act of '92 (Commerce granted a license to AstroVision AVSAT-1 on January 23, 1995). This license was granted by NOAA/DOC National Environmental, Satellite, Data, and Information Service, Office of Systems Development. The location of the proposed transmitter is 345 West One North Street, Ephraim, San Pete County, UT, 84627.

33 Based on information received from the FCC, AstroVision Inc. experimental license expired on 1 March 1997 and the FCC has not received an application to renew this license. AstroVision was contacted (April 1997) and they are attempting to renew this application.

34 The excessive uplink bandwidth is for future use systems.

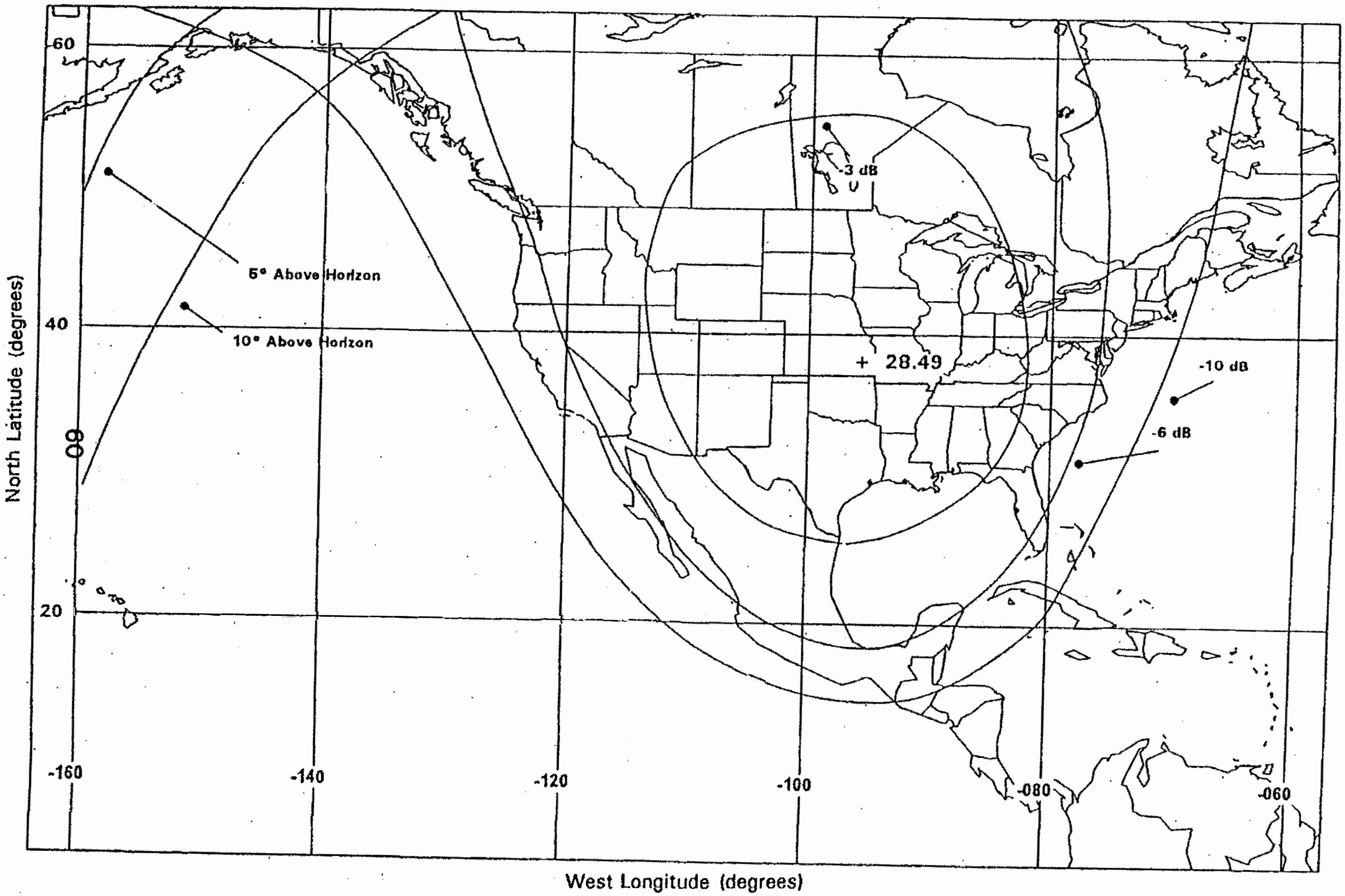

Figure 3-15. Earth coverage footprint of the planned AVSAT-1 Geostationary Satellite (as of June 1995).

systems in low-Earth orbit. The systems will operate in sun-synchronous[35] circular orbits with an inclination of approximately 98° and at an altitude of 680 km. The Commercial Remote Sensing System (CRSS) frequency plan requires the use of the entire EESS (space-to-Earth) band; however, the link will only be in operation when directly over a ground station. The first CRSS satellite is to be launched in late 1997 with the second satellite available for launch nine months later (see Figure 3-16). An application for license to radiate[36] was submitted to the FCC in August 1994. This satellite system was coordinated with the Interdepartment Radio Advisory Committee (IRAC) under the name Lockheed Commercial Remote Sensing System (see note 36 below) and during the coordination process the DoD identified certain potential interference problems with respect to the DCSC transmitting earth stations and the Space Imaging receiving earth stations. That resolution is still under consideration by Space Imaging LP.

Space Imaging LP is planning to have two ground earth stations for the collection of data only and one ground station to be used for command and control as well as data collection.[37] The U.S. domestic ground earth stations will have the responsibility for operations, maintenance, planning and management of the space segment; i.e. command and control functions, while the non-U.S. domestic (or regional affiliates) will be limited to issuing sensor tasking requests. Both station types will use the same communications links. The wideband (or sensor) downlink center frequency is at 8185 MHz with its first null-to-first null bandwidth of 320 MHz. This wideband downlink uses SQPSK modulation and has the capability of a data rate of 320 Mbps with error correction and other overhead. A bandpass filter is used to eliminate interference with the NASA Deep Space Network at Goldstone, CA. The wideband downlink's maximum EIRP is 28.4 dBW with a mechanically steerable 0.5 meter parabolic high

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35 A sun-synchronous orbit permits the Earth observing remote-sensing satellite to pass directly over a given place on the ground at the same local time; i.e., with the sun in essentially the same position in the sky from one day to the next. As a result, the shadows in the pictures taken on different days by a satellite are at the identical angle, thus making it easy to detect any Earth environmental change over time.

36 An *APPLICATION FOR NEW OR MODIFIED RADIO STATION AUTHORIZATION UNDER PART 5 OF FCC RULES - EXPERIMENTAL RADIO SERVICE (OTHER THAN BROADCAST)*, FCC Form 442, submitted by Lockheed Missiles and Space Company (LMSC). Licensing requests by U.S. firms to operate private remote sensing space systems are reviewed on case-by-case basis by the Department of Commerce in accordance with the Sensing Act of '92 (Commerce granted a license to LMSC on April 22, 1994). The authority to construct, launch, and operate a commercial remote-sensing satellite system was given by the FCC on January 19, 1995. LMSC subsequently filed amendments furnishing new ownership information and substituting Space Imaging L.P. as the applicant for the system and subsequently Space Imaging was granted authority to continue construction as new applicant on August 22, 1995.

37 Typically the Space Imaging satellite would contact any given earth station less than 10% of the time (satellites are in a 98 minute orbit that would be in range of an earth station approximately 8 minutes per orbit). Therefore, orbits that pass over the two earth terminals would give a maximum contact time of about 16 minutes for that orbit (16% of the time).

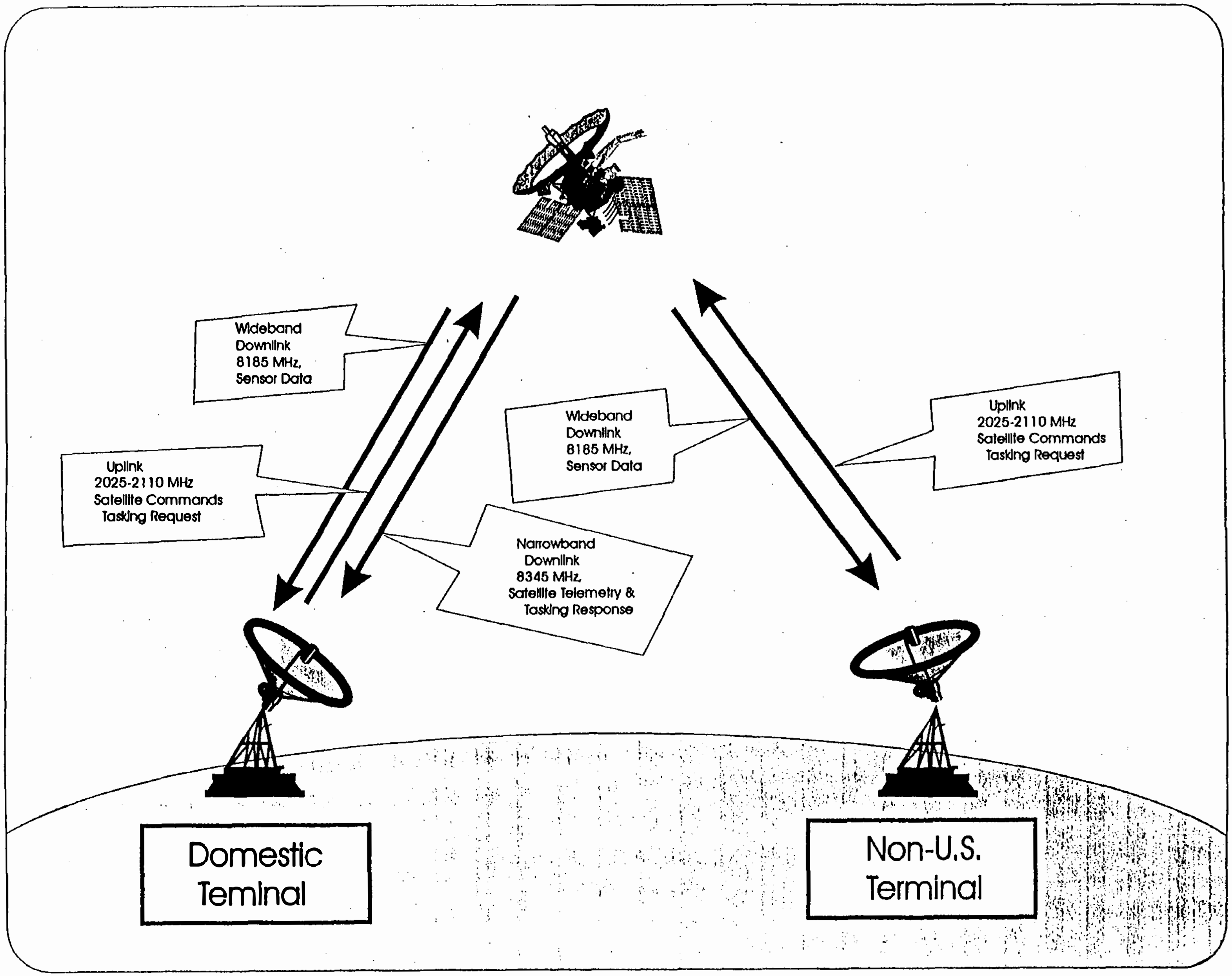

Figure 3-16. Space Imaging LP's communications architecture and operations mode for their sun synchonous satellite(s).

gain antenna having a 5.33° beamwidth. The narrowband downlink center frequency is 8346 MHz with a first null-to-first null bandwidth of 64 kHz for output power controls and telemetry. This narrowband downlink uses 32 kbps BPSK modulation. A band rejection filter is used to eliminate interference to the NASA Deep Space Network at Goldstone. The narrowband downlink maximum EIRP is -11.2 dBW at the output of the omnidirectional antennas. The uplink frequency range is 2025-2110 MHz and will not be addressed.

At the NASA X-Band Workshop II, Space Imaging LP representatives pointed out (and other non-Government commercial entities agreed) that the bandwidth restriction of 375 MHz within the 8025-8400 MHz frequency range severely limits their technical design for higher levels of data transmission and also may limit their ability to increase resolution imagery and incorporate future enhancement in area coverage. Space Imaging also stressed that NASA should lead the effort to expand the frequency allocations for Earth exploration-satellite services (i.e., developing technology near 26 GHz). They stated that interference between and among EESS systems and other users of the band is a major concern. Several recommendations for interference management were discussed at the meeting, including: autonomous output power control for satellites when over Earth stations, limiting use of direct broadcast systems, and high rejection bandpass and band reject filters installed on satellites. It was also noted that due to the nature of the missions supported by NASA's Deep Space Network, interference between EESS systems and the Deep Space Network should be reduced to the maximum extent possible.

Orbital Sciences Corporation (OSC). The OSC plans to deploy three satellite systems in sun-synchronous orbits of 460 km at 98.2 degrees inclination which will be called the "Eyeglass" system. The primary function of the Eyeglass Global Imagery Information System is to provide high-resolution data to numerous customers world-wide. This privately owned and operated system is to supply high-quality, low cost imagery products and services for commercial, civil, and military markets. The proposed launch date is late 1997.

The downlink frequency range would be 8025-8325 MHz with bandwidth of 300 MHz centered at 8175 MHz. The planned satellites are to use QPSK modulation and transmitter power of 10 watts. The EIRP at the beam edge is planned to be 70.7 dBm. The data rate goes between 75 - 150 Mbps and the compression rate is a 2:1 ratio or greater. The antenna is a 10° steerable pencil beam antenna (±5° off boresight). The satellite will have an "ON/OFF"switch that can be activated via command when over a tracking station. When an earth station is not visible to the satellite the spacecraft computer will store the earth imagery data. Command and control will use a different frequency range.

The three current proposed locations of tracking earth stations are at OSC-Headquarters Dulles, VA; in the State of Wyoming, and one external to the United States in Saudi Arabia. Use of other customer Earth stations are unknown at this time; however, it should be noted that OSC is planning to market their Earth exploration-satellite data on a worldwide basis. Earth station antennas are on the order of 4.4 meters in diameter with antenna gains of approximately 50 dBi.

At the NASA X-Band Workshop II in a roundtable discussion, an OSC representative stressed several points that might be helpful in the use of the 8025-8400 MHz frequency range for the Earth exploration-satellite service. The points raised were: 1) to maximize the Earth exploration-satellite operations an "orbit re-use" investigation should be initiated, 2) investigate the option that all new satellites have directive antennas, 3) investigate the upgrade for the primary status of the EESS allocations (Region 1 & 3), and 4) investigate initiatives to support the FCC/NTIA to establish and develop the procedures for a joint planning effort between Government and industry.

EarthWatch Incorporated. EarthWatch Incorporated[38] plans to deploy two Earth exploration-satellites in sun-synchronous inclined orbits of 468 km at 97.3 degrees inclination to the equator with a 93.8 minute period, 16 orbits per day. The downlink plans are to use 35 MHz of bandwidth, proposed 8305-8340 MHz, in the 8025-8400 MHz frequency range. The Earth exploration-satellites are planned to have 3 meter and 15 meter resolution Earth imaging. The satellites will use SQPSK modulation with a feature of 25 Mbps downlink data encrypted signals. The antenna will have right hand circular polarization, a body-fixed pointing antenna with a nominal beamwidth of 140 degrees and an azimuthal symmetric gain pattern. The satellite antenna itself will be a 4.5 inch long x 1 inch diameter five-turn Quadrifilter Helix antenna. The Helix antenna pattern will lead to an EIRP at the beam edge of 38.7 dBm.

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38 The original FCC applicant in this proceeding was WorldView Imaging Corporation (WorldView) which applied for a construction permit on December 28, 1992. However, the licensing requests by U.S. firms to operate private remote sensing space systems are reviewed on case-by-case basis by the Department of Commerce in accordance with the Sensing Act of '92. The DOC granted a license to operate to WorldView on January 14, 1993 with a letter from the Director, Office of Space Commerce to the Chairman, FCC. WorldView subsequently filed for authority to construct, launch, and operate a commercial remote-sensing satellite system and amended its pending application to substitute EarthWatch as the applicant on March 25, 1995. The FCC granted the authority to construct, launch, and operate a commercial remote-sensing satellite system on August 1, 1995 (WorldView will hold about 44% interest in EarthWatch and the remaining 56% will be held by Ball Corporation's Aerospace and Communications Group).

The satellite earth stations are proposed for Longmont, CO; Fairbanks, AK; and Esrange, Sweden or Tromso, Norway. The earth stations will use 6 meter Azimuth-Elevation tracking antennas with antenna gain of 52 dBi. The satellites are planned to transmit only on command and when visible, above the horizon, to a ground station (that means there will be no broadcast capability and the tracking station antennas are shut down when the satellites are not visible). The EarthWatch Incorporated has completed all FCC domestic provisions of footnote US258. In addition, the US258 suggested case-by-case electromagnetic compatibility (EMC) analysis was conducted by a member agency of the IRAC (IRAC Doc. 29458/1) on the EarthWatch satellites/earth stations. This analysis identified potential interference from the DCSC earth stations to reception to the EarthWatch earth stations. The EarthWatch has not responded to this analysis. Also, no Government agency has provided any analysis with respect to fixed terrestrial stations. However, the FCC is coordinating with the FAS for an additional 320 MHz bandwidth down-link requirement along with a 4.2 MHz bandwidth telemetry requirement. Again, these two new requirements may present potential interference problems at the Fairbanks and Longmont earth station sites.

At the NASA X-Band Workshops in roundtable discussions, an EarthWatch representative stressed several points that might be helpful in the use of the 8025-8400 MHz frequency range for the Earth exploration-satellite service. The points raised were: 1) an investigation should be initiated to determine an equitable channelization plan for the 8025-8400 MHz frequency range (currently no plan exists), 2) an investigation should be initiated to determine if continuous broadcast mode operations are needed, and 3) restated the need for an investigation to upgrade the existing status to primary for the EESS allocations (Region 1 & 3).

Resource 21. Resource 21[39] plans to deploy four satellite systems in circular sun-synchronous orbits of 743 km at approximately 98 degrees inclination. The primary function of the Resource 21 satellite imagery system is to provide high-resolution data to numerous customers world-wide. This privately owned and operated system is to supply high-quality, low cost imagery products and services for agriculture, national resources, scientific, commercial, civil, and military markets. The proposed launch date is late 1999.

The wideband and telemetry downlink occupies the 8025-8400 MHz band, and broadcasts at 320 Mbps. The command uplink occupies the 2025-2110 MHz band, and transmits at 2 kbps. The satellite will have an "ON/OFF"switch that can be activated via command when over a tracking station. When an earth station is not visible to the satellite the spacecraft

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39 As of April 1996, the business developmental partners of Resource 21 were Agrium, US; Boeing Commercial Space Company; Farmland Industries; GDE Systems; Institute for Technology Development; and Pioneer Hi-Bred International.

computer will store the Earth imagery data. Other communications details are in final system engineering.

Deep Space Research Systems

Space Research (space-to-Earth)(deep space only) Systems. For nearly three decades, the scientific investigation of the solar system and beyond has been carried out by NASA, mainly through the use of unmanned automatic satellites. These highly sophisticated exploring satellites have sent back wondrous and surprising new information about Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune, and in general, far beyond our solar system. None of these missions would have been possible without the Deep Space Network (DSN), which provides the earth-based radiocommunications link for all unmanned interplanetary satellites. Since 1958, the DSN has become a world leader in the development of state-of-the-art low-noise receivers, tracking systems, telemetry and command systems for space radiocommincations that meet or exceed the requirements of the new missions while maintaining support for the current missions.

The NASA Deep Space Network is the largest and most sensitive scientific telecommunications and radionavigation network in the world. The Deep Space communications complexes are located at Goldstone, CA; near Madrid, Spain; and near Canberra, Australia (about 120^{o} apart in longitude, which ensures continuous observation and suitable overlap for the transfer of spacecraft radio links from one complex to the next). The network consists of 4 deep space (earth stations) stations equipped with ultrasensitive receiving systems and large parabolic dish antennas (approximately 26 - 70 meters) at each location with network operations control center located in the Jet Propulsion Laboratory (JPL) in Pasadena, CA. These large parabolic dish antennas in conjunction with the liquid cooled receivers are designed to receive power levels on the order of -210 dBW (10^{-21} Watts). Support for inner-planet exploration began in 1962 with the JPL's Mariner series, then the NASA's Pioneer series, then the Voyager series, and others like Vega series (Venus Balloon and Pathfinder Mission), the Japanese Sakigake and Suesei spacecraft, the European Space Agency's Giotto spacecraft and others.

Space research service (deep space) space-to-Earth in the band 8400-8450 MHz may experience interference from LOS terrestrial sources as well as from current and future EESS sources in the lower adjacent ranges of 8025-8400 MHz. There is a need to protect the deep space earth stations from harmful interference that may arise from unwanted emissions in the lower adjacent frequency band.

Because highly sensitive receivers are required for deep space communications (space-to-Earth links), it is desirable to provide the requested protection from any interference as is listed in TABLE 2-3. The World Administrative Radio Conference of 1979 was convinced to exclude aeronautical mobile sources in the 2 and 8 GHz Deep Space downlink bands, this resulted in the Recommendation 578 protection criteria. Deep Space earth stations are vulnerable when interference comes from the terrestrial LOS sources and highly vulnerable when the potential interference comes from air or spaceborne transmissions. Problems may arise even when the sources of unwanted emissions are from the EESS systems in the lower adjacent band. The potential for interference can be illustrated through an example presented at the 1994 X-Band Workshop. This example was also presented at the Space Frequency Coordination Group 14 (SFCG-14) meeting in September 1994 at Rothenburg, Germany.

The example shows there is a potential for adjacent band interference from an aircraft within 400 km at an altitude of 12 km to a space vehicle that is communicating with an earth station on a deep space downlink. The example indicates a difference in spreading loss of 100 dB between a source near Venus (at the closest Earth approach of 42×10^6 km) and a line-of-sight aircraft at the maximum range from the earth station of 390 km at 12 km altitude (a potential interference threat). Then compare the same Venus source and a satellite at 1000 km in altitude; a spreading loss differences of more than 90 dB is calculated. The near Earth orbiting satellite is only 10 dB less of an interference potential than the recognized aeronautical mobile source. It is therefore easily appreciated that the high data rates (especially wideband modes) from near Earth orbiting satellites may directly interfere by way of unwanted spectral components that fall within the upper adjacent band. The recommended power spectral density and power spectral flux density allowable to protect the deep space Earth stations in the 8400-8450 MHz deep space downlink band are located in the Rules and Regulations section of this report, TABLE 2-5.

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SECTION 4

INTERFERENCE SCENARIOS

SUMMARY

Summary of Potential Interference Scenarios

There are several potential interference scenarios of significance: 1) fixed stations-to-EESS earth stations (downlink), 2) EESS space station (downlink)-to-fixed service stations, 3) FSS/MSS earth stations (uplink)-to-EESS earth stations (downlink), 4) MSS aircraft stations (adjacent-band uplink)-to-EESS earth stations (downlink), 5) EESS space stations (downlink)-to-FSS/MSS space stations (uplink), 6) EESS space stations (downlink)-to-EESS earth stations (downlink), 7) EESS space stations (downlink)-to-(adjacent-band) deep space research earth stations (downlink), and 8) EESS space station (downlink)-to-MetSat space station (uplink) in GEO orbit, and 9) MetSat space station (uplink)-to-EESS earth station (downlink). These scenarios are discussed below.

TABLE 4-1, which is also shown in TABLE 2-6, shows the applicability of the ITU-R rules, regulations, and recommendations concerning the EESS systems. This table is presented here for the convenience of the reader and the scenarios discussed in this section are the more critical cases.

(1) Fixed stations-to-EESS earth stations (downlink), Figure 4-1

The methods for determining coordination areas for transmitting and receiving earth stations will be considered by WRC-97. In general, Recommendation ITU-R IS.847-1, Annex 1 or ITU-R IS.849-1, Annex 1 should be used for complete or partial updating of the procedures currently set forth in Appendix 28 of the ITU Radio Regulations. With the proposed reallocation of the band 1710-1755 MHz, increased use of the band 8025-8400 MHz by Government fixed operations can be expected. Fixed service station transmissions could be a source of interference to the EESS earth stations. Procedures contained in Recommendation ITU-R IS.847-1 or ITU-R IS.849-1 should be used to determine the coordination contours. Recommendation ITU-R IS.847-1 is used for the determination of the coordination regions of an earth station operating with a geostationary spacecraft in bands shared with terrestrial services. Recommendation ITU-R IS.849-1 is used for the determination of the coordination regions of an earth station operating with a non-geostationary spacecraft in bands shared with terrestrial services. New fixed stations located within the coordination contours will

TABLE 4-1 (TABLE 2-6 repeated here for easy of reading)

APPLICABILITY OF INTERNATIONAL RULES, REGULATIONS AND RECOMMENDATIONS CONCERNING COMPATIBILITY WITH EESS

Source \ Victim	FIXED	FSS/MSS ↑ in GEO orbit	EESS ↓ in GEO orbit	EESS ↓ in LEO orbit	SPACE RESEARCH ↓ (earth stations)	METSAT ↑ in GEO orbit	METSAT ↑ in LEO orbit
FIXED			Rec.IS.847[40] (*scenario 1*)	Rec.IS.849[40] (*scenario 1*)			
FSS/MSS ↑			Appendix 29, Case 2 and Rec.IS.848 (*scenario 3*)	Rec.IS.849[41] (*scenario 3*)			
MSS ↑ Airborne			Rec.SM.329[42] (*scenario 4*)	Rec.SM.329[42] (*scenario 4*)			
EESS ↓ in GEO orbit	Article 28, (RR 2569) (*scenario 2*)	Appendix 29, Case 2 (*scenario 5*)	Appendix 29, Case 1 (*scenario 6*) [S-C1]	Article 28,[43] (RR 2569) (*scenario 6*) [S-C2]	Rec.SM.329[42] (*scenario 7*)	Appendix 29, Case 2 (*scenario 8*) [S-C5]	(simulation[44]) (*scenario 8*) [S-C6]
EESS ↓ in LEO orbit	Article 28, (RR 2569) (*scenario 2*)	Article 29, (RR 2613), (RR 2631) (*scenario 5*)	Article 28,[43] (RR 2569) (*scenario 6*) [S-C3]	Article 28,[43] (RR 2569) (*scenario 6*) [S-C4]	Rec.SM.329[42] (*scenario 7*)	(simulation[44]) (*scenario 8*) [S-C6]	(simulation[44]) (*scenario 8*) [S-C6]
METSAT ↑ in GEO orbit			Appendix 29, Case 2 and Rec.IS.848 (*scenario 9*) [S-C7]	Rec.IS.849,[45] (*scenario 9*) [S-C8]			
METSAT ↑ in LEO orbit			Rec.IS.847[46] (*scenario 9*) [S-C9]	Rec.IS.849,[45] (*scenario 9*) [S-C8]			

Note: ↑ indicates satellite uplink. ↓ indicates satellite downlink. **S-C#** indicates sub-case #.

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40 The methods for determining coordination areas of transmitting and receiving earth stations described in Recommendation ITU-R IS.847-1, Annex 1 or ITU-R IS.849-1, Annex 1 should be used for the complete or partial updating of the procedures currently set forth in Appendix 28 of the ITU Radio Regulations.

41 There is no ITU-R recommendation that covers this type of interaction. However, ITU-R IS.849 might be adapted to this potential interference case by treating the FSS/MSS uplink earth station as a terrestrial station.

42 The out-of-band emissions that may be associated with unwanted emissions will not be discussed in this report (see footnote 7, page 16 for re-write details on Appendix 8). Also, see page 18 for in-band space research criteria.

43 Article 28 (RR2569) might be adapted to this potential interferencecase by treating the victim earth stations in either the GEO or LEO case as terrestrial stations.

44 Rules or regulations applicable to these cases were not identified during this study; however, if the interference potential requires analysis, there are models similar to FlySat (see Section 3, page 37) that might be used for the sharing criteria.

45 There is no ITU-R recommendation that covers this type of interaction. However, ITU-R IS.849 might be adapted to this potential interference case by treating the MetSat uplink earth station as a terrestrial station.

46 There is no ITU-R recommendation that covers this type of interaction. However, ITU-R IS.847 might be adapted to this potential interference case by treating the MetSat uplink earth station as a terrestrial station.

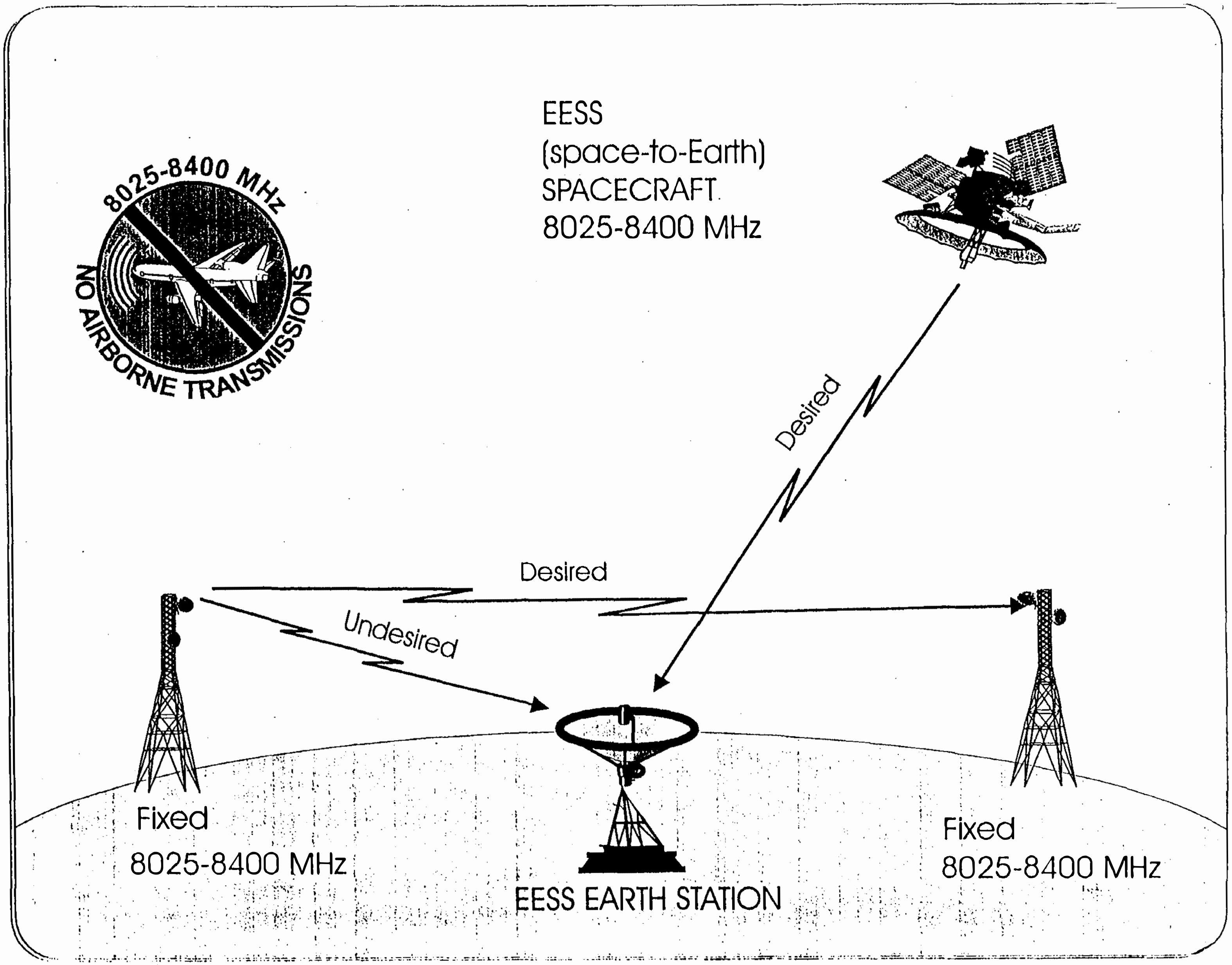

Figure 4-1. Fixed stations – to – EESS earth stations (downlink).

require a case-by-case EMC analysis with the EESS earth station.

(2) EESS space station (downlink)-to-fixed service stations, Figure 4-2

EESS satellite transmitters have the potential to cause interference to fixed service receivers. To ensure electromagnetic compatibility between EESS space station transmissions and the terrestrial service receivers, the international and national communities have adopted [identical] power-flux density limits. These limits are contained in Section 8.2.36 of the NTIA Manual and in Article 28 (RR2569-2572) of the ITU Radio Regulations and are measured in units of dB(W/m^2) in any 4 kHz bandwidth at the surface of the Earth. These limits vary from -150 to -140 dB(W/m^2) in any 4 kHz bandwidth depending on the angle of arrival and will serve as the sharing criteria necessary to preclude interference. These PFD limits were established for geostationary orbiting satellites whereas EESS may be located at any altitude and inclination. Because of the number of EESS systems in the future and possible cumulative interference effects into multiple hop, analog microwave systems with frequency reuse in every other hop, these PFD limits may need to be revised. New fixed systems may need to be designed to tolerate these PFD levels for interference signals.

(3) FSS/MSS earth stations (uplink)-to-EESS earth stations (downlink) Figure 4-3.

The signal level of the FSS/MSS earth station transmissions in the 8025-8400 MHz band (including numerous transportable earth stations) could be higher than the signal level received by the EESS earth stations from corresponding EESS satellite transmissions in the frequency range 8025-8400 MHz. These high power FSS/MSS (uplink) transmissions in the band 7900-8400 MHz could be a source of interference to EESS downlink receptions. Coordination procedures between these high powered FSS/MSS in-band and adjacent-band uplink operations and the EESS earth station downlink operations have been developed and accepted by the ITU-R. The FSS/MSS earth station transmitting to a GEO satellite interacting with the EESS earth station receiving data from a GEO satellite could be managed using coordination practices found in Recommendation ITU-R IS.848-1 or those practices found in Appendix 29, case 2 (note: they are only methods for determining whether coordination is required). The coordination practices found in Recommendation ITU-R IS.849-1 could be applied for the EESS earth station receivers associated with low Earth orbiting satellites interacting with the FSS/MSS earth station transmitting to a GEO satellite, if the FSS/MSS uplink earth station is treated as a terrestrial station. The international coordination procedures are contained in RR Article 11 and 14 (new

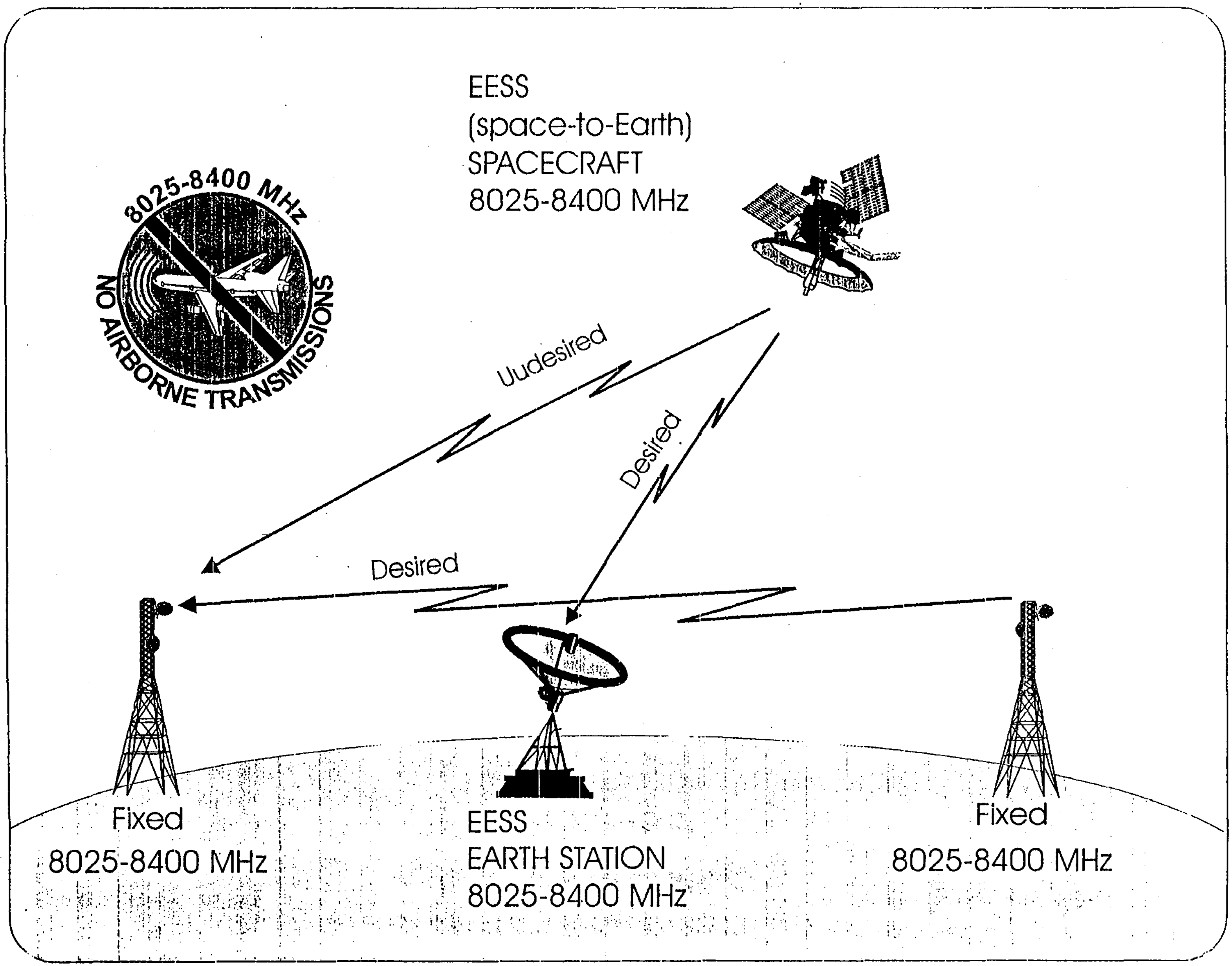

Figure 4-2. EESS space station (downlink) – to – fixed stations.

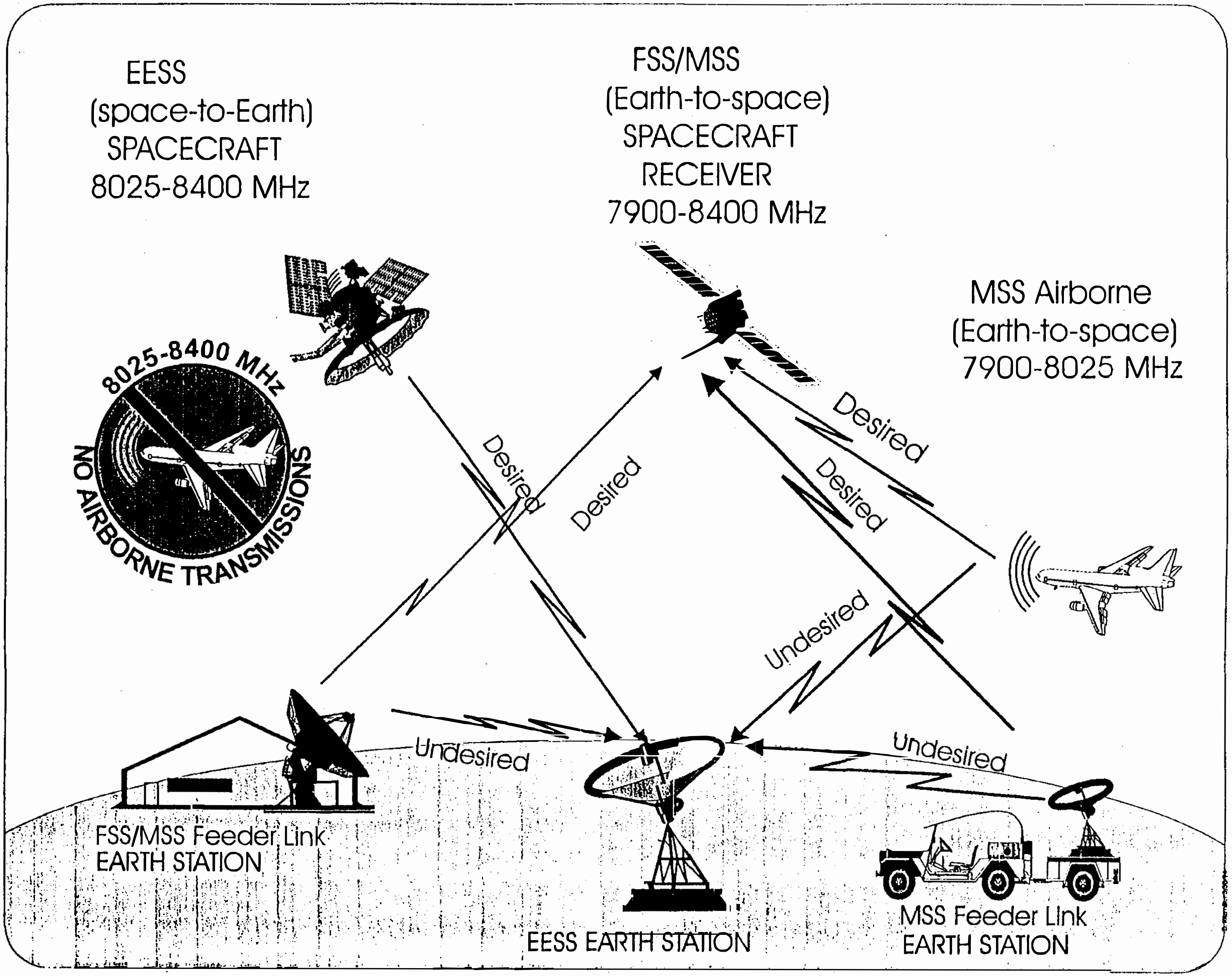

Figure 4-3. FSS/MSS earth/aircraft stations (uplink)-to-EESS earth stations (downlink).

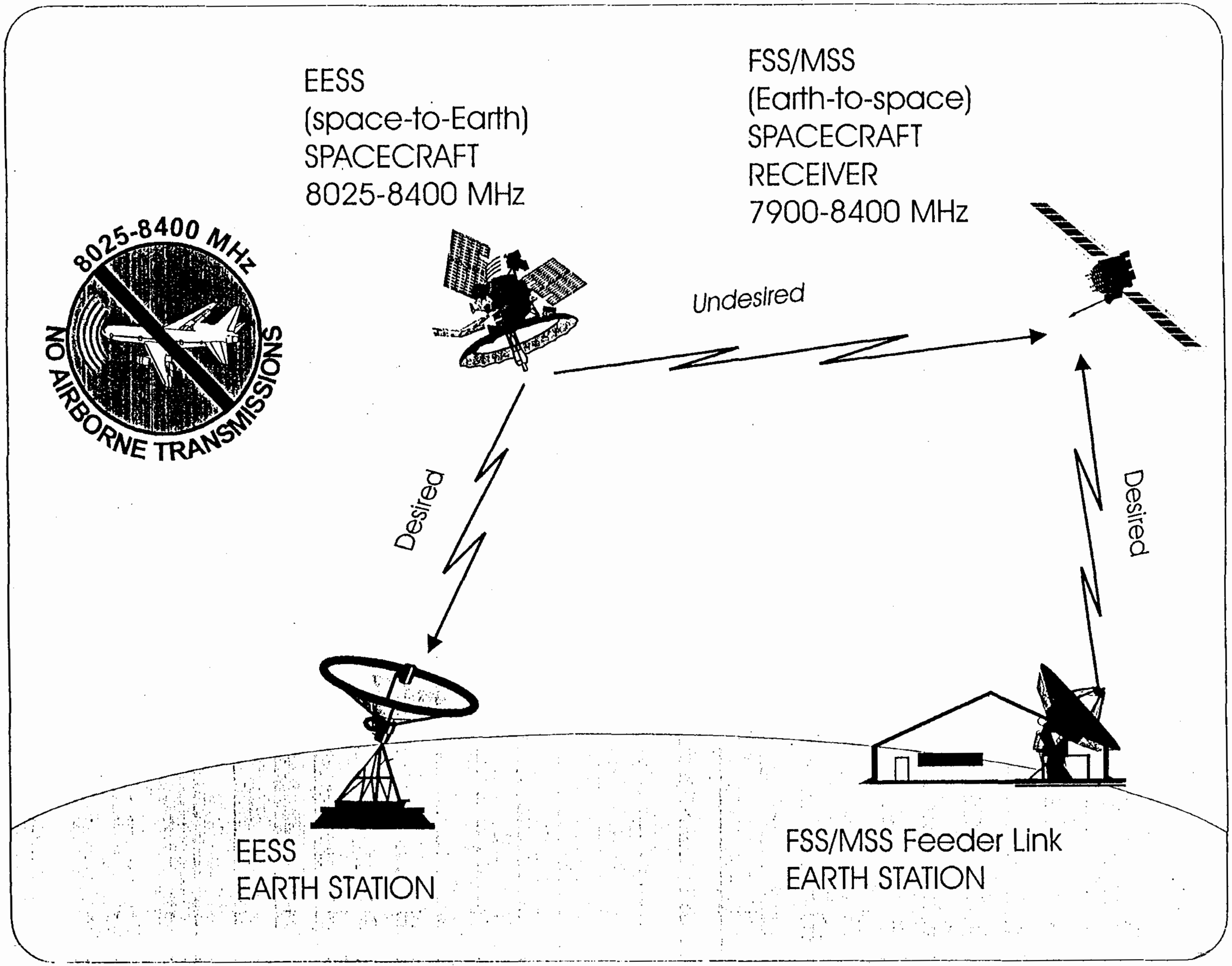

Figure 4-4. EESS space stations (downlink) – to – FSS/MSS space stations.

Article S9, WRC-95, which directs to ITU-R IS.848-1 and Appendix 29, case 2), and nationally these types of interactions are dealt with by the FAS. Note these procedural rules are coordination practices or procedures not interference analyses. If either the EESS earth station receivers associated with GEO orbiting satellite or the EESS earth station receivers associated with LEO orbiting satellite is located within the coordination area of the FSS/MSS earth station uplink transmitter, then further coordination is required or a specific electromagnetic compatibility analysis may have to be performed.

(4) MSS aircraft stations (adjacent-band uplink)-to-EESS earth stations (downlink), Figure 4-3.

The signal level of the MSS aircraft stations (service links) in the 7900-8025 MHz band could be higher than the signal level received by the EESS earth stations from corresponding EESS satellite transmissions in the frequency range 8025-8400 MHz. These high power MSS aircraft (adjacent-band uplink) transmissions in the band 7900-8025 MHz could be a source of interference to EESS (downlink) receptions. Because of the mobility of the MSS aircraft station transmitter (adjacent-band), this interaction becomes more difficult to manage. The requirement for the MSS aircraft station transmitters (adjacent-band) on downlink frequencies in the 7900-8025 MHz band is that these MSS aircraft stations have to meet the spurious emission limit set forth in Appendix 8 of the ITU Radio Regulations (See footnote 6 pertaining to the re-write of Appendix 8; however, it should be noted that this appendix covers spurious and harmonic emissions but not the fall-off requirements of out-of-band emissions. The draft revision of Recommendation ITU-R SM.329-6 deals not only with spurious emissions but out-of-band emissions and unwanted emissions).

(5) EESS space stations (downlink)-to-FSS/MSS space stations (uplink), Figure 4-4

EESS satellite transmitters have the potential to cause interference to the geostationary FSS/MSS satellite receivers. Appendix 29, Case 2 are the calculation to determine if coordination is required to ensure electromagnetic compatibility between geostationary EESS space station transmissions and the geostationary FSS/MSS satellite receivers. If the EESS GEO space stations violate these coordination procedures then a case-by-case electromagnetic compatibility analysis would have to be performed.

To ensure electromagnetic compatibility between non-geostationary EESS space station transmissions and the geostationary FSS/MSS satellite receivers, the international and national communities have adopted an identical power-flux density limit (PFD). This limit is contained in Section 8.2.36 of the NTIA Manual and RR2631 (Article 29) of the ITU Radio Regulations and is measured in units of dB(W/m²) in any 4 kHz bandwidth measured at the geostationary-satellite orbit. RR2631 sets forth a PFD limit at the geostationary-satellite orbit to protect FSS space station receivers from non-geostationary space stations transmitting in the 8025-8400 MHz range. This limit is −174 dB(W/m²) in any 4 kHz bandwidth and will serve as the sharing criteria necessary to preclude interference.

(6) EESS space stations (downlink)-to-EESS earth stations (downlink), Figure 4-5

Footnote US258 states that non-Government EESS (space-to-Earth) is allocated on a primary basis subject to a case-by-case electromagnetic compatibility analysis if interference or a threat of interference exists. There are four sub-cases [S-C's] involving EESS earth stations associated with LEO and GEO orbiting satellites as potential victims of interference and EESS earth stations associated with LEO and GEO orbiting satellites as potential sources of interference (see chart on page 70).

In the sub-case #1, an EESS earth station receiving data from a GEO orbiting satellite and being interfered with by another EESS GEO orbiting satellite transmission, [S-C1], Appendix 29, Case 1 would be the proper coordination procedure. However, it should be noted that as of the date of this report there is only one Earth exploration-satellite network in geostationary orbit.

In the sub-case #2, an EESS earth station receiving data from a LEO orbiting satellite and being interfered with by an EESS GEO orbiting satellite transmission, [S-C2]; if both the LEO and GEO satellite transmitters are designed to equal or almost equal the PFD limits of Article 28, the sharing situation will be highly dependent on the technical parameters (e.g., locations, antenna gain, and antenna pattern) of the earth station receiving transmissions from the LEO satellite and the orbital location of the GEO satellite. Orbital simulations will be necessary to determine the extent of the interference.

In the sub-case #3, an EESS earth station receiving data from a GEO orbiting satellite and being interfered with by an EESS LEO orbiting satellite transmission, [S-C2]; if both the GEO and LEO satellite transmitters are designed to equal or almost equal the PFD limits of Article 28, the sharing situation will be highly dependent on the technical parameters (e.g., locations, antenna gain, and antenna pattern) of the earth station receiving transmissions from the GEO satellite and the periods when the LEO satellite will be transmitting. Orbital simulations will be necessary to determine the extent of the interference.

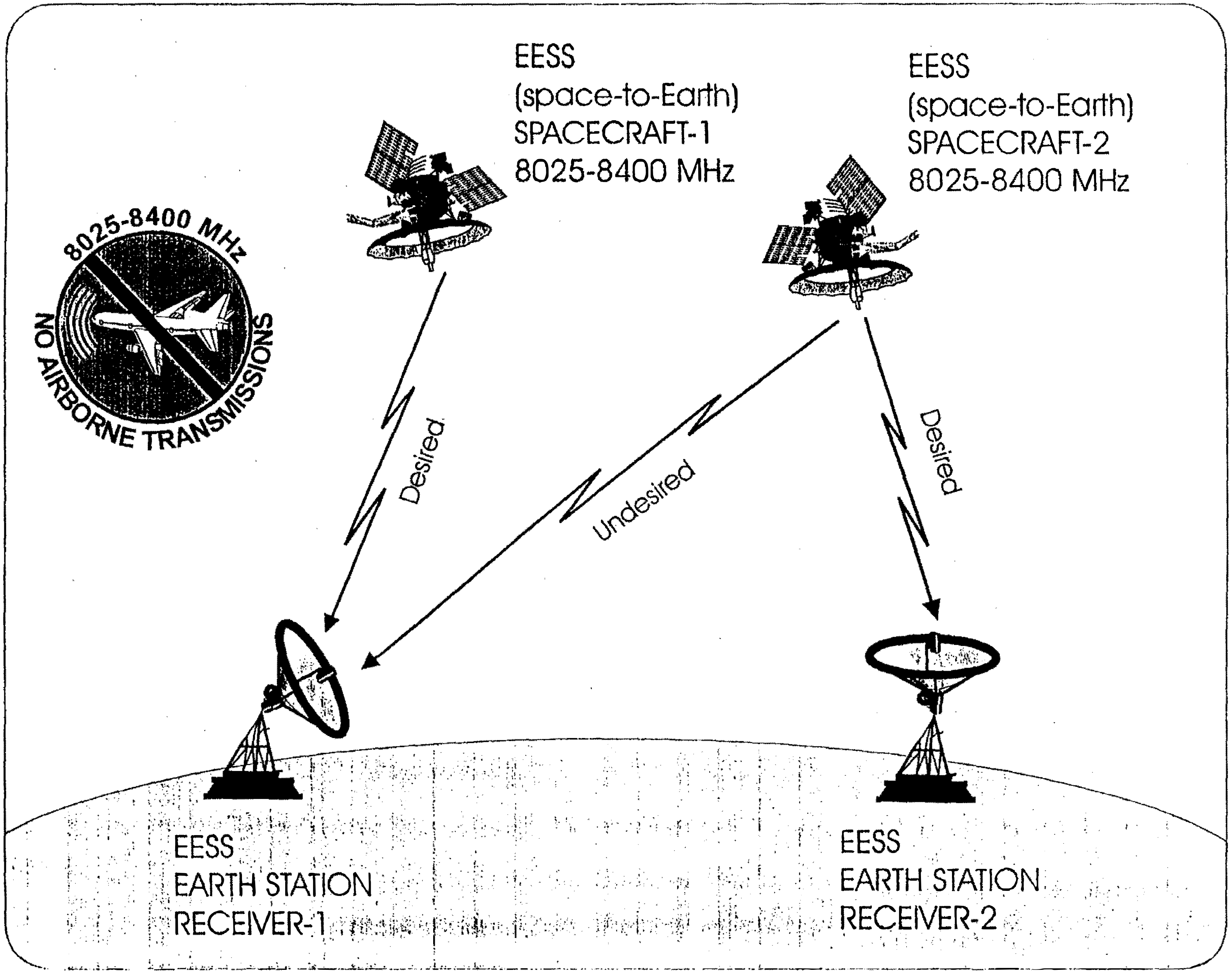

Figure 4-5. EESS space stations (downlink) – to – EESS earth stations (downlink).

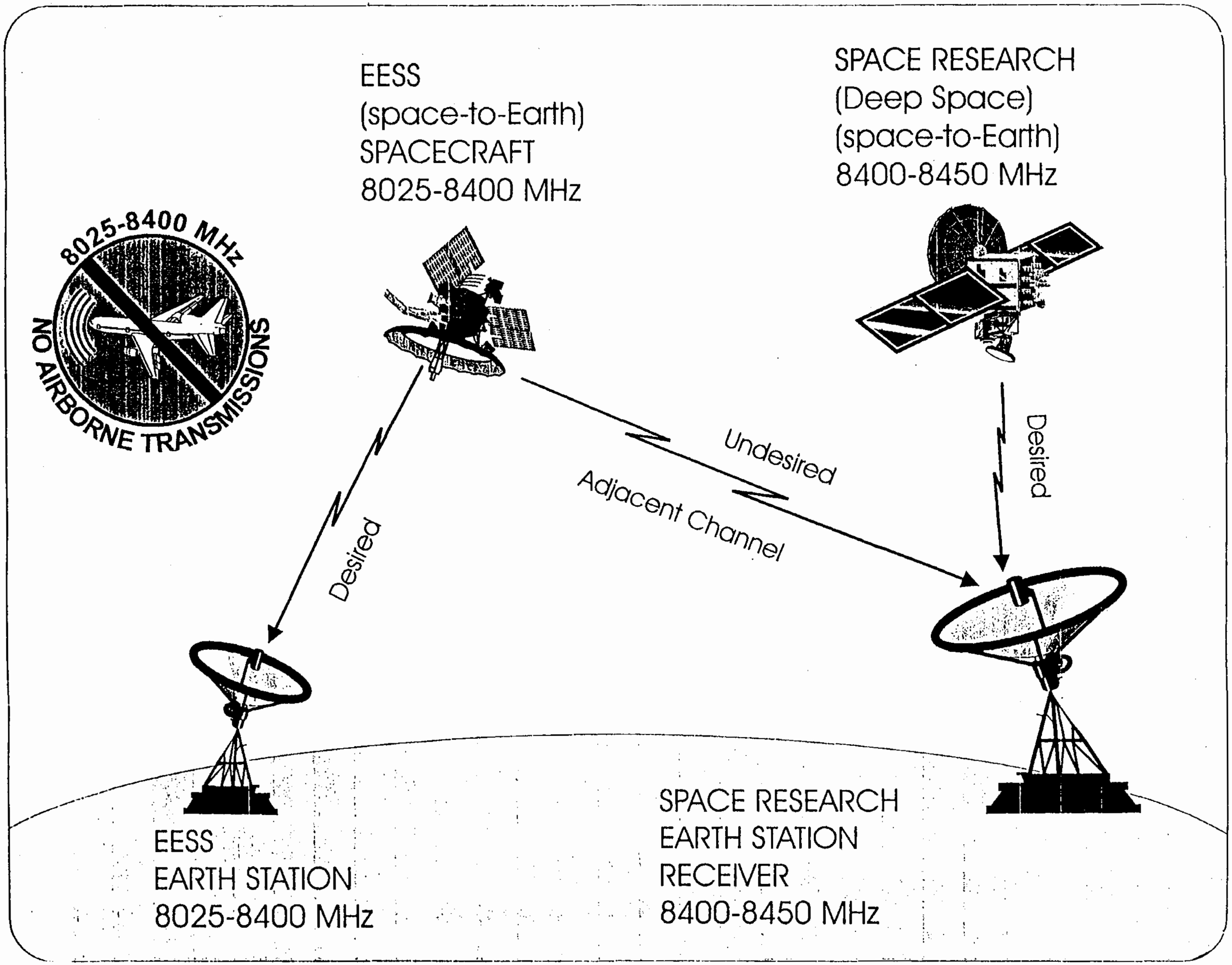

Figure 4-6. EESS space stations (downlink) – to – space research (deep space) stations (downlink).

In the sub-case #4, two separate EESS satellite networks operating simultaneously in LEO orbit, there is the potential for interference from a transmitting EESS satellite in one network to the receiver of an EESS earth station in the other network. The PFD limits of Article 28 have been supplemented by the following analyses done by a NASA contractor.

An analysis was presented at the NASA X-Band Workshop-II in July 1994 by a NASA contractor. The purpose of this LEO vs. LEO analysis was to answer two questions: 1) based on current loading conditions, is the 8025-8400 MHz frequency range becoming overcrowded? and 2) what is the potential interference between EESS systems in the 8025-8400 MHz range? This analysis[47] using a 0 dB interference-to-noise (I/N) ratio showed that protection levels would be violated approximately 0.1% to 0.5% of the time. In other words, due to inter-satellite interference, the EESS links would be unavailable 0.1% to 0.5% of the satellite-to-earth station visibility time. The analysis was conducted for 15 satellite systems that were operational as of 1990.[48] At this 1994 X-Band workshop, NASA requested that this analysis be up dated with a new, agreed upon, I/N ratio of -3 dB, with 1% of the time as the criteria for the loss of EESS data (this criteria should be for non-critical events), and new/updated satellite constellations. At the 95 X-Band workshop[49] the results were given in two cases in LEO orbit: the Worst Case in which all interfering satellites were always transmitting their downlink signals using omnidirectional satellite antennas, and the Normal Case in which the interfering satellites were only transmitting when in view of their own earth station with steerable satellite antennas. In the Worst Case, due to interference, the link could be unavailable from 0.29% to 4.1% of the time. In the Normal Case, due to interference, the link could be unavailable from 0.02% to 0.5% of the time. The loss of EESS data in the 8025-8400 MHz band is less than the 1% specified in the SFCG Recommendation 14-3 (provisional). Therefore, the potential for interference (using an I/N of -3 dB and 28 satellites, normal case) between EESS systems appears to be acceptable for the current 8025-8400 MHz band loading projection. If an SFCG recommendation is used as a criteria (the loss of EESS data is not to exceed 1%), then, the

47 Several satellite systems were not used in the analysis because their technical parameters were unknown. The unknown satellite systems were the United States of America CRSS, EYEGLASS, AVSAT-1, and Early Bird systems, the French ENVISAT-1 and XXM systems, and the South African GREENSAT-1 and GREENSENSE systems.

48 This Stanford Telecom Incorporated analysis only dealt with Earth exploration-satellite to Earth exploration-satellite interference. Analysis assumptions include: one satellite was tested against all other satellites on an individual basis, all satellites were on at all times, the interference-to-noise (I/N) ratio equals 0 dB, and the antenna pattern was that of the LANDSAT-4 antenna.

49 X-Band Workshop III 8025-8400 MHz, Vandenburg AFB, June 1995, Volume 2, *Interference Between EES Systems in the Band 8025-8400 MHz*, by J. Hart.

normal case in LEO orbit (above), appears to be acceptable for the current 8025-8400 MHz band loading projection.

(7) EESS space stations (downlink)-to-space research (deep space) stations (downlink), Figure 4-6

The space research deep space receivers are very susceptible to any interference, especially from spaceborne transmissions. There is a potential for adjacent band interference from the EESS space stations on downlink frequencies in the 8025-8400 MHz band to the Government space research (space-to-Earth, Deep Space) earth station receivers in the band 8400-8450 MHz. A requirement for the EESS space stations on downlink frequencies in that band is they would have to meet the spurious emission limit set forth in the Draft Revision of Recommendation ITU-R SM.329-6, Spurious Emissions, if approved by the ITU and adopted via Treaty. Coordination will be required to protect those receiving earth stations at Goldstone, CA; Spain; Australia; Eypatoriya (Ukraine); Medvethi, Ozerc, and Ussumisk (Russia); and Usado/Nagano (Japan). However, spurious coordination between DSN space stations and earth station is a new concept. If this new spurious emissions limit becomes the standard, these new limits, if adhered to, should make the EESS space station downlink transmissions and the adjacent-band DSN earth station reception manageable.

Criteria for in-band potential interference to the DSN is expressed in Section 2, TABLE 2-5 of this report. If out-of-band or spurious emissions (as appropriate) are suppressed at the DSN receiver to the limits requested, there should not be an interference interaction.

(8) EESS space station (downlink) transmitters-to-MetSat space station (uplink) receivers, Figure 4-7

There are four sub-cases [S-C's] involving MetSat earth stations associated with LEO and GEO orbiting satellites as potential victims of interference and EESS earth stations associated with LEO and GEO orbiting satellites as potential sources of interference (see chart on page 70).

EESS space station downlink transmitters in GEO orbit [S-C5] in the 8025-8400 MHz range have the potential to cause (in-band or lower adjacent-band or upper adjacent-band) interference to MetSat receivers in GEO orbit in the 8175-8215 MHz range depending on relative location of each satellite. Appendix 29, Case 2 are the calculation to determine if coordination is required to ensure electromagnetic compatibility between geostationary EESS space station transmissions and the future geostationary meteorological-satellite receivers. If the EESS GEO space stations

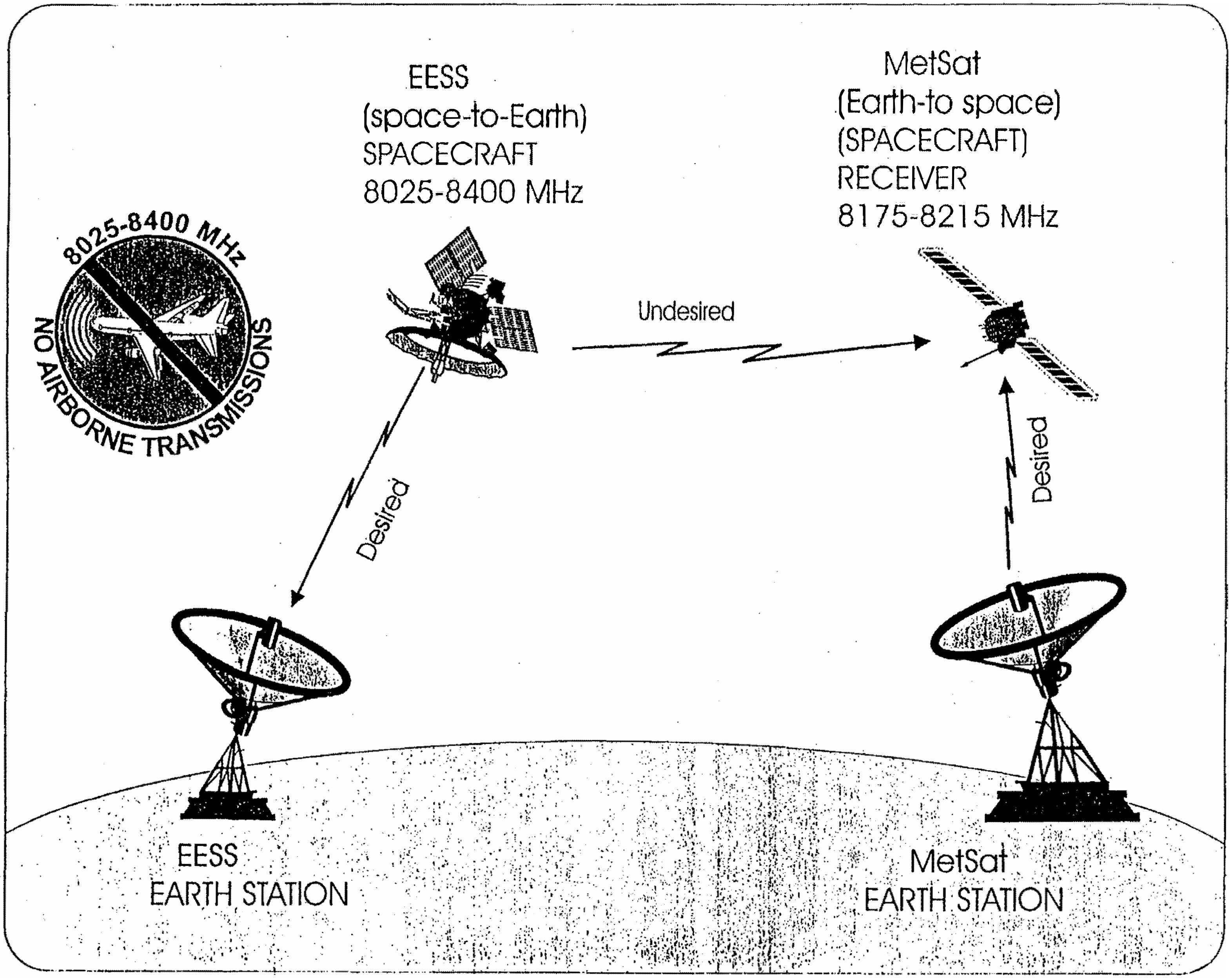

Figure 4-7. EESS space station downlink transmitters to meteorological-satellite space station uplink receivers.

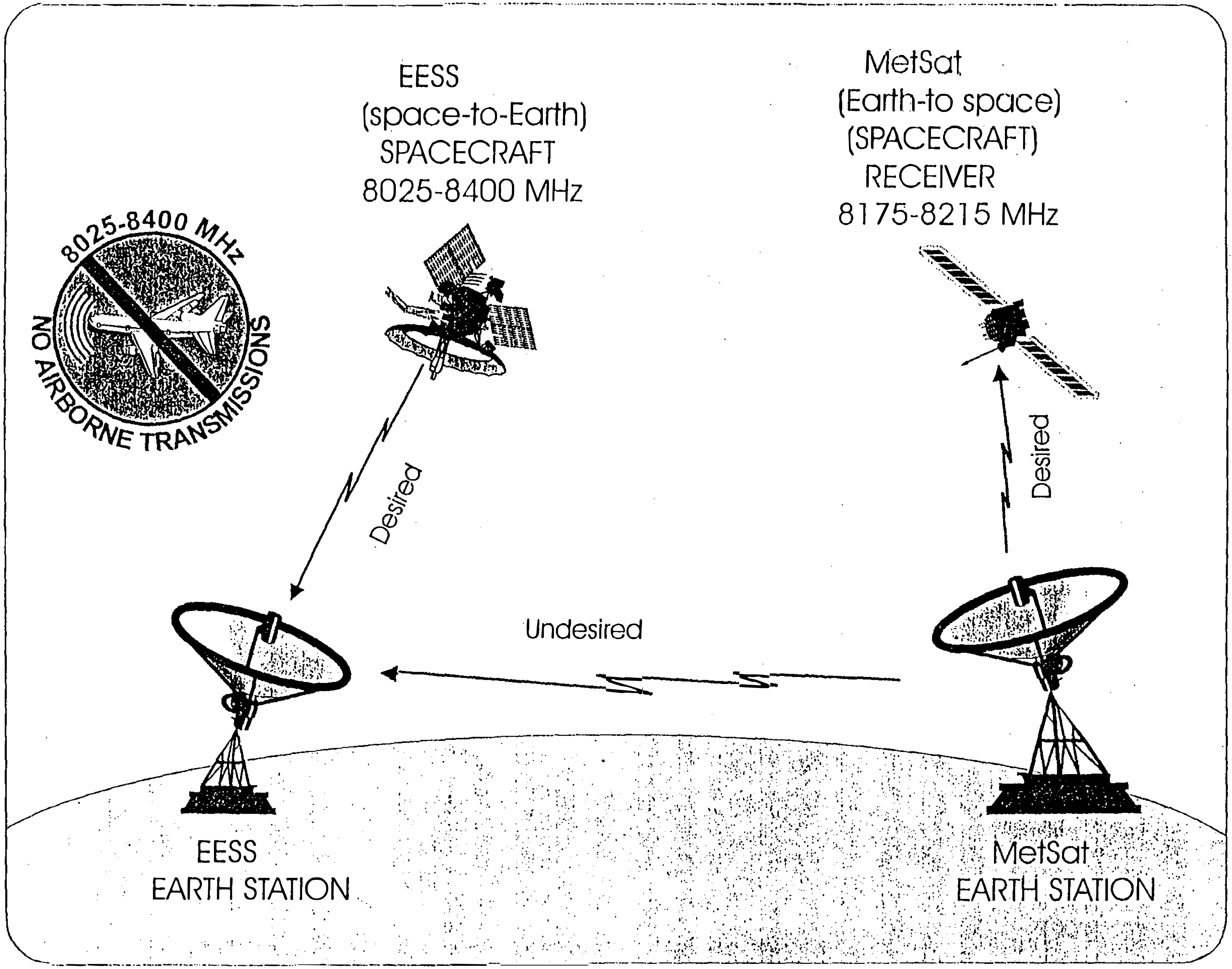

Figure 4-8. Meteorological-satellite earth station uplink transmitters to the EESS earth station receivers.

violate these coordination procedures then a case-by-case electromagnetic compatibility analysis would have to be performed.

Three other interactions are possible: EESS space station downlink transmitters in GEO orbit to MetSat receivers in LEO orbit, EESS space station downlink transmitters in LEO orbit to MetSat receivers in GEO orbit, and EESS space station downlink transmitters in LEO orbit to MetSat receivers in LEO orbit, all labelled [S-C6]. Orbital simulations should be used on these three interactions to provide sharing analysis. However, it should be noted that no firm decisions have been reached regarding developing these MetSat satellites by NOAA/DOC.

(9) <u>MetSat earth station (uplink) transmitters-to-EESS earth station receivers,</u> Figure 4-8

There are four sub-cases [S-C's] involving EESS earth stations associated with LEO and GEO orbiting satellites as potential victims of interference and MetSat earth station transmitters associated with LEO and GEO orbiting satellites as potential sources of interference (see chart on page 70). MetSat earth station uplink transmitters in the 8175-8215 MHz range have the potential to cause (in-band or lower adjacent-band or upper adjacent-band) interference to EESS earth station receivers in the 8025-8400 MHz range depending on the relative location of each earth station. Coordination between MetSat earth station transmitters regardless of whether the system is in geostationary or non-geostationary orbit and the EESS earth station receivers is required.

The coordination procedures for a MetSat earth station transmitting to a GEO orbiting satellite [S-C7] and the EESS earth station reception from a GEO orbiting satellite may be found in the ITU Radio Regulations, Appendix 29, Case 2 and ITU-R recommendation IS.848-1.

There are no ITU-R recommendations to cover the MetSat earth station transmitting to a LEO or GEO orbiting satellite [both labelled S-C8] and the EESS earth station reception from a LEO orbiting satellite. However, Recommendation ITU-R IS.849-1 might be adapted to this potential interference case by treating the MetSat uplink earth station as a terrestrial station.

There are no ITU-R recommendations to cover the MetSat earth station transmitting to a LEO orbiting satellite [S-C9] and the EESS earth station reception from a GEO orbiting satellite. However, Recommendation ITU-R IS.847-1 might be adapted to this potential interference case by treating the MetSat uplink earth station as a terrestrial station.

Again it should be stressed that no firm decisions have been reached regarding these MetSat satellites by NOAA/DOC. Further discussions by satellite managers and the frequency management community are needed prior to launch.

Many of these potential interference scenarios addressed here were considered by the attendees at the NASA X-Band Workshops. Many of these considerations have been expressed to the Space Frequency Coordination Group (SFCG) before their meeting in Rothenburg, Germany. The final report recommendations that came out of the Space Frequency Coordination Group (SFCG) meeting in Rothenburg, Germany from September 14-22, 1994 are included in Appendix-B.

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SECTION 5

SUMMARY OF SPECTRUM ASSESSMENT

GENERAL

The frequency range 8025-8400 MHz is allocated on a shared basis to the Earth exploration-satellite (space-to-Earth) service and the Government has expressed interest in this range for the expansion of downlink data from Earth sensing satellites. This frequency range is also very attractive to non-Government entities (commercial providers) to provide saleable Earth sensing data. The fact that the range is shared with a large number of users in the fixed, mobile, fixed-satellite, mobile-satellite and meteorological-satellite services does present a variety of sharing problems. Coordination with these services is a prerequisite before any Earth-sensing use of this frequency range is possible.

The majority of frequency assignment use in the 7900-8450 MHz range is for fixed microwave medium-to-high capacity terrestrial communications and fixed-satellite (Earth-to-space) transmissions (see TABLE 3-1). The FAA RCL terrestrial links are the dominate user in the 7900-8450 MHz range with just under 40% of the frequency assignments. However, there are currently no fixed DOE or FAA assignments in the 8025-8400 MHz band in Alaska where the majority of users[50] plan to put these EESS earth station systems. The principal users of the space radiocommunications within the 7900-8450 MHz range are the Defense Satellite Communications System (DSCS) and the Fleet Satellite Communications (FLTSATCOM) System (fixed-satellite service). The Earth exploration-satellite (space-to-Earth) service in the 8025-8400 MHz range is expected to increase dramatically in the future with the increased requirements of the LANDSAT satellite system, the NASA Earth Observing System (EOS), and at least six new commercial vendors within the U.S. Those commercial vendors are AstroVision Inc., EarthWatch Inc., Space Imaging LP, Orbital Science Corporation, Resource 21 and Motorola.[51] External to the U.S., other Administrations have or plan to have EESS systems operating in that same frequency range.

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50 See footnote 31 on page 52 for a possible change regarding the use and the majority of locations.

51 If Motorola decides to design and deploy an EESS system, they have a license to operate granted by the NOAA/DOC; however, currently they are doing no work on an EESS System (See footnote 19 on page 31).

In the United States there are no assignments in the meteorological-satellite service in the 8175-8215 MHz band. However, NOAA has indicated they are investigating the possibility of using this band for weather observation.[52] There are several ITU-R recommendations (which are not binding on any Administration) that can be used concerning both the Earth exploration-satellites and meteorological-satellites. These ITU-R recommendations are for the methodology for determining performance objectives, interference criteria, and sharing & coordination criteria for both services. The Resolution 712 states that studies of sharing between the EESS systems vs. meteorological-satellite systems are in progress and should be completed by 1996.[53]

NASA hosted several workshops[54] in the summers of 1994 and 1995 to discuss what direction the U.S. Government should go on a national and international scale and the critical spectrum management issues concerning the implementation of numerous new EESS systems in the 8025-8400 MHz range and the adjacent bands. In both workshops, NASA stressed the need to try to gain the support of the Space Frequency Coordination Group (SFCG), which is an informal international group. The NASA/NOAA members of the SFCG played a major role in the workshops. In 1994, the draft NASA/NOAA SFCG Recommendation went forward to the SFCG meeting in Rothenburg, Germany (attached as the last three pages of Appendix B). Many of the NASA/NOAA proposals[55] were not adopted in the final SFCG Recommendation 14-3 (attached as the first two pages of Appendix B). The workshops were attended by representatives from the FCC, NASA, NOAA, NTIA, DoD, and several commercial vendors.

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52 *NOAA X-Band Requirement*, by Lester Riddle, Document - 3 (presented at the *X-Band Workshop III, 8025-8400 MHz*, Vandenberg Air Force Base, June 21-22, 1995) states that an Integrated Program Office will be established at NOAA to develop the "converged" polar orbiting satellite series for the AF, NOAA, and NASA.

53 *ITU Radiocommunication Sector, Conference Preparatory Meeting For WRC-95 & WRC-97, PART B. - WRC-95 agenda item 3b*, Geneva, 22 March - 5 April 1995. Resolution No. 712 (WARC-92) states that these studies are in progress and should be completed in 1996 with the results available for CPM-97.

54 NASA hosted two workshops, the *X-Band Workshop 8025-8400 MHz*, (referred to as X-Band II) Goddard Space Flight Center, July 25-27, 1994, minutes contained in 2 volumes and the *X-Band Workshop III*, (referred to as X-Band III) Vandenberg Air Force Base, June 21-21, 1995, minutes contained in 2 volumes.

55 The NASA/NOAA draft SFCG proposals for 95 WRC included an I/N ratio of -3 dB and set the value of 1% of the time as the non-critical event for the loss of an EESS data.

A LEO-to-LEO analysis was presented at the NASA X-Band Workshop-III considering the conditions of an I/N ratio of -3 dB and 28 satellite constellations. This analysis evaluated two cases: case 1; where all interfering satellites were always transmitting downlink signals with omnidirectional satellite antennas, and case 2; where the interfering satellites were only transmitting while viewing their own earth stations with steerable satellite antennas. In case 1, due to interference, the link could be unavailable from 0.29% to 4.1% of the time. In case 2, the link could be unavailable from 0.02% to 0.5% of the time. If the draft NASA/NOAA SFCG recommendation is used as a criteria[56] then the normal case 2 appears to be acceptable for the current 8025-8400 MHz band loading projection.[57]

INTERFERENCE SCENARIOS SUMMARY

Nine potential interference scenarios have been identified with issues involving the various uses in the 7900-8450 MHz frequency range. Methods for coordination between space stations, earth stations, terrestrial stations have been developed, and the calculations necessary for coordination contours have been automated in the ITU-R appendices. Other technical standards for equipment that are used in the frequency range were also identified; these standards are included to further reduce the interference potential between EESS and other various stations.

Those nine scenarios are: 1) fixed station transmissions-to-EESS earth station receptions (downlink), 2) EESS space station transmissions (downlink)-to-fixed station receptions, 3) FSS/MSS earth/aircraft station transmissions (in-band uplink)-to-EESS earth station receptions (downlink), 4) MSS aircraft station transmissions (adjacent-band uplink)-to-EESS earth station receptions (downlink), 5) EESS space station transmissions (downlink)-to-FSS/MSS space station receptions (uplink), 6) EESS space station transmissions (downlink)-to-EESS space station transmissions (downlink), 7) EESS space station transmissions (downlink)-to-adjacent band deep space research earth station receptions (downlink), 8) EESS space station transmissions (downlink)-to-MetSat (meteorological-satellite) space station receptions (uplink), and 9) MetSat space station (uplink)-to-EESS earth station (downlink).

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56 The draft SFCG Recommendation 14- specifies the loss of EESS data in the 8025-8400 MHz band due to interference, except for time criteria events, should be 1% of the time. The final SFCG Recommendation 14-3 does not specify the percentage of time for critical or non-critical events.

57 NASA has proposed using a 30 cm dish size for their earth station. The normal case 2 analysis did not consider this inexpensive 30 cm dish size. This 30 cm dish size was not be addressed in this report.

In summary, the interference scenarios for 4 and 7 should be manageable with the existing spurious limits. The existing PFD limits contained in Article 28 are sufficient to preclude the interference presented in scenario 6 (S-C2, S-C3, and S-C4), if the PFD's are equal (if the PFD's are not equal, then orbital simulations become necessary). The existing PFD limits may not be sufficient in scenario 2 for multiple EESS systems coupling into multiple hop microwave system in the fixed service. Similarly, the PFD limit of Article 29 should cover the case of scenario 5 (EESS ↓ in LEO orbit).

Existing coordination contours and procedures can be used to identify potential interference problems for scenarios 1, 3, 5 (EESS ↓ in GEO orbit), 6 (S-C1), 8 (S-C5), and 9. If within these coordination contours, further analysis is required, it should be on a case-by-case basis. Orbital simulations are required for scenario 8 (S-C6).

APPENDIX A

IRAC INFORMATION COPY, IRAC Doc. 28714/1-4.9.1/6.4
on the announcement concerning
THE ADMINISTRATION'S NEW POLICY ON REMOTE SENSING SPACE CAPABILITIES

This Appendix contains the U.S. Department of Commerce News article on the Administration's New Policy on Land Remote Sensing Space Capabilities that was provided to the IRAC for information. The IRAC Doc. contains the *Commerce News for Immediate Release* as of March 10, 1994 and a *Fact Sheet for the U.S. Policy on Foreign Access to Remote Sensing Space Capabilities*.

FOR INFORMATION Doc. 28714/1-4.9.1/6.4

UNITED STATES DEPARTMENT OF
COMMERCE NEWS
WASHINGTON, D.C. 20230

OFFICE OF THE SECRETARY

G 94-20

FOR IMMEDIATE RELEASE:
Thursday, March 10, 1994

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U.S. DEPUTY SECRETARY OF COMMERCE DAVID J. BARRAM ANNOUNCES ADMINISTRATION'S NEW POLICY ON REMOTE SENSING SPACE CAPABILITIES

WASHINGTON -- In another Clinton administration breakthrough effort to increase global market access for American business, and help create jobs, Deputy Commerce Secretary David J. Barram announced today the President's decision to allow for the commercial sale of remote sensing technology.

"On behalf of the President and Secretary Brown, I am pleased to announce today a major milestone in the commercialization of space-based imagery. After a high level policy review, the Clinton Administration has decided to allow expanded sales of commercial images from space and the export of the remote sensing systems themselves. This Administration's policy unleashes the potential of a critical 21st century information technology at a time when the international market for space-based imagery appears poised for significant expansion," Deputy Secretary Barram said.

This new remote sensing policy is expected to open the way for U.S. firms to aggressively compete in a market that already accounts for nearly $400 million worldwide, and is expected to grow to more than $2 billion by the year 2000. Including the market for geographic information systems, the market for space-based imagery could be in the range of $5 to $15 billion by the turn of the century.

Deputy Secretary Barram continued, "This policy is particularly significant because it acknowledges the relationship between this country's national security and its long-term economic security. It recognizes the two as inextricably woven together: our long term national security is directly tied to our ability to effectively compete in this critical global imaging market. In short, this policy will assist U.S. companies to succeed commercially by supporting a 21st century industry. It means high-skill, high-wage jobs, and enhanced business productivity and opportunity."

-more-

Remote Sensing Policy Announcement
Page Two

As emphasized this morning by Vice President Gore, this new policy also will help the defense industry find new commercial applications for defense technologies. This timely, high-quality data, which will include global change and environmental data, also is expected to become an important part of our country's National Information Infrastructure.

Under this policy, U.S. companies will be licensed by the Secretary of Commerce to operate private remote sensing systems and sell those images to domestic and foreign entities. The export of "turn-key" systems will be considered on a case-by-case basis under an export license issued by the State Department. National security and international obligations will be protected through specific conditions in the license. The export of sensitive technologies will be considered on a restricted basis to protect advanced capabilities.

-30-

Fact Sheet

US POLICY ON FOREIGN ACCESS TO REMOTE SENSING SPACE CAPABILITIES

Background

Remote sensing from space provides scientific, industrial, civil governmental, military and individual users with the capacity to gather data for a variety of useful purposes. The US Government operates very high resolution space-based reconnaissance systems for intelligence and military purposes. These systems are among the most valuable US national security assets because of their high quality data collection, timeliness, and coverage and the capability they provide to monitor events around the world on a near real-time basis. More nations have discovered the value of these satellites and are developing their own indigenous capabilities, or are seeking the purchase of data or systems.

Policy Goal

The fundamental goal of our policy is to support and to enhance US industrial competitiveness in the field of remote sensing space capabilities while at the same time protecting US national security and foreign policy interests. Success in this endeavor will contribute to maintaining our critical industrial base, advancing US technology, creating economic opportunities, strengthening the US balance of payments, enhancing national influence, and promoting regional stability.

Scope of Policy

The policy covers foreign access to remote sensing space systems, technology, products, and data. With respect to commercial licenses, this would include operating licenses granted under the Land Remote Sensing Policy Act of 1992 and export licenses for certain items controlled on the US Munitions List (USML). While the policy will define certain restrictions for export of items on the USML, export of items on either the USML or the Commerce Control List (CCL) would continue to be licensed in accord with existing law and regulations.

Licensing and Operation of Private Remote Sensing Systems

License requests by US firms to operate private remote sensing space systems will be reviewed on a case-by-case basis in accordance with the Land Remote Sensing Policy Act of 1992 (the Act). There is a presumption that remote sensing space systems whose performance capabilities and imagery quality characteristics are available or are planned for availability in the world marketplace (e.g., SPOT, Landsat, etc.) will be favorably considered, and that the following conditions will apply to any US entity that receives an operating license under the Act.

1. The licensee will be required to maintain a record of all satellite tasking for the previous year and to allow the USG access to this record.

2. The licensee will not change the operational characteristics of the satellite system from the

application as submitted without formal notification and approval of the Department of Commerce, which would coordinate with other interested agencies.

3. The license being granted does not relieve the licensee of the obligation to obtain export license(s) pursuant to applicable statutes.

4. The license is valid only for a finite period, and is neither transferable nor subject to foreign ownership, above a specified threshold, without the explicit permission of the Secretary of Commerce.

5. All encryption devices must be approved by the US Government for the purpose of denying unauthorized access to others during periods when national security, international obligations and/or foreign policies may be compromised as provided for in the Act.

6. A licensee must use a data downlink format that allows the US Government access and use of the data during periods when national security, international obligations and/or foreign policies may be compromised as provided for in the Act.

7. During periods when national security or international obligations and/or foreign policies may be compromised, as defined by the Secretary of Defense or the Secretary of State, respectively, the Secretary of Commerce may, after consultation with the appropriate agency(ies), require the licensee to limit data collection and/or distribution by the system to the extent necessitated by the given situation. Decisions to impose such limits only will be made by the Secretary of Commerce in consultation with the Secretary of Defense or the Secretary of State, as appropriate. Disagreements between Cabinet Secretaries may be appealed to the President. The Secretaries of State, Defense and Commerce shall develop their own internal mechanisms to enable them to carry out their statutory responsibilities.

8. Pursuant to the Act, the US Government requires US companies that have been issued operating licenses under the Act to notify the US Government of its intent to enter into significant or substantial agreements with new foreign customers. Interested agencies shall be given advance notice of such agreements to allow them the opportunity to review the proposed agreement in light of the national security, international obligations and foreign policy concerns of the US Government. The definition of a significant or substantial agreement, as well as the time frames and other details of this process, will be defined in later Commerce regulations in consultation with appropriate agencies.

Transfer of Advanced Remote Sensing Capabilities

1. Advanced Remote Sensing System Exports: The United States will consider requests to export advanced remote sensing systems whose performance capabilities and imagery quality characteristics are available or are planned for availability in the world marketplace on a case-by-case basis.

   The details of these potential sales should take into account the following:

   -- the proposed foreign recipient's willingness and ability to accept commitments to the US Government concerning sharing, protection, and denial of products and data; and

   -- constraints on resolution, geographic coverage, timeliness, spectral coverage, data processing and exploitation techniques, tasking capabilities, and ground architectures.

   Approval of requests for exports of systems would also require certain diplomatic steps be taken, such as informing other close friends in the region of the request, and the conditions we would likely attach to any sale; and informing the recipient of our decision and the conditions we would require as part of the sale.

   Any system made available to a foreign government or other foreign entity may be subject to a formal government-to-government agreement.

Transfer of Sensitive Technology

The United States will consider applications to export sensitive components, subsystems, and information concerning remote sensing space capabilities on a restricted basis. Sensitive technology in this situation consists of items of technology on the US Munitions List necessary to develop or to support advanced remote sensing space capabilities and which are uniquely available in the United States. Such sensitive technology shall be made available to foreign entities only on the basis of a government-to-government agreement. This agreement may be in the form of end-use and retransfer assurances which can be tailored to ensure the protection of US technology.

Government-to-Government Intelligence and Defense Partnerships

Proposals for intelligence or defense partnerships with foreign countries regarding remote sensing that would raise questions about US Government competition with the private sector or would change the US Government's use of funds generated pursuant to a US-foreign government partnership arrangement shall be submitted for interagency review.

APPENDIX – B

This appendix contains the SFCG final Recommendation 14-3 (provisional) that went forward to the WRC '95 and the NASA/NOAA/MITRE Recommendation 14- that went forward to the Rothenburg, Germany meeting that preceeded the WRC '95. The final recommendation is contained on page B–2 and B–3. The NASA/MITRE recommendattion is contained on pages B-4 through B-6.

SPACE FREQUENCY COORDINATION GROUP

Recommendation 14-3 (provisional)

USE OF THE 8025-8400 MHz BAND BY EARTH EXPLORATION SATELLITES

The SFCG,

CONSIDERING

a) that Earth exploration-satellites are an increasingly important tool for acquiring information about the Earth and its environment;

b) that the 8025-8400 MHz band is allocated to the Earth exploration-satellite service on a primary basis in ITU Region 2 and on a secondary basis in ITU Regions 1 and 3;

c) that this band is the only currently allocated band both technically and economically feasible for transmission of wideband data from Earth exploration satellites direct to Earth;

d) that the band 8025-8400 MHz is shared with the fixed, mobile and fixed-satellite (Earth-to-space) services and the band 8175-8215 MHz is also shared with the meteorological satellite (Earth-to-space) service;

e) that use of the band by Earth exploration-satellites operated by both commercial interests and space agencies is increasing and could result in harmful interference between Earth exploration-satellite systems,

f) that Earth-based, deep space research receivers operated in the adjacent 8400-8450 MHz band are extremely sensitive and highly susceptible to interference;

g) that time-critical events occur in both deep space research and Earth exploration -satellite operations,

h) that guidelines for use of the band are desirable to maximize the capacity of the band and to minimize harmful interference;

i) that a need exists for additional spectrum for future Earth exploration-satellite operations beyond that available in the band 8025-8400 MHz;

RECOGNIZING

a) that as per Resolution 12-1R2, a worldwide allocation is vital for assured protection for commercial and space agency operations and that members agencies advocate an upgrade of the EES allocation status in ITU Regions 1 and 3 at the 1995 and 1997 WRCs;

b) that as per Resolution 12-1R2, EES parameters are needed in Appendix 28 of the Radio Regulations in order to carry out coordination of receiving EES earth stations with transmitting earth stations and terrestrial stations and that member agencies advocate incorporation of EES parameters into Appendix 28 of the Radio Regulations at the 1995 and 1997 WRCs;

RECOMMENDS

1. that transmitters on Earth exploration-satellites only radiate when transmitting data to one or more earth stations;

2. that consultations be effected if unwanted emissions from an Earth exploration-satellite exceed the deep space interference criterion of -220,9 dBW/Hz into a deep space receiver in the band 8400-8450 MHz.

SFCG-14
Rothenburg
14-22 September, 1994

SF14- /D
August 1, 1994

NASA/MITRE

Draft New Recommendation 14-

USE OF THE 8025-8400 MHz BAND BY EARTH EXPLORATION SATELLITES

The SFCG,

CONSIDERING

a) that Earth exploration-satellites are an increasingly important tool for monitoring the Earth's environment for the welfare of mankind;

b) that the 8025-8400 MHz band is allocated to the Earth exploration-satellite service on a primary basis in ITU Region 2 but on a secondary basis in ITU Regions 1 and 3;

c) that this band is the only allocated band also technically feasible for transmission of wideband image data from Earth exploration satellites direct to Earth;

d) that the band is shared with the fixed, mobile and fixed-satellite (Earth-to-space) services;

e) that use of the band by Earth exploration-satellites operated by both commercial interests and space agencies is increasing and may result in excessive mutual interference between Earth exploration-satellites;

f) that sensitive, Earth-based, deep space research receivers which are susceptible to interference are operated in the adjacent 8400-8450 MHz band;

Information obtained from the X-Band Workshop

g) that time-critical events occur in both deep space research and Earth exploration-satellite operations where either interference would seriously threaten the successful completion of the mission objectives (priority 1) or where missions have limited opportunities for achieving mission objectives (priority 2);

h) that guidelines on use of the band are desirable to maximize the capacity of the band and to minimize interference;

i) that a need has been identified for wider bandwidths for future Earth exploration-satellite missions than is available in the band 8025-8400 MHz;

RECOMMENDS

1. that transmitters on Earth exploration-satellites, except for broadcast mode transmissions, be turned on only when needed to transmit data to an earth station;

2. that all Earth exploration-satellites with a broadcast mode capability place these transmissions at the lower edge of the 8025-8400 MHz band;

3. that adequate filtering combined with spectrum efficient modulation methods be incorporated in Earth exploration-satellites to meet the deep space interference criteria of -220 dBW/Hz in the band 8400-8450 MHz except for coupling through the deep-space receiving antenna main beam;

4. that the criterion for interference to an Earth exploration-satellite is an interference-to-noise ratio of -3 dB;

5. that the criterion for loss of Earth exploration-satellite data due to interference, except for time critical events, is 1% of the time;

6. that a worldwide primary allocation is vital for assured protection for commercial and space agency operations and member agencies advocate an upgrade of the EES allocation status at the 1995 and 1997 WRCs;

Information obtained from the X-Band Workshop

7. that EES parameters are needed in Appendix 28 of the Radio Regulations in order to carry out coordination of receiving EES earth stations with transmitting fixed-satellite earth stations and fixed terrestrial stations;

8. that data asymmetry of EES transmissions be limited to 3%;

9. that member agencies advocate incorporation of EES parameters into Appendix 28 of the Radio Regulations at the 1995 and 1997 WRCs;

10. that the SFCG establish a procedure for operational coordination of transmission schedules to be used during time critical events to avoid interference among EES systems and to deep space research;

11. that the SFCG also establish a procedure for coordination of orbital parameters of Earth exploration-satellites in order to minimize the possibility for interference by appropriately phasing orbits;

12. that member agencies determine the bandwidth requirements for future Earth exploration-satellite missions and investigate additional bands that could be allocated to the Earth exploration-satellite service at a future competent World Radiocommunication Conference;

13. that there is a need to improve methods for sharing and coordination of use of the band 8025-8400 MHz and that member agencies study appropriate methods including:
    - spectrally efficient spacecraft transmitter modulation methods,
    - improved data compression techniques,
    - improved spacecraft transmitter high power amplifier technology,
    - improved spacecraft transmitter filtering characteristics,
    - methods of low-earth-orbit satellite sharing,
    - improved interference modeling techniques,
    - improved methods of determining appropriate space station e.i.r.p. levels,
    - appropriate protection levels for Earth exploration-satellites operating in the geostationary satellite orbit,
    - improved spacecraft directive antenna technology.

Information obtained from the X-Band Workshop

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This report assesses the expansion of the Earth exploration-satellite service in the 8025-8400 MHz frequency range. The report identifies allocations, standards, regulations and current and planned spectrum usage applicable to this range for Government, non-Government, and international operations. In addition, various potential interference scenarios among the EESS systems and the various other services (operating in this range) are identified.

U.S. Government and non-Government entities will launch Earth exploration-satellite service (EESS) systems in the 8025-8400 MHz frequency range based on the policy directive on remote sensing space capabilities signed by President Clinton (attached in Appendix-A; this policy is dictated by public law, Land Remote Sensing Policy Act of 1992). With the introduction of new and increased use of the EESS systems in that range, the potential for harmful interference exists among the various users of these and adjacent bands. NASA, among other Government agencies, is concerned by Earth exploration-satellite service use in the 8025-8400 MHz frequency range in today's as well as future markets. One method of monitoring the use of the 8025-8400 MHz frequency range by Earth exploration-satellite services is the Space Frequency Coordination Group (SFCG), (September 1994) of which NASA and NOAA are members.

16. Key Words *(Alphabetical order, separated by semicolons)*

8025-8400 MHz Band
Fixed-Satellite Service (FSS)
Mobile-Satellite Service (MSS)
Earth Exploration-Satellite Service (EESS)
Meteorological-Satellite Service (MetSat)
Fixed Service

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