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SPECTRUM RESOURCE ASSESSMENT OF THE FREQUENCY BANDS FROM 17.7-40.5 GHz

KARL NEBBIA
NORBERT SCHROEDER

U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

David J. Markey, Assistant Secretary
for Communications and Information

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PREFACE

The President's authority stemming from Section 305 of the Communications Act of 1934--to assign frequencies to radio stations or to classes of radio stations belonging to and operated by the United States, including the authority to amend, modify, or revoke such assignments--was transferred to the Secretary of Commerce under Executive Order 12046. The operating unit within the Department now vested with this authority, under Organization Order 10-10, is the National Telecommunication and Information Administration (NTIA). Functions assigned to NTIA relative to this authority include establishing policies concerning radio frequency spectrum allocation, assignment, and use plus providing the various Federal Government departments and agencies with guidance to assure that their execution of telecommunications related functions is consistent with these policies. A major portion of the detailed analysis performed in developing this guidance is conducted in the NTIA Spectrum Resource Assessment (SRA) Program.

Objectives of the SRA Program include i) review and documentation of current and proposed Government uses of the radio frequency spectrum; ii) identification of potential problems that would prevent Government requirements for operating frequencies in given bands from being satisfied, or would prevent the efficient use of the spectrum; iii) analysis of potential solutions for resolving identified problems; iv) recommendation of approaches for more efficient and effective use of the spectrum and for improved spectrum management procedures and; v) development of specific guidance regarding the implementation of federal spectrum management policy.

Copies of this report are available from the National Technical Information Service (NTIS), Department of Commerce. Additional information regarding the NTIA Spectrum Resource Assessment Program are available from the Chief, Spectrum Engineering and Analysis Division, NTIA, Department of Commerce, 179 Admiral Cochrane Drive, Annapolis, Maryland 21401 (301-261-8013).

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ABSTRACT

This report constitutes a Spectrum Resource Assessment (SRA) of the band 17.7-40.5 GHz. Included is information on rules and regulations, allocations, technical standards, current and proposed usage, and planning and coordination procedures. Major issues concern Government and non-Government telecommunications requirements, and planning and coordination procedures for these bands. Recommendations include retaining the current allocation tables and planning structure, making changes to assignment procedures and documenting long range plans.

KEY WORDS

Frequency Coordination
Radio Frequency Spectrum Management
Long Range Planning
17.7-40.5 GHz

SECTION 1

INTRODUCTION

BACKGROUND

The National Telecommunications and Information Administration (NTIA) is responsible for managing the U.S. Federal Government use of the radio spectrum. Part of NTIA's responsibility is to: "...establish policies concerning spectrum assignment, allocation and use, and provide the various departments and agencies with guidance to assure that their conduct of telecommunications activities is consistent with these policies" (NTIA, 1983). In support of these requirements, NTIA has undertaken a number of spectrum resource assessments and analysis studies. The objectives of these studies are: to assess spectrum utilization, identify existing/or potential compatibility problems between systems of various departments and agencies, provide recommendations for resolving any compatibility conflicts, and recommend changes that result in more efficient and effective use of the spectrum and improved spectrum management procedures.

In order to ensure efficient and effective use of the spectrum, Executive Order 12046 and Department of Commerce Order 25-7 direct NTIA to develop in cooperation with the Federal Communications Commission (FCC) a long range plan for spectrum use. As part of this planning effort several tasks have been initiated:

(1) Spectrum Resource Assessments of the bands 947 MHz-17.7 GHz and 17.7 GHz-40.5 GHz (These SRAs are proceeding concurrent to the FCC Docket 82-334 which addresses identification of suitable spectrum for licensees displaced under Docket 80-603 by the Broadcasting Satellite Service (BSS) in the 12.2-12.7 GHz band).

(2) Spectrum Resource Assessment of the 2900-3100 MHz band.

(3) Spectrum Resource Assessment evaluating the use of narrowband communications techniques.

(4) IRAC Technical Subcommittee (TSC) determination of a method for evaluating spectrum efficiency - TSC Working Group (WG)-13 has been tasked under IRAC documents 23191/1, 23199/2 and 23748/1 to complete this work. TSC WG-13 has defined a Technical Spectrum Efficiency Factor and is proceeding with development of a related computer model. This efficiency factor concept will be applied where feasible to fixed and mobile systems in selected bands within the overall 947 MHz-40.5 GHz range.

Pertinent portions of the SRAs will be incorporated into the Joint NTIA/FCC Long Range Plan (LRP).

The 17.7-40.5 GHz frequency range reviewed herein, with its associated emerging technology permits the use of increasingly higher frequencies and is a relief to spectrum planners as certain lower portions of the spectrum become extensively used. Development has begun and plans are being made by both Government and non-Government users creating increasing interest in the management of these bands.

OBJECTIVES

(1) To document rules and regulations for the frequency bands between 17.7-40.5 GHz.

(2) To document the existing and proposed uses for the 17.7-40.5 GHz band.

(3) To determine the necessity for modifications to current allocation tables in accordance with Government/non-Government requirements.

(4) To evaluate established spectrum management procedures with respect to their ability to handle the planning and coordination responsibilities peculiar to this band.

(5) To assist in development and implementation of a long range plan.

APPROACH

(1) Members of the IRAC were requested to:

- validate and augment, as necessary, the frequency assignment information contained in the Government Master File (GMF);

- provide data for correlating the number of operating units, transmitting and receiving, associated with given frequency assignments;

- identify their planned uses of the bands to be addressed here;

- provide information for correlating given frequency assignments to mandated mission functions that are performed;

- identify the nature of the requirement for spectrum use (instantaneous, random access, scheduled access...) associated with given frequency assignments.

(2) Responses received, along with data obtained from NTIA (Government Master File (GMF) May, 1984 and non-Government Master File (NGMF) September 1983) and the Electromagnetic Compatibility Analysis Center (ECAC) files were compiled.

(3) Allocations and standards were identified.

(4) Allocations and standards were evaluated in the light of current and proposed use.

(5) Planning and coordination procedures were reviewed.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

The 17.7-40.5 GHz frequency bands represent the next step in the growth of telecommunications through the use of higher and higher frequencies. The growing congestion in lower bands is providing the impetus to begin development of components and systems in this frequency range by both Government and non-Government users. The use of these bands, therefore, will continue to be scrutinized due to their future value to all spectrum users.

During the past twenty years, Government and non-Government communications strategists have coordinated the allocation of these bands, designating services and Government/non-Government use. This ongoing process has recently brought about the promulgation of revised allocation tables derived from the results of WARC-79 and follow-on discussions. The contents of the tables were determined partly on the basis of known or predicted requirements, partly on technical reasoning, and to a great extent on an attempt to share the spectrum between the various services and between Government and non-Government users. Current NTIA and FCC agreements have divided the band as follows:

Exclusively Non-Government	25%
Exclusively Government	0%
Non-Government Primary/Government Secondary	1%
Government Primary/Non-Government Secondary	31%
Shared Primary	43%

After a detailed review of the allocation tables, as well as existing and planned spectrum uses in the 17.7-40.5 GHz bands, insufficient current or proposed use could be identified to recommend any major changes to the tables. As technology progresses, a continuous review process will be needed to guarantee that no hindrances to development occur while ensuring the availability of spectrum to essential services. The structures required to perform this task are already in place within NTIA, FCC, and the IRAC Spectrum Planning Subcommittee (SPS), Frequency Assignment Subcommittee (FAS), and Technical Subcommittee (TSC). This framework has proven itself acceptable in the planning and coordination effort of currently shared bands and should continue to be acceptable for the near future. Interference due to spectrum crowding and coordination problems, which require policy changes, channeling, or strict standards, can only be perceived as long term possibilities.

The following conclusions take into account allocation tables, standards, current and planned use, and existing planning and coordination procedures, leading directly to the formulation of the presented recommendations. Essential for evaluating specific Government/non-Government spectrum allocation trade-offs are agency missions (These frequently deal with national security, emergency services and safety) and costs and time already invested in system development and production.

CONCLUSIONS

1. The bands from 17.7-40.5 GHz have a relatively low number of assignments. Few operational Government or non-Government commitments (with the exception of the 24.05-24.25 GHz band that has speed radars) and proposals have been made for systems using these bands; however, some of the current and planned systems represent significant individual commitments.

2. Years of planning and coordination have gone into the current allocation tables and led to investment in technology and component development. Without demonstrated requirements and/or development, changes to the allocation tables are unnecessary.

3. As the use of these bands grows, changes to the tables, sharing criteria, standards, or other spectrum management techniques may be required.

4. Some standards do currently apply to these bands. However, the fact that development is just beginning requires caution in the creation of standards which might be prematurely restrictive thereby deterring further development. Also, consistency between standards for Government and non-Government equipment is essential to simplify the process and reduce costs associated with component development.

5. Interest by Government agencies in each specific band is summarized in TABLE 1.

A. Bands with Co-Primary Sharing - Bands are just beginning development with no significant trends or problems.

B. Government Primary/Non-Government Secondary Bands - Where the Government is making use of these bands, the non-Government is also. Government agencies have indicated no definite plans for use of the Fixed and Mobile allocations within the 25.25-27.5 GHz bands. Non-Government Fixed and Mobile could be allowed in these bands. NASA has stated a desire to add an allocation to cover inter-satellite communications.

C. Non-Government Exclusive Bands - Little development has been done by the private sector and little or no long-term planned use has been shown by the Government agencies.

D. Non-Government Primary/Government Secondary Bands - Little existing or planned use has been shown by either the non-Government or the Government.

6. Records in the GMF indicating that Federal Aviation Administration (FAA) Airport Surface Detection Equipment (ASDE) radars occupy the 23.6-24.0 GHz band were found to be in error and require correction.

7. In the 17.7-40.5 GHz bands, where there is relatively little current use and attention is primarly directed toward the future, long range planning procedures are particularly important.

8. Structures which are capable of performing the long range planning function already exist within the Government. However, no requirement for a regularly updated multi-year planning document which will tie Government planning together is included in current directives.

TABLE 1

SUMMARY OF CURRENT AND PROPOSED TELECOMMUNICATIONS FROM 17.7-40.5 GHz

NON-GOVERNMENT EXCLUSIVE BANDS

Freq. in GHz	FCC	USAF C P	USA C P	USN C P	DOE C P	DOI C P	FAA C P	CIA C P	DOC C P	NASA C P	VA C P	HHS C P	TVA C P	DOA C P	NSA C P	NG C P	CG C P	GSA C P	DOJ C P
17.7-17.8	X									X									
17.8-18.6	X	X								X						X			
18.8-19.7	X	X								X						X			
19.7-20.2	X	X								X						X			
24-24.05	X																		
27.5-29.5	X	X							X	X						X			
29.5-30	X									X									
38.6-39.5	X																		

GOVERNMENT PRIMARY/NON-GOVERNMENT SECONDARY BANDS

20.2-21.2	X	X	X	X X						X						X			
24.05-24.25	X	X	X	X	X	X			X		X	X	X	X		X			
25.25-27	X									X						X			
27-27.5	X									X									
30-31		X							X	X									
33.4-36	X	X	X	X X	X				X	X X						X			

NON-GOVERNMENT PRIMARY/GOVERNMENT SECONDARY BANDS

31-31.3	X																		

C - CURRENT
P - PROPOSED
X - DOCUMENTED SYSTEMS
NG - Non-Government Assignments in the Government Master File
FCC licenses located in Non-Government Master File on September, 1983
Agency Assignments located in Government Master File on May, 1984
Proposed System Information taken from Agency Submissions

TABLE 1 (cont.)

SHARED PRIMARY BANDS

Freq. in GHz	FCC	USAF C P	USA C P	USN C P	DOE C P	DOI C P	FAA C P	CIA C P	DOC C P	NASA C P	VA C P	HHS C P	TVA C P	DOA C P	NSA C P	NG C P	CG C P	GSA C P	DOJ C P
18.6-18.8	X									X									
21.2-21.4																			
21.4-22	X	X	X	X	X X					X					X	X	X	X	
22-22.21	X	X														X			
22.21-22.5	X			X	X											X			
22.5-22.55																			
22.55-23	X			X															
23-23.55	X	X		X	X					X				X	X	X	X	X	X
23.55-23.6																			
23.6-24	X						X									X			
24.25-25.25	X	X														X			
31.3-31.8		X								X						X			
31.8-32	X	X								X									
32-33		X																	
33-33.4	X			X X					X	X									
36-37	X	X		X				X	X										
37-38.6	X	X	X	X X				X		X						X			
39.5-40	X	X																	
40-40.5	X	X																	

C - CURRENT
P - PROPOSED
X - DOCUMENTED SYSTEMS

NG - Non-Government Assignments in the Government Master File
FCC licenses located in Non-Government Master File on September, 1983
Agency Assignments located in Government Master File May, 1984
Proposed System Information Taken from Agency Submissions.

A. NTIA is currently working with the FCC to draw up a long-term plan.

B. The SPS has the spectrum planning responsibilities within the Government and the SPS systems review process provides planning information for new systems.

C. IRAC Ad Hoc committees are commonly formed to address a wide ranging set of planning issues.

9. The FAS procedure for coordination with the FCC has successfully handled the assignment of shared bands. Though the 17.7-40.5 GHz bands are primarily shared and will inevitably increase the coordination burden, no evidence exists that this structure will be overloaded in the near future.

10. Current SPS/FAS procedures do not ensure the implementation of spectrum plans.

A. The FAS is unable to determine whether the "major system" definition within the NTIA Manual Section 8.3.3 applies to the equipment submitted within a frequency assignment request. These loosely defined "Major Systems" require SPS review.

B. Existing procedures do not ensure compliance with SPS guidance on "Major Systems".

C. Existing procedures do not ensure that data provided on a frequency assignment request is accurate.

11. The NTIA Radio Spectrum Measurement System (RSMS) van though limited by availability, is capable of monitoring Government spectrum use up to 18.0 GHz. Hardware modifications would be required to extend the capability to 40 GHz.

12. Review of developing policy within the private sector and coordination of spectrum management decisions will be required as the FCC continues to address these bands through their own Documents, such as 82-334.

13. No determination can be made of spectrum efficiency at this time. Insufficient development has occurred above 17.7 GHz to evaluate new systems in terms relative to existing technology.

14. Difficulty exists in identifying future plans through the GMF because a large number of assignments are experimental or developmental and do not contain sufficient information concerning the service or the end function.

RECOMMENDATIONS

The following are NTIA staff recommendations based on the technical findings contained in this report. Any action to implement these recommendations will be accomplished under separate correspondence by modification of established rules, regulations and procedures.

It is recommended that:

1. NTIA continue to review and plan the 17.7-40.5 GHz bands as they mature, documenting trends and initiating appropriate modifications of the allocation tables, developing channeling or assignment procedures, and establishing technical sharing criteria. (Conclusions 1,2,3)

2. Spectrum standards pertaining to these bands should be reviewed by NTIA on a periodic basis. (Conclusion 4)

3. Due to demonstrated or planned use of the spectrum or a combined lack of existing or planned use by the Government and non-Government, the allocations for the following bands should be left unchanged:

17.7-17.8 GHz	24.05-24.25 GHz
17.8-18.6 GHz	24.25-25.25 GHz
18.6-18.8 GHz	27.5-29.5 GHz
18.8-19.7 GHz	29.5-30 GHz
19.7-20.2 GHz	30-31 GHz
20.2-21.2 GHz	31-31.3 GHz
21.2-21.4 GHz	31.3-31.8 GHz
21.4-22 GHz	31.8-32 GHz
22-22.21 GHz	32-33 GHz
22.21-22.5 GHz	33-33.4 GHz
22.5-22.55 GHz	33.4-36 GHz
22.55-23 GHz	36-37 GHz
23-23.55 GHz	37-38.6 GHz
23.55-23.6 GHz	38.6-39.5 GHz
23.6-24 GHz	39.5-40 GHz
24-24.05 GHz	40-40.5 GHz

(Conclusion 5)

4. Due to a lack of existing or planned use by the Government and some existing or planned use demonstrated by the non-Government, the status of allocated services should be reviewed for the following bands.

25.25-27 GHz (Suggested Change - Add non-Government Fixed and Mobile secondary)

27-27.5 GHz (Suggested Change - Add non-Government Fixed and Mobile secondary) (Conclusion 5)

5. The operating frequencies of ASDE radars, currently listed in the GMF within the 23.6-24.0 GHz band should be corrected by the FAA. (Conclusion 6)

6. The following planning activities should continue for the 17.7-40.5 GHz band;

A. The joint NTIA and FCC long range planning effort should develop a regularly updated multi-year planning document as part of its overall task.

B. The SPS should review new systems, initiate spectrum appraisals and make recommendations to the IRAC for changes to the allocation tables or

other actions as appropriate based upon a continuing appraisal of current and anticipated requirements at various points, e.g., 5,10,15 and 20 years ahead.

C. Ad Hoc committees should be used to address specific issues identified for these bands. (Conclusions 7,8)

7. NTIA and the FCC should continue to utilize established FAS coordination procedures while evaluating those procedures on a periodic basis, ensuring that they remain capable of handling the number of assignments and amount of coordination required in shared bands from 17.7 GHz to 40.5 GHz. (Conclusion 9)

8. In that current planning-to-implementation procedures (incorporated within the long range plan, SPS and FAS) do not ensure the carrying out of planning guidance, a review should be completed by the IRAC to determine the level of planning effectiveness (the ability of spectrum planners to direct future system characteristics) required and the means by which that level should be achieved. (Conclusion 10)

9. NTIA should use the RSMS Van to measure emitted signals associated with Government assignments determining the accuracy of assignment information and compliance with SPS guidance. In addition, the capability of the van should be extended to 40 GHz. (Conclusion 10,11)

10. NTIA should continue to review the progress of and coordinate the Government responses to FCC Documents addressing these bands. (Conclusion 12)

11. The FCC should coordinate via the IRAC all rule making proceedings pertaining to these bands. (Conclusion 12)

12. NTIA should determine in coordination with the IRAC/TSC and apply a method for evaluating spectrum efficiency as these bands mature. (Conclusion 13)

13. Experimental station classes should be altered to reflect the intended service of the final operational product in those systems leading to operational systems or technology related to a specific radio service. (Conclusion 14)

SECTION 3

ALLOCATIONS AND STANDARDS

INTRODUCTION

This section presents a discussion of the international and national allocation rules pertaining to spectrum use from 17.7-40.5 GHz and the U.S. Government technical standards for equipment operating in the band.

INTERNATIONAL ALLOCATIONS

APPENDIX A provides the frequency allocation tables which break up the spectrum into three international regions (United States is in Region 2) and fifteen radio services. Also listed in Appendix A are footnotes which clarify or alter the listed allocation provisions. The services allocated within these bands are summarized in TABLE 2.

These allocation tables were developed over years of international discussions and negotiations. The World Administrative Radio Conference of 1979 (WARC-79) provided the most recent opportunity for completely updating the tables. The tables included in APPENDIX A are those resulting from that conference now included in the NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management (NTIA Manual). Prior to and during the conference, representatives from both the U.S. Government and non-Government sectors developed, coordinated and presented the U.S. position. That position represented a best estimate of collective needs distributing available spectrum to the various radio services.

Historically, international allocation provisions have lagged behind experimentation, proof of need and feasibility studies. These bands, however, have been allocated in advance providing some, yet not restrictive, order for development.

Some allocations have certainly resulted from technical considerations. Shorter propagation distances lend themselves to short range fixed, mobile, radiolocation and radionavigation systems. The 30/20 GHz links provide new room for expansion of satellite use. Also, the currently "quiet" nature of these bands has provided spectrum for Space Research and Radio Astronomy.

NATIONAL ALLOCATIONS

APPENDIX A provides the frequency allocation tables covering U.S. Government and non-Government use of the 17.7-40.5 GHz band. These tables have resulted from negotiations between the Government and the FCC.

As the international tables, the national tables are based primarily upon predicted requirements and a distribution of services, Government and non-Government use. The information in APPENDIX A is summarized in TABLE 3.

TABLE 3 reveals that no bands are allocated to the Government exclusively, while 25% of the total spectrum is provided solely for non-Government use. Bands designated for equal sharing cover another 43% of the band. Government primary/non-Government secondary frequencies take up six bands totalling 7.05 GHz or 31%.

TABLE 2

SUMMARY OF INTERNATIONAL ALLOCATION TABLES

	PRIMARY ALLOCATIONS			SECONDARY ALLOCATIONS		
	# of Bands	Bandwidth Covered in GHz	% of 17.7-40.5 GHz	# of Bands	Bandwidth Covered in GHz	% of 17.7-40.5 GHz
Fixed	20	13.45	59			
Mobile	20	13.45	59			
Fixed Satellite	12	10.0	44			
Earth Exploration Satellite	7	2.59	11	3	1.45	6
Space Research	7	2.59	11	4	1.8	8
Radionavigation	6	3.4	15			
Radio Astronomy	4	1.19	5			
Inter-Satellite	4	2.0	9			
Mobile Satellite	3	3.0	13	2	1.0	4
Radiolocation	3	2.0	9			
Broadcast Satellite	2	.5	2			
Meteorological Aids	1	.8	4			
Amateur	1	.05	.2	1	.2	.9
Amateur Satellite	1	.05	.2			
Standard Time & Frequency				4	4.05	18

TABLE 3

SUMMARY OF NATIONAL ALLOCATION TABLES

	# of Bands	Total Bandwidth in GHz	% of 17.7-40.5 GHz
Exclusive Non-Government 17.7-17.8 17.8-18.6 18.8-19.7 19.7-20.2 24-24.05 27.5-29.5 29.5-30 38.6-39.5	8	5.75	25
Exclusive Government	0	0	0
Non-Government Primary/ Government Secondary 31-31.3	1	.3	1
Government Primary/ Non-Government Secondary 20.2-21.2 24.05-24.25 25.25-27 27-27.5 30-31 33.4-36	6	7.05	31
Shared Primary 18.6-18.8 21.2-21.4 21.4-22 22-22.21 22.21-22.5 22.5-22.55 22.55-23 23-23.55 23.55-23.6 23.6-24 24.25-25.25 31-31.3 31.3-31.8 31.8-32 32-33 33-33.4 36-37 37-38.6 39.5-40 40-40.5	20	9.7	43

Any discussion of increased sharing or availability for the non-Government must therefore deal with these six bands. Non-Government use is unhindered by designated allocations in all other bands. Increased sharing by the non-Government would then be defined as upgrading existing non-Government services to primary, adding new non-Government services or eliminating the existing Government allocations in these bands.

Increased sharing for the Government would involve adding new Government services to exclusive non-Government bands, or altering the status of Government and non-Government services in the one non-Government primary/Government secondary band (31-31.3 GHz).

Due to the effort that has been expended in planning and coordinating these bands, caution should be exercised in making changes unless the following can be demonstrated:

1. Non-Government Exclusive and non-Government Primary/Government Secondary Bands - Insignificant existing or planned use by non-Government interests, combined with significant demonstrated or proposed use by the Government.

2. Government Primary/non-Government Secondary - Insignificant existing or planned use by the Government, combined with significant demonstrated or proposed use by the non-Government.

TECHNICAL STANDARDS

Government standards applying to this band are presented in APPENDIX B. Lack of developmental or operational experience from 17.7-40.5 GHz makes it difficult to define required limits. Also, the present level of spectrum use greatly decreases the urgency to define limits which may have a secondary result in inhibiting development and production of initial systems. Consistency between Government and non-Government standards would be useful in allowing the use of new technology, components and systems by all interested parties.

SECTION 4

ASSIGNMENTS AND PLANNED SYSTEMS

INTRODUCTION

This section contains a description of the radio spectrum environment in the 17.7-40.5 GHz band. TABLES 4-6 provide statistical summaries of current assignments. Though it is a fact that each of these assignments may actually represent many equipment, the number of experimental and developmental station classes (usually one per equipment) would indicate that the assignment number closely represents the actual equipment count. These summaries reveal that use of these bands is still extremely limited. Even in the 24.05-24.25 GHz band there are only 3061 assignments or licenses (most are police radars that combine low power with highly directional antennas).

CURRENT ASSIGNMENTS

APPENDIX C provides data in detail concerning the current assignment of spectrum. The information presented is data drawn from the GMF in May, 1984. Many of the current systems are experimental and some others are not in accordance with the allocation tables. Non-Government data was drawn from the NGMF in September, 1983. Contact with the FAA determined that frequency assignments for ASDE radars in the 23.6-24.0 GHz band were in error. All other agencies confirmed that the GMF accurately reflected current use.

TABLE 4 shows that the number of assignments in each band is very small. The 24.05-24.25 GHz band far exceeds all others.

TABLE 5 indicates that the Department of Defense (DOD) is the primary user of these frequencies. The non-Government assignments within the GMF often represent initial tests by commercial vendors developing systems for DOD.

TABLE 6 shows that a large number of Government stations (40%) are experimental in nature. Most of the non-Government systems listed in the NGMF are Mobile (MO). Those that are police radars should actually be listed as Mobile Radiolocation (MR).

The first portion of TABLE 7 lists existing systems operating in these bands.

PROPOSED SYSTEMS

APPENDIX C provides additional information drawn from IRAC agency input, ECAC and NTIA files concerning developing or proposed systems. The second half of TABLE 7 summarizes this information.

Some Government agencies appear to be hesitant about developing systems in bands where passive systems are allocated. Also, the lack of separation of fixed and mobile systems in Fixed and Mobile non-Government bands is a deterrent to Government interest.

TABLE 4

SUMMARY OF ASSIGNMENTS BY BAND
17.7 GHz to 40.5 GHz

BAND		Assignments Reported in Government Master File		Licenses Reported in Non-Government Master File
		Government	Non-Government	Non-Government
17.7-17.8	GHz	0	0	14
17.8-18.6	GHz	3	5	26
18.6-18.8	GHz	0	0	74
18.8-19.7	GHz	2	2	23
19.7-20.2	GHz	1	0	8
20.2-21.2	GHz	19	1	11
21.2-21.4	GHz	0	0	0
21.4-22	GHz	25	37	25
22-22.21	GHz	2	27	6
22.21-22.5	GHz	21	22	1
22.5-22.55	GHz	0	0	0
22.55-23	GHz	36	0	1
23-23.55	GHz	32	90	20
23.55-23.6	GHz	13	0	0
23.6-24	GHz	13	1	1
24-24.05	GHz	0	0	4
24.05-24.25	GHz	65	8	2988
24.25-25.25	GHz	1	0	16
25.25-27	GHz	0	1	3
27-27.5	GHz	1	0	2
27.5-29.5	GHz	1	2	7
29.5-30	GHz	2	0	1
30-31	GHz	1	0	0
31-31.3	GHz	0	0	4
31.3-31.8	GHz	3	2	5
31.8-32	GHz	0	0	1
32-33	GHz	15	0	0
33-33.4	GHz	15	1	1
33.4-36	GHz	48	7	9
36-37	GHz	41	1	2
37-38.6	GHz	27	0	1
38.6-39.5	GHz	0	0	11
39.5-40	GHz	2	0	3
40-40.5	GHz	0	0	3
	TOTALS	389	207	3261

GMF - May, 1984
NGMF - September, 1983

TABLE 5

SUMMARY OF AGENCY ASSIGNMENTS
FROM
17.7-40.5 GHz

Agency	Total Assignments	21.4-22 GHz Band Only	23-23.55 GHz Band Only	24.05-24.25 GHz Band Only	33.4-36 GHz Band Only
GSA	3	1	2	--	--
DOJ	1	--	1	--	--
USAF	101	6	7	15	17
NG	216	35	91	10	8
USA	58	4	3	19	4
USN	117	4	4	7	8
DOE	31	6	8	2	12
DOI	18	--	--	18	--
FAA	13	--	--	--	--
CIA	8	--	--	--	--
DOC	6	--	--	1	3
NASA	6	1	1	1	3
VA	5	--	--	5	--
HHS	1	--	--	1	--
TVA	1	--	--	1	--
DOA	2	--	1	1	--
NSA	5	3	2	--	--
CG	4	2	2	--	--
TOTAL	596	62	122	81	55

GMF - May, 1984

*The 21.4-22 GHz, 23-23.55 GHz, 24.05-24.25 GHz, and 33.4-36 GHz are shown because they have the greatest number of assignments.

TABLE 6

SUMMARY OF STATION CLASS ASSIGNMENTS
FROM
17.7-40.5 GHz

Government Stations (as defined by the NTIA Manual)

	Station Class	File Count
Radiolocation - Mobile	MR	86
Experimental Testing	XT	103
Experimental Contract Development	XC	45
Experimental Development	XD	62
Experimental Research	XR	40
Radiolocation - Land	LR	22
Fixed	FX	263
Radionavigation - Land	RL	7
Experimental Composite	XM	2

Non-Government Station (as defined by the non-Government Master File)

	Station Class	File Count
Mobile	MO	1786
Operational Fixed	FXO	152
Fixed	FX	123
Fixed Base with Mobile	FX/MO	23
TV Pickup Mobile	MLT	17
*	FX5	4
Antenna Test Station	ANT	3
*	DT	2
Flight Test Station	FAT	2
Radio Astronomy	RA	2
Radiodetermination - Satellite Fixed Earth Station	TF	2
Cable Antenna Relay	CAR	1
Fixed Base	FB	1
TV Intercity Relay	FXN	1
Remote Pickup - Mobile	MLR	1
Mobile Radiolocation	MR	613
Mobile Radiolocation	PO	750

*No title could be found for these designators. They are most likely data errors.

GMF - May, 1984
NGMF - September, 1983

TABLE 7

SUMMARY OF PLANNED AND PROPOSED SYSTEMS

Existing Requirements

1. GENLSV112A, GENLSD122A, GENSTO82A

   A number of agencies operate these systems in the 21-23 GHz band at a number of locations within the United States. The General Electric Company products permit data transmission between host computers and remote terminals.

2. Remote Video Security Monitoring System - MVI-23VFM

   The National Security Agency (NSA) and Department of Energy operate this system in the 21-23 GHz band. The M/A-COM Inc. equipment permits communication links between buildings of a given facility for transmitting data, video conferencing, or security and surveillance applications.

3. Ratscat Radar 1482

   This Air Force radar operates in the 22-27 GHz bands in New Mexico.

4. Surveillance and Protection System - GENLSV042A.

   This DOE and Navy system operates in the 21-23.6 GHz band permitting the establishment of a one way videolink for experimental purposes at a number of locations.

5. Computer Data Link - RQMRACON III

   DOE operates this in the 23-23.55 GHz band for the transfer of computer data at various locations.

6. Airport Surface Detection Equipment (ASDE Radars)

   These FAA systems operate in the 24-24.05 GHz band in thirteen locations (eleven states and the District of Columbia).

7. Mobile Traffic Radar Guns

   These devices are used by nine federal agencies in approximately 65 locations throughout the United States. The equipment used includes KUSKR10, KUSHR12, KUSKR11, KUXKR11, KUSHR8, KUXHR4, KUSMR0007, KUSHR-4, KUSKR4, DCE724, and KUSHR11 and operate in the 24.05-24.25 GHz band.

8. Research Study of Clouds

   This work performed by the Department of Commerce (DOC) in Colorado uses the 24.05-24.25 GHz band. The equipment used is the SPRE-34.

9. Aircraft Landing Systems

These Navy systems operate in the 32-33 GHz band along the Atlantic and Pacific coasts plus Tennessee (training). The equipment used includes the AN/SPN-42A, (T1&T4) plus the AN/SPN-10.

10. LES 8/9 Satellite Program

These Air Force satellites are used in the development of uplink and downlink systems operated in the 33.4-38.6 GHz bands. The equipment used includes the AN/ASC-22 and AN/ASC-28.

11. Cloud Detection Radar

This experimental work by the DOE is conducted in the 33.4-36 GHz band in Nevada and New Mexico. The equipment consists of the LAPQ-1 cloud detection radar.

12. Radar Cross Section Measurements

This work performed by the Air Force uses the 33.4-36 GHz band in New Mexico. The equipment used is the RAT SCAT Radar.

13. Study of Precipitation and Cloud Physics

This work by the Air Force conducted in Massachusetts uses the 33.4-36 GHz band. The equipment used is the AN/TPQ-11.

14. Cloud Detection and Cloud Seeding Operations.

This work by the DOC is conducted in Utah and uses the 33.4-36 GHz band. The equipment used is the AN/TPQ-11.

15. Aircraft (A-10) Test Program

This work by the Air Force is conducted in California, Florida, and Nevada and uses the 33.4-36 GHz band. The equipment used is the WES WX-50.

16. Airborne Rainfall Rate Measurements

This work by the National Aeronautics and Space Administration (NASA) is conducted over the Pacific and Atlantic Oceans and uses the 33.4-36 GHz band.

17. Millimeter Wave Command Post Radio System

This experimental Army system is operated in Georgia in the 36-37 GHz band. The equipment used is the NOD3800.

18. HUG44440H

This Navy fixed equipment operates in the 37-38.6 GHz band in California.

19. NORDEN 3800

This experimental Air Force EHF Communication equipment operates in the 37-38 GHz band in New York.

20. Digital Instrumentation Radar

This NASA equipment operates in the 33-33.4 GHz and the 33.4-36 GHz bands in Virginia.

21. Instrumentation Radar

This Army system operates in the 33.4-36 GHz band in the vicinity of Goldstone, California. The equipment used is the AN/MPS-36 (modified).

22. Satellite Communications Set

This Air Force system operates in the 36-38.6 bands as a replacement for the AN/ASC-24.

23. FLEETSAT 7 and 8

This DOD system will use transponders between 20.2-21.2 GHz.

Projected Requirements

1. Transmission of data from airborne platform--infrared photography

This Department of Agriculture (DOA) requirement is expected to grow from one to three systems by 1990.

2. Short path digital links between computer facilities.

This DOA requirement is expected to grow to several hundred systems operating over short distances in the 23 GHz band.

3. Mobile Satellite

The DOA is examining applications of this developmental technology. Projected requirements have not yet been defined.

4. Short path digital data links between computer facilities.

This Bonneville Power Administration (within DOE) requirement has been examined; however, final definition of the scope awaits further analysis. Tentatively, the 21.4-22 GHz and the 22-22.21 GHz bands are being considered for this application.

5. Short path digital data links between host computer and remote terminal.

Projected requirements have not yet been defined by NASA.

6. Passive Remote Sensing

NASA has a vested interest in both earth exploration and space research (passive sensing) activities conducted in the 18.6-18.8 GHz band.

7. Advanced Communications Technology Satellite (ACTS).

This NASA program is expected to use the 17.7-20.2 GHz bands for space-to-Earth transmissions and the 27.5-30 GHz bands for Earth-to-space transmissions.

8. Ocean Circulation Mission - Topography Experiment (TOPEX).

This NASA program is expected to use the 20.2-21.2 GHz and the 31.3-31.8 GHz bands. Initial operation is expected by 1986.

9. Deep Space Use of 30/20 Technology

This NASA program is expected to use the 31.8-32.3 GHz and 34.2-34.7 GHz bands. Initial operation is planned for 1990.

10. Soil and Snow Moisture Research and Assessment Mission

This NASA program is expected to use the 18 and 37 GHz bands. Initial operation is planned for 1990.

11. Geopotential Research Mission (GPM).

This NASA program is expected to use the 40 GHz band. Initial operation is planned for 1989.

12. Tracking and Data Acquisition System (TDAS).

This NASA program is expected to use the 17.7-21.2 GHz bands for transmissions from space-to-Earth and the 27.5-31 GHz bands for transmissions from Earth-to-space. Initial operation is planned for 1990.

13. Environmental Satellite Sensors

This DOC program is expected to use operating frequencies near 23.8 and 31.4 GHz for passive operations plus operating frequencies near 37.5 GHz for active operations.

14. Very Long Baseline Array (VLBA).

This National Science Foundation program is expected to use the 21.3-25.3 GHz bands. Tentative locations, within the United States, for the receiver operations in this program include Haystack, Massachusetts; Iowa City, Iowa; Fort Davis, Texas; Kitt Peak, Arizona; Owens Valley, California; Oroville, Washington; Puerto Rico; Mauna Kea, Hawaii; Los Alamos, New Mexico; and Pie Town, New Mexico.

15. Airport Packet Radio

This FAA program is expected to use the following frequency bands: 21.2-22.5, 23-23.6, 25.25-27.5, and 36-38.6 GHz.

16. Monopulse Tracking Radar System

This Navy system is expected to use the 33.4-36 GHz band.

17. Millimeter Wave Active Seeker

This Air Force system is expected to use the 33.4-38.6 GHz band.

18. Multichannel Command Post Radio

This Army system is expected to use the 36-38.6 GHz band.

19. Microwave Fence Sensor

This Air Force system is expected to use the 36-37 GHz band.

20. MILSTAR EHF Satellite System

This DOD system will occupy the 20.2-21.2 GHz band.

21. Space Station

NASA is currently pursuing the development of a permanently manned space station which will have various spectrum requirement between 2 and 60 GHz. A specific requirement for Inter-Satellite and Space Research systems within the 25.25-27 GHz bands is being investigated.

22. AN/SPN-46(v) Carrier Landing System.

The Navy is planning this replacement for the AN/SPN-42 in the 33-33.46 GHz band. A frequency agile AN/SPN-46A(u) is planned for the 1990 timeframe.

23. TRAKX Radar System

This Navy system is a high angle resolution monopulse radar planned to operate from 34.7-35 GHz.

24. Multimode Guidance System

The Navy is experimenting with missile guidance systems made by Hughes and General Dynamics in the 33.4-36 GHz band.

25. K-Band Transponder Beacon

The Navy is experimenting with this beacon in the 33.07-33.22 GHz band.

26. Norden Millimeter Wave Communications System

The Navy is testing short range communications from 38-38.6 GHz.

SECTION 5

PLANNING AND COORDINATION

INTRODUCTION

This section presents a discussion of the application of planning and coordination procedures within the Government as they pertain to the 17.7-40.5 GHz frequency range. These procedures have long been characterized by decentralized responsibilities and authority, flexibility, and interagency trust and cooperation. The statement within the NTIA Manual that the allocation tables are a "guide" is one example of this structure. However, the years of successful performance by these procedures seem to confirm their ability to meet their objectives up to this point.

PLANNING

Though it would be difficult to say that more time and effort is required for planning the 17.7-40.5 GHz bands than most, it can certainly be said that planning these bands well requires significant attention. Few operational components exist for establishing a base of technical capabilities and equipment characteristics. Little time has been given to modeling and testing of environmental effects at these frequencies. Requirements are apt to change rapidly because relatively little money has been expended on operational inventories. Technological advance will make many of the systems developed today obsolete within ten years.

As each agency within the IRAC has a mission and communications requirements of its own, each is left to develop its own plan for meeting those needs. NTIA with the assistance of the IRAC serves a function of assembling those plans into one which will help avoid conflicts and duplication of effort. Avoiding duplication of effort will become a great challenge in these bands as new technologies are developed which allow many users access to the same frequencies. Coordination of Government use of satellite as well as terrestrial systems employing computer control of channel access, channel reuse through cellular configurations and advanced methods of encoding, modulating, trunking and multiplexing will be part of the technological advance.

To accomplish coordinated long range planning the Government process must incorporate a known, documented and regularly updated plan, the ability to fit new systems in that plan, and a capability to deal with specific issues that arise.

Executive Order 12046 places the responsibility upon NTIA for developing a comprehensive long range plan for Federal Government spectrum use. The content, frequency of update, and form of documentation are not specified by that order. Resources are now designated within NTIA to develop this documented plan as part of an NTIA-FCC joint effort for spectrum planning. This plan, if it is to be useful, requires cooperation from individual agencies through regular, timely and accurate submission of planning information. The job of coordinating the development of a Government plan is hindered by agency security restrictions and the lack of policing authority held by the spectrum management officials over their own agency's communications development and procurement. Also, in undeveloped bands like these many systems are noted as

experimental within the data bases collected. This is encouraged by the use of experimental station classes. Some of these are truly for concept experimentation, but many represent the initial steps in development of a future operational system within a specific service. Having to identify the planned radio function and service for each of these greatly adds to the data compilation effort of all agencies.

The SPS is that organization currently tasked with presenting long term requirements and making recommendations for apportioning the spectrum appropriately.

New systems are added into the plan through the systems review process outlined within Section 8.3 of the NTIA Manual. This process revolves around the review of a loosely defined category of systems called "major". This term clearly eliminates many systems from being included in the planning process. However, the lack of clarity in definition allows for variations in interpretation and determination whether a new system will have a major impact on the environement. This problem does not exist for space systems which all require submission to the SPS.

Because the SPS is responsible for providing system developers with spectrum management guidance and that guidance is implemented through frequency assignments, the SPS/FAS interaction is extremely important to the effectiveness of the planning process. The implementation of SPS guidance is hindered by several factors:

(1) Much of the guidance particularly in the area of standards and system characteristics cannot be checked by the FAS due to insufficient data required in the submission of a frequency assignment.

(2) Actual system characteristics cannot be verified so the submitters' word in matters of compliance with SPS guidance must be accepted by the FAS.

The third aspect of the planning process deals with issues that arise in implementing the overall plan. This includes determining services allocated, calculating sharing criteria, developing technical standards and establishing channeling plans. Though not specifically directed, this responsibility has fallen on the TSC and various Ad Hoc committees within the IRAC. One particular issue being addressed currently is the definition of spectrum efficiency. The technical expertise and experience resident in these commmittees have served well to resolve past issues.

COORDINATION

The fact that 57% of the individual bands between 17.7 and 40.5 GHz are shared will have an impact on one particular aspect of spectrum management, Government/non-Government coordination. This coordination is currently carried out within the FAS where the FCC presents memoranda requests on non-Government use. All agencies within the FAS are given a period of time to review the requests and voice objections.

The FAS currently processes approximately 60,000 assignment actions per year. At this point, no great complaints exist in the functioning of this system. Though no advanced computer modeling capability is used in checking

each new assignment for compatibility, problems continue to be avoided through personal communication between members of the FAS. However, because the NTIA Manual states that dealing directly with interference sources is the first step to eliminating interference, problems probably do not surface as specific complaints against the FAS system. Though a higher percentage of assignments within these bands will require Government/non-Government coordination, the numbers still remain so small that a great impact within the next ten years does not appear probable.

One aspect of coordination with the FCC that could benefit from dedicated resources stems from the fact that the FCC is regularly establishing Documents for proposed changes to the FCC Rules. These rules at times touch upon the allocation tables themselves or other technical operating criteria. Though the Government has responded to these inquires before, no specific responsibility or method to review and respond to them exists in the NTIA Manual.

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LIST OF ABBREVIATIONS

ACTS	Advanced Communications Technology Satellite
ASDE	Airport Surface Detection Equipment
BSS	Broadcasting Satellite Service
CG	Coast Guard
CIA	Central Intelligence Agency
DOA	Department of Agriculture
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DOJ	Department of Justice
ECAC	Electromagnetic Compatibility Analysis Center
EIRP	Effective Isotropically Radiated Power
EMC	Electromagnetic Compatibility
FAA	Federal Aviation Administration
FAS	Frequency Assignment Subcommittee
FCC	Federal Communications Commission
GMF	Government Master File
GSA	Government Services Administration
HHS	Department of Health and Human Services
IRAC	Interdepartment Radio Advisory Committee
LRP	Long Range Plan
NASA	National Aeronautics and Space Administration
NG	Non-Government
NGMF	Non-Government Master File
NSA	National Security Agency
NTIA	National Telecommunications and Information Administration
SPS	Spectrum Planning Subcommittee
SRA	Spectrum Resource Assessment
TDAS	Tracking and Data Acquisition System
TOPEX	Topography Experiment
TSC	Technical Subcommittee
TVA	Tennessee Valley Authority
USA	U.S. Army
USAF	U.S. Air Force
USN	U.S. Navy
VA	Veterans Administration
WARC-79	World Administrative Radio Conference 1979
WG	Working Group

APPENDIX A

FREQUENCY ALLOCATIONS FOR THE 17.7-40.5 GHz BAND

INTERNATIONAL			UNITED STATES				
Region 1 *GHz*	*Region 2* *GHz*	*Region 3* *GHz*	*Band* *GHz* *1*	*National Provisions* *2*	*Government Allocation* *3*	*Non-Government Allocation* *4*	*Remarks* *5*
17.7-18.1 FIXED FIXED-SATELLITE (Space-to-Earth) (Earth-to-space) 869 MOBILE			17.7-17.8	US271		FIXED FIXED-SATELLITE (Space-to-Earth) (Earth-to-space) MOBILE NG140	
18.1-18.6 FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE 870			17.8-18.6	870		FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE	
18.6-18.8 FIXED FIXED-SATELLITE (Space-to-Earth) 872 MOBILE except aeronautical mobile Earth Exploration-Satellite (Passive) Space Research (Passive) 871	18.6-18.8 EARTH EXPLORATION-SATELLITE (Passive) FIXED FIXED-SATELLITE (Space-to-Earth) 872 MOBILE except aeronautical mobile SPACE RESEARCH (Passive) 871	18.6-18.8 FIXED FIXED-SATELLITE (Space-to-Earth) 872 MOBILE except aeronautical mobile Earth Exploration-Satellite (Passive) Space Research (Passive) 871	18.6-18.8	US254 US255	EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)	

INTERNATIONAL			UNITED STATES				
Region 1 *GHz*	*Region 2* *GHz*	*Region 3* *GHz*	*Band* *GHz* *1*	*National Provisions* *2*	*Government Allocation* *3*	*Non-Government Allocation* *4*	*Remarks* *5*
18.8–19.7	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE		18.8–19.7			FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE	
19.7–20.2	FIXED-SATELLITE (Space-to-Earth) Mobile-Satellite (Space-to-Earth) 873		19.7–20.2			FIXED-SATELLITE (Space-to-Earth) Mobile-Satellite (Space-to-Earth)	
20.2–21.2	FIXED-SATELLITE (Space-to-Earth) MOBILE-SATELLITE (Space-to-Earth) Standard Frequency and Time Signal-Satellite (Space-to-Earth) 873		20.2–21.2		FIXED-SATELLITE (Space-to-Earth) MOBILE-SATELLITE (Space-to-Earth) Standard Frequency and Time Signal-Satellite (Space-to-Earth) G117	Standard Frequency and Time Signal-Satellite (Space-to-Earth)	
21.2–21.4	EARTH EXPLORATION-SATELLITE (Passive) FIXED MOBILE SPACE RESEARCH (Passive)		21.2–21.4	US263	EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive) FIXED MOBILE	FIXED MOBILE EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)	
21.4–22	FIXED MOBILE		21.4–22		FIXED MOBILE	FIXED MOBILE	
22–22.21	FIXED MOBILE except aeronautical mobile 874		22–22.21	874	FIXED MOBILE except aeronautical mobile	FIXED MOBILE except aeronautical mobile	

INTERNATIONAL			UNITED STATES				
Region 1 *GHz*	*Region 2* *GHz*	*Region 3* *GHz*	*Band* *GHz* *1*	*National* *Provisions* *2*	*Government* *Allocation* *3*	*Non-Government* *Allocation* *4*	*Remarks* *5*
22.21–22.5 EARTH EXPLORATION-SATELLITE (Passive) FIXED MOBILE except aeronautical mobile RADIO ASTRONOMY SPACE RESEARCH (Passive) 875 876			22.21–22.5	US263 875	FIXED MOBILE except aeronautical mobile RADIO ASTRONOMY EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)	FIXED MOBILE except aeronautical mobile RADIO ASTRONOMY EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)	
22.5–22.55 FIXED MOBILE	22.5–22.55 FIXED MOBILE BROADCASTING-SATELLITE 877 878		22.5–22.55	US211	FIXED MOBILE	FIXED MOBILE BROADCASTING-SATELLITE	
22.55–23 FIXED INTER-SATELLITE MOBILE 879	22.55–23 FIXED INTER-SATELLITE MOBILE BROADCASTING-SATELLITE 877 878 879		22.55–23	US278 879	INTER-SATELLITE FIXED MOBILE	FIXED MOBILE BROADCASTING-SATELLITE INTER-SATELLITE	
23–23.55 FIXED INTER-SATELLITE MOBILE 879			23.-23.55	US278 879	FIXED MOBILE INTER-SATELLITE	FIXED MOBILE INTER-SATELLITE	
23.55–23.6 FIXED MOBILE			23.55–23.6		FIXED MOBILE	FIXED MOBILE	
23.6–24 EARTH EXPLORATION-SATELLITE (Passive) RADIO ASTRONOMY SPACE RESEARCH (Passive) 880			23.6–24	US74 US246	RADIO ASTRONOMY EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)	RADIO ASTRONOMY EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)	

INTERNATIONAL			UNITED STATES				
Region 1 GHz	*Region 2 GHz*	*Region 3 GHz*	*Band GHz 1*	*National Provisions 2*	*Government Allocation 3*	*Non-Government Allocation 4*	*Remarks 5*
24–24.05	AMATEUR AMATEUR-SATELLITE 881		24–24.05	US211 881		AMATEUR AMATEUR-SATELLITE	
24.05–24.25	RADIOLOCATION Amateur Earth Exploration-Satellite (Active) 881		24.05–24.25	US110 881	RADIOLOCATION Earth Exploration-Satellite (Active) G59	Amateur Radiolocation Earth Exploration-Satellite (Active)	(ISM 24.125±125 MHz)
24.25–25.25	RADIONAVIGATION		24.25–25.25		RADIONAVIGATION	RADIONAVIGATION	
25.25–27	FIXED MOBILE Earth Exploration-Satellite (Space-to-space) Standard Frequency and Time Signal-Satellite (Earth-to-space)		25.25–27		FIXED MOBILE Earth Exploration-Satellite (Space-to-space) Standard Frequency and Time Signal-Satellite (Earth-to-space)	Standard Frequency and Time Signal-Satellite (Earth-to-space) Earth Exploration-Satellite (Space-to-space)	
27–27.5 FIXED MOBILE Earth Exploration-Satellite (Space-to-space)	27–27.5 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (Space-to-space)		27–27.5		FIXED MOBILE Earth Exploration-Satellite (Space-to-space)	Earth Exploration-Satellite (Space-to-space)	
27.5–29.5	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE		27.5–29.5			FIXED FIXED-SATELLITE (Earth-to-space) MOBILE	
29.5–30	FIXED-SATELLITE (Earth-to-space) Mobile-Satellite (Earth-to-space) 882 883		29.5–30	882		FIXED-SATELLITE (Earth-to-space) Mobile-Satellite (Earth-to-space)	

INTERNATIONAL			UNITED STATES				
Region 1 *GHz*	*Region 2* *GHz*	*Region 3* *GHz*	*Band* *GHz* *1*	*National Provisions* *2*	*Government Allocation* *3*	*Non-Government Allocation* *4*	*Remarks* *5*
30–31	FIXED-SATELLITE (Earth-to-space) MOBILE-SATELLITE (Earth-to-space) Standard Frequency and Time Signal-Satellite (Space-to-Earth) 883		30–31		FIXED-SATELLITE (Earth-to-space) MOBILE-SATELLITE (Earth-to-space) Standard Frequency and Time Signal-Satellite (Space-to-Earth) G117	Standard Frequency and Time Signal-Satellite (Space-to-Earth)	
31–31.3	FIXED MOBILE Standard Frequency and Time Signal-Satellite (Space-to-Earth) Space Research 884 885 886		31–31.3	US211 886	Standard Frequency and Time Signal-Satellite (Space-to-Earth)	FIXED MOBILE Standard Frequency and Time Signal-Satellite (Space-to-Earth)	
31.3–31.5	EARTH EXPLORATION-SATELLITE (Passive) RADIO ASTRONOMY SPACE RESEARCH (Passive) 887		31.3–31.8	US74 US246	RADIO ASTRONOMY EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)	RADIO ASTRONOMY EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)	
31.5–31.8 EARTH EXPLORATION-SATELLITE (Passive) RADIO ASTRONOMY SPACE RESEARCH (Passive) Fixed Mobile except aeronautical mobile 888 889	31.5–31.8 EARTH EXPLORATION-SATELLITE (Passive) RADIO ASTRONOMY SPACE RESEARCH (Passive) 888	31.5–31.8 EARTH EXPLORATION-SATELLITE (Passive) RADIO ASTRONOMY SPACE RESEARCH (Passive) Fixed Mobile except aeronautical mobile 888					

INTERNATIONAL			UNITED STATES				
Region 1 GHz	*Region 2 GHz*	*Region 3 GHz*	*Band GHz* 1	*National Provisions* 2	*Government Allocation* 3	*Non-Government Allocation* 4	*Remarks* 5
31.8–32 RADIONAVIGATION Space Research 890 891 892			31.8–32.0	US69 US211 US262	RADIONAVIGATION	RADIONAVIGATION	
32–32.3 INTER-SATELLITE RADIONAVIGATION Space Research 890 891 892 893			32–0–33.0	US69 US262 US278 893	RADIONAVIGATION INTER-SATELLITE	RADIONAVIGATION INTER-SATELLITE	
32.3–33 INTER-SATELLITE RADIONAVIGATION 892 893							
33–33.4 RADIONAVIGATION 892			33.0–33.4	US69	RADIONAVIGATION	RADIONAVIGATION	
33.4–34.2 RADIONAVIGATION 892 894			33.4–36.0	US110 US252 897	RADIOLOCATION	Radiolocation	
34.2–35.2 RADIOLOCATION Space Research 895 896 894							
35.2–36 METEOROLOGICAL AIDS RADIOLOCATION 894 897					G34		

INTERNATIONAL			UNITED STATES				
Region 1 GHz	*Region 2 GHz*	*Region 3 GHz*	*Band GHz* *1*	*National Provisions* *2*	*Government Allocation* *3*	*Non-Government Allocation* *4*	*Remarks* *5*
36–37	EARTH EXPLORATION-SATELLITE (Passive) FIXED MOBILE SPACE RESEARCH (Passive) 898		36–37	US263 898	FIXED MOBILE EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)	FIXED MOBILE EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)	
37–37.5	FIXED MOBILE 899		37–38.6		FIXED MOBILE	FIXED MOBILE	
37.5–39.5	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE 899		38.6–39.5	US291		FIXED MOBILE FIXED-SATELLITE (Space-to-Earth)	
39.5–40.5	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE MOBILE-SATELLITE (Space-to-Earth)		39.5–40	US291	FIXED-SATELLITE (Space-to-Earth) MOBILE-SATELLITE (Space-to-Earth) G117	FIXED MOBILE FIXED-SATELLITE (Space-to-Earth) MOBILE-SATELLITE (Space-to-Earth)	
			40–40.5		FIXED-SATELLITE (Space-to-Earth) MOBILE-SATELLITE (Space-to-Earth) G117	FIXED-SATELLITE (Space-to-Earth) MOBILE-SATELLITE (Space-to-Earth)	

881—The band 24–24.25 GHz (centre frequency 24.125 GHz) is designated for industrial, scientific and medical (ISM) applications. Radiocommunication services operating within this band must accept harmful interference which may be caused by these applications. ISM equipment operating in this band is subject to the provisions of No. 1815.

882—The band 29.95–30 GHz may be used for space-to-space links in the earth exploration-satellite service for telemetry, tracking, and control purposes, on a secondary basis.

883—Additional allocation: in Afghanistan, Saudi Arabia, Bahrain, Cameroon, China, the Republic of Korea, the United Arab Emirates, Ethiopia, India, Indonesia, Iran, Iraq, Israel, Japan, Kenya, Kuwait, the Lebanon, Malaysia, Mali, Morocco, Mauritania, Nepal, Pakistan, Qatar, Syria, Singapore, Somalia, Sudan, Sri Lanka, Chad and Thailand, the band 29.5–31 GHz is also allocated to the fixed and mobile services on a secondary basis. The power limits specified in Nos. 2505 and 2508 shall apply.

885—Different category of service: in Bulgaria, Cuba, Hungary, Mongolia, Poland, the German Democratic Republic, Czechoslovakia and the U.S.S.R., the allocation of the band 31–31.3 GHz to the space research service is on a primary basis (see No. 425).

886—In making assignments to stations of other services, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference in the band 31.2–31.3 GHz. Emissions from space or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. 343 and 344 and Article 36).

887—All emissions in the band 31.3–31.5 GHz are prohibited.

888—In Regions 1 and 3, in making assignments to stations of other services to which the band 31.5–31.8 GHz is allocated, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. Emissions from space or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. 343 and 344 of Article 36). In Region 2, all emissions in the band 31.5–31.8 GHz are prohibited.

889—Different category of service: in Bulgaria, Egypt, Hungary, Mongolia, Poland, the German Democratic Republic, Roumania, Czechoslovakia and the U.S.S.R., the allocation of the band 31.5–31.8 GHz to the fixed and mobile, except aeronautical mobile, services is on a primary basis (see No. 425).

890—Different category of service: in Australia, Spain and the United States, the allocation of the band 31.8–32.3 GHz to the space research service (deep space) in the space-to-Earth direction is on a primary basis (see No. 425). This use shall not impose power flux-density constraints on the inter-satellite service in the band 32–32.3 GHz.

891—Different category of service: in Bulgaria, Cuba, Hungary, Mongolia, Poland, the German Democratic Republic, Czechoslovakia and the U.S.S.R., the allocation of the band 31.8–32.3 GHz to the space research service is on a primary basis (see No. 425).

892—Subject to agreement obtained under the procedure set forth in Article 14, the band 31.8–33.8 GHz may also be used in Japan for space-to-Earth transmissions in the fixed-satellite service up to 31 December 1990.

893—In designing systems for the inter-satellite and radionavigation services in the band 32–33 GHz, administrations shall take all necessary measures to prevent harmful interference between these two services, bearing in mind the safety aspects of the radionavigation service (see Recommendation 707).

894—Additional allocation: in Afghanistan, Saudi Arabia, Bahrain, Bangladesh, Egypt, the United Arab Emirates, Spain, Finland, Gabon, Guinea, Indonesia, Iran, Iraq, Israel, Kenya, Kuwait, the Lebanon, Libya, Malaysia, Malawi, Mali, Malta, Morocco, Mauritania, Nepal, Niger, Nigeria, Oman, Pakistan, the Philippines, Qatar, Syria, Senegal, Singapore, Somalia, Sudan, Sri Lanka, Sweden, Tanzania, Thailand, Togo, Tunisia, Yemen A.R. and Zaire, the band 33.4–36 GHz is also allocated to the fixed and mobile services on a primary basis.

897—Radars located on spacecraft may be operated on a primary basis in the band 35.5–35.6 GHz.

898—In making assignments to stations of other services, administrations are urged to take all practicable steps to protect the spectral line observations of the radio astronomy service in the band 36.43–36.5 GHz from harmful interference. Emissions from space or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. 343 and 344 and Article 36).

899—Subject to agreement obtained under the procedure set forth in Article 14, the band 37–39 GHz may also be used in Japan for Earth-to-space transmissions in the fixed-satellite service up to 31 December 1990.

US69—In the band 31.8–33.4 GHz, ground-based radionavigation aids are not permitted except where they operate in co-operation with airborne or shipborne radionavigation devices.

US74—In the bands 25.55–25.67, 73–74.6, 406.1–410, 608–614, 1400–1427, 1660.5–1670, 2690–2700, and 4990–5000 MHz and in the bands 10.68–10.7, 15.35–15.4, 23.6–24, 31.3–31.8, 86–92,105–116, and 217–231 GHz, the radio astronomy service shall be protected from extraband radiation only to the extent such radiation exceeds the level which would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates.

US110—In the frequency bands 3100–3300 MHz, 3500–3700 MHz, 5250–5350 MHz, 8500–9000 MHz, 9200–9300 MHz, 9500–10000 MHz, 13.4–14.0 GHz, 15.7–17.3 GHz, 24.05–24.25 GHz and 33.4–36 GHz, the non-Government radiolocation service shall be secondary to the Government radiolocation service and to airborne doppler radars at 8800 MHz, and shall provide protection to airport surface detection equipment (ASDE) operating between 15.7–16.2 GHz.

US211—In the bands 1670–1690, 5000–5250 MHz, and 10.7–11.7, 15.1365–15.35, 15.4–15.7, 22.5–22.55, 24–24.05, 31.0–31.3, 31.8–32, 40.5–42.5, 84–86, 102–105, 116–126, 151–164, 176.5–182, 185–190, 231–235, 252–265 GHz, applicants for airborne or space station assignments are urged to take all practicable steps to protect radio astronomy observations in the adjacent bands from harmful interference; however, US74 applies.

US246—No stations will be authorized to transmit in the bands 608–614 MHz, 1400–1427 MHz, 1660.5–1668.4 MHz, 2690–2700 MHz, 4990–5000 MHz, 10.68–10.70 GHz, 15.35–15.40 GHz, 23.6–24.0 GHz, 31.3–31.8 GHz, 51.4–54.25 GHz, 58.2–59.0 GHz, 64–65 GHz, 86–92 GHz, 100–102 GHz, 105–116 GHz, 164–168 GHz, 182–185 GHz and 217–231 GHz.

US252—The bands 2110–2120 and 7145–7190 MHz, 34.2–34.7 GHz are also allocated for earth-to-space transmissions in the Space Research Service, limited to deep space communications at Goldstone, California.

US255—In the band 18.6–18.8 GHz, the fixed satellite service shall be limited to a power flux density at the Earth's surface of -101 dbW/M^2 in a 200 MHz band for all angles of arrival.

US262—The band 31.8–32.3 GHz is also allocated for space-to-earth transmissions in the Space Research Service, limited to deep space communications at Goldstone, California.

US263—In the frequency bands 21.2–21.4, 22.21–22.5, 36–37, 50.2–50.4, 54.25–58.2, 116–126, 150–151, 174.5–176.5, 200–202 and 235–238 GHz, the Space Research and the Earth Exploration-Satellite Services shall not receive protection from the Fixed and Mobile Services operating in accordance with the Table of Frequency Allocations.

US271—The use of the band 17.3–17.8 GHz by the Fixed-Satellite Service (Earth-to-space) is limited to feeder links for Broadcasting-Satellite Service.

US278—In the 22.5–23.55 and 32–33 GHz bands, non-geostationary intersatellite links may operate on a secondary basis to geostationary intersatellite links.

US291—Television pickup stations in the mobile service may be authorized to use frequencies in the band 38.6–40 GHz on a secondary basis to stations operating in accordance with the Table of Frequency Allocations.

G59—In the bands 902–928 MHz, 3100–3300 MHz, 3500–3700 MHz, 5250–5350 MHz, 8500–9000 MHz, 9200–9300 MHz, 13.4–14.0 GHz, 15.7–17.7 GHz and 24.05–24.25 GHz, all Government non-military radiolocation shall be secondary to military radiolocation, except in the sub-band 15.7–16.2 GHz airport surface detection equipment (ASDE) is permitted on a co-equal basis subject to coordination with the military departments.

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.

NG140—Pending adopting of further specific rules concerning usage of the band 17.3–17.8 GHz by the fixed-satellite service for the purpose of providing feeder links to the broadcasting-satellite service, systems may be authorized for this purpose subject to the condition that adjustments in certain system design or technical parameters may become necessary during the system lifetime. The necessity for such adjustments, and their extent, will be dependent upon the Final Acts of the 1983 Regional Administrative Radio Conference and subsequent Commission decisions.

APPENDIX B

GOVERNMENT STANDARDS

The following are the frequency tolerance standards for transmitters, stated in parts per million, as required by Section 5.2 of the NTIA Manual. The standard for spurious emission levels is designated by the letters F, I, or K which refer to other portions of 5.2.

Frequency Bands and Station Types	*Tolerances*	
	Spurious	*Frequency*
BAND: 10.5 to 30 GHz		
1. Fixed Stations	I	50
2. Land Stations	I	100
3. Mobile Stations	I	100
4. Radionavigation Stations		
4.1 radar	F	2500
4.2 other than above	I	2500
5. Radiolocation Stations		
5.1 radar	F	2500
5.2 other than above	I	2500
6. Earth Stations	K	50
7. Space Stations	K	50
8. Broadcasting Stations	K	100
BAND: 30 to 40 GHz		
1. Fixed Stations	I	75
2. Land Stations	I	150
3. Mobile Stations	I	150
4. Radionavigation Stations		
4.1 radar	F	5000
4.2 other than above	I	5000
5. Radiolocation Stations		
5.1 radar	F	5000
5.2 other than above	I	5000
6. Earth Stations	K	75
7. Space Stations	K	75
8. Broadcasting Stations	K	100
BAND: Above 40 GHz		
1. Fixed Stations	I	75
2. Land Stations	I	150
3. Mobile Stations	I	150
4. Radionavigation Stations	I	5000
5. Radiolocation Stations	I	5000
6. Earth Stations	K	75
7. Space Stations	K	75

The applicable portions of 5.2 providing spurious emission guidance are as follows:

F. Spurious tolerances for radionavigation radars and radiolocation radars are found in Section 5.3.

I. The mean power of any emission supplied to the antenna transmission line, as compared with the mean power of the fundamental, shall be in accordance with the following (above 40 GHz these are design objectives pending further experience at these orders of frequency):

1. On any frequency removed from the assigned frequency by more than 75 percent, up to and including 150 percent of the authorized bandwidth, at least 25 decibels attenuation:

2. On any frequency removed from the assigned frequency be more than 150 percent, up to and including 300 percent of the authorized bandwidth, at least 35 decibels attenuation; and

3. On any frequency removed from the assigned frequency by more than 300 percent of the authorized bandwidth, for transmitters with mean power of 5 kilowatts or greater, at least 80 decibels attenuation; and for transmitters with mean power less than 5 kilowatts, at least 43 plus 10 $\log_{10}$ (mean power of the fundamental in watts) decibels attenuation (i.e., 50 microwatts absolute level).

K. Development of spurious tolerances in pending.

Note that the letter "F" further refers to Section 5.3 the Radar Spectrum Engineering Criteria. These criteria vary based upon the particular radar signal employed. Paragraphs 4,5,6,7, on pages 5-11 provide requirements for emission levels, antenna patterns, frequency tolerance and tunability for all radars regardless of the emission type.

5.3 Radar Spectrum Engineering Criteria (RSEC)

General

The wide application of radar for various functions makes large demands on the electromagnetic spectrum, and requires the application of effective frequency management measures for the equipment and systems involved. Criteria for certain equipment characteristics are specified herein to ensure an acceptable degree of electromagnetic compatibility among radar systems, and between such systems and those of other radio services sharing the frequency spectrum. (See Section 5.3.4 for instructions for determining the basic Radar Emission Bandwidth and Maximum Spectral Level.)

These criteria are concerned with promoting efficient use of the spectrum, and in specifying them there is no intent to require particular numerical values from the standpoint of the radar's mission. For example, characteristics such as power, sensitivity, pulse repetition rate, pulse duration, pulse rise time, and the range of radio frequency emission are closely related to operational requirements. Accordingly, where limits for some of these characteristics are specified herein, the criteria have been chosen to avoid undue degradation of operational effectiveness. Moreover, the specification of these criteria is compatible with the policy of encouraging a free and unrestricted approach in further research looking toward more effective radars. Nevertheless, any proposals for new approaches and new system concepts involving radar must be reviewed from a frequency management viewpoint prior to development of new equipment.

Useful receiver techniques are available for reduction of the susceptibility of radars to low-duty-cycle pulse interference. The applicability of such devices as video integrators, correlators, PRF and pulse width discriminators varies with factors such as cost, availability, and their adaptability to specific equipments and environmental situations. While the mandatory incorporation of such devices is not specified herein, their application is recommended for low-duty-cycle radars intended for operation in congested frequency bands and geographic areas.

All primary radars[1] shall be classified in one of four groups as shown in the following table and then shall come under the criteria indicated for that group.

[1] Primary Radar: A radiodetermination system based on the comparison of reference signals with radio signals reflected from the position to be determined. (No. 95 of the ITU Radio Regulations, 1982 Edition.)

For radars employing more than a single emitter, including phased array radars, variable PRF radars, radars whose modulation changes from pulse to pulse, and other special types of radars for which any of the following criteria cannot be directly applied, special methods may be required in establishing appropriate criteria. Pending adoption of technical criteria for such radars, values submitted for these parameters shall be accompanied by an explanation of their derivation.

The provisions of Section 5.3.1, Criteria B, are applicable to Class 1 spacebased radar systems [2] on a case-by-case basis. The provisions of Section 5.3.1 or Section 5.3.2 (i.e. Criteria B or C as appropriate) are applicable to Class 2 spacebased radar systems [3] and active spaceborne sensors [4] on a case-by-case basis. See Section 8.2.41 for further guidance concerning spacebased radiolocation and active sensor systems.

In the special case where government radionavigation radars operate in the shared government/non-government band 9300–9500 MHz, an acceptable degree of electromagnetic compatibility is deemed to be that degree of compatibility associated with the radar equipments commercially available to the non-government community of users. The vast preponderance of the use of this band by non-government domestic and foreign ships and aircraft creates a situation where relatively inexpensive commercial equipment is available "off the shelf" and at the same time equipment improvements which might be incorporated unilaterally by small numbers of government stations would have little effect on the band as a whole. Accordingly, government radionavigation radars to be operated in this band having a rated peak power of 100 kW or less are placed in Group A with the understanding that government agencies would procure equipments that are acceptable for non-government use and that this exemption will be reexamined should the situation in this band change.

Radar Description	Applicable Criteria
Group A	*Criteria A*
Pulsed radars of 1 kW or less rated peak power; or Radars with an operating frequency above 40 GHz; or Man-portable[5] radars; or Man-transportable[6] radars; or Radionavigation radars in the band 9300–9500 MHz; as described above. Expendable, nonrecoverable radars on missiles	Presently exempt from any RSEC.
Group B	*Criteria B*
Radars having a rated peak power of more than 1 kW but not more than 100 kW and operating between 2900 MHz and 40 GHz.	See 5.3.1.
Group C	*Criteria C*
All radars not included in Group A, B, or D	See 5.3.2.
Group D	*Criteria D*
All fixed radars in the 2700–2900 MHz band.	See 5.3.3

[2] Spacebased Radiolocation System—Class 1: a radiolocation system in space the primary function of which is the detection and location of objects on or near the surface of the Earth.

[3] Spacebased Radiolocation System—Class 2: a radiolocation system installed aboard a spacecraft for the purpose of determining the relative positions or velocities of one or more extravehicular objects.

[4] Active Spaceborne Sensor—a measuring instrument in the Earth Exploration Service, or in the Space Research Service, by means of which physical measurements of various phenomena are obtained through transmission and reception of radio waves.

[5] Man-portable: Items which are designed to be carried as a component part of individual, crew-served or team equipment in conjunction with assigned duties. Upper weight limit is approximately 30 pounds.

[6] Man-transportable: Items which are usually transported on wheeled, tracked or air vehicles but have integral provisions to allow periodic handling by one or more individuals for limited distances (i.e. 100–500 meters). Upper weight limit approximately 65 pounds per individual.

Waivers

Waiver of the requirements herein may be requested when supported by reasonable justification. When technical and engineering data are supplied in support of a request for waiver or in evaluating the performance of equipment pursuant to provisions of paragraph 2 of part 5.0, an explanation of the non-conforming parameters and measurement methods employed shall be furnished. Manufacturer's data may be used where deemed appropriate and adequate.

Symbols Used

B = emission bandwidth, in MHz.

B_c = bandwidth of the frequency deviation. (The total frequency shift during the pulse duration) in MHz.

B_d = bandwidth of the frequency deviation (peak difference between instantaneous frequency of the modulated wave and the carrier frequency)—(FM/CW radar systems).

B_s = maximum range in MHz over which the carrier frequency will be shifted for a frequency hopping radar.

d = pulse compression ratio = emitted pulse duration/compressed pulsed duration (at 50% amplitude points).

F_o = operating frequency in MHz. For non-FM pulse radars the peak of the power spectrum; for FM pulse radars the average of the lowest and highest carrier frequencies during the pulse.

N = total number of chips (subpulses) contained in the pulse. ($N = 1$ for non-FM and FM pulse radars.)

PG = processing gain (dB).

P_p = peak power (dBm)

PRR = pulse repetition rate in pulses per second.

P_t = maximum spectral power density $-$dBm/kHz.

t = emitted pulse duration in u sec. at 50% amplitude (voltage) points. For coded pulses the pulse duration is the interval between 50% amplitude points of one chip (sub-pulse). The 100% amplitude is the nominal flat top level of the pulse (see Fig. 1).

t_r = emitted pulse rise time in u sec. from the 10% to the 90% amplitude points on the leading edge. See Fig. 1. For coded pulses it is the rise time of a sub-pulse; if the sub-pulse rise time is not discernible, assume that it is 40% of the time to switch from one phase or sub-pulse to the next.

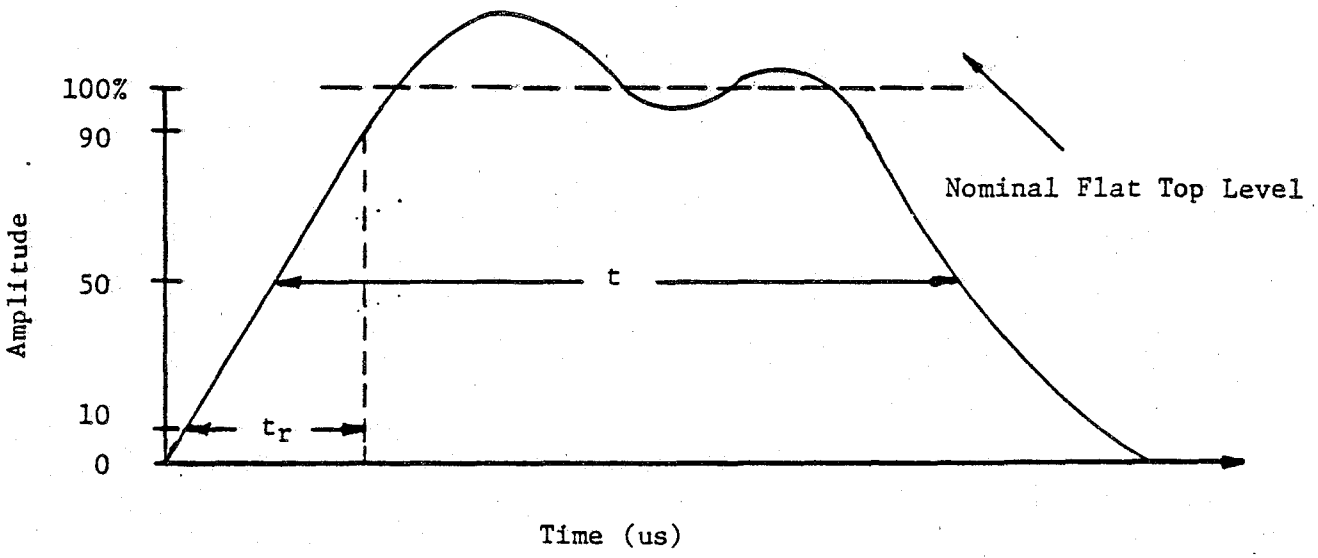


Figure 1. Determination of t and t_r

5.3.1 Criteria B

1. Effective Dates

Technical criteria for new radars shall become effective 1 October 1977 except as noted herein. (New radars are those for which development and subsequent procurement contracts are let after 1 October 1977.)

2. Applicability

These criteria are applicable to radars of Group B, "Radars having a rated peak power of more than 1 kW but not more than 100 kW and operating between 2900 MHz and 40 GHz."

3. Radar Emission Bandwidth

Radars for which development and subsequent procurement contracts are let after 1 October 1977 but before 1 October 1980, shall meet the criteria in Column A below. Radars for which development and subsequent procurement contracts are let after 1 October 1980 shall meet the criteria in Column B below.

All radars procured after 1 October 1986 shall be in compliance with Column B below.

All radars procured subsequent to 1 January 1978 and prior to 1 October 1986 shall be brought into compliance with Column B by 1 October 1991.

All radars procured prior to 1 January 1978 should be brought into compliance with B when undergoing major overhaul.

The emission bandwidth for radars at the antenna input shall not exceed the following limits:

NOTE: There is also the "necessary bandwidth" parameter that is defined for radars. For the method of calculation, see Annex J.

3.1 For Non-FM pulse radars (including spread spectrum or coded pulse radars):

Column A	*Column B*
$B(-40dB)=\frac{10}{\sqrt{t_r t}}$ or $\frac{64}{t}$	$B(-40dB)=\frac{7.6}{\sqrt{t_r t}}$ or $\frac{64}{t}$
whichever is less	whichever is less

3.2 For FM-pulse radars (intentional FM):

Column A	*Column B*
$B(-40dB)=\frac{10}{\sqrt{t_r t}}+2Bc$	$B(-40dB)=\frac{7.6}{\sqrt{t_r t}}+2Bc$

For FM-pulse radars with pulse rise time of less than 0.1 microsecond, an operational justification for the short rise time shall be provided.

3.3 For frequency hopping radars[7]:

Column A	*Column B*
$B(-40dB)=\frac{10}{\sqrt{t_r t}}+2Bc+Bs$	$B(-40dB)=\frac{7.6}{\sqrt{t_r t}}+2Bc+Bs$

For frequency hopping radars **with** pulse compression, but with pulse rise time of less than 0.1 microsecond, an operational justification for the short rise time shall be provided.

For frequency hopping radars **without** pulse compression, but with pulse rise time of less than 0.01 microsecond, an operational justification for the short rise time shall be provided.

3.4 For CW radars:

Column A	*Column B*
$B(-40dB)=0.0003\ F_o$	$B(-40dB)=0.0003\ F_o$

3.5 For FM/CW radars:

Column A	*Column B*
$B(-40dB)=0.0003\ F_o + 2B_d$	$B(-40dB)=0.0003\ F_o + 2B_d$

4. Emission Levels

The radar emission level at the antenna input shall be no greater than the values obtainable from the curve in Figure 2. At the frequency $\pm$ B(−40dB)/2 displaced from F_o, the level shall be at least 40 dB below the maximum value. At and beyond the fre-

[7] These formulas yield the total composite B(−40 dB) bandwidth of a frequency hopping radar as if all channels included within B_s were operating simultaneously. Individual channels will have a B(−40 dB) radar emission bandwidth given by 3.1 or 3.2 above. For frequency hopping radars, the radar spectrum shall not intrude into adjacent spectrum regions on the high or low side of the band, defined by B_s, more than would occur if the radar was fixed tuned at carrier frequencies equivalent to the end values of B_s and was complying with the constraints of 3.1 and 3.2 above.

quencies ± B(−XdB)/2 from F_o, the level shall be at least the dB value below the maximum spectral power density given by:

X(dB) = 60 dB, or
X(dB) = P_t + 30
whichever is the larger value

Between the −40dB and −XdB frequencies the level shall be below the 20dB per decade (S=20) roll-off lines in Figure 2.

NOTE: P_t may be measured or may for the purpose of these criteria be calculated from the following:

$$P_t = P_p + 20 \log (Nt) + 10 \log (PRR) - PG - 90$$

where PG= 0, for non-FM, non-encoded pulse radars
10 log (d), for FM pulse radars
10 log (N), for coded pulse radars

5. Antenna Pattern

No requirement is specified at present.

6. Frequency tolerance

Radar transmitters shall meet a frequency tolerance no larger than those noted in the following table:

Frequency Range (MHz)	*Tolerance (Parts/Million)*
2900–4000	800
4000–10,500	1250
10,500–30,000	2500
30,000–40,000	5000

7. Radar Tunability

Each radar shall be tunable in an essentially continuous manner either over the allocated bands for which it is designed to operate, or over a band which is 10% of the midband frequency. Crystal controlled radars conform to this requirement if operation at essentially any frequency across the band can be achieved with a crystal change.

8. Radar Receivers

The overall receiver selectivity characteristics shall be commensurate with or narrower than the transmitter bandwidth, as portrayed in Figure 2. Rejection of spurious responses, other than image responses, shall be 50 dB or better except where broadband front ends are required operationally. Receivers shall not exhibit any local oscillator radiation greater than −40 dBm at the receiver input terminals. The frequency stability shall be commensurate with, or better than, that of the associated transmitter.

9. Measurement Capability

In order to coordinate radar operations in the field, an accurate measurement of the operating frequency is necessary. An accuracy of ± 1 part of 10^6 is desirable, although, for most radars ± 100 parts in 10^6 is adequate. Of comparable importance is the capability to measure pulse rise time and spectrum occupancy. Accordingly, each Government agency shall have access to the instrumentation necessary to make a frequency measurement to at least ± 100 parts in 10^6 and suitable oscilloscopes and spectrum analyzers to measure time and frequency parameters necessary to determine conformance with these criteria. For fast rise time devices, such as magnetrons, oscilloscopes with bandwidths of at least 50 MHz should be used.

5.3.2 Criteria C

1. Effective Dates

Technical criteria for new radars shall become effective 1 October 1977 except as noted herein. (New radars are those for which development and subsequent procurement contracts are let after 1 October 1977.)

2. Applicability

These criteria are applicable to radars of Group C, "all radars below 40 GHz not included in Group A, B or D".

3. Radar Emission Bandwidth

Radars for which development and subsequent procurement contracts are let after 1 October 1977, but before 1 October 1980, shall meet the criteria in Column A below. Radars for which development and subsequent procurement contracts are let after 1 October 1980 shall meet the criteria in Column B below.

All radars procured after 1 October 1986 shall be in compliance with Column B below.

All radars procured subsequent to 1 January 1978 and prior to 1 October 1986 shall be brought into compliance with Column B by 1 October 1991.

All radars procured prior to 1 January 1978 should be brought into compliance with B when undergoing major overhaul.

The emission bandwidth for radars at the antenna input shall not exceed the following limits:

NOTE: There is also the "necessary bandwidth" parameter that is defined for radars. For the method of calculation, see Annex J.

3.1 For non-FM pulse radars (including spread spectrum or coded pulse radars):

Column A

$$B(-40dB) = \frac{7.6}{\sqrt{t_r t}} \text{ or } \frac{64}{\tau}$$

whichever is less

Column B

$$B(-40dB) = \frac{6.2}{\sqrt{t_r t}} \text{ or } \frac{64}{\tau}$$

whichever is less

3.2 For FM-pulse radars (intentional FM):

Column A

$$B(-40dB) = \frac{7.6}{\sqrt{t_r t}} + 2Bc$$

Column B

$$B(-40dB) = \frac{6.2}{\sqrt{t_r t}} + 2Bc$$

For FM pulse radars with pulse rise time of less than 0.1 microseconds, an operational justification for the short rise time shall be provided.

3.3 For Frequency hopping radars: [8]

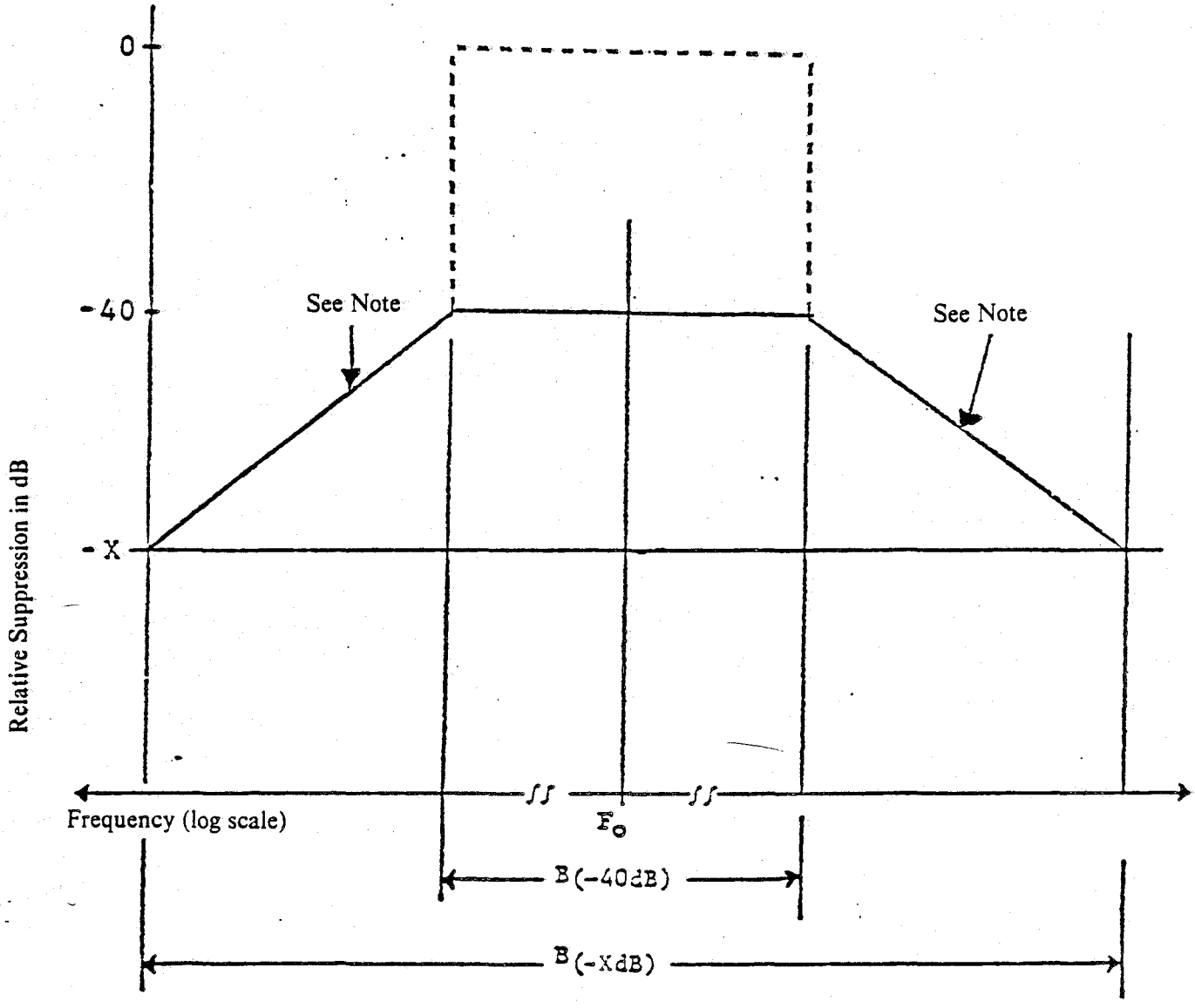
Column A

$$B(-40dB) = \frac{7.6}{\sqrt{t_r t}} + 2Bc + Bs$$

Column B

$$B(-40dB) = \frac{6.2}{\sqrt{t_r t}} + 2Bc + Bs$$

[8] These formulas yield the total composite B(−40 dB) bandwidth of a frequency hopping radar as if all channels included within B_s were operating simultaneously. Individual channels will have a B(−40 dB) radar emission bandwidth given by 3.1 or 3.2 above. For frequency hopping radars, the radar spectrum shall not intrude into adjacent spectrum regions on the high or low side of the band, defined by B_s, more than would occur if the radar were fixed tuned at carrier frequencies equivalent to the end values of B_s and was complying with the constraints of 3.1 and 3.2 above.



NOTE: The roll-off slope, *S*, from the −40 dB to −X dB points is at 20 dB per decade *for Criteria B and C, and 40 to 80 dB per decade for Criteria D. The maximum emission spectrum level between the* −40 dB and −X dB points for S dB per decade slope is described by the formula:

$$\text{Suppression (dB)} = -S \cdot \log \left| \frac{F - F_o}{\frac{1}{2}B(-40dB)} \right| - 40$$

$$\text{where: } \tfrac{1}{2}B(-40dB) \leq \left| F - F_o \right| \leq \tfrac{1}{2}B(-XdB)$$

$$\text{and: } B(-XdB) = (10^a)\, B(-40dB)$$

$$a = \frac{X-40}{S}$$

Figure 2. Radar Emission Bandwidth and Emission Levels

For frequency hopping radars **with** pulse compression, but with pulse rise time of less than 0.1 microseconds, an operational justification for the short rise time shall be provided.

For frequency hopping radars **without** pulse compression, but with pulse rise time of less than 0.01 microseconds, an operational justification for the short rise time shall be provided.

3.4 For CW radars:

Column A	*Column B*
$B(-40dB) = 0.0003\ F_o$	$B(-40dB) = 0.0003\ F_o$

3.5 For FM/CW radars:

Column A	*Column B*
$B(-40dB) = 0.0003\ F_o + 2B_d$	$B(-40dB) = 0.0003\ F_o + 2B_d$

4. Emission Levels

The radar emission levels at the antenna input shall be no greater than the values obtainable from the curve in Figure 2. At the frequency $\pm$ B(−40dB)/2 displaced from F_o, the level shall be at least 40 dB below the maximum value. At and beyond the frequencies $\pm$ B(−XdB/2 from F_o, the level shall be at least the dB value below the maximum spectral power density given by:

$$X(dB) = 60\ dB, \text{ or}$$
$$X(dB) = P_t + 30$$
whichever is the larger value

Between the −40dB and −XdB frequencies the level shall be below the 20dB per decade (S=20) roll-off lines in Figure 2.

NOTE: P_t may be measured or may for the purpose of these criteria be calculated from the following:

$$P_t = P_p + 20 \log (Nt) + 10 \log (PRR) - PG - 90$$

where PG=
- 0, for non-FM, non-encoded pulse radars
- 10 log (d), for FM pulse radars
- 10 log (N), for coded pulse radars

5. Antenna Pattern

Since electromagnetic compatibility considerations involved phenomena which may occur at any angle, the allowable antenna patterns for many radars may be usefully described by "median gain" relative to an isotropic antenna.[9] Antennas operated by their rotation through 360° of the horizontal plane shall have a "median gain" of −10 dB or less, as measured on an antenna test range, in the principal horizontal plane. For other antennas, suppression of lobes other than the main antenna beam shall be provided to the following levels, referred to the main beam:

first three sidelobes—17 dB;
all other lobes—26 dB.

6. Frequency Tolerance

Radar transmitters shall meet a frequency tolerance no larger than those noted in the following table:

Frequency Range (MHz)	*Tolerance (Parts/Million)*
Below 960	400
960–4,000	800
4,000–10,500	1,250
10,500–30,000	2,500
30,000–40,000	5,000

7. Radar Tunability

Each radar shall be tunable in an essentially continuous manner either over the allocated bands for which it is designed to operate, or over a band which is 10% of the midband frequency. Crystal controlled radars conform to this requirement if operation at essentially any frequency across the band can be achieved with a crystal change.

8. Radar Receivers

The overall receiver selectivity characteristics shall be commensurate with the transmitter bandwidth, as portrayed in Figure 2. Receivers shall be capable of switching bandwidth limits to appropriate values whenever the transmitter bandwidth is switched (pulse shape changed). Receiver image rejection shall be at least 50 dB; rejection of other spurious responses shall be at least 60 dB. Radar receivers shall not exhibit any local oscillator radiation greater than −40 dBm at the receiver input terminals. Frequency stability of receivers shall be commensurate with, or better than, that of the associated transmitters.

9. Measurement Capability

In order to coordinate radar operations in the field, an accurate measurement of the operating frequency is necessary. An accuracy of ± 100 parts in 10^6 is adequate. Of comparable importance is the capability to measure pulse rise time and spectrum occupancy. Accordingly, each Government agency shall have access to the instrumentation necessary to make a frequency measurement to at least $\pm$ 100 parts in 10^6 and suitable oscilloscopes and spectrum analyzers to measure time and frequency parameters necessary to determine conformance with these criteria. For fast rise time devices, such as magnetrons, oscilloscopes with bandwidths of at least 50 MHz should be used.

5.3.3 Criteria D

1. Effective Dates

Technical criteria for new fixed radars in the 2700–2900 MHz band shall become effective on 1 October 1982. (New radars are those for which the initial system procurement contract is let after 1 October 1982.)

2. Applicability

These criteria are applicable to fixed radars in the 2700–2900 MHz band. All radars subject to these criteria shall be designed and constructed to meet the basic minimum electromagnetic compatibility (EMC) requirements stated herein. In addition to the basic minimum EMC requirements, radar systems in the 2700–2900 MHz band which are intended to operate in close proximity to other equipment in the band or operate in areas specified in Annex D shall be designed and constructed to permit, without modifica-

[9] Median gain is defined as that level over an angular region at which the probability is 50% that the observed or measured gain at any position of the antenna will be less than or equal to that level.

tion to the basic equipment, field incorporation of EMC enhancement provisions. These additional provisions will improve the electromagnetic compatibility of the radar thus improving the accommodation of the radar system in the band. These provisions are stated in Section 5.3.3, paragraph 9.

3. Radar Emission Bandwidth

The emission bandwidth for radars at the antenna input shall not exceed the following limits:

a. For non-FM pulse radars (including spread spectrum or coded pulse radars):

$$B(-40dB)=\frac{6.2}{\sqrt{t_r t}}$$

For non-FM pulse radars, a pulse rise time of less than 0.1t shall be justified

b. For FM-pulse radars (intentional FM):

$$B(-40dB)=\frac{6.2}{\sqrt{t_r t}}+2B_c$$

For FM pulse radars with pulse rise time of less than 0.1 microseconds, a justification for the short rise time shall be provided.

c. For Frequency hopping radars:[10]

$$B(-40dB)=\frac{6.2}{\sqrt{t_r t}}+2B_c+B_s$$

For frequency hopping radars with pulse compression, but with pulse rise time of less than 0.1 microseconds, a justification for the short rise time shall be provided.

For frequency hopping radars without pulse compression, but with pulse rise time of less than 0.01 microseconds, an operational justification for the short rise time shall be provided.

d. For CW radars:

$$B(-40dB) = 0.0003\ F_o$$

e. For FM/CW radars:

$$B(-40dB) = 0.0003\ F_o + 2B_d$$

4. Emission Levels

The radar emission levels at the antenna input shall be no greater than the values obtainable from the curve in Figure 2. At the frequency $\pm B(-40\ dB)/2$ displaced from F_o the level shall be at least 40 dB below the maximum value. Beyond the frequencies $\pm B(-40\ dB)/2$ from F_o, the emission level (s) shall be below the 40 dB per decade (S=40) roll-off lines of Figure 2 down to a $-X$ dB level that is 80 dB below the maximum spectral power density.

5. Antenna Pattern

Since electromagnetic compatibility considerations involved phenomena which may occur at any angle, the allowable antenna patterns for many radars may be usefully described by "median gain" relative to an isotropic antenna.[11] Antennas operated by their rotation through 360 degrees of the horizontal plane shall have a "median gain" of -10 dB or less, as measured on an antenna test range, in the principal horizontal plane. For other antennas, suppression of lobes other than the main antenna beam shall be provided to the following levels, referred to the main beam:

first three sidelobes—17 dB;
all other lobes—26 dB.

6. Frequency Tolerance

Radar transmitters shall meet a frequency tolerance no greater than 800 parts/million.

7. Radar Tunability

Radar systems shall be tunable over the entire 2700–2900 MHz band.

8. Radar Receiver

The overall receiver selectivity characteristics shall be commensurate with the transmitter bandwidth, as portrayed in Figure 2. Receivers shall be capable of switching bandwidth limits to appropriate values whenever the transmitter bandwidth is switched (pulse shape changed). Receiver image rejection shall be at least 50 dB; rejection of other spurious responses shall be at least 60 dB. Radar receivers shall not exhibit any local oscillator radiation greater than -40 dBm at the antenna input terminals. Frequency stability of receivers shall be commensurate with, or better than, that of the associated transmitters.

9. Additional EMC Provisions

To improve the accommodation of radar systems in the 2700–2900 MHz band which operate in close proximity to other equipment in the band or operate in areas specified in Annex D, the radar shall be designed and constructed to permit, without modification to the basic equipment, field incorporation of system EMC provisions. These provisions include the requirement to meet specifications in accordance with paragraphs a. and b. below and the recommendation to meet guidelines in accordance with paragraph c. below.

a. Emission Levels

The radar emission levels at the antenna input shall be no greater than the values obtainable from the curves in Figure 2. At the frequency $\pm\ B(-40\ dB)/2$ displaced from F_o, the level shall be at least 40 dB below the maximum value. Beyond the frequencies $\pm\ B(-40\ dB)/2$ from F_o, the equipment shall have the capability to achieve up to 80 dB per decade (S= 80) roll-off lines of Figure 2. The emission levels shall be below the appropriate dB per decade roll-off lines of Figure 2 down to a $-X$ dB level that is 80 dB below the maximum spectral power density.

b. Radar System PRF

The radar system shall be designed to operate with an adjustable pulse repetition frequency (s), PRF (s), with a nominal difference of $\pm$ 1% (minimum). This will permit the selection of PRF's to allow cer-

[10] These formulas yield the total composite B(−40 db) bandwidth of a frequency hopping radar as if all channels included within B_s were operating simultaneously. Individual channels will have a B(−40 dB) radar emission bandwidth given by a. or b. above. For frequency hopping radars, the radar spectrum shall not intrude into adjacent spectrum regions on the high or low side of the band, defined by B_s, more than would occur if the radar were fixed tuned at carrier frequencies equivalent to the end values of B_s and was complying with the constraints of a. and b. above.

[11] Median gain is defined as that level over an angular region at which the probability is 50% that the observed or measured gain at any position of the antenna will be less than or equal to that level.

tain types of receiver interference suppression circuitry to be effective.

c. Receiver Interference Suppression Circuitry

Radar systems in this band should have provisions incorporated into the system to suppress pulsed interference. The following information is intended for use as an aid in the design and development of receiver signal processing circuitry or software to suppress asynchronous pulsed interference. A description of the parametric range of the expected environmental signal characteristics at the receiver IF output is:

Peak Interference-to-Noise Ratio: $\leq$ 50 dB
Pulse width: 0.5 to 4.0 μsec
PRF: 100 to 2000 pps

10. Measurement capability

In order to coordinate radar operations in the field, an accurate measurement of the operating frequency is necessary. An accuracy of $\pm$ 100 parts in 10^6 is adequate. Of comparable importance is the capability to measure pulse rise time and spectrum occupancy. Accordingly, each Government agency shall have access to the instrumentation necessary to make a frequency measurement to at least $\pm$ 100 parts in 10^6 and suitable oscilloscopes and spectrum analyzers to measure time and frequency parameters necessary to determine conformance with these criteria. For fast rise time devices, such as magnetrons, oscilloscopes with bandwidths of at least 50 MHz should be used.

5.3.4 Instructions on the Use of Nomograms (1) and (2) for determining the basic Radar Emission Bandwidth and Maximum Spectral Level, respectively.

1. Nomogram (1) can be used to determine the basic allowable radar emission bandwidth at the −40 dB level based on any one of the following formulas presented in paragraphs 5.3.1 and 5.3.2 above:

$$10/\sqrt{t_r t};\ 7.6/\sqrt{t_r t};\ 6.2/\sqrt{t_r t} \text{ or } 64/t$$

It also can be used to determine the allowable radar emission bandwidth at the −X dB level and at any dB level between the −40 dB and −X dB points where the allowable slope (roll-off) is established at 20 dB per decade.

It also can be used to determine the basic necessary bandwidth for radars at the −20 dB level from the peak of the spectrum given by the formulas in paragraph Annex J of this Manual:

$$1.79/\sqrt{t_r t} \text{ or } 6.36/t$$

2. Nomogram (2) can be used to determine the Maximum Spectral Level (dBm/kHz) based on the following formula presented in paragraphs 5.3.1 and 5.3.2 above:

$$P_t = P_p + 20 \log (Nt) + 10 \log PRR - PG - 90$$

NOTE: In those cases where n ≠ 1, consider the product of (Nt) when using the Emitted Pulse Duration (microseconds) scale on this nomogram.

3. The use of the two nomograms can best be illustrated by an example. Consider a radar with the following characteristics operating above 2900 MHz:

a. Peak Power (P_p):	750 kW (88.75 dBm)
b. Processing Gain (PG):	15 dB
c. Pulse Repetition Rate (PRR):	600 pulses per second
d. Emitted Pulse Duration (t):	4 microseconds
e. Emitted Pulse Rise Time (t_r):	0.25 microseconds
f. Total number of chips (subpulses) contained in the pulse (N):	1 (Unity)

4. A review of the radar description reveals that Criteria C (paragraph 5.3.2) applies. Further, consider the condition such that Column A is applicable.

5. Under Column A, paragraph 3.1 of paragraph 5.3.2 states that the radar emission bandwidth at the antenna input shall not exceed $7.6/\sqrt{t_r t}$ or 64/t (whichever is less) at the −40 dB level.

6. To determine the allowable basic radar emission bandwidth, the following steps illustrate how nomogram (1) can be used. The radar characteristics listed in paragraph 3. above are used in this example.

a. Place a straightedge between 0.25 microsecond on the Emitted Pulse Rise Time scale and 4 microseconds on the Emitted Pulse Duration scale and place a "mark" on the Reference Line where the straightedge crosses the Reference Line.

b. With this "mark" as a reference, place the straightedge between this "mark" and 7.6 on the Numerator Factor scale and read a value of 7.6 MHz on the Radar Emission Bandwidth (−40 dB) scale. This value is then compared with the value obtained using the 64/t criterion to determine which criterion gives the smaller value.

c. The $64/\sqrt{t}$ value on the Radar Emission Bandwidth (−40 dB) 64/t criterion scale is opposite the t value on the Emitted Pulse Duration scale. Thus, 4 microseconds (the emitted pulse duration for this example) on the Emitted Pulse Duration (t) scale gives a Radar Emission Bandwidth of 16 MHz for the 64/t criterion. Since this value is larger than that previously determined (7.6 MHz), using the $7.6/\sqrt{t_r t}$ criterion, that criterion applies. Thus the value of 7.6 MHz is then compared with measured or calculated bandwidth at the −40 dB level to determine if the criteria have been met. For this example, the −40 dB level corresponds to an absolute level of −16.65 dBm/kHz (23.35 dBm/kHz −40 dB) and no emission should exceed this level at $\pm$ 3.8 MHz [$\pm$B(−40 dB)/2] from F_o. (Note: The P_t value of 23.35 dBm/kHz for the radar in this example can be determined through the use of Nomogram (2)). (See paragraphs 7.a., 7.b., and 7.c. below).

d. An additional requirement in the criteria allows a frequency roll-off of 20 dB per decade between the −40 dB and −X dB levels. Thus, at the −60 dB level, the allowable radar emission bandwidth would be 76 MHz (7.6 MHz (the allowable bandwidth at the −40 dB level) times 10 (a decade)). In this example, a straightedge is placed between the previously determined value of 7.6 MHz on the Radar Emission Bandwidth (−40 dB) scale and 60 on the Spectral Level in dB value below P_t scale. A value of 76 MHz is then read on the Radar Emission Bandwidth (−X dB) scale. In like manner, a straightedge placed between 7.6 MHz on the Radar Emission

Bandwidth (−40 dB) scale and any dB value below P_t scale between the −40 dB and −X dB levels will determine the allowable radar emission bandwidth at any particular dB level below P_t governed by the frequency roll-off criteria of 20 dB per decade between the −40 dB and −X dB levels.

e. The criteria further states that "At and beyond the frequencies [±B(−X dB)/2] from F_o, the level shall be at least the dB value below the maximum spectral power density given by:

$$X_{(dB)}=60 \text{ dB, or}$$
$$X_{(dB)}=P_t+30$$

whichever is the larger value,"

For the −X dB level, the radar in this example has a numerical (P_t+30) value of 53.35 dB (23.35 dBm/kHz+30). Since this value is less than 60 dB, the 60 dB criterion applies at the $-X_{(dB)}$ level. This corresponds to an absolute level of −36.65 dBm/kHz (23.35 dBm/kHz −60 dB) and no emission should exceed this level at and beyond±38 MHz [±B(−X dB)/2] from F_o. In this case, $-X_{(dB)}$ equals −60 dB and the value of 76 MHz was determined in paragraph d. above.

f. Now consider the case where (P_t+30) is greater than 60 dB. Assume B(−40 dB)=7.6 MHz, as determined before, but (P_t+30) equals 73 dB. In this case, P_t would be equal to 43 dBm/kHz. The allowable bandwidth at the $X_{(dB)}$ level (in this example, −73 dB) can be determined by placing a straightedge between 7.6 MHz on the $B_{(-40\ dB)}$ Radar Emission Bandwidth scale and 73 on the Spectral Level in dB value below P_t scale and reading about 340 MHz where the straightedge crosses the $B_{(-X\ dB)}$ Radar Emission Bandwidth scale. Thus, no emission shall exceed −30 dBm/kHz (P_t−73 dB, where P_t=43 dBm/kHz in this case) at and beyond ±170 MHz[±B (−73dB)/2] from F_0.

g. By extending the Numerator Factor scale, nomogram (1) may be used also to determine the basic necessary bandwidth as defined in paragraph Annex J of the Manual. Place the straightedge between 1.79 on the "extended" Numerator Factor scale and the "mark" on the Reference Line scale (previously determined under paragraph 5.a. above) and read a value of 1.79 on the $B_{(-40\ dB)}$ Radar Emission Bandwidth scale. (Note: A value of 17.9 also has been placed on the "extended" Numerator Factor scale to permit determination of the necessary bandwidth in those cases where the "straightedge" line between the 1.79 on the "extended" Numerator Factor scale and the "mark" on the Reference Line falls outside the existing Radar Emission Bandwidth $B_{(-40\ dB)}$ scale. When using the 17.9 value and the "mark" on the Reference Line, it must be remembered that the reading where the straightedge crosses the $B_{(-40\ dB)}$ Radar Emission Bandwidth scale is ten (10) times the value of the necessary bandwidth—the ratio of 17.9 to 1.79.)

h. The other criterion for non-FM pulsed radars, by which the necessary bandwidth is compared, is given by the expression 6.36/t. This expression is approximately one-tenth (1/10) of the 64/t criterion by which the bandwidth at the −40 dB level is compared. Thus, the necessary bandwidth using the 6.36/t criterion could be approximated by using the 64/t bandwidth scale, remembering that the value read on the scale is slightly greater than ten (10) times the actual value of the necessary bandwidth when considering the 6.36/t criterion. As determined under paragraph 6.c. above, a value of 16 MHz was read on the 64/t bandwidth scale. Dividing 16 MHz by ten (10) gives a necessary bandwidth of 1.6 MHz (actually 1.59 MHz when using 6.36/t computation). Since this value is less than the 1.79 MHz determined under paragraph 5.g. above, the 1.59 MHz criterion prevails as the necessary bandwidth for the radar in this example.

i. It is interesting to note that in this example, the necessary bandwidth (the bandwidth at the −20 dB level) came about as a result of the 6.36/t criterion, vice the $1.79/\sqrt{t_r t}$ criterion; whereas, the limit for the radar emission bandwidth at the −40 dB level came about using the $7.6/\sqrt{t_r t}$ criterion, vice the 64/t criterion. These results can come about since the slope of the emission bandwidth between the −20 dB level and the −40 dB level can vary depending upon the numerator factor and the terms involved. For instance, the slope between the 6.36/t and the 64/t criteria between the −20 dB and −40 dB levels is approximately 20 dB per decade; whereas, the slopes in dB per decade between the $1.79/\sqrt{t_r t}$ and the $6.2/\sqrt{t_r t}$, $7.6/\sqrt{t_r t}$ and $10/\sqrt{t_r t}$ criteria between the −20 dB and −40 dB levels are approximately 37, 32, and 27, respectively. For the radar in this example having a necessary bandwidth of 1.59 MHz and an allowable radar emission bandwidth of the 7.6 MHz, the "effective" frequency roll-off between the −20 dB and −40 dB levels is approximately 29.5 dB per decade.

7. Nomogram (2) can be used to determine P_t, the Maximum Spectral Level (dBm/kHz), based on the following formula presented in paragraphs 5.3.1 and 5.3.2 above:

$$P_t=P_p+20\log(NT)+10\log PRR-PG-90$$

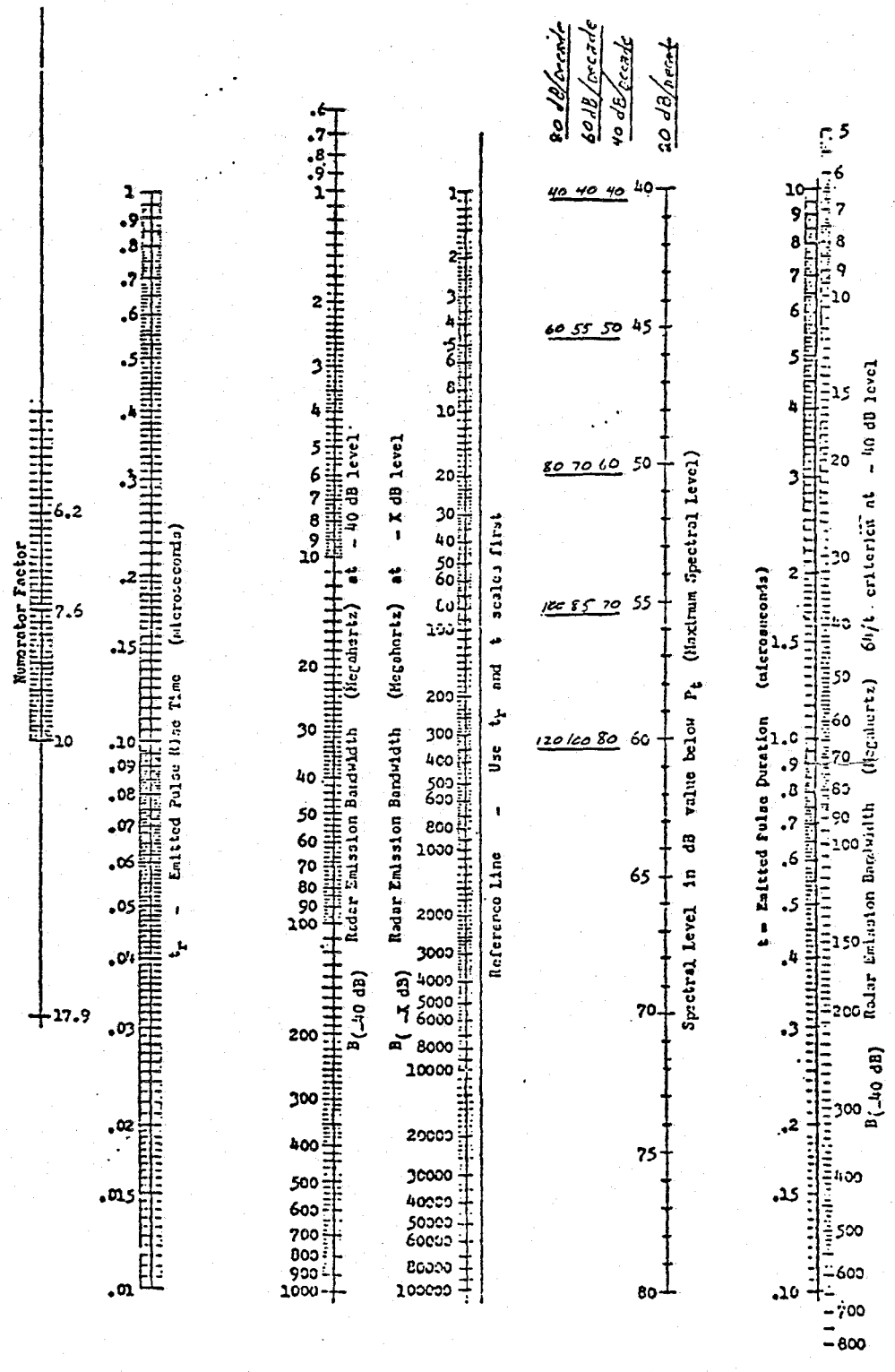
(NOTE: In those cases where N≠1, consider the product of (Nt) when using the Emitted Pulse Duration (microseconds) scale). The following steps illustrate how nomogram (2) is used applying those radar characterstics listed in paragraph 3. above.

a. Place a straightedge between 15 dB on the Processing Gain scale and 600 pulses per second on the Pulse Repetition Rate scale and place a mark on the reference line where the straightedge crosses the reference line.

b. With this "mark" as a reference, place the straightedge between that "mark" and 4 microseconds on the Emitted Pulse Duration scale and read a value of about −65.4 dBm/kHz per 0 dBm on the Normalized Maximum Spectral Level scale.

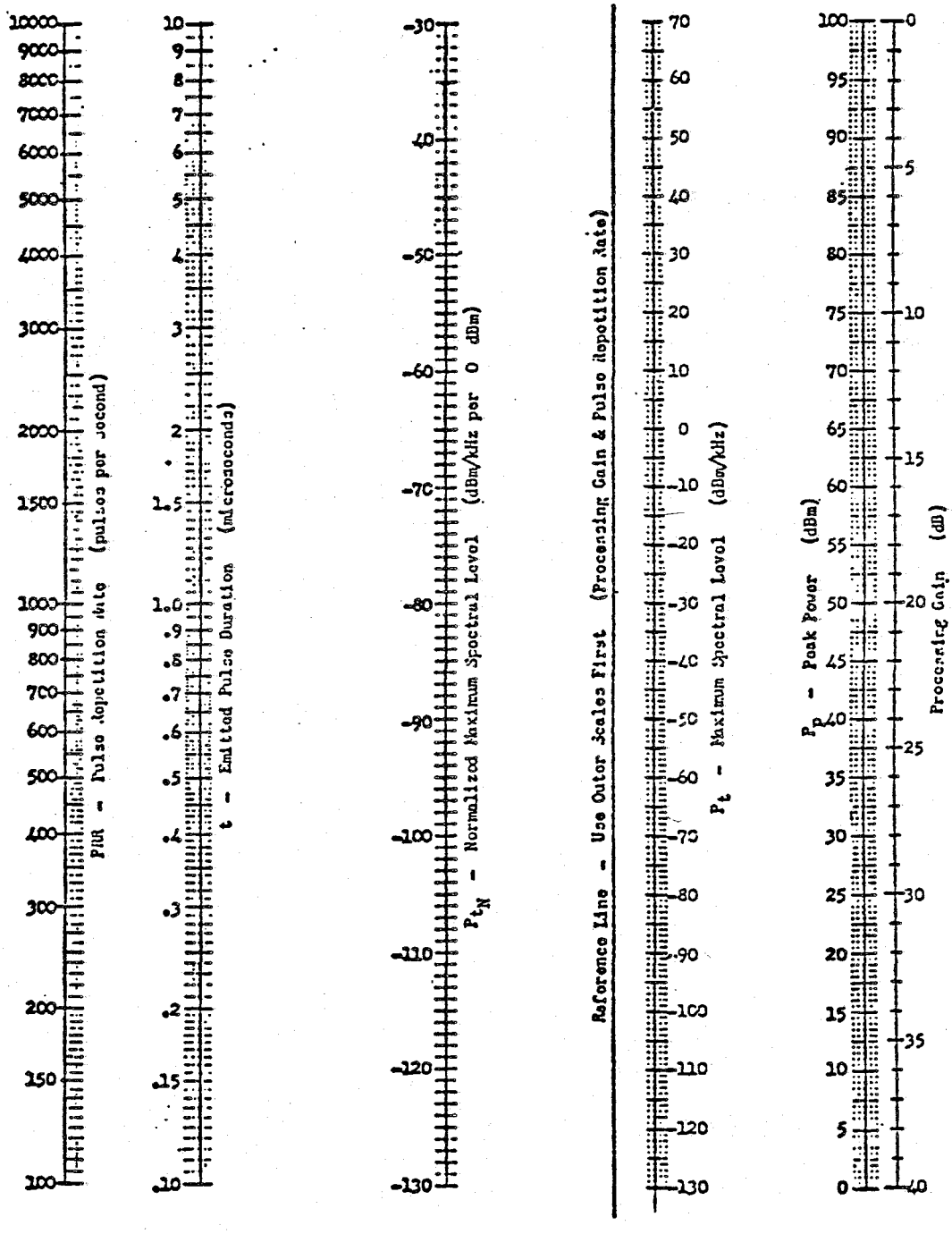
c. Since this scale is normalized to 0 dBm, the peak power of the radar in dB above 0 dBm must be added to the normalized value. In this example, the peak power of the radar is 88.75 dBm; thus, the Maximum Spectral Level (P_t) value for this radar is +23.35 dBm/kHz (−65.4 dBm/kHz per 0 dBm+88.75 dBm).

d. As an alternative, since the Peak Power (P_p) scale is also included on this nomogram, a straightedge placed between the value of −65.4 dBm/kHz



NOMOGRAM (1)

For Determining Basic Radar Emission Bandwidth at −40 dB and −X dB Spectral Levels



NOMOGRAM (2)

For Determining Normalized Maximum Spectral Level (P_tN) and Maximum Spectral Level (P_t)

per 0 dBm on the Normalized Maximum Spectral Level scale and 88.75 dBm on the Peak Power scale will yield a value of +23.35 dBm/kHz on the Maximum Spectral Level (dBm/kHz) scale.

e. The value of the Maximum Spectral Level (P_t) in dBm/kHz becomes the basis of determining the absolute spectral level at the −20 dB point at which the necessary bandwidth is determined and compared with appropriate bandwidth data, and the −40 dB and −X dB levels at which the allowable radar emission bandwidth is determined and compared with appropriate bandwidth data.

f. Since the radar in this example has a Maximum Spectral Level (P_t) value of +23.35 dBm/kHz, the absolute spectral levels at the −20 dB, −40 dB and −60 dB points are +3.35 dBm/kHz, −16.65 dBm/kHz and −36.65 dBm/kHz, respectively.

g. For the case stated in paragraph 6.f., where (P_t+30) is greater than 60 dB, and, in particular, 73 dB, which made P_t=43 dBm/kHz; the absolute spectral levels at the −20 dB, −40 dB and −73 dB (the −X dB level in this case) points are +23 dBm/kHz, +3 dBm/kHz and −30 dBm/kHz, respectively.

APPENDIX C

CURRENT AND PROPOSED ASSIGNMENTS AND PLANNED USE

I. Bands Allocated for Exclusive Use by Non-Government Users
bands addressed--

17.7-17.8 GHz	24-24.05 GHz
17.8-18.6 GHz	27.5-29.5 GHz
18.8-19.7 GHz	29.5-30 GHz
19.7-20.2 GHz	38.6-39.5 GHz

subjects addressed in each band--

i) Allocations
ii) Existing and Planned Non-Government Uses
iii) Existing and Planned Government Uses

II. Bands Allocated for Shared Use by Government and Non-Government Users
bands addressed--

18.6-18.8 GHz	25.25-27 GHz
20.2-21.2 GHz	27-27.5 GHz
21.2-21.4 GHz	30-31 GHz
21.4-22 GHz	31-31.3 GHz
22-22.21 GHz	31.3-31.8 GHz
22.21-22.5 GHz	31.8-32 GHz
22.5-22.55 GHz	32-33 GHz
22.55-23 GHz	33-33.4 GHz
23-23.55 GHz	33.4-36 GHz
23.55-23.6 GHz	36-37 GHz
23.6-24 GHz	37-38.6 GHz
24.05-24.25 GHz	39.5-40 GHz
24.25-25.25 GHz	40-40.5 GHz

subjects addressed in each band--

i) Allocations
ii) Existing and Planned Non-Government Uses
iii) Existing and Planned Government Uses

I. BANDS ALLOCATED FOR EXCLUSIVE USE BY NON-GOVERNMENT USERS

i) 17.7-17.8 GHz Band

Spectrum Allocations

Primary Allocation: Fixed -- non-Government
Fixed-Satellite (space-to-Earth)(Earth-to-space) -- non-Government
Mobile -- non-Government

Secondary Allocation: None

Footnotes:

869 - "The use of the band 17.3-18.1 GHz by the fixed-satellite (Earth-to-space) is limited to feeder links for the broadcasting-satellite service."

US271 - "The use of the band 17.3-17.8 GHz by the Fixed-Satellite Service (Earth-to-space) is limited to feeder links for Broadcasting-Satellite Service"

NG140 - "Pending adopting of further specific rules concerning usage of the band 17.3-17.8 GHz by the fixed-satellite service for the purpose of providing feeder links to the broadcasting-satellite service, systems may be authorized for this purpose subject to the condition that adjustments in certain system design or technical parameters may become necessary during the system lifetime. The necessity for such adjustments, and their extent, will be dependent upon the Final Acts of the 1983 Regional Administrative Radio Conference and subsequent Commission decisions."

Existing Government Spectrum Uses --frequency band (17.7-17.8 GHz)--

Station Class	Agency	Assignments
0	0	0

Planned Government Uses --frequency band (17.7-17.8 GHz)--

Tentative plans exist for use of this band in the NASA Tracking and Data Acquisition System (TDAS) program. This program is a sequel to the current Tracking and Data Relay Satellite System (TDRSS). The TDAS, to become operational about 1994 with the launch of two or three satellites into geosynchronous orbit, will serve as the primary communications network for world-wide coverage of most U.S. space missions and many foreign space missions also. When the TDAS becomes operational, the 27.5-31 GHz band will be used for Earth-to-satellite transmission and the 17.7-21.2 GHz band will be used for satellite-to-Earth transmissions.

Tentative plans exist for use of this band in the NASA Advanced Communications Technology Satellite (ACTS) program (previously known as the 30/20 GHz program). This program includes the launch of a satellite into geosynchronous orbit during 1988; at that time the 27.5-30 GHz band will be used for Earth-to-satellite transmissions and the 17.7-20.2 GHz band will be used for satellite-to-Earth transmissions. This program is intended to demonstrate innovative technologies, and at the completion of the planned testing, operation of the satellite could be transferred to industry.

NASA is also planning a Soil and Snow Moisture Research and Assessment Mission. Frequencies required for passive sensing - 1.4 GHz, 10.7 GHz, 18 GHz, 37 GHz, 94 GHz. The scientific objectives of this mission are: (1) conduct research to remotely determine soil/snow moisture, (2) exploit the potential benefit of combining microwave (passive and active) with visible and IR data for parameter determinations, and (3) simulatenous measurements of active and passive microwave signatures are mandatory for mutual validation since it might not be possible to calibrate active microwave suficiently accurate for soil/snow moisture determination. Shuttle flights will be used for comparison of microwave derived parameters with ground truth and also facilitate the technological development of future systems for space stations/platforms. Any shuttle flights are usable for soil moisture experiments, but it is necessary to have highly inclined (greater than 40 degrees) orbits for snow moisture experiments constrained to winter months. It is preferable to have all the instruments (e.g.,passive/active microwave, visible and infared) on the same Shuttle flight. For future missions aboard the space station/platform sun synchronous orbits at about 400 km altitude are preferred. There is likely to be interference to the planned passive measurements in the 18 GHz band if that band is used for satellite communcations. The system is anticipated to be operational in 1990 and will be in use for 10 years.

Existing Non-Government Spectrum Uses
--frequency band (17.7-17.8 GHz)--

Station Class	Assignments
FX	4-California
	1-New Jersey
MO	5-New Jersey
DT	1-California
	1-Washington
TF	1-New Jersey
	1-Colorado

Fixed and mobile systems are primarily experimental FM telegraphy operated by telephone companies. The other functions pertain to point-to-point microwave; the TF designation indicates microwave use in conjunction with a fixed satellite earth station. (see FCC action in General Document 82-334)

ii) 17.8-18.6 GHz Band

Spectrum Allocations

Primary Allocation: Fixed -- non-Government
Fixed-Satellite (space-to-Earth) -- non-Government
Mobile -- non-Government
Meteorological Satellite (space-to-Earth)--870
-- non-Government (allocation provided by footnote 870)

Secondary Allocation: None

Footnotes:

870 - "The band 18.1-18.3 GHz is also allocated to the meteorological-satellite service (space-to-Earth) on a primary basis. Its use is limited to geostationary satellites and shall be in accordance with the provisions on No. 2578."

2578 - "The power flux-density at the Earth's surface produced by emissions from a space station, including emissions from a reflecting satellite, for all conditions and for all methods of modulation, shall not exceed the following values:

-115 dB (W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;

$-115 + 0.5 (\delta - 5)$ dB (W/m^2) in any 1 MHz band for angles of arrival ? (in degrees) between 5 and 25 degrees above the horizontal plane;

-105 dB (W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

These limits relate to the power flux-density which would be obtained under assumed free-space propagation conditions."

Existing Government Spectrum Uses
--frequency band (17.8-18.6 GHz)--

Station Class	Agency	Assignments
XC	USAF	2-California
	NG	3-California
XD	NG	2-California
XT	USAF	1-Washington

Assignments in this band are used in tests of antennas, and satellites developed under both domestic and foreign Government contracts.

Planned Government Uses
--frequency band (17.8-18.6 GHz)--

Tentative plans exist for use of this band in the NASA Tracking and Data Acquisition System (TDAS) program. This program is a sequel to the current Tracking and Data Relay Satellite System (TDRSS). The TDAS, to become operational about 1994, with the launch of two or three satellites into geosynchronous orbit, will serve as the primary communications network for world-wide coverage of most U.S. space missions and many foreign space missions also. When the TDAS becomes operational, the 27.5-31 GHz band will be used for Earth-to-satellite transmissions and the 17.7-21.2 GHz band will be used for satellite-to-Earth transmissions.

Tentative plans exist for use of this band in the NASA Advanced Communications Technology Satellite (ACTS) program (previously known as the 30/20 GHz program). This program includes the launch of a satellite into geosynchronous orbit during 1988; at that time the 27.5-30 GHz band will be used for Earth-to-satellite transmissions and the 17.7-20.2 GHz band will be used for satellite-to-Earth transmissions. This program is intended to demonstrate innovative technologies, and at the completion of the planned testing, operation of the satellite could be transferred to industry.

NASA is also planning a Soil Snow Moisture Research and Assessment Mission. Frequencies required for passive sensing - 1.4 GHz, 10.7 GHz, 18 GHz, 37 GHz, 94 GHz, The scientific objectives of this mission are: (1) conduct research to remotely determine soil/snow moisture, (2) exploit the potential benefit of combining microwave (passive and active) with visible and IR data for parameter determinations, and (3) simultaneous measurements of active and passive microwave signatures are mandatory for mutual validation since it might not be possible to calibrate active microwave sufficiently accurate for soil/snow moisture determination. Shuttle flights will be used for comparison of microwave derived parameters with ground truth and also facilitate the technology development of future systems for space stations/platforms. Any shuttle flights are usable for soil moisture experiments, but it is necessary to have highly inclined (greater than 40 degrees) orbits for snow moisture experiments constrained to winter months. It is preferable to have all the instruments (e.g., passive/active microwave, visible and infrared) on the same Shuttle flight. For future missions aboard the space station/platform sun synchronous orbits at about 400 km altitude are preferred. There is likely to be interference to the planned passive measurements in the 18 GHz band if that band is used for satellite communications. The system is anticipated to be operational in 1990 and will be in use for 10 years.

Existing Non-Government Spectrum Uses
--frequency band (17.8-18.6 GHz)--

Station Class	Assignments
FB/MO	3-Alabama
	7-Texas
FX	3-New York
	4-California
FXO	2-Alaska
	3-California
FAT	2-Indiana
	1-California
MO	1-New York

This band is used to transmit CW for monitoring offshore drilling positioning in the Gulf of Mexico. FM systems are used for telephone company point-to-point and experimentation and non-public operations. Fixed operations handle business, local government, transit company, press, and emergency communications via FM. (see FCC action in General Docket 82-334)

iii) 18.8-19.7 GHz Band

Spectrum Allocations

Primary Allocation: Fixed -- non-Government
Fixed-Satellite (space-to-Earth) -- non-Government
Mobile -- non-Government

Secondary Allocation: None

Footnotes: None

Existing Government Spectrum Uses
--frequency band (18.8-19.7 GHz)--

Station Class	Agency	Assignments
XC	USAF	1 - California
	NG	1 - California
XT	USAF	1 - Missouri

Assignments in this band are used in tests of antennas.

Planned Government Uses
--frequency band (18.8-19.7 GHz)--

Tentative plans exist for use of this band in the NASA Tracking and Data Acquisition System (TDAS) program. This program is a sequel to the current Tracking and Data Relay Satellite System (TDRSS). The TDAS, to become operational about 1994, with the launch of two or three satelltes into geosynchronous orbit, will serve as the primary communications network for world-wide coverage of most U.S. space missions and many foreign space missions also. When the TDAS becomes operational, the 27.5-31 GHz band will be used for Earth-to-satellite transmissions and the 17.7-21.2 GHz band will be used for satellite-to-Earth transmissions.

Tentative plans exist for use of this band in the NASA Advanced Communications Technology Satellite (ACTS) program (previously known as the 30/20 GHz program). This program includes the launch of a satellite into geosynchronous orbit during 1988; at that time the 27.5-30 GHz band will be used for Earth-to-satellite transmissions and the 17.7-20.2 GHz band will be used for satellite-to-Earth transmission. This program is intended to demonstrate innovative technologies, and at the completion of the planned testing, operation of the satellite could be transferred to industry.

Existing Non-Government Spectrum Uses
--frequency band (18.8-19.7 GHz)--

Station Class	Assignments
FXO	6 - Alaska
	3 - California
	1 - Indiana
	1 - Kansas
	1 - Massachusetts
	1 - New Jersey
	1 - Wisconsin
FX	3 - New York
	1 - California
	4 - US
MLT	1 - Pennsylvania

FM & AM Fixed operations for transit, business and local Government make up the primary uses. Some fixed point-to-point and experimental mobile systems are being used by telephone companies for FM telegraphy. One instance of a mobile TV pickup was identified.

iv) 19.7-20.2 GHz Band

Spectrum Allocations

Primary Allocation: Fixed-Satellite (space-to-Earth) -- non-Government

Secondary Allocation: Mobile-Satellite (space-to-Earth) -- non-Government

Footnotes:

873 - In certain countries, other than the United States, the 19.7-21.2 GHz band is also allocated on a primary basis to fixed and mobile services; however, this additional allocation does not impose any limitations on the power flux-density of space stations in the fixed-satellite service.

Existing Government Spectrum Uses
--frequency band (19.7-20.2 GHz)--

Station Class	Agency	Assignments
XC	USAF	1 - California
	NG	1 - California

Assignments in this band are used in tests of antennas.

Planned Government Uses
--frequency band (19.7-20.2 GHz)--

Tentative plans exist for use of this band in the NASA Tracking and Data Acquisition System (TDAS) program. This program is a sequel to the current Tracking and Data Relay Satellite System (TDRSS). The TDAS, to become operational about 1994 with the launch of two or three satellites into geosynchronous orbit, will serve as the primary communications network for world-wide coverage of most U.S. space missions and many foreign space missions also. When the TDAS becomes operational, the 27.5-31 GHz band will be used for Earth-to-satellite transmissions and the 17.7-21.2 GHz band will be used for satellite-to-Earth transmission.

Tentative plans exist for use of this band in the NASA Advanced Communications Technology Satellite (ACTS) program (previously known as the 30/20 GHz program). This program includes the launch of a satellite into geosynchronous orbit during 1988; at that time the 27.5-30 GHz band will be used for Earth-to-satellite transmissions and the 17.7-20.2 GHz band will be used for satellite-to-Earth transmissions. This program is intended to demonstrate innovative technologies, and at the completion of the planned testing, operation of the satellite could be transferred to industry.

Existing Non-Government Spectrum Uses
--frequency bands (19.7-20.2 GHz)--

Station Class	Assignments
MLT	1-Texas
	1-California
	1-Washington
	1-Kansas
FX	3-California
ANT	1-California

The primary use in this band is mobile FM TV pickup. Several instances of experimental fixed systems exist.

v) 24-24.05 GHz Band

Spectrum Allocations

Primary Allocation: Amateur -- non-Government
Amateur-Satellite -- non-Government
Industrial, Scientific, and Medical applications (as defined in footnote 881) -- non-Government

Secondary Allocation: None

Footnotes:

881 - "The band 24-24.25 GHz (center frequency 24.125 GHz)-- is designated for industrial, scientific and medical (ISM) applications. Radio communication services operating within this band must accept harmful interference which may be caused by these applications. ISM equipment operating in this band is subject to the provisions of No. 1815."

1815 - "Administrations shall take all practicable and necessary steps to ensure that radiation from equipment used for industrial, scientific and medical applications is minimal and that, outside the bands designated for use by this equipment, radiation from such equipment is at a level that does not cause harmful interference to a radio communication service and, in particular, to a radionavigation or any other safety service operating in accordance with the provisions of these Regulations... In this matter, administrations should be guided by the latest relevant CCIR recommendations."

US211 - "In the bands...24-24.05 GHz...applicants for airborne or space station assignments are urged to take all practicable steps to protect radio astronomy observations in the adjacent bands from harmful interference; however, US74 applies."

US74 - "In the bands...23.6-24 GHz...the radio astronomy service shall be protected from extraband radiation only to the extent such radiation exceeds the level which would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates."

Existing Government Spectrum Uses
--frequency band (24-24.05 GHz)--

Station Class	Agency	Assignments
0	0	0

FAA ASDE Radars--see 23.6-24 GHz band (These radars are operating in this band)

Existing Non-Government Spectrum Uses
—frequency band (24-24.05 GHz)—

Station Class	Assignments
FX	3-California
MO	1-New York

This band is now used for the operation of fixed and mobile experimental doppler radars. The actual station class should be listed as LR or MR.

vi) 27.5-29.5 GHz Band

Spectrum Allocations

Primary Allocation: Fixed -- non-Government
Fixed-Satellite (Earth-to-space) -- non-Government
Mobile -- non-Government

Secondary Allocation: None

Footnotes: None

Existing Government Spectrum Uses
--frequency band (27.5-29.5 GHz)--

Station Class	Agency	Assignments
XC	NG	2 - California
	USAF	1 - Colorado
XR	DOC	1 - Colorado

Assignments in this band are used to test antennas and atmospheric conditions.

Planned Government Uses
--frequency band (27.5-29.5 GHz)--

Tentative plans exist for use of this band in the NASA Tracking and Data Acquisition System (TDAS) program. This program is a sequel to the current Tracking and Data Relay Satellite System (TDRSS). The TDAS, to become operational about 1994 with the launch of two or three satellites into geosynchronous orbit, will serve as the primary communications network for world-wide coverage of most U.S. space missions and many foreign space missions also. When the TDAS becomes operational, the 27.5-31 GHz band will be used for Earth-to-satellite transmissions and the 17.7-21.2 GHz band will be used for satellite-to-Earth transmission.

Tentative plans exist for use of this band in the NASA Advanced Communications Technology Satellite (ACTS) program (previously known as the 30/20 GHz program). This program includes the launch of a satellite into geosynchronous orbit during 1988; at that time the 27.5-30 GHz band will be used for Earth-to-satellite transmissions and the 17.7-20.2 GHz band will be used for satellite-to-Earth transmissions. This program is intended to demonstrate innovative technologies, and at the completion of the planned testing, operation of the satellite could be transferred to industry.

Existing Non-Government Spectrum Uses
--frequency band 27.5-29.5 GHz)--

Station Class	Assignments
FX	5-California
MO	2-New Jersey

Fixed and mobile system experimentation and development of AM, FM, CW Doppler are being conducted using this band.

vii) 29.5-30 GHz Band

Spectrum Allocations

Primary Allocation: Fixed-Satellite (Earth-to-space) -- non-Government

Secondary Allocation: Mobile-Satellite (Earth-to-space) -- non-Government
Earth Exploration-Satellite (space-to-space)
as defined in footnote 882--non-Government

Footnotes:

882 - "The band 29.95-30 GHz may be used for space-to-space links in the earth exploration-satellite service for telemetry tracking, and control purposes, on a secondary basis."

883 - In certain countries, other than the United States, the 29.5-31 GHz band is also allocated on a secondary basis to fixed and mobile services; however, power limits specified by Nos. 2505 and 2508 shall apply to these operations.

2505 - The maximum equivalent isotropically radiated power (e.i.r.p.) of a station in the fixed or mobile service shall not exceed +55 dBW.

2508 - The power delivered by a transmitter to the antenna of a station in the fixed or mobile service in frequency bands above 10 GHz shall not exceed +10 dBW.

Existing Government Spectrum Uses
--frequency band (29.5-30 GHz)--

Station Class	Agency	Assignments
-0-	-0-	-0-

Planned Government Uses
--frequency band (29.5-30 GHz)--

Tentative plans exist for use of this band in the NASA Tracking and Data Acquisition System (TDAS) program. This program is a sequel to the current Tracking and Data Relay Satellite System (TDRSS). The TDAS, to become operational about 1994 with the launch of two or three satellites into geosynchronous orbit, will serve as the primary communications network for world-wide coverage of most U.S. space missions and many foreign space missions also. When the TDAS becomes operational, the 27.5-31 GHz band will be used for Earth-to-satellite transmissions and the 17.7-21.2 GHz band will be used for satellite-to-Earth transmission.

Tentative plans exist for use of this band in the NASA Advanced Communications Technology Satellite (ACTS) program (previously known as the 30/20 GHz program). This program includes the launch of a satellite into geosynchronous orbit during 1988; at that time the 27.5-30 GHz band will be

used for Earth-to-satellite transmissions and the 17.7-20.2 GHz band will be used for satellite-to-Earth transmissions. This program is intended to demonstrate innovative technologies, and at the completion of the planned testing, operation of the satellite could be transferred to industry.

Existing Non-Government Spectrum Uses
--frequency band (29.5-30.0 GHz)--

Station Class	Assignments
FB/MO	1-Michigan

The only use found was for business base and mobile units.

viii) 38.6-39.5 GHz Band

Spectrum Allocations

Primary Allocation: Fixed -- non-Government
Mobile -- non-Government
Fixed-Satellite (space-to-Earth) -- non-Government

Secondary Allocation: Mobile television pick-up station applications (as defined in US291) -- non-Government

Footnotes:

899 - "Subject to agreement obtained under the procedure set forth in Article 14, the band 37-39 GHz may also be used in Japan for Earth-to-space transmissions in the fixed-satellite service up to 31 December 1990."

US291 - "Television pickup stations in the mobile service may be authorized to use frequencies in the band 38.6-40 GHz on a secondary basis to stations operating in accordance with the Table of Frequency Allocations."

Existing Government Spectrum Uses
--frequency bands (38.6-39.5 GHz)--

Station Class	Agency	Assignments
0	0	0

Existing Non-Government Spectrum Uses
--frequency band (38.6-39.5 GHz)--

Station Class	Assignments
FX	3-California
	1-US
	4-New Jersey
FXO	2-Ohio
MLT	1-New York
	1-California
MO	1-New York
	1-US
TF	1-US

Fixed and mobile experimentation with CW and FM is being conducted. Also low power fixed operation is being used by business. One mobile TV pickup was identified.

II. BANDS ALLOCATED FOR SHARED USE BY GOVERNMENT AND NON-GOVERNMENT RADIO SERVICE USERS

i) 18.6-18.8 GHz Band

Spectrum Allocations

Primary Allocation: Earth Exploration-Satellite (passive)--Government & non-Government
Space Research (passive) -- Government & non-Government
Fixed--non-Government
Fixed-Satellite (space-to-Earth)-- non-Government
Mobile except Aeronautical Mobile-- non-Government

Secondary Allocation: None

Footnotes:

871 - "In making assignments to stations in the fixed and mobile services, administrations are invited to take account of passive sensors in the earth-exploration satellite and space research services operating in the band 18.6-18.8 GHz. In this band, administrations should endeavor to limit as far as possible both the power delivered by the transmitter to the antenna and the e.i.r.p. in order to reduce the risk of interference to passive sensors to the minimum."

872 - "In assigning frequencies to stations in the fixed-satellite service in the direction space-to-Earth, administrations are requested to limit as far as practicable the power flux-density at the Earth's surface in the band 18.6-18.8 GHz, in order to reduce the risk of interference to passive sensors in the earth exploration-satellite and space research services."

US254 - "In the band 18.6-18.8 GHz, the fixed and mobile services shall be limited to a maximum equivalent isotropically radiated power of +35 dBW and the power delivered to the antenna shall not exceed -3 dBW."

US255 - "In the band 18.6-18.8 GHz, the fixed-satellite service shall be limited to a power flux-density at the Earth's surface of -101 dBW/m^2 in a 200 MHz band for all angles of arrival."

Existing Government Spectrum Uses --frequency band (18.6-18.8 GHz)--

Station Class	Agency	Assignments
0	0	0

Planned Government Uses
--frequency band (18.6-18.8 GHz)--

Tentative plans exist for use of this band in the NASA Tracking and Data Acquisition System (TDAS) program. This program is a sequel to the current Tracking and Data Relay Satellite System (TDRSS). The TDAS, to become operational about 1994 with the launch of two or three satellites into geosynchronous orbit, will serve as the primary communications network for world-wide coverage of most U.S. space missions and many foreign space missions also. When the TDAS becomes operational, the 27.5-31 GHz band will be used for Earth-to-satellite transmissions and the 17.7-21.2 GHz band will be used for satellite-to-Earth transmission.

Tentative plans exist for use of this band in the NASA Advanced Communications Technology Satellite (ACTS) program (previously known as the 30/20 GHz program). This program includes the launch of a satellite into geosynchronous orbit during 1988; at that time the 27.5-30 GHz band will be used for Earth-to-satellite transmissions and the 17.7-20.2 GHz band will be used for satellite-to-Earth transmissions. This program is intended to demonstrate innovative technologies, and at the completion of the planned testing, operation of the satellite could be transferred to industry.

Existing Non-Government Spectrum Uses
--frequency band (18.6-18.8 GHz)--

Station Class	Assignments
FXO	158-Used across USA. Heaviest use in Alaska, California, and Indiana.
FX	1-Texas

FM Fixed operations support local Government, business, press, transit, petrolium companies, some emergency services, and power companies. Equipment power generally ranges from 70-100 milliwatts.

ii) 20.2-21.2 GHz Band

Spectrum Allocations

Primary Allocation: Fixed-Satellite (space-to-Earth)--Government
Mobile-Satellite (space-to-Earth)--Government

Secondary Allocation: Standard Frequency and Time Signal-Satellite (space-to-Earth)--Government & non-Government

Footnotes:

873 - In certain countries, other than the United States, the 19.7-21.2 GHz band is also allocated on a primary basis to fixed and mobile services; however, this additional allocation does not impose any limitation on the power flux-density of space stations in the fixed-satellite service.

G117 - "In the bands...20.2-21.2 GHz...the Government fixed-satellite and mobile-satellite services are limited to military systems."

Existing Government Spectrum Uses
--frequency band (20.2-21.2 GHz)--

Station Class	Agency	Assignments
XT	USN	19-Space
XR	NG	1-Massachusetts

Planned Government Spectrum Uses
--(20.2-21.2 GHz)--

NASA is planning an Ocean Circulation Mission - Topography Experiment (TOPEX). The system will consist of two satellites built around existing subsystems (Orbit/3000km circular, 65 degree, 10-day repeat within 1km).

It will use the following frequencies: 2106.4 MHz, 2287.5 MHz, 20.3 GHz, 31.46 GHz (center frequency), 5 MHz (bandwidth)

The objective of the topography experiment (TOPEX) is to map the surface topography of the ocean, which -- when combined with knowledge of the geoid (obtained from Gravsat and ship gravity surveys) -- will then enable the absolute value of the surface geostrophic current to be determined. This, plus ship-derived subsurface measurement of the density structure of the ocean, will enable the general circulation to be determined. In addition to surface topography, the altimeter will provide surface roughness along nadir--from which surface wind speed and significant wave heights can be determined; all of this data will permit a demonstration of usefulness for ocean applications. Definition studies were conducted during FY 1980 and 1981. Topex is anticipated to be operational in 1986 and will be in use for 5 years.

The Department of Defense is planning a MILSTAR EHF Satellite System. In addition, prior to MILSTAR, the FLEETSAT 7 and 8 satellites will carry 20.2-21.2 GHz transponders. Both FLEETSATCOM and MILSTAR are designed for extensive use by mobile terminals.

Existing Non-Government Spectrum Uses
--frequency band (20.2-21.2 GHz)--

Station Class	Assignments
MLT	10-Various Areas
FXN	1-North Dakota

This band is being used for mobile FM TV pickup. In North Dakota, one license exists for intercity TV relay.

iii) 21.2-21.4 GHz Band

Spectrum Allocations

Primary Allocation: Earth Exploration-Satellite (passive)--
Government & non-Government
Space Research (passive)--Government & non-Government
Fixed--Government & non-Government
Mobile--Government & non-Government

Secondary Allocation: None

Footnotes:

US263 -"In the frequency bands...21.2-21.4 GHz...the Space Research and the Earth Exploration-Satellite Services shall not receive protection from the Fixed and Mobile Services operating in accordance with the Table of Allocations."

Existing Government Spectrum Uses
--frequency band (21.2-21.4 GHz)--

Station Class	Agency	Assignments
0	0	0

Existing Non-Government Spectrum Uses
--frequency band (21.2-21.4 GHz)--

Station Class	Assignments
0	0

iv) 21.4-22 GHz Band

Spectrum Allocations

Primary Allocation: Fixed--Government & non-Government
Mobile--Government & non-Government

Secondary Allocation: None

Footnotes: None

Existing Government Spectrum Uses
--frequency band (21.4-22)--

Station Class	Agency	Assignments
XC	USAF	2 - California
FX	USA	2 - California
		2 - Texas
	NSA	3 - Maryland
	DOE	2 - California
		2 - Washington
		1 - Nevada
		1 - New York
	USAF	2 - California
		1 - Ohio
		1 - Utah
	CG	2 - California
	GSA	1 - Massachusetts
	USN	4 - California
	NASA	1 - Texas
	NG	12 - Hawaii
		1 - Washington, D.C.
		1 - California
XD	NG	3 - Colorado
		9 - Texas
		11 - US
		2 - Washington
		1 - Wyoming

Assignment in this band are used in i) fixed microwave backbone and C-SPAN systems involving the following equipment: GENLSV112A/122A (GEMLINK by General Electric), and MVI23VFM; ii) tests of antennas; and iii) tests of low power microwave systems.

Planned Government Spectrum Uses
--(21.4-22 GHz)--

DOE is planning short path digital data links operating in the 21.4-22.21 GHz band. These systems, operated by the Bonneville Power Administration, will be used for interconnecting computers.

Existing Non-Government Spectrum Uses
--frequency band (21.4-22 GHz)--

Station Class	Assignments
FXO	1-Virginia
	4-California
	1-Illinois
	2-Maryland
	1-Minnesota
	2-New Jersey
	1-Tennessee
	5-Texas
	1-West Virginia
	1-Ohio
	1-Colorado
FX	2-California
	1-Hawaii
	1-New Mexico
MR	1-Texas

This band is used by business and local Government for operations. Several experimental assignments also exist.

v) 22-22.21 GHz Band

Spectrum Allocations

Primary Allocation: Fixed--Government & non-Government
Mobile except Aeronautical Mobile--
Government & non-Government

Special Consideration noted: Radio astronomy observations in the 22.0-22.21 GHz band are noted in footnote 874

Secondary Allocation: None

Footnotes:

874 - "In making assignments to stations of other services, administrations are urged to take all practicable steps to protect the spectral line observations of the radio astronomy service in the band 22.01-22.21 GHz from harmful interference. Emissions from space or airborne stations can be particularly serious sources of interference to the radio astronomy service (see also Nos. 343 and 344 and Article 36)."

343 - "The frequency assigned to a station of a given service shall be separated from the limits of the band allocated to this service in such a way that, taking account of the frequency band assigned to a station, no harmful interference is caused to services to which frequency bands immediately adjoining are allocated."

344 - "For the purpose of resolving cases of harmful interference, the radio astronomy service shall be treated as a radiocommunication service. However, protection from services in other bands shall be afforded the radio astronomy service only to the extent that such services are afforded protection from each other."

Article 36 - Radio Astronomy Service--from Final Acts WARC 79, Geneva

"Section I. General Provisions

Administrations shall cooperate in protecting the radio astronomy service from interference bearing in mind:

a) the exceptionally high sensitivity of radio astronomy stations:

b) the frequent need for long periods of observation without harmful interference; and

c) that the small number of radio astronomy stations in each country and their known locations often make it practicable to give special consideration to the avoidance of interference.

The locations of the radio astronomy stations to be protected and their frequencies of observation shall be notified to the IFRB in accordance with No.

1492 and published by the Secretary-General in accordance with No. 2237 for communication to Members.

Section II. Measures to Be Taken in the Radio Astronomy Service

The locations of radio astronomy stations shall be selected with due regard to the possibility of harmful interference to these stations.

All practicable technical means shall be adopted at radio astronomy stations to reduce their susceptiblity to interference. The development of improved techniques for reducing susceptibility to interference shall be pursued, including participation in cooperative studies through the CCIR.

Section III. Protection of the Radio Astronomy Service

The status of the radio astronomy service in the various frequency bands is specified in the Table of Frequency Allocations, Article 8. Administrations shall provide protection from interference to stations in the radio astronomy service in accordance with the status of this service in those bands (see also Nos. 344, 2632, to 2634 and 2635).

In providing protection from interference to the radio astronomy service on a permanent or temporary basis, administrations shall use appropriate means such as geographical separation, site shielding, antenna directivity and the use of time-sharing and the minimum practicable transmitter power.

In bands adjacent to those in which observations are carried out in the radio astronomy service, operating in accordance with these Regulations, administrations are urged, when assigning frequencies to stations of other services, to take all practicable steps to protect the radio astronomy service from harmful interference in accordance with No. 343. In addition to the measures referred to in No. 2900, technical means for minimizing the power radiated at frequencies within the band used for radio astronomy should be given special consideration (see also No. 344).

When assigning frequencies to stations in other bands, administrations are urged, as far as practicable, to take into consideration the need to avoid spurious emissions which could cause harmful interference to the radio astronomy service operating in accordance with these Regulations (see also No. 344).

In applying the measures outlined in this Section, administrations are urged to bear in mind that the radio astronomy service is extremely susceptible to interference from space and airborne transmitters.

Administrations shall take note of the relevant CCIR recommendations with the aim of limiting interference to the radio astronomy service from other services."

Existing Government Spectrum Uses
--frequency band (22-22.21 GHz)--

Station Class	Agency	Assignments
XC	USAF	1 - Colorado
	NG	2 - Califoria
XD	NG	1 - US&P
XM	USAF	1 - New Mexico
FX	NG	4 - California
		4 - Hawaii
		12 - Massachusetts
		4 - New York

Assignments in this band are fixed microwave video and data links.

Existing Non-Government Spectrum Uses
--frequency band (22-22.21 GHz)--

Station Class	Assignments
FX	3-California
	2-Kentucky
MO	1-Puerto Rico

Experimental fixed and mobile FM assignments exist in this band.

vi) 22.21-22.5 GHz Band

Spectrum Allocations

Primary Allocation: Radio Astronomy -- Government & non-Government
Earth Exploration (passive) -- Government & non-Government
Space Research (passive) -- Government & non-Government
Fixed -- Government & non-Government
Mobile except Aeronautical Mobile -- Government & non-Government

Secondary Allocation: None

Footnotes:

875 - "In making assignments to stations of other services administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference in the band 22.21-22.5 GHz. Emissions from space or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. 343 and 344 and Article 36)."

[for 343, 344 and Article 36 see 22-22.21 GHz band]

876 - "The use of the band 22.21-22.5 GHz by earth exploration-satellite (passive) and space research (passive) services shall not impose constraints upon the fixed and mobile, except aeronautical mobile, services."

US263 - "In the frequency bands...22.21-22.5 GHz...the Space Research and the Earth Exploration-Satellite Services shall not receive protection from the Fixed and Mobile Services operating in accordance with the Table of Allocations."

Existing Government Spectrum Uses
--frequency band (22.21-22.5 GHz)--

Station Class	Agency	Assignments
XC	NG	1 - California
XT	DOE	3 - New Mexico
FX	USN	2 - Arizona
		4 - California
		2 - Florida
		1 - Georgia
		4 - North Carolina
		3 - Nevada
		2 - Oregon
	NG	5 - California
		6 - Hawaii
		6 - Indiana
		1 - Iowa
		2 - New Jersey
		1 - Utah

Assignments in this band are predominantly for video and data links. The GE GEMLINK is commonly used.

Existing Non-Government Spectrum Uses
--frequency band (22.21-22.5 GHz)--

Station Class	Assignments
ANT	1-California

The only license is for an antenna test station.

vii) 22.5-22.55 GHz Band

Spectrum Allocations

Primary Allocation: Fixed -- Government & non-Government
Mobile -- Government & non-Government
Broadcasting-Satellite -- non-Government

Secondary Allocation: Non-Geostationary Intersatellite (as defined by footnote US278) -- non-Government

Footnotes:

877 - "In Regions 2 and 3, the broadcasting-satellite service is authorized in the band 22.5-23 GHz, subject to agreement obtained under the procedure set forth in Article 14."

878 - "Additional allocation: in Japan, the band 22.5-23 GHz is also allocated to the broadcasting service on a primary basis.

US211 - "In the bands...22.5-22.55 GHz...applicants for airborne or space station assignments are urged to take all practicable steps to protect radio astronomy observations in the adjacent bands from harmful interference, however, US74 applies."

US74 - "In the bands...15.35-15.4, 23.6-24 GHz... the radio astronomy service shall be protected from extraband radiation only to the extent such radiation exceeds the level which would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates."

[note that the immediately adjacent band 22.21-22.5 GHz--where radio astronomy holds primary status, is not listed in US74]

[note US278 applies to this band, but this footnote is not listed in the Table of Frequency Allocations]

Existing Government Spectrum Uses
--frequency band (22.5-22.55 GHz)--

Station Class	Agency	Assignments
0	0	0

Existing Non-Government Spectrum Uses
--frequency band (22.5-22.55 GHz)--

Station Class	Assignments
0	0

viii) 22.55-23 GHz Band

Spectrum Allocations

Primary Allocation: Fixed -- Government & non-Government
Mobile -- Government & non-Government
Inter-Satellite -- Government & non-Government
Broadcasting-Satellite -- non-Government

Secondary Allocation: Non-Geostationary Inter-Satellite (as defined by footnote US278) -- non-Government

Special Consideration note: Radio Astronomy Observations in the 22.81-22.86 GHz band as defined in footnote 879.

Footnotes:

878 - "Additional allocation: in Japan, the band 22.5-23 GHz is also allocated to the broadcasting service on a primary basis."

879 - "In making assignments to stations of other services, administrations are urged to take all practicable steps to protect the spectral line observations of the radio astronomy service in the bands 22.81-22.86 GHz and 23.07-23.12 GHz from harmful interference. Emissions from space or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. 343 and 344 and Article 36)."

[for 343, 344 and Article 36 see 22-22.21 GHz Band]

US278 - "In the 22.5-23.55 and 32-33 GHz bands, non-geostationary intersatellite links may operate on a secondary basis to geostationary intersatellite links.

Existing Government Spectrum Uses
--frequency band (22.55-23 GHz)--

Station Class	Agency	Assignments
XC	USN	2 - Arizona 4 - California 2 - Florida 3 - Georgia 10 - North Carolina 10 - Nevada 4 - Oregon 1 - Puerto Rico

Existing Non-Government Spectrum Uses
--frequency band (22.55-23 GHz)--

Station Class	Assignments
FX	1-California

One fixed station is being used for experimentation.

ix) 23-23.55 GHz Band

Spectrum Allocations

Primary Allocation: Inter-Satellite -- Government & non-Government
Fixed -- Government & non-Government
Mobile -- Government & non-Government

Secondary Allocation: Non-Geostationary Inter-Satellite (as defined in footnote US278 -- non-Government

Special Consideration note: Radio Astronomy Observations in the 23.07-23.12 GHz band as defined in footnote 879

Footnotes:

879 - "In making assignments to stations of other services, administrations are urged to take all practicable steps to protect the spectral line observations of the radio astronomy service in the bands 22.81-22.86 GHz and 23.07-23.12 GHz from harmful interference. Emissions from space or airborne stations can be particularly serious sources of interference to the radio astronomy service (see also Nos. 343 and 344 and Article 36)."

[for 343, 344 and Article 36 see 22-22.21 GHz band]

US278 - "In the 22.5-23.55 GHz bands, non-geostationary intersatellite links may operate on a secondary basis to geostationary intersatellite links."

Existing Government Spectrum Uses
--frequency band (23-23.55 GHz)--

Station Class	Agency	Assignments
XC	USAF	3-California
XD	NG	1-Colorado
		8-Texas
		1-US
		1-Washington
XT	DOE	3-New Mexico
FX	DOA	1-Iowa
	USAF	4-California
		1-Ohio
	CG	2-California
	DOE	1-California
		1-Nevada
		1-New York
		2-Washington
	GSA	2-Massachusetts
	DOJ	1-Florida
	USN	4-California
	NASA	1-Texas
	NSA	2-Maryland
	NG	14-California
		1-Georgia
		19-Hawaii
		7-Indiana
		2-Iowa
		1-Louisiana
		8-Massachusetts
		12-Minnesota
		1-North Dakota
		8-New York
		1-Pennsylvania
		4-Texas
		2-Utah

Assignments in this band are used in i) fixed video and telecommand systems involving RQMRACONII, GENLSR-112A, GENLSV042D, GENLSO-122A, GEMLINK, and MV123VFM equipment; ii) development of 23 GHz video link systems; iii) development of mobile surveillance systems involving GENLSV042A equipment; and iv) study of rainfall effects on a propagation loss.

DOA is planning applications for the Mobile Satellite as that technology becomes avaialbe. Demands for using the 23 GHz band are expected to increase to satisfy requirements for limited path length high speed data links. This demand will however be balanced by development of fiber optic technology.

Existing Non-Government Spectrum Uses
--frequency band (23-23.55 GHz)--

Station Class	Assignments
FXO	52-Various Areas
FX5	1-Florida
	1-Michigan
	1-Unknown
FX	1-Illinois
FAT	1-Florida

AM Fixed operations for business is the primary function. One flight test station was identified.

x) 23.55-23.6 GHz Band

Spectrum Allocations

Primary Allocation: Fixed -- Government & non-Government
Mobile -- Government & non-Government

Secondary Allocation: None

Footnotes: None

Existing Government Spectrum Uses
--frequency band (23.55-23.6 GHz)--

Station Class	Agency	Assignments
0	0	0

Existing Non-Government Spectrum Uses
--frequency band (23.55-23.6 GHz)--

Station Class	Assignments
0	0

xi) 23.6-24 GHz Band

Spectrum Allocations

Primary Allocation: Radio Astronomy -- Government & non-Government
Earth Exploration-Satellite (passive) -- Government & non-Government
Space Research (passive) -- Government & non-Government

Secondary Allocation: None

Footnotes:

880 - "All emissions in the band 23.6-24 GHz are prohibited."

US74 - "In the bands...23.6-24 GHz...the radio astronomy service shall be protected from extra-band radiation only to the extent such radiation exceeds the level which would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates."

US246 - "No stations will be authorized to transmit in the bands...23.6-24 GHz..."

Existing Government Spectrum Uses
--frequency band (23.6-24 GHz)--

Station Class	Agency	Assignments
LR	FAA	2-California 1-Washington, D.C. 1-Georgia 1-Illinois 1-Massachusetts 1-Maryland 1-New Jersey 1-New York 1-Ohio 1-Oregon 1-Virginia 1-Washington
FX	NG	1-Hawaii

Assignments identified above are all associated with the operation of the ASDE. A preliminary field review indicates that not all of the assignments identified above are being used; a detailed review has been initiated to identify the actual operating frequencies of the thirteen systems that are now in operation.

Existing Non-Government Spectrum Uses
--frequency band (23.6-24 GHz)--

Station Class	Assignments
RA	1-Location Not Given

Current use is for Radio Astronomy.

xii) 24.05-24.25 GHz Band

Spectrum Allocations

Primary Allocation: Radiolocation -- Government
Industrial, Scientific, and Medical application (as defined in footnote 881) -- non-Government

Secondary Allocation: Earth Exploration-Satellite (active) -- Government & non-Government
Radiolocation -- non-Government
Amateur -- non-Government

Footnotes:

881 - "The band 24-24.25 GHz (center frequency 24.125 GHz)-- is designated for industrial, scientific, and medical (ISM) applications. Radiocommunication services operating within this band must accept harmful interference which may be caused by these applications. ISM equipment operating in this band is subject to the provisions of No. 1815."

1815 - "Administrations shall take all practicable and necessary steps to ensure that radiation from equipment used for industrial, scientific and medical applications is minimal and that, outside the bands designated for use by this equipment, radiation from such equipment is at a level that does not cause harmful interference to a radiocommunication service and, in particular, to a radionavigation or any other safety service operating in accordance with the provisions of these Regulations...in this matter, administrations should be guided by the latest relevant CCIR Recommendations."

US110 - "In the frequency bands...24.05-24.25 GHZ...the non-Government radiolocation service shall be secondary to the Government radiolocation service..."

G59 - "In the bands...24.05-24.25 GHz, all Government non-military radiolocation shall be secondary to military radiolocation..."

Existing Government Spectrum Uses
--frequency band (24.05-24.25 GHz)--

Station Class	Agency	Assignments
MR	USA	18
	VA	5
	DOI	17
	USAF	10
	USN	5
	HHS	1
	DOE	2
	TVA	1
	DOA	1
	NG	4
XD	NG	1 - US
XC	NG	1 - California
XR	NG	1 - US
LR	DOC	1 - Colorado

--See also ASDE Radars identified in 23.6-24 GHz Band--

Assignments in this band are used primarily in the operation of traffic radar systems that include the following equipment: KUSKR10, KUSHR12, KUSKRDD11, KUSHR8, KUSHR-4, KUSTOM HR-4, KUSTOMMR7, and DCE 724; other uses include the testing of developmental traffic radars, the testing of antennas, and the study of clouds.

Existing Non-Government Spectrum Uses
--frequency band (24.05-24.25 GHz)--

Station Class	Assignments
MO	1480-Various Areas
ANT	1-Location not given
MR	613-Various Areas
PO	750--Various Areas

The mobile stations in this band are actually 100-200 mw police CW doppler radars. They should actually be classified MR.

xiii) 24.25-25.25 GHz Band

Spectrum Allocations

Primary Allocation: Radionavigation -- Government & non-Government

Secondary Allocation: None

Footnotes: None

Existing Government Spectrum Uses
--frequency band (24.25-25.25 GHz)--

Station Class	Agency	Assignments
XD	NG	1 - New York
XC	USAF	1 - California

--See also ASDE Radars identified in 23.6-24 GHz Band--

Assignments in this band are used in tests of developmental radionavigation equipment and in tests of antennas associated with the B-1 aircraft development.

Existing Non-Government Spectrum Uses
--frequency band (24.25-25.25 GHz)--

Station Class	Assignments
MO	14-Various Areas
CAR	1-Ohio
MLT	1-California

Police CW doppler radars are the primary equipment in this band. Stations for cable relay and mobile TV pickup were identified.

xiv) 25.25-27 GHz Band

Spectrum Allocations

Primary Allocation: Fixed -- Government
Mobile -- Government

Secondary Allocation: Earth Exploration-Satellite (space-to-space) -- Government & non-Government
Standard Frequency and Time Signal-Satellite (Earth-to-space) -- Government & non-Government

Footnotes: None

Existing Government Spectrum Uses
--frequency band (25.25-27 GHz)--

Station Class	Agency	Assignments
XC	Non-Government	1 - Florida

The assignment in this band is used in tests of a short range terminal guidance radar being developed for the Army. NASA is currently investigating the use of this band for satellite-to-satellite communications as part of the Space Station.

Existing Non-Government Spectrum Uses
--frequency band (25.25-27 GHz)--

Station Class	Assignments
FX	1-Florida
	1-California
MLR	1-Michigan

Fixed experimental FM systems are being used. One additional station was found operating a mobile remote pickup for broadcasting.

xv) 27-27.5 GHz Band

Spectrum Allocations

Primary Allocation: Fixed -- Government
Mobile -- Government

Secondary Allocation: Earth Exploration-Satellite (space-to-space) --
Government and non-Government

Footnotes: None

Existing Government Spectrum Uses
--frequency band (27-27.5 GHz)--

Station Class	Agency	Assignments
-0-	-0-	-0-

NASA is currently investigating the use of this band for satellite-to-satellite communications as part of the Space Station.

Existing Non-Government Spectrum Uses
--frequency band (27-27.5 GHz)--

Station Class	Assignments
FB/MO	1-Indiana 1-Michigan

Businesses operating base and mobile AM units occupy this band.

xvi) 30-31 GHz Band

Spectrum Allocations

Primary Allocation: Fixed-Satellite (Earth-to-space) -- Government
Mobile-Satellite (Earth-to-space) -- Government

Secondary Allocation: Standard Frequency and Time Signal-Satellite (space-to-Earth) -- Government & non-Government

Footnotes:

883 - In certain countries, other than the United States, the band 29.5-31 GHz is also allocated to the fixed and mobile services on a secondary basis. The power limits specified in Nos. 2505 and 2508 shall apply.

2505 - "The maximum equivalent isotropically radiated power (e.i.r.p.) of a station in the fixed or mobile service shall not exceed +55 dBW."

2508 - "The power delivered by a transmitter to the antenna of a station in the fixed or mobile service in frequency bands above 10 GHz shall not exceed +10 dBW."

G117 - "In the bands...30-31 GHz...the Government fixed-satellite and mobile-satellite services are limited to military systems."

Existing Government Spectrum Uses
--frequency band (30-31 GHz)--

Station Class	Agency	Assignments
XC	USAF	2 - California
XR	DOC	1 - Colorado

Assignments in this band are used in antenna tests associated with the B-1 aircraft development and in research of atmospheric conditions.

Planned Government Uses
--frequency band (30-31 GHz)--

Tentative plans exist for use of this band in the NASA Tracking and Data Acquisition System (TDAS) program. This program is a sequel to the current Tracking and Data Relay Satellite System (TDRSS). The TDAS, to become operational about 1994 with the launch of two or three satellites into geosynchronous orbit, will serve as the primary communications network for worldwide coverage of most U.S. space missions and many foreign space missions also. When the TDAS becomes operational, the 27.5-31 GHz band will be used for Earth-to-satellite transmissions and the 17.7-21.2 GHz band will be used for satellite-to-Earth transmission.

The Defense Communications Agency is planning fixed and mobile satellite communications systems for operation in this band.

Existing Non-Government Spectrum Uses
--frequency band (30-31 GHz)--

Station Class	Assignments
0	0

xvii) 31-31.3 GHz Band

Spectrum Allocation

Primary Allocation: Fixed--non-Government
Mobile--non-Government

Secondary Allocation: Standard Frequency and Time Signal-Satellite (space-to-Earth) -- Government & non-Government

Special Consideration noted: Radio Astronomy Observations in the 31.2-31.3 GHz band as defined in footnote 886.

Footnotes:

885 - In certain countries, other than the United States, the 31-31.3 GHz band is allocated on a primary basis to the space research service -- see No. 425.

425 - "Where a band is indicated in a footnote of the Table as allocated to a service "on a primary basis", or "on a permitted basis" in an area smaller than a Region, or in a particular country, this is a primary service or a permitted service only in that area or country..."

886 - "In making assignments to stations of other services, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference in the band 31.2-31.3 GHz. Emissions from space or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. 343 and 344 and Article 36)."

[for 343, 344, and Article 36 see band 22-22.21 GHz]

US211 - "In the bands...31-31.3 GHz...applications for airborne or space station assignments are urged to take all practicable steps to protect radio astronomy observations in the adjacent bands from harmful interference; however, US74 applies."

US74 - "In the bands...31.3-31.8 GHz...the radio astronomy service shall be protected from extraband radiation only to the extent such radiation exceeds the level which would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates."

Existing Government Spectrum Uses
--frequency band (31-31.3 GHz)--

Station Class	Agency	Assignments
0	0	0

Existing Non-Government Spectrum Uses
--frequency band (31-31.3 GHz)--

Station Class	Assignments
RA	1-Location Not Given
FB	1-New York
FX	1-New Jersey
MO	1-New Jersey

Bell Labs Inc. is testing fixed and mobile equipment. Also one station for radio astronomy and one for business base operations were identified.

xviii) 31.3-31.8 GHz Band

Spectrum Allocations

Primary Allocation: Radio Astronomy -- Government & non-Government
Earth Exploration-Satellite (passive) -- Government & non-Government
Space Research (passive) -- Government & non-Government

Secondary Allocation: None

Footnotes:

887 - "All emissions in the band 31.3-31.5 GHz are prohibited."

US246 - "No stations will be authorized to transmit in the bands ...31.3-31.8 GHz..."

US74 - "In the bands...31.3-31.8 GHz...the radio astronomy service shall be protected from extraband radiation only to the extent such radiation exceeds the level which would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates."

Existing Government Spectrum Uses
--frequency band (31.3-31.8 GHz)--

Station Class	Agency	Assignments
XC	NG	1 - California
	USAF	1 - California
XT	USAF	1 - Missouri

Assignments in this band are used in tests of developmental antennas for aircraft and satellite programs.

Planned Government Spectrum Uses (31.3-31.8 GHz)--

NASA is planning an Ocean Circulation Mission - Topography Experiment (TOPEX). This system will consist of two satellites built around existing subsystems (Orbit/300km circular, 65 degrees, 10-day repeat within 1km).

It will use the following frequencies: 2106.4 MHz, 2287.5 MHz, 20.3 GHz, 31.4 GHz (center frequency) (5 MHz bandwidth).

The objective of the topography experiment (TOPEX is to map the surface topography of the ocean, which -- when combined with knowledge of the geoid (obtained from Gravsat and ship gravity surveys) -- will then enable the absolute value of the surface geostrophic current to be determined. This, plus ship-derived subsurface measurements of the density structure of the ocean, will enable the general circulation to be determined. In addition to surface topography, the altimeter will provide surface roughness along nadir -- from

which surface wind speed and significant wave heights can be determined; all of this data will permit a demonstration of usefulness for ocean applications. Definition studies were conducted during FY 1980 for TOPEX and are continuing in 1981. TOPEX is anticipated to be operational in 1986 and will be in use for 5 years.

Existing Non-Government Spectrum Uses
--frequency band (31.3-31.8 GHz)--

Station Class	Assignments
FX	4-California
	1-New York

Experimentation with FM and CW systems is being performed.

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15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This report constitutes a Spectrum Resource Assessment (SRA) of the frequency bands from 17.7-40.5 GHz. Included is information on rules and regulations, allocations, technical standards, current and proposed usage, and planning and coordination procedures. Major issues concern Government and non-Government telecommunications requirements, and planning and coordination procedures for these bands. Recommendations include retaining the current allocation tables and planning structure, making changes to assignment procedures and documenting long range plans.

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

Frequency Coordination; Radio Frequency;Spectrum Management; Long Range Planning; 17.7-40.5 GHz

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