NTIA REPORT 84-161

SPECTRUM RESOURCE ASSESSMENT OF THE FIXED AND MOBILE SERVICES IN THE 947 - 17,700 MHz BAND

PHASE I

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ABSTRACT

The National Telecommunications and Information Administration (NTIA), in keeping with its responsibility for managing the Government's use of the radio frequency spectrum, researches particular bands when changes in national and/or international allocations occur, when assignments to particular services show crowding, or when new systems coming into bands may present compatibility problems with existing systems. Both the Federal Communications Commission (FCC) and NTIA recognize a need at this time to review the use, rules and regulations, and technical standards for the fixed and mobile allocations between 947 MHz and 17.7 GHz. This review was prompted by a number of factors influencing assignments in this portion of the radio frequency spectrum, including changes in allocations as a result of the World Administrative Radio Conference (WARC) held in 1979, increased use of these bands by Space Communication Services, crowding of assignments in some of the bands containing Fixed and Mobile Services, and the need to establish a long-range plan for spectrum use.

This report constitutes a Spectrum Resource Assessment of the bands containing Fixed and Mobile Services in the 947 MHz to 17.7 GHz portion of the radio frequency spectrum. Included is information on rules and regulations, allocations, technical standards, frequency assignments, and major system characteristics. The possibility of increased sharing between Government agencies and between Government and non-Government entities is considered for the various bands. Conclusions are drawn and recommendations made on sharing potential based on current usage data. This is a Phase I Report; A Phase II Report will include actual system and equipment counts and projected future use by the various Government agencies who presently have, or plan, future services in these bands.

KEY WORDS

Fixed and Mobile Services
947 - 17,700 MHz Band
Government exclusive bands
Government/non-Government shared bands
spectrum management
spectrum sharing
long-range plan

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SECTION 1

1. INTRODUCTION

BACKGROUND

The National Telecommunications and Information Administration (NTIA) is responsible for managing the 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" (United States Department of Commerce, 1982). In support of these requirements, NTIA has undertaken a number of Spectrum Resource Assessments. The objectives of these studies are to: assess spectrum utilization, identify existing and/or potential compatibility problems among the telecommunication systems that belong to various departments and agencies, provide recommendations for resolving any compatibility conflicts that may exist in the use of frequency spectrum, recommend changes to increase spectrum efficiency and improve spectrum management procedures, and help establish a long-range plan for spectrum use. This spectrum resource assessment considers the Fixed and Mobile Services in 947 MHz-17.7 GHz frequency range.

In order to ensure efficient and effective use of the spectrum, Executive Order 12046 and Department of Commerce Order 10-10 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 covering the bands 947 MHz-17.7 GHz and 17.7 GHz-40.5 GHz. (These SRA's are proceeding concurrent to FCC Docket 82-334 which addresses identification of suitable spectrum for licenses displaced under Docket 80-603 by the Broadcasting-Satellite Service (BSS) in the 12.2-12.7 GHz band.

(2) Spectrum Resource Assessment covering 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 23648/1 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 SRA's will be incorporated into the Joint NTIA/FCC Long-Range Plan (LRP).

On September 30, 1983, the FCC released the First Report and Order (FCC 83-393) in General Docket 82-334 to provide frequencies and revised rules for the reaccommodation of existing 12 GHz fixed microwave users. This was necessary because the

12 GHz band (12.2 to 12.7 GHz) has been allocated to the Broadcasting-Satellite Service (BSS) on a primary basis, and Fixed Service and BSS cannot use the same frequencies in a geographic area due to potential interference. The First Report and Order also allocated spectrum in the 18 GHz band to Fixed Service.

On January 13, 1983, the Commission adopted and released a Notice of Proposed Rule Making (NPRM) (FCC 83-2) in General Docket 82-334 proposing spectrum allocations and standards for certain microwave bands. A major purpose of the NPRM was to propose changes in the Commission's Rules to accommodate private fixed users who might be displaced from the 12 GHz frequency band by the allocation of this band to the Broadcasting-Satellite Service. Earlier, the Commission had released a Notice of Inquiry (NOI) (FCC 82-286) in this proceeding to examine spectrum allocations and technical standards for certain Fixed and Mobile Services' bands between 17.7 and 40 GHz. The scope of the proceeding was expanded by the NPRM to include consideration of certain additional bands between 947 MHz and 17.7 GHz to provide a means for developing provisions to accommodate the displaced 12 GHz users. This was in response to the Commission's instruction in the Report and Order in Docket 80-603 authorizing BSS in the 12.2-12.7 GHz band (12 GHz band). In that Report and Order (FCC 82-285) the Commission instructed its staff to prepare a notice of proposed rule making to make spectrum available for Private Fixed Service users who might be displaced from the 12 GHz band by the BSS. While the Commission recognized that many displaced 12 GHz fixed operations could be supported at frequencies of 18 GHz and higher, it tentatively identified other spectrum that might also support some of them. In particular, it noted that the bands at 6525-6875 MHz and 12.7-13.25 GHz might be used with significantly lower costs than those associated with the 18 GHz band. The Commission stated that it intended to propose a considerable amount of sharing or pooling of microwave spectrum among the Broadcast Auxiliary, Cable Television Relay, and Private Operational Fixed Services, and to consider the possibility of sharing between these services and common carrier services. By opening up lower bands through interservice sharing, opportunities would be created to reaccommodate displaced 12 GHz users at less cost than would occur if they were restricted to moving only to bands at 18 GHz and higher. Among other issues that the Commission expressed intent to address were: (1) the need for minimum path length criteria for the use of each of the available bands, (2) bandwidth requirements and appropriate channeling plans for the bands, (3) feasibility of continued private fixed use of the 12.2-12.7 GHz band on a secondary basis, (4) coordination and loading practices needed to ensure efficient use of the spectrum, and (5) consolidating noncommon carrier microwave licensing within the Commission. Some of these had already been discussed in the NOI in this proceeding as they affect the bands between 17.7-40 GHz. The issues are relevant to determining efficiency of use of the spectrum and should be considered during the development of utilization policy. Though the above discussions deal mainly with non-Government use of the spectrum allocated to their use, concern was generated by both Government and non-Government spectrum users and managers as to long-range impacts of such problems on spectrum use and sharing. This concern prompted this special study of Government use of spectrum between 947 MHz and 40 GHz which would influence the continuing effort at long-range planning for effective and efficient use of the spectrum administrated by NTIA.

In the United States the spectrum from 947 MHz to 17.7 GHz has been divided into 88 separate bands. The effort here will be focused on the Fixed and Mobile Services and there are 50 bands allocated to those services. The 50 bands which contain Fixed and Mobile allocations are represented by 7917 MHz of spectrum. The 7917 MHz of spectrum is allocated to Government/non-Government shared, non-Government exclusive, and Government exclusive uses. Even though the allocation table may seem to allocate a band to Government or non-Government exclusive use, the band may actually be shared by action of a footnote to the allocation table. An example would be the three bands between 8025-8400 MHz. These bands appear to be Government exclusive bands. However, U.S. Footnote 258 states that, "In the band 8025-8400 MHz, the non-Government Earth Exploration-Satellite Service (space-to-Earth) is allocated on a primary basis. Authorizations are subject to a case-by-case electromagnetic compatibility analysis." By virtue of the footnote, this portion of the spectrum becomes a Government/non-Government shared band.

The 7917 MHz of spectrum containing Fixed and Mobile Services in the frequency range from 947 MHz to 17.7 GHz is allocated as follows:

Government/non-Government shared -

Shared by direct allocation,	11 bands containing 744 MHz of spectrum
Shared by footnote,	14 bands containing 1403.5 MHz of spectrum
Total shared,	25 bands containing 2147.5 MHz of spectrum (27%)
Non-Government exclusive,	14 bands containing 3,578 MHz of spectrum (45%)
Government exclusive,	11 bands containing 2,191.5 MHz of spectrum (28%).

Major services in the remaining 38 bands that make up the allocations in the 947 MHz to 17.7 GHz spectrum range include Radiolocation, Aeronautical Radionavigation, Aeronautical Telemetering, Fixed-Satellite, Mobile-Satellite, Meteorological-Satellite, Broadcasting-Satellite, and Radio Astronomy Services.

The frequencies between 947 MHz and 17.7 GHz represent a large portion of the usable radio frequency spectrum and represent a very important and valuable asset as part of this resource. There is a need at this time to review the Government use, rules and regulations, and technical standards governing this portion of the spectrum in light of the Commission's NOI, NPRM, and Report and Order; the changes in allocations and standards implemented as a result of the 1979 World Administrative Radio Conference (WARC-79); and changes in market demands and applications of new technologies being addressed. Continued examination of Government spectrum requirements is necessary to assure that assigned mission functions are satisfied and that the spectrum is used efficiently.

For an overview of the U.S. Government's use of the spectrum, both by the military and civilian agencies, see Appendix D which gives a general summary.

A multiphase program to evaluate sharing potential in the 947 MHz-17.7 GHz frequency bands was undertaken as follows:

<u>Phase I</u>: The first phase involves the gathering of all information presently in NTIA files on assignments, uses, major systems, etc., in the bands involved; from the GMF, NGMF, past SRA reports in this frequency range, other NTIA

and Government agency reports, equipment manufacturers' system descriptions and reports, and any other readily accessible source with pertinent information to this study. This will lead to the generation of preliminary recommendations for the band's sharing potential. This document is the Phase I report for the 947 MHz-17.7 GHz band-sharing investigation.

Phase II: This phase will incorporate detailed information from each Federal agency represented in the IRAC giving system/equipment counts, missing re-requirements, and projections of future use in all bands containing Fixed and Mobile Services from 947 MHz to 17.7 GHz. Based on Phase I recommendations, certain bands will be explored in more detail to assess the impact of band sharing. The concept of regional sharing as recommended in the Phase I report will be more detailed in the Phase II report.

Additional Phases: These phases will be conducted in particular bands as required. These assessments take into account new inputs such as new system design, other system changes, allocations changes, and EMC impact. They will continue until satisfactory solutions to the problems of sharing are obtained, or until the point when sufficient decisions have been made, such that further assessments are no longer necessary.

OBJECTIVES

To assist in the development of long-range spectrum management plans and policies, the following objectives are identified for this spectrum resource assessment:

1. Review and document the existing and proposed uses of the bands between 947 MHz and 17.7 GHz by the Government and non-Government Fixed and Mobile Services, particularly emphasizing those specifically addressed in the FCC documents and including those which could be expected in response to the results of the WARC-79 and other international and national agreements.
2. Assess the nature and scope of present and future potential compatibility problems between Government and non-Government planned uses of this spectrum.
3. Evaluate the feasibility of increased sharing between Government and non-Government services without affecting critical Government needs.
4. Recommend specific changes to the existing rules, regulations, and frequency management practices that would improve overall management of the band.
5. Identify and outline specific problem areas requiring additional analysis, if any.

APPROACH

In order to accomplish the objectives of the 947 MHz to 17.7 GHz Spectrum Resource Assessment, the following approach was taken:

1. Review the various FCC documents concerned with this band to determine the likely effect to Government radio services.

2. Review the Final Acts of the WARC-79 and the NTIA Manual to determine the allocations to Fixed and Mobile Services and the regulations pertaining to the frequency bands of concern between 947 MHz and 17.7 GHz.

3. Review the systems that are currently operating in the band, where they are deployed, and their technical characteristics by:

   a. Using the Government Master File (GMF), the non-Government Master File (NGMF), previous NTIA reports, the System Review File (SRF), and other Government reports to identify frequency assignments and usage for Government and non-Government operations.

   b. Contacting the Government frequency managers through the IRAC and using surveys of major equipment manufacturers and users.

4. Identify future systems proposed for the band by using data in the IRAC/SPS system review process for Government systems and equipment.

5. Review the compatibility analysis of systems within the 947 MHz to 17.7 GHz bands concerned with the Fixed and Mobile Services accomplished by other Government agencies and those analyses made in support of the IRAC system review process.

6. Recommend specific changes or further studies relative to the existing rules, regulations, and frequency management practices that would improve overall management of the Government Fixed and Mobile Services in the bands involved.

7. Identify remaining key issues that affect spectrum management of the Fixed and Mobile Services in the band and recommend follow-on activities to address these issues.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

Conclusions and recommendations are general in this Phase I report and are based on file data within NTIA and easily accessible file data from other-agency sources (November 1983). The Phase II report is intended to include more explicit data on future Government need for services in these bands and actual present-day system/equipment counts. It will be noticed in a number of bands there are recommendations for regional sharing of frequency assignments between Government and non-Government entities. These recommendations are general in nature and will be considered in more detail in light of all data available, particularly planned future use by the various Government agencies, in the Phase II report. However, the concept of regional sharing should be a serious consideration for the future since frequency assignments to a service in some bands tend to concentrate in certain geographic areas leaving other areas with few or no assignments.

General Conclusion

The forces influencing the allocation of spectrum resources by the FCC and the Federal Government are basically very different. Economic and political pressures by the private sector upon the FCC for increased spectrum resources establish a criteria for spectrum efficiency. The Government's requirements are dictated by planning requirements for national exigencies, and Federal Government's National Security and Emergency Preparedness programs, which complicates the efficiency of Government spectrum use. It is this difference in the national planning concept that establishes the basis upon which Government needs are satisfied and why sharing with non-Government entities requires special management and rules.

While there is a concept of geographical sharing between Government and non-Government entities presented in this report, if this concept should be pursued, the ramifications and implications upon existing and future Government and non-Government spectrum needs would require a detailed and vigorous examination. The National Table of Frequency Allocations is a representative document of the Governments detailed long-range planning requirements. However, it would facilitate planning if a regional concept were established. [By designating geographical areas, sharing and nonsharing and the terms under which this could be accomplished could be more definitely specified.] To accomplish this, private sector long-range plans must be identified and addressed to make a comprehensive assessment of this important issue. The FCC liaison representatives to IRAC and Frequency Assignment Subcommittee (FAS) has provided a needed and satisfactory procedure for coordination of civil and Government requirements in the past. This liaison must become even more effective in the future as pressure from both Government and non-Government users of the frequency spectrum become more demanding on this important national resource. (See IRAC Document 23993/1-2.7.13.2, Letter from R. M. Lewis to Robert J. Mayher, July 5, 1984).

Specific Conclusions

Government exclusive bands--sharing not possible

1. The 1710-1850 MHz band: This band is one of the heaviest used bands for Government Fixed Services. There are 41 systems presently in the systems review process, which is indicative of the anticipated growth in the band. Based on present assignments and

the critical nature of the services in the band, it seems highly improbable there could be sharing with the non-Government sector.

2. The 2200-2290 MHz band: This band is an important band for Government with many assignments to the Mobile Service for telemetering. There are also a considerable number of experimental assignments along with growing space research and fixed assignments. The band is actually now a shared band by footnote. The band shares the use of 2285-2290 MHz for the TDRSS by a recent footnote. With present nature of band usage and expanding space research use, this band does not lend itself well to increased sharing with non-Government users at this time. This band should be looked at in more detail in the Phase II report.

3. The 4400-4500 MHz and 4800-4990 MHz bands: These bands are used by the military services for tactical communications--both line-of-site microwave and tropospheric scatter operations. There is some room for growth in these bands, but until future use is determined in the Phase II study, these bands should be held for Government exclusive use.

4. The 7125-8450 MHz band: These bands are used mainly for Government fixed systems (87%). Most of the 13 subbands contain some type of satellite communications allocation, and this is a growth area in assignments for the future. Twenty Government departments and agencies have assignments in the bands (over 7700). The three bands from 8025-8400 MHz are shared with non-Government users for the Earth Exploration-Satellite Service by U.S. footnote 258. Because of the importance of the Government systems operating in the bands and the congestion already present in many areas of CONUS, there is little possibility of increased sharing with non-Government users. (See important, expanded conclusions, page 215).

5. The 14.5-15.35 GHz band: Present assignments in this band are primarily to the Fixed Service (75%). The band has shown a 500% growth in assignments in the past 10 years. It is expected that this growth trend will continue in the near future. Although there is room for growth, until all information is in on future Government needs for this band (to be given in Phase II report), sharing possibilities cannot be determined.

<u>Government exclusive bands--limited sharing may be possible</u>

6. The 1350-1400 MHz band: This band is primarily a radiolocation band with Fixed and Mobile secondary. Because of the importance of this band to the national defense, general sharing with the private sector is not practical. However, there are 25 states with no present assignments. After future proposed usage is known in the Phase II Report, this band should be investigated for possible sharing opportunities in certain geographic areas with non-Government users.

Government/non-Government shared bands

7. The 1427-1535 MHz band: This band is heavily used by the Government and non-Government for telemetering purposes. Provisions have been made for the Fixed Service on a secondary basis for the private sector. There doesn't seem to be a need to change allocations in this band at this time.

8. The 1700-1710 MHz band: The band is used mainly by Government for meteorological-satellite data links. This band does have growth potential but the allocations are such that both Government and non-Government users can be accommodated without changes at this time.

9. The 2290-2390 MHz band: The 2290-2300 MHz portion of the band is used mainly for Space Research (deep space only) assignments and has the least potential for increased sharing. The 2300-2390 MHz portion is basically a Govermment radiolocation band; however, radiolocation use of frequencies between 2310 and 2390 MHz is very sparse. There are 26 states in CONUS that do not presently have Government assignments in the 2290-2390 MHz band with another 9 that have only one. The 2300-2390 MHz portion of the band could support more fixed assignments and might be considered for a non-Government Fixed Service on a secondary basis as is presently allocated to Government. However, the impact of new Mobile Services should be evaluated before any changes in allocation are recommended.

10. The 4500-4800 MHz band: The major assignments in this band are to the Government Fixed Services (75%). Tropospheric scatter systems that operate in this band are very important to the military for tactical communication purposes. The new fixed-satellite allocation to non-Government may pose some interference potential to existing systems. This band at present tends to have many assignments in a few geographic areas. There are 15 states with no assignments and another 9 with only one assignment. However, because of the importance of the troposcatter systems, limited sharing is desirable.

11. The 8450-8500 MHz band: This is not a heavily used band by either Government or non-Government services. There are only nine states with assignments in this band. There may be room for a non-Government Fixed Service on a secondary basis. There is some concern about adjacent channel interference from high-power radars in the 8500-9000 MHz band but distance criteria can be developed to help in assignment placements. Further investigation is necessary before a final decision is made on further sharing.

12. The 10.6-10.68 GHz band: There are no Government assignments in this band. However, there are two Government assignments and one non-Government assignment in the lower adjacent band that can range tune into this band. There is an allocation to the non-Government Fixed Service on a shared primary basis with other services . At present there are only 12 states that have any assignments. It would seem that this band could be used by some of the non-Government fixed stations to be displaced from the 12 GHz band by the Broadcasting-Satellite Service. However, the new Digital Termination System services will be the new growth area for this band.

13. The 14.4-14.5 GHz band: The primary allocation in this band is to the non-Government Fixed-Satellite Service. Government fixed and mobile assignments are secondary. Though satellite systems are a growth area nationally, they have not significantly changed the number of assignments in the band over the past 5 years. However, this is misleading since there are 112 satellite-related systems that require bandwidths that extend into this band from the lower adjacent band. These wideband assignments show about a 10% growth per year over the past 3 years.

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, or procedures.

Government exclusive bands

1. After future needs have been fully explored in the Phase II report, it is recommended that the 1350-1400 MHz band be studied for possible regional sharing of non-Government Fixed and Mobile Services on a secondary basis as shown in the shaded area of Figure 1.

2. After future needs have been fully explored in the Phase II report, it is recommended that the 14.5-15.35 GHz band be studied for possible regional sharing of non-Government Fixed and Mobile Services on a secondary basis in the shaded area of Figure 2.

Government/non-Government shared bands

3. It is recommended that the 2310-2390 MHz band be studied for the possibility of adding non-Government Fixed Services on a secondary basis in the regional area shown by the shading in Figure 3, if Phase II findings warrant.

4. It is recommended that the 8450-8500 MHz band be considered for non-Government Fixed Services on a secondary basis if Phase II studies show possible success.

5. It is recommended that the 10.6-10.68 GHz band be considered as a band to be used for some of the displaced fixed stations from the 12.2-12.7 GHz band. However, the new DTS services will be expanding rapidly in the near future and the 12 GHz users would have to be well coordinated with these new systems.

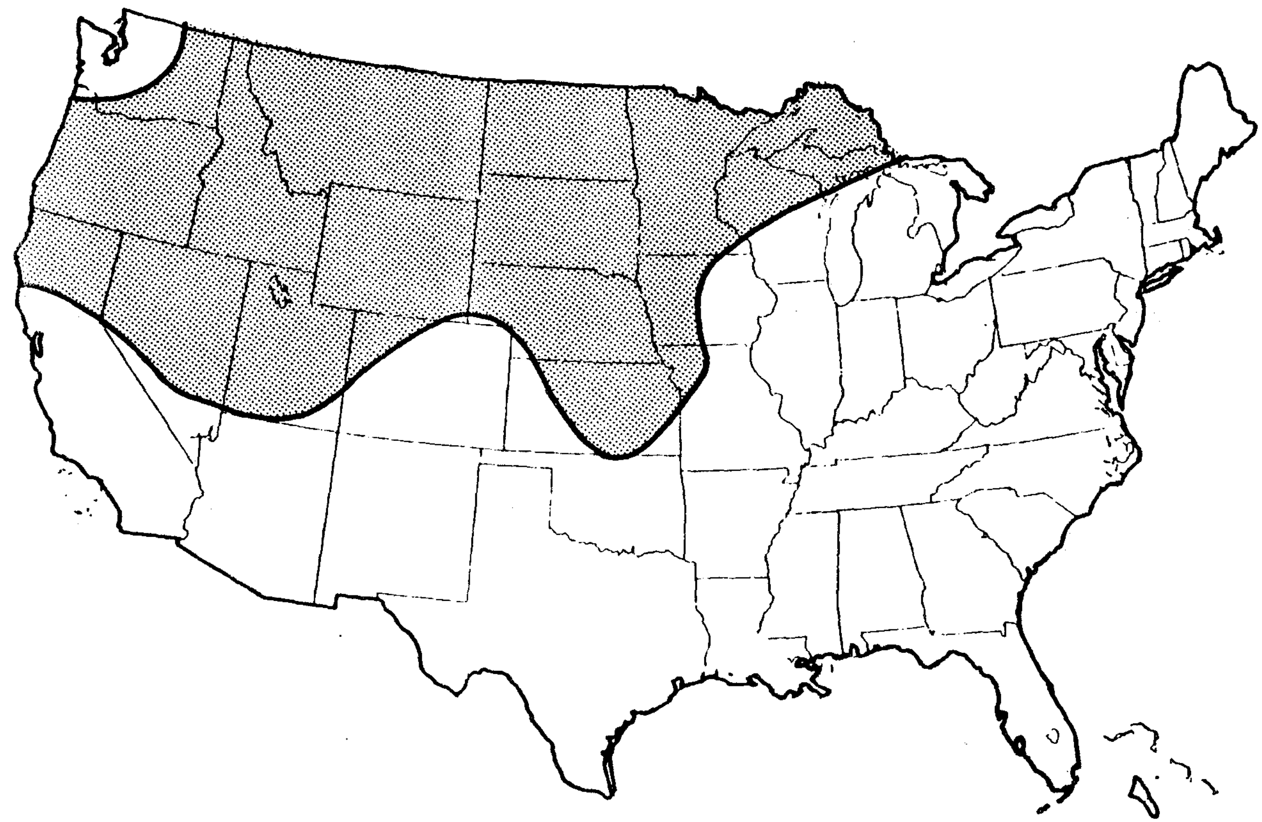


Figure 1. Geographic Area (Shaded) for Possible Sharing in the 1350-1400 MHz Band.

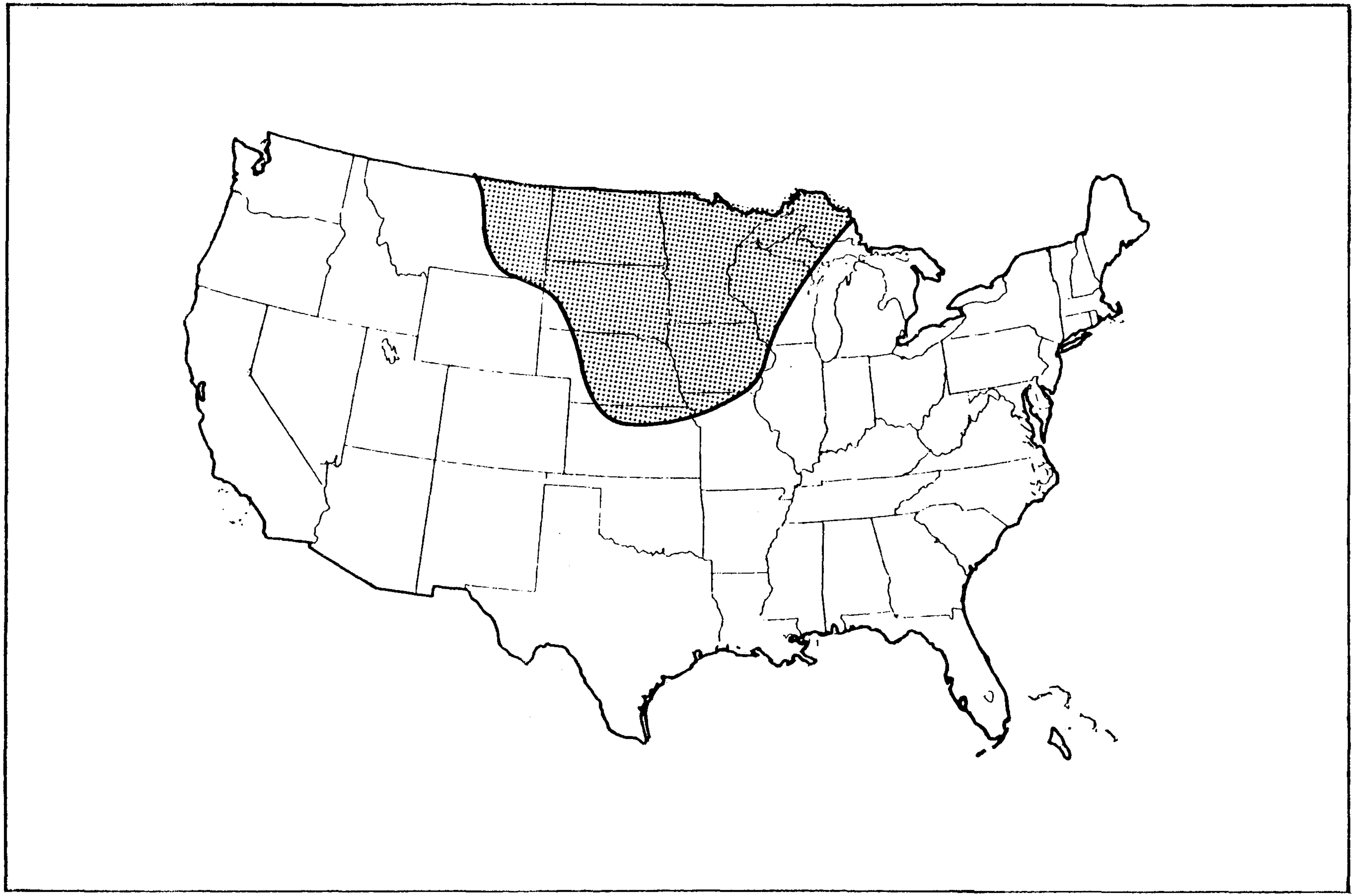


Figure 2. Geographic Area (Shaded) for Possible Sharing in the 14.5-15.35 GHz Band.

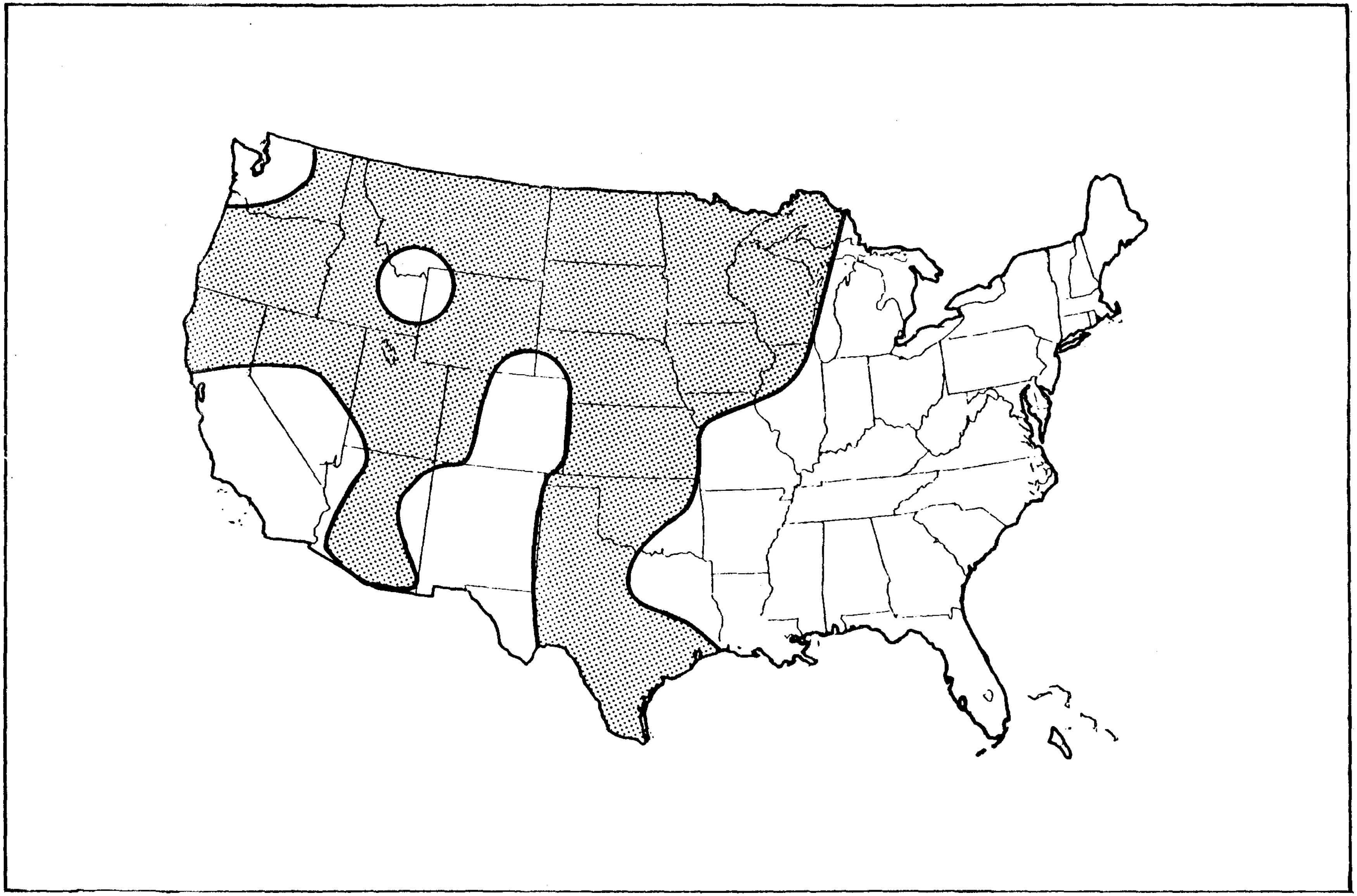


Figure 3. Geographic Area (Shaded) for Possible Increased Sharing in the 2290-2390 MHz Band.

SECTION 3

SUMMARY OF FREQUENCY ASSIGNMENTS, RULES AND REGULATIONS, SPECTRUM USAGE, AND MAJOR SYSTEMS FOR THE 947 MHZ-17.7 GHZ BAND

FREQUENCY ASSIGNMENTS

Frequency assignments are made according to the International Telecommunication Union (ITU) Table of Frequency Allocations and the U.S. National Table of Frequency Allocations, which is comprised of the U.S. Government Table and the non-Government Table of Frequency Allocations. The U.S. Government Table of Frequency Allocations is used as a guide in the assignment of radio frequencies to Government radio stations in the United States and possessions. The exceptions to the National Table of Frequency Allocations as given in the NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management are as follows:

> A Government frequency assignment may be authorized in a non-Government band, as an exception, provided, (a) the assignment is coordinated with the FCC and, (b) no harmful interference will be caused to the service rendered by non-Government stations, present or future.
>
> A non-Government frequency assignment may be authorized in a Government band, as an exception, provided, (a) the assignment is coordinated with the IRAC and, (b) no harmful interference will be caused to the service rendered by Government stations, present or future.
>
> In the case of bands shared by Government and non-Government services, frequency assignments therein shall be subject to coordination between the IRAC and the FCC and no priority is recognized unless the terms of such priority are specifically defined in the National Table of Frequency Allocations or unless they are subject to mutually agreed arrangements in specific cases.

Tables 1 through 3 (tables are at end of section) show the 947 MHz to 17.7 GHz allocations (extracted from Chapter 4 of the NTIA Manual) for the Government exclusive, Government and non-Government shared (Tables 4 through 6), and non-Government exclusive (Tables 7 and 8). These bands are summarized below:

Summary of Government Exclusive Bands

The Government exclusive bands in the 947 MHz to 17.7 GHz region of the spectrum are displayed in Tables 1 through 3. There are 21 discrete bands allocated to the Government in this region that contain fixed and mobile assignments. Only three of these bands are allocated exclusively to the Fixed Service, and only three are shared on a coequal basis by the Fixed and Mobile Services. The remaining 15 bands are shared by the Fixed and Mobile with Space Research, Fixed-Satellite,

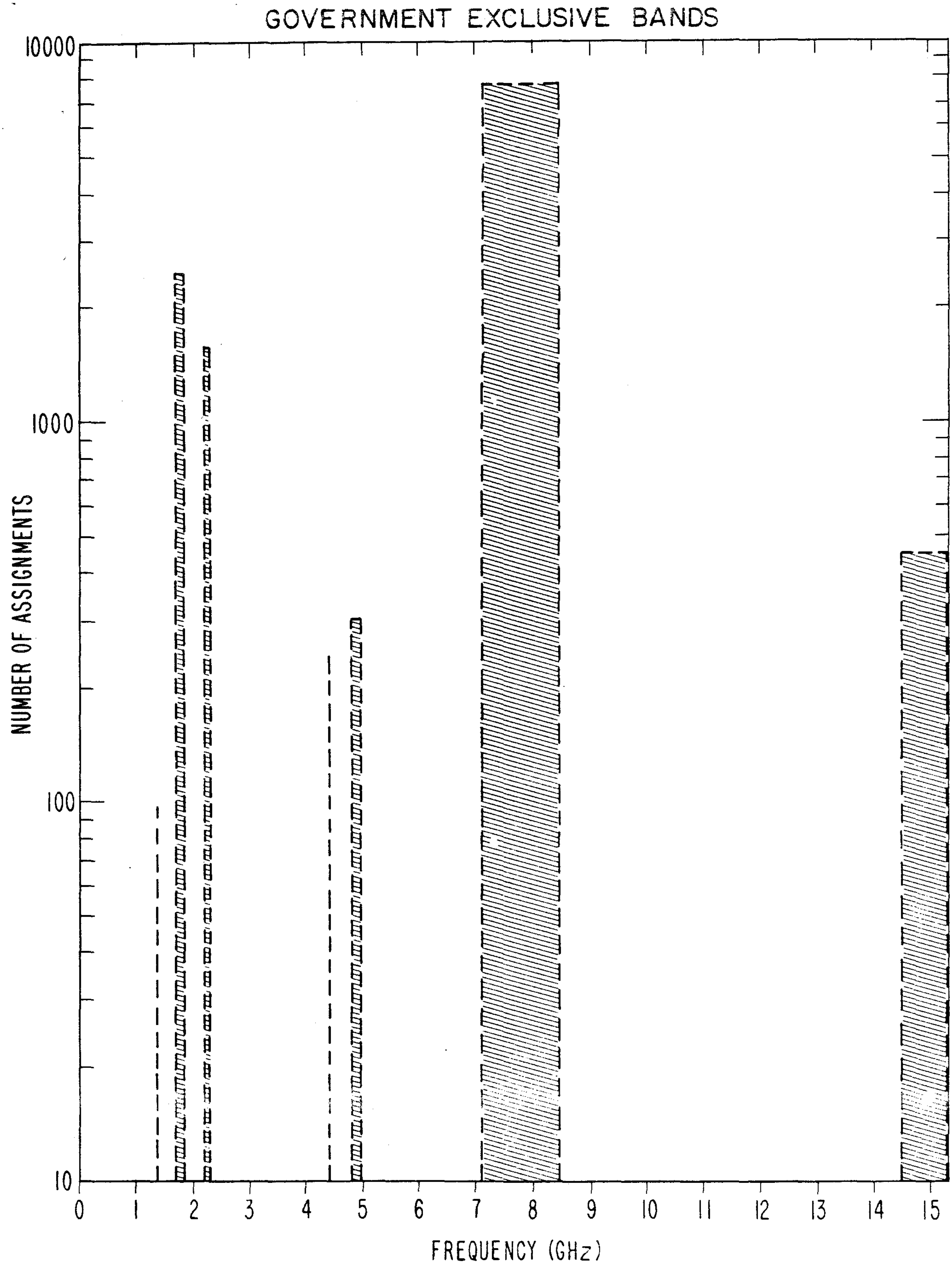


Figure 4. Assignment Distribution for the Government Exclusive Bands.

Meteorological-Satellite, Mobile-Satellite, and Earth Exploration-Satellite. These bands and the radio service allocation are tabulated in Table 2; and the Government agencies using the band, together with their number of assignments, are listed by band in Table 3. Note that in almost all the bands there are a small number of non-Government assignments (1 to 15) used mainly by contractors working on Government research, development, and testing programs.

Figure 4 shows the assignment distribution for the Government exclusive bands. There are 12,851 total assignments in these bands, of which 12,296 are unclassified assignments and 555 are classified assignments.

The Government and non-Government shared bands containing Fixed and Mobile Services allocated in the 947 MHz to 17.7 GHz portion of the spectrum are shown in Table 4. There are 13 discrete frequency bands in the Government and non-Government shared portion of this region which contain fixed and mobile assignments. Of these, only one band (1435-1530 MHz) is assigned exclusively to the Mobile Service, and only one band (1429-1435 MHz) is assigned on a coequal basis to the Fixed and Mobile Services; the remaining 11 bands are a mix of Fixed and Mobile with Maritime Mobile-Satellite, Meteorological-Satellite, Space Research, Radiolocation, Broadcasting-Satellite, Earth Exploration-Satellite, and Amateur assignments. For convenience of comparison the Government and non-Government allocations have been tabulated in Tables 5 and 6 to show the number of assignments for Government radio service in each band by Government agency.

Figure 5 shows the assignment distribution as a function of frequency for the 13 shared bands. There are 1,597 total assignments in these bands, of which only 24 are Classified and the remaining 1,573 are Unclassified. The 12.2 to 12.7 GHz is shown here because it was in effect shared by Government (5 assignments) and non-Government (10 assignments). However, since this band has been allocated to the Broadcasting-Satellite Service on a primary basis, the present users will have to vacate this band. The Report and Order in FCC General Docket 82-334 establishes a spectrum utilization policy for this band and gives specific provisions for recommendation of Fixed Service users who will be displaced from the 12.2-12.7 band by BSS operations. These include provisions for future use of the 17.7 to 19.7 GHz band by terrestrial microwave services.

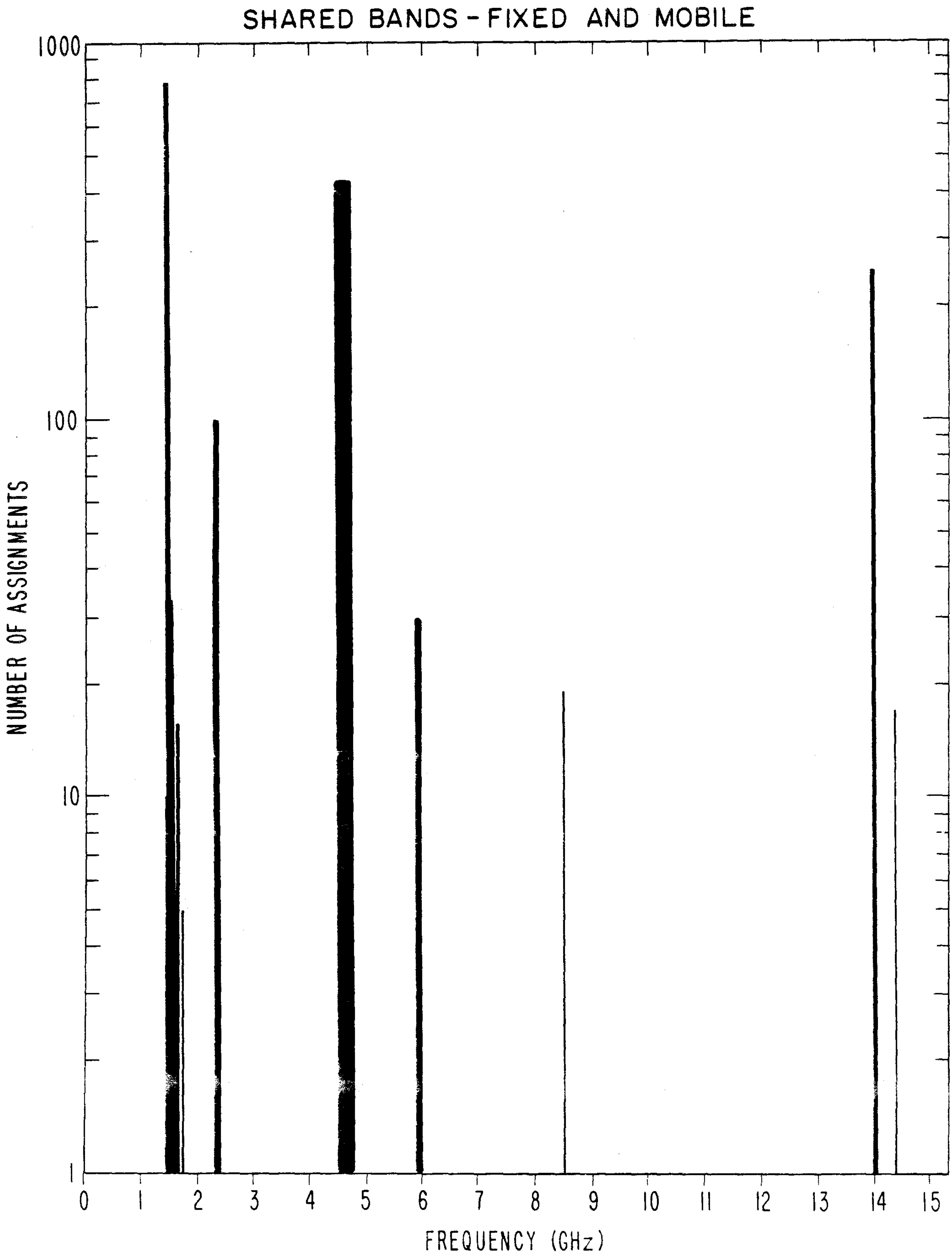


Figure 5. Assignment Distribution for the Government and non-Government Shared Bands.

Summary of non-Government Exclusive Bands

The non-Government exclusive bands containing fixed and mobile assignments in the 947 MHz to 17.7 GHz region of the spectrum are displayed along with the ITU allocations in Table 7. There are 18 discrete non-Government bands in this region that contain fixed and mobile assignments. Four are assigned exclusively to the Fixed Service, and three are shared on a coequal basis by the Fixed and Mobile Services. The remaining 11 bands are shared by the Fixed and Mobile Services with the Fixed-Satellite, Broadcasting-Satellite, and Radiolocation Services. Table 8 lists only the radio service by band. Table 9 lists the number of frequency assignments for Government radio services in the non-Government exclusive bands by Government agency for the six (6) non-Government bands involved.

Figure 6 shows only the Government frequency assignment distribution in the non-Government exclusive bands. There are, as can be seen from Table 9, a total of 455 Government assignments in these six bands. Also shown in Table 9 are the various types of Government systems using these bands. Most of the assignments in the 1850-2200 MHz band are NASA assignments (310) for satellite communications such as the Pioneer, Voyager, and Viking Space probes, as well as several geophysical satellites such as GOES, Nimbus, Landsat, Space telescope, Space Shuttle links, etc.

Frequency Assignments and FCC Recommendations

As can readily be seen from Figure 7, which displays the number of assignments as a function of frequency for Fixed and Mobile Service bands in the 947 MHz to 17.7 GHz band, the number of band assignments varies from as few as three to several thousand (7,716) thus requiring four-cycle logarithmic graph paper to adequately display the variation.

The recent allocation by the FCC of the 12.2-12.7 GHz band for the Broadcasting-Satellite Service has resulted in the need to relocate numerous private fixed systems currently using this band. The objective of the FCC in the First Report and Order was twofold: first, to provide for the reaccommodation of the 12 GHz private users and, second, to propose a common spectrum utilization policy for the terrestrial microwave services. While the NPRM took the approach that the reaccommodation would be accomplished within the actions taken to improve spectrum utilization in all microwave bands, the need to decide the reaccommodation issue quickly does not allow for all of the broader issues to be resolved at this time. They also recognized that it would not be appropriate to impose new technical standards on the existing 12 GHz licensees who would be relocated because these users should be considered as being "grandfathered" in the new frequency bands. The reaccommodation of the 12 GHz private users must be accomplished in a very timely fashion while the scope and complexity of the policy issues, as demonstrated in the responses to the NPRM, call for more lengthy consideration of the other issues raised in the NOI and NPRM. Therefore, the broader issues in the utilization of some of the microwave bands and technical standards discussed in the NPRM were pursued further in Docket 82-334, by the FCC.

The intent of the FCC in the First Report and Order was to set forth a procedure for the reàccommodation of existing terrestrial 12 GHz users. They anticipate that the assignment of new frequencies for these users can begin immediately and that users can be accommodated by September 1988. They are making available sufficient spectrum in the 13 GHz band and 6 GHz band, as well as in the 18 GHz band so that reaccommodation can be successfully completed in a timely, cost-efficient manner. The Commission will assist the licensees in this process in any way possible. However, the selection of replacement frequencies and other aspects of their microwave operations will remain the responsibility of the microwave licensees. In addition, as indicated above, terrestrial use of the 12 GHz band will be permitted to continue after September 1988, provided no interference is caused to operating broadcasting-satellite systems. The comments regarding the procedure needed to reaccommodate 12 GHz users were analyzed and the Commission determined in the BSS rulemaking, Docket 80-603, that those users licensed in the 12.2-12.7 GHz band as of the date the instant Report and Order is adopted would be reaccommodated. The FCC prepared a list of all licensed 12 GHz band users as of September 9, 1983, the date of adoption of this Report and Order. This list will be issued in a Public Notice after this Report and Order is released. While concern of existing 12 GHz users that significant expense will be incurred, even given use of 13 GHz frequencies where available, few alternatives exist. Several comments were made that continued use of the 12 GHz band will be necessary for some users and that this may be possible if BSS does not develop as planned. Since the full 12 GHz band has been allocated to BSS by the 1983 RARC and the Commission anticipates that several BSS systems will be in operation by 1988, continued use of the 12 GHz band for terrestrial operations will only be possible on a secondary basis after September 9, 1988. Licensees who choose to stay in the 12 GHz band on that basis do so at their own risk after that date.

In analyzing possible frequency bands that could be used for reaccommodation, the Commission examined bands that offered technical compatibility, suitable bandwidths, some available capacity, and suitable path lengths. The Commission, in the BSS rulemaking, determined that bands at 18 GHz and higher would be suitable for many private fixed uses of the type now supported at 12 GHz. The Commission noted that it was taking action to promote development of low-cost, low-power microwave equipment in the 22 GHz band (Docket 79-337) and to restructure the 18 GHz band (Docket 79-188) to accommodate some of the existing and future operations displaced from 12 GHz. However, these bands do not offer all existing 12 GHz users adequate reaccommodation options in terms of cost, path length, or achievable reliability. The 13 GHz band is the most obviously appropriate band due to its proximity to the 12 GHz band, possibly allowing existing microwave towers and equipment to be reused in many cases. However, a lower frequency band is also required for longer path lengths and where 13 GHz frequencies are not available. This review indicates that the 6 GHz private band can accommodate additional users and should also be made available for reaccommodation.

Other options proposed by commentors included shared use of the 11.7 to 12.2 GHz band by terrestrial users. However, this band is now allocated to the Fixed-Satellite Service for use by small, uncoordinated, receive-only Earth stations. Since these operations are continuing to expand in all geographical areas due to the introduction of video and other services, it would not be possible for terrestrial operations to protect these receivers from interference. Commentors also suggested that portions of several bands (e.g., 2, 5, 15 GHz) allocated to the Government be examined for possible non-Government fixed uses. This possibility has been considered but it does not appear that any of these Government bands could be made available at this time because of high-priority and national security-related use, or because of incompatible operations, such as radiolocation, in these bands. In the NPRM the 2 and 7 GHz broadcast auxiliary bands were also proposed, but these have been found to be too heavily used by mobile facilities to be of use for reaccommodation.

Several commentors stated that systems which could only be accommodated using more than one frequency band, for example some links using 13 GHz, others using 18 or 6 GHz, would not be acceptable because of operational difficulties and costs in maintaining equipment in more than one band. However, large microwave systems today often use a combination of frequency bands. Consequently, where necessary, a "mixed band" system will provide a satisfactory reaccommodation option. The Region 2 Administrative Radio Conference was concluded July 18, 1983. The Final Acts of the Conference were signed by the United States (FCC Public Notice, Memo No. 5605, July 28, 1983). The United States was allocated the entire 500 MHz band for satellite use. Consequently, the allocation for BSS in the entire 12.2-12.7 band

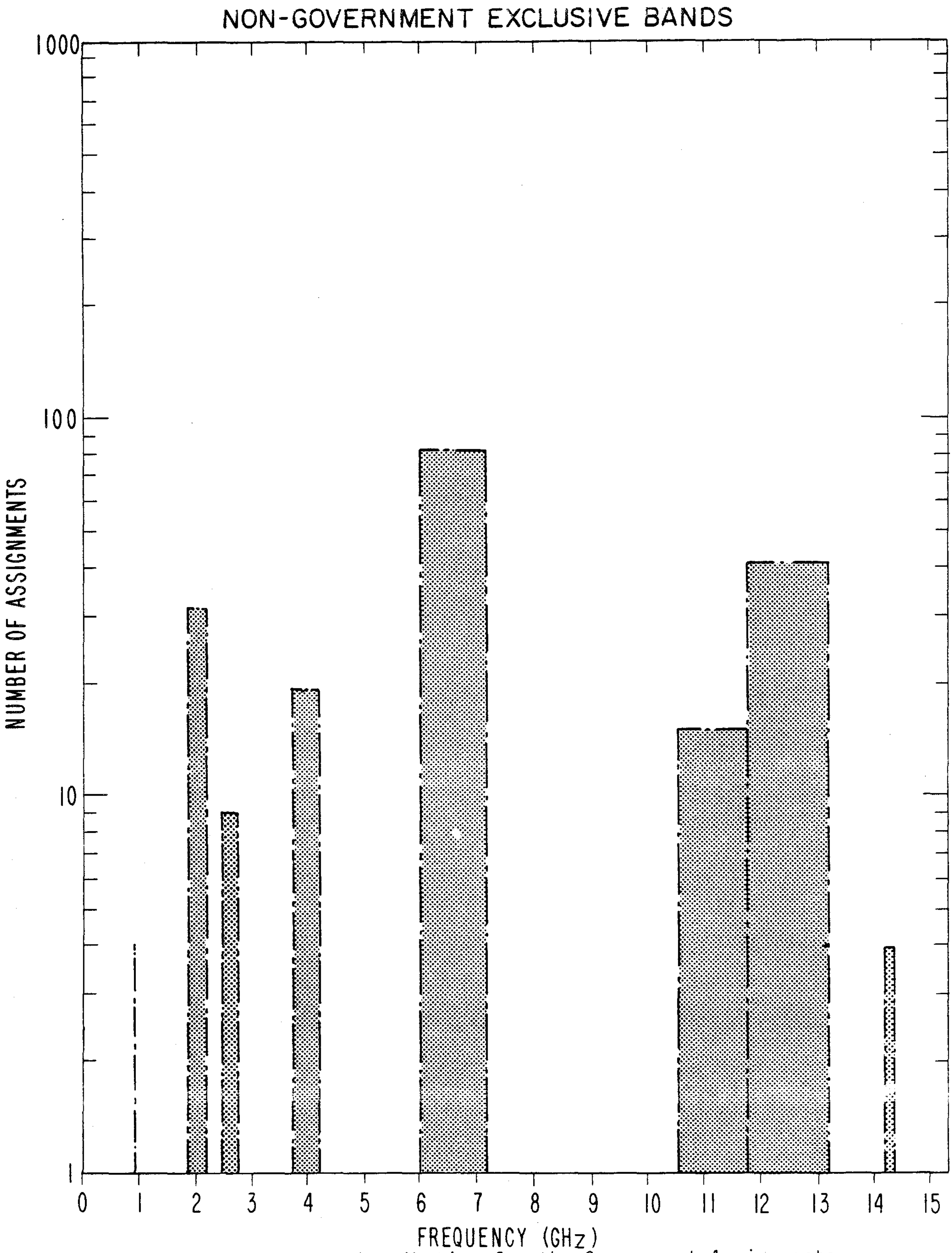


Figure 6. Assignment Distribution for the Government Assignments in the non-Government Exclusive Bands.

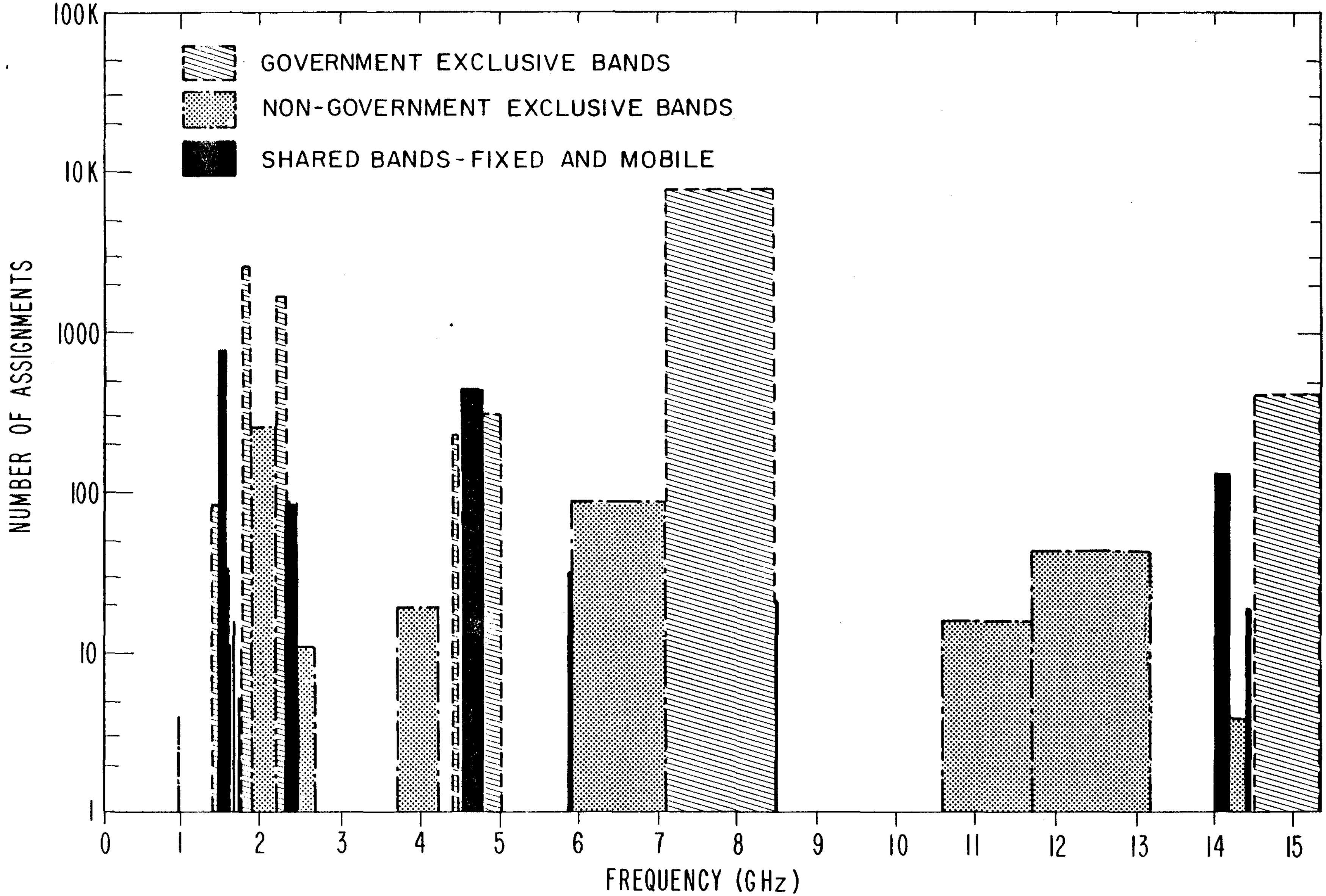


Figure 7. Composite Assignment Distribution Showing the Number of Assignments as a Function of Frequency in the 947 MHz to 17.7 GHz band.

made in Docket 80-603 will remain in effect, domestically, as planned. The Fixed Service is secondary to the Broadcasting-Satellite Service except that existing terrestrial uses will not become secondary to broadcasting-satellite use until 5 years after the date this rulemaking item is adopted.

The bands that are being considered for changes in allocation by the FCC are listed in Table 10, and the frequency assignments being addressed in these bands are listed in Table 11. The Systems Review File of the Spectrum Planning Subcommittee (SPS) indicates that there are 226 systems currently under review in the Government exclusive bands, 27 systems in the shared bands, and 31 systems in the non-Government exclusive bands. The number breakdown by band is given in Table 12, and the breakdown by types of system and stage of review is given in Table 13.

The FCC proposals and recommendations for these bands are as follows:

1850-1990 MHz Band

Access to this band would be allowed for business service users, who are not currently permitted in this band, to improve its utilization.

1990-2110 GHz Band (2 GHz Band)

This band is allocated coequally to the Fixed and Mobile Services and is used by broadcast companies for the transmission of frequency modulated video between studio and transmitter sites (fixed operations) and between remote locations and broadcast transmitter sites (mobile operations). The FCC proposed to change the current channeling plan to accommodate three 20 MHz channel pairs (which would also be available on an unpaired basis if required) and to adopt more efficient antenna standards similar to those imposed on the 1850-1990 MHz band. This band would be shared by all services except common carriers not providing service to broadcast or cable entities. Stations licensed under current technical standards would be permitted to continue operating on a primary basis for 10 years, after which they would be secondary to stations employing the then current technical standards. However, no change in this band is being adopted (FCC Docket 82-334, September 30, 1983) and this band is not being made available for reaccommodation of 12 GHz Users. It should be noted that this band is also being shared with the Space Research and Earth Exploration-Satellite Services by virtue of U.S. footnotes 90, 111, 219, and 222 (see next section, RULES AND REGULATIONS).

6525-6875 MHz Band (6 GHz Band)

This band is allocated to the Fixed Service and is used by the private sector for the transmission of frequency-modulated, frequency division multiplexed voice signals and amplitude and frequency modulated, digital signals between fixed points. This 350 MHz band was channelized by the FCC to accommodate thirty-four 10-MHz channel pairs and fifteen 5 MHz channel pairs.

In the NPRM, the FCC proposed to create six 20 MHz channel pairs by combining 10 MHz channel pairs together, and to revise the 5 MHz channel pairing plan. The transmission of video signals would not be permitted. All services except common carriers would be allowed access.

By creating the 20 MHz channel pairs, the option of using 6 GHz spectrum would also be available to long-haul wide-band users. Since the band segments 6525-6530 and 6870-6875 MHz have been used primarily as guard bands, it was proposed to divide them into 1 MHz channels, which would be useful to support the interconnection of radio broadcast studios and transmitters.

6875-7125 MHz Band (7 GHz Band)

This band is allocated coequally to the Fixed and Mobile Services and is used by broadcasters for the transmission of frequency-modulated television signals between studio and transmitter sites (fixed operations), and between remote locations and broadcast transmitter sites (mobile operations). This 250 MHz band was channelized by the FCC into ten 25 MHz channels. It is now proposed that the current channeling plan be revised to provide pairing of these channels into five 25 MHz channel pairs, which would also be available on an unpaired basis if required, and that antenna standards which would parallel those imposed on the 6525-6875 MHz band be imposed. All services would be permitted equal access to this band, with the exception of common carriers not providing service to broadcast organizations. These proposed changes would permit private users and others operating video distribution systems to make use of the lower frequencies and where long circuit distances are involved, to minimize the number of radio links and discrete frequencies employed. At this time (September 30, 1983, FCC Docket 82-334) no change is being adopted and this band is not being made available for reaccomodation of 12 GHz users.

12.7-13.25 GHz Band (13 GHz Band)

This band is allocated to the Fixed and Mobile Services and is used by broadcast and cable organizations for the transmission of television signals between studio and transmitter sites, between cable head ends (fixed or fixed point-to-multi-point), and between remote locations and broadcast transmitter sites and cable studios (mobile operations). This band is channelized into 6.0, 12.5, and 25.0 MHz channels, including offset channels. It was proposed that the current channeling plan be revised to provide 12.5 and 25 MHz channel pairs, which would also be available on an unpaired basis if required. All services would be permitted equal access to this band except that common carriers would be restricted to the band segment 12.7-13.2 GHz.

GOVERNMENT EXCLUSIVE
EXCERPTS FROM THE INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS

TABLE 1.

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
1350-1400 FIXED MOBILE RADIOLOCATION 718 719 720	1350-1400 RADIOLOCATION 714 718 720		1350-1400	714 718 720	RADIOLOCATION Fixed Mobile G2 G27 G114	
1710-2290 FIXED Mobile	1710-2290 FIXED MOBILE		1710-1850	US256 722	FIXED MOBILE G42	
			2200-2290		FIXED (LOS*only) MOBILE (LOS only including aeronautical telemetering, but excluding flight testing of manned aircraft) SPACE RESEARCH (Space-to-Earth) (Space-to-space) G101	
4400-4500 FIXED MOBILE			4400-4500		FIXED MOBILE	
4800-4990 FIXED MOBILE 793 Radio Astronomy 720 778 794			4800-4990	US203 US257 720 778	FIXED MOBILE	
7075-7250 FIXED MOBILE 809 810 811			7125-7190	US252 809	FIXED G116	
			7190-7235	809	FIXED SPACE RESEARCH (Earth-to-space)	
			7235-7250	809	FIXED	
7250-7300 FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE 812			7250-7300		FIXED-SATELLITE (Space-to-Earth) MOBILE-SATELLITE (Space-to-Earth) Fixed G117	
7300-7450 FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile 812			7300-7450		FIXED FIXED-SATELLITE (Space-to-Earth) Mobile-Satellite (Space-to-Earth) G117	

GOVERNMENT EXCLUSIVE

TABLE 1. (Continued)

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
7450-7550	FIXED FIXED-SATELLITE (Space-to-Earth) METEOROLOGICAL-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile		7450-7550		FIXED FIXED-SATELLITE (Space-to-Earth) METEOROLOGICAL- SATELLITE (Space-to-Earth) Mobile- Satellite (Space-to-Earth) G104 G117	
7550-7750	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile		7550-7750		FIXED FIXED-SATELLITE (Space-to-Earth) Mobile- Satellite (Space-to-Earth) G117	
7750-7900	FIXED MOBILE except aeronautical mobile		7750-7900		FIXED	
7900-7975	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 812		7900-8025		Fixed FIXED-SATELLITE (Earth-to-space) MOBILE- SATELLITE (Earth-to-space) G117	
7975-8025	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 812					
8025-8175 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Explora- tion-Satellite (Space-to-Earth) 813 815	8025-8175 EARTH EXPLORA- TION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 814	8025-8175 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Exploration- Satellite (Space-to-Earth) 813 815	8025-8175	US258	EARTH EXPLORA- TION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) Mobile-Satellite (Earth-to-space) (No Airborne Transmission) G117	
8175-8215 FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL- SATELLITE (Earth-to-space) MOBILE Earth Explora- tion-Satellite (Space-to-Earth) 813 815	8175-8215 EARTH EXPLORA- TION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL- SATELLITE (Earth-to-space) MOBILE 814	8175-8215 FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL- SATELLITE (Earth-to-space) MOBILE Earth Exploration- Satellite (Space-to-Earth) 813 815	8175-8215	US258	EARTH EXPLORA- TION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) METEOROLOGICAL- SATELLITE (Earth-to-space) Mobile-Satellite (Earth-to-space) (No Airborne Transmissions) G104, G117	

GOVERNMENT EXCLUSIVE

TABLE 1. (Continued)

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
8215-8400 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (Space-to-Earth) 813 815	8215-8400 EARTH EXPLORATION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) MOBILE 814	8215-8400 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE Earth Exploration-Satellite (Space-to-Earth) 813 815	8215-8400	US258	EARTH EXPLORATION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-space) Mobile-Satellite (Earth-to-space) (No Airborne Transmissions) G117	
8400-8500 FIXED MOBILE except aeronautical mobile SPACE RESEARCH (Space-to-Earth) 816 817			8400-8450		FIXED SPACE RESEARCH (Space-to-Earth) (Deep Space Only)	

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
14.5-14.8 FIXED FIXED-SATELLITE (Earth-to-space) 863 MOBILE Space Research			14.5-14.7145		FIXED Mobile Space Research	
			14.7145-15.1365		Fixed MOBILE Space Research	
14.8-15.35 FIXED MOBILE Space Research 720			15.1365-15.35	US211 720	FIXED Mobile Space Research	

TABLE 2. ALLOCATIONS FOR GOVERNMENT EXCLUSIVE BANDS (947 MHz - 17.7 GHz)

Band	Radio Services Allocated
1.350-1.400 GHz	RADIOLOCATION/Fixed/Mobile (G2, G27, G114)
1.710-1.850 GHz	FIXED/MOBILE (US256, 722, G42)
2.2-2.290 GHz	FIXED (line of sight only)/MOBILE (line of sight only including aeronautical telemetering, but excluding flight testing of manned aircraft)/ SPACE RESEARCH (Space-to-Earth, Space-to-space) (G101)
4.4-4.5 GHz	FIXED/MOBILE
4.8-4.99 GHz	FIXED/MOBILE (US203, US257, 720, 778)
7.125-7.190 GHz	FIXED (US252, 809, G116)
7.190-7.235 GHz	FIXED/SPACE RESEARCH (Earth-to-space) (809)
7.235-7.250 GHz	FIXED (809)
7.250-7.300 GHz	FIXED-SATELLITE (Space-to-Earth)/MOBILE-SATELLITE (Space-to-Earth)/Fixed (G117)
7.3-7.450 GHz	FIXED/FIXED-SATELLITE (Space-to-Earth)/ Mobile-Satellite (Space-to-Earth) (G117)
7.450-7.550 GHz	FIXED/FIXED-SATELLITE (Space-to-Earth)/ METEOROLOGICAL-SATELLITE (Space-to-Earth)/ Mobile-Satellite (Space-to-Earth) (G104, G117)
7.550-7.750 GHz	FIXED/FIXED-SATELLITE (Space-to-Earth) Mobile-Satellite (Space-to-Earth) (G117)
7.750-7.900 GHz	FIXED

TABLE 2. (Continued)

Band	Radio Services Allocated
7.9-8.025 GHz	Fixed/FIXED SATELLITE (Earth-to-space) MOBILE-SATELLITE (Earth-to-space) (G117)
8.025-8.175 GHz	EARTH EXPLORATION-SATELLITE (Space-to-Earth)/ FIXED/FIXED-SATELLITE (Earth-to-space)/ Mobile-Satellite (Earth-to-space - no airborne transmission) (US258, G117)
8.175-8.215 GHz	EARTH EXPLORATION-SATELLITE (Space-to-Earth)/ FIXED/FIXED-SATELLITE (Earth-to-space)/ Meteorological-Satellite (Earth-to-space)/ Mobile Satellite (Earth-to-space - no airborne transmissions) (US258, G104, G117)
8.215-8.400 GHz	EARTH EXPLORATION-SATELLITE (Space-to-Earth)/ FIXED/FIXED-SATELLITE (Earth-to-space)/ Mobile Satellite (Earth-to-space - no airborne transmissions) (US258, G117)
8.400-8.450 GHz	FIXED/SPACE RESEARCH (Space-to-Earth - deep space only)
14.5-14.7145 GHz	FIXED/Mobile/Space Research
14.7145-15.1365 GHz	Fixed/MOBILE/Space Research
15.1365-15.35 GHz	FIXED/Mobile/Space Research (US211, 720)

TABLE 3. FREQUENCY ASSIGNMENTS FOR BANDS ALLOCATED TO GOVERNMENT EXCLUSIVE USE (947 MHz - 17.7 GHz)

Band	Agency	Assignments	Total
1.350-1.40 GHz	National Security Agency	1	
	Air Force	13	
	Navy	21	
	Army	62	
	Non-Government	7	
			104
1.710-1.850 GHz	FEMA	17	
	National Security Agency	2	
	NASA	30	
	HHS	6	
	Commerce	6	
	Treasury	16	
	FAA	48	
	GSA	14	
	Justice	18	
	Transportation	29	
	TVA	80	
	Coast Guard	36	
	Energy	280	
	Air Force	419	
	Navy	240	
	Interior	168	
	Agriculture	606	
	Army	363	
	Non-Government	9	
			2437
2.2-2.290 GHz	FAA	2	
	Commerce	3	
	Central Intelligence Agency	4	
	FEMA	8	
	Transportation	10	
	Coast Guard	22	
	NASA	129	
	Army	229	
	Energy	242	
	Navy	434	
	Air Force	493	
	Non-Government	12	
			1588

TABLE 3. (Continued)

	Agency	Assignments	Total
4.4-4.5 GHz	NASA	1	
	Energy	13	
	Navy	54	
	Air Force	65	
	Army	109	
	Non-Government	3	
			245
4.8-4.99 GHz	NASA	1	
	Energy	15	
	Navy	86	
	Air Force	135	
	Army	68	
			305
7.125-7.190 GHz	Central Intelligence Agency	4	
	USIA	6	
	Commerce	2	
	TVA	11	
	VA	5	
	Army	23	
	Navy	52	
	Air Force	60	
	Energy	61	
	FAA	272	
	Interior	2	
	NASA	5	
	Coast Guard	6	
	FEMA	1	
	Justice	1	
	GSA	2	
	Non-Government	2	
			515
7.190-7.235 GHz	Interior	2	
	Central Intelligence Agency	3	
	VA	3	
	Coast Guard	3	
	NASA	3	
	USIA	4	
	Commerce	7	
	TVA	10	
	Army	15	
	Navy	30	
	Energy	32	
	Air Force	37	
	FAA	173	
	GSA	1	
	Non-Government	1	
			324

TABLE 3. (Continued)	Agency	Assignments	Total
7.235-7.250 GHz	NASA	1	
	VA	1	
	Interior	1	
	TVA	2	
	USIA	4	
	Navy	8	
	Air Force	9	
	Energy	9	
	Army	11	
	FAA	19	
	GSA	1	
	Justice	1	
			67
7.25-7.3 GHz	National Security Agency	2	
	Army	13	
	Air Force	31	
	Navy	72	
	FAA	239	
	Non-Government	2	
			359
7.3-7.450 GHz	FEMA	1	
	National Security Agency	7	
	Commerce	2	
	Interior	3	
	NASA	7	
	Central Intelligence Agency	7	
	Coast Guard	9	
	USIA	16	
	TVA	35	
	Army	63	
	Energy	99	
	Navy	140	
	Air Force	143	
	FAA	526	
	GSA	1	
	Non-Government	1	
			1060
7.450-7.550 GHz	FEMA	1	
	National Security Agency	4	
	Interior	2	
	Central Intelligence Agency	4	
	NASA	5	
	USIA	7	
	Coast Guard	8	
	TVA	29	
	Navy	115	
	Air Force	69	
	Army	73	
	Energy	103	
	FAA	438	
	GSA	3	
	Non-Government	3	
			864

TABLE 3. (Continued)

	Agency	Assignments	Total
7.55-7.750 GHz	FEMA	1	
	Central Intelligence Agency	5	
	Interior	5	
	NASA	8	
	VA	12	
	National Security Agency	15	
	Commerce	13	
	USIA	15	
	Coast Guard	22	
	TVA	47	
	Army	87	
	Navy	109	
	Air Force	119	
	Energy	177	
	FAA	641	
	Non-Government	3	
			1279
7.75-7.9 GHz	FEMA	1	
	National Science Foundation	2	
	Interior	4	
	National Security Agency	4	
	Commerce	6	
	NASA	8	
	VA	11	
	Coast Guard	16	
	TVA	23	
	Navy	78	
	Air Force	81	
	Army	89	
	Energy	111	
	FAA	284	
	GSA	4	
	Non-Government	1	
			723
7.9-8.025 GHz	Central Intelligence Agency	3	
	National Security Agency	5	
	Coast Guard	3	
	NASA	5	
	Commerce	7	
	TVA	9	
	Army	58	
	Energy	55	
	Air Force	72	
	Navy	116	
	FAA	229	
	Non-Government	7	
			569

TABLE 3. (Continued)

	Agency	Assignments	Total
8.025-8.175 GHz	Interior	1	
	Central Intelligence Agency	1	
	Commerce	4	
	Coast Guard	6	
	NASA	9	
	National Security Agency	12	
	TVA	36	
	Army	71	
	Energy	90	
	Navy	95	
	Air Force	117	
	FAA	327	
	Justice	1	
	Non-Government	2	
			772
8.175-8.215 GHz	National Security Agency	3	
	Central Intelligence Agency	3	
	Commerce	3	
	Coast Guard	3	
	NASA	3	
	TVA	7	
	Air Force	12	
	Navy	28	
	Army	32	
	Energy	38	
	FAA	109	
	Non-Government	1	
			242
8.215-8.4 GHZ	National Science Foundation	1	
	Central Intelligence Agency	2	
	Justice	4	
	National Security Agency	12	
	Commerce	10	
	NASA	11	
	Coast Guard	15	
	TVA	35	
	Navy	129	
	Air Force	87	
	Energy	124	
	Army	143	
	FAA	336	
	Non-Government	2	
			916

TABLE 3. (Continued)

	Agency	Assignments	Total
8.4-8.450 GHz	Air Force	3	
	Coast Guard	1	
	Energy	1	
	Justice	3	
	Navy	3	
	Treasury	4	
	NASA	8	
	Non-Government	3	
			26
14.5-14.715 GHz	National Security Agency	2	
	NASA	11	
	Energy	10	
	Navy	13	
	FAA	12	
	Army	30	
	Air Force	49	
			127
14.7145-15.1365 GHz	Agriculture	1	
	National Security Agency	1	
	Energy	12	
	Navy	14	
	NASA	30	
	Army	56	
	Air Force	51	
	FAA	98	
			263
15.1365-15.35 GHz	NASA	9	
	Navy	2	
	Energy	3	
	Air Force	8	
	Army	12	
	FAA	30	
	Justice	1	
	National Security Agency	1	
			66
		TOTAL ASSIGNMENTS	12,851

GOVERNMENT AND NON-GOVERNMENT SHARED

EXCERPTS FROM THE INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS

TABLE 4.

INTERNATIONAL			UNITED STATES			
Region 1 MHz	**Region 2** MHz	**Region 3** MHz	**Band** MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
1427-1429 SPACE OPERATION (Earth-to-space) FIXED MOBILE except aeronautical mobile 722			1427-1429	722	FIXED MOBILE except aeronautical mobile SPACE OPERATION (Earth-to-space) G30	SPACE OPERATION (Earth-to-space) Land Mobile (Telemetering and tele-command) Fixed (Telemetering)
1429-1525 FIXED MOBILE except aeronautical mobile 722	1429-1525 FIXED MOBILE 723 722		1429-1435	722	FIXED MOBILE G30	Land Mobile (Telemetering and tele-command) Fixed (Telemetering)
1525-1530 SPACE OPERATION (Space-to-Earth) FIXED Earth Exploration-Satellite Mobile except aeronautical mobile 724 722 725	1525-1530 SPACE OPERATION (Space-to-Earth) Earth Exploration-Satellite Fixed Mobile 723 722	1525-1530 SPACE OPERATION (Space-to-Earth) FIXED Earth Exploration-Satellite Mobile 723 724 722	1435-1530	US78 722	MOBILE (Aeronautical telemetering)	MOBILE (Aeronautical telemetering)
1530-1535 SPACE OPERATION (Space-to-Earth) MARITIME MOBILE-SATELLITE (Space-to-Earth) Earth Exploration-Satellite Fixed Mobile except aeronautical mobile 722 726	1530-1535 SPACE OPERATION (Space-to-Earth) MARITIME MOBILE-SATELLITE (Space-to-Earth) Earth Exploration-Satellite Fixed Mobile 723 722 726		1530-1535	US78 US272 722	MARITIME MOBILE-SATELLITE (Space-to-Earth) Mobile (Aeronautical telemetering)	MARITIME MOBILE-SATELLITE (Space-to-Earth) Mobile (Aeronautical telemetering)
1700-1710 FIXED METEOROLOGICAL-SATELLITE (Space-to-Earth) Mobile except aeronautical mobile 671 722	1700-1710 FIXED METEOROLOGICAL-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile 671 722 743		1700-1710	671 722	FIXED METEOROLOGICAL-SATELLITE (Space-to-Earth) G118	Fixed METEOROLOGICAL-SATELLITE (Space-to-Earth)
2290-2300 FIXED SPACE RESEARCH (Deep Space) (Space-to-Earth) Mobile except aeronautical mobile	2290-2300 FIXED MOBILE except aeronautical mobile SPACE RESEARCH (Deep Space) (Space-to-Earth)		2290-2300		SPACE RESEARCH (Space-to-Earth) (Deep Space Only) FIXED MOBILE except aeronautical mobile	SPACE RESEARCH (Space-to-Earth) (Deep Space Only)

GOVERNMENT AND NON-GOVERNMENT SHARED

TABLE 4. (Continued)

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
2300-2450 FIXED Amateur Mobile Radiolocation 664 752	2300-2450 FIXED MOBILE RADIOLOCATION Amateur 664 751 752		2300-2310	US253	RADIOLOCATION Fixed Mobile G2	Amateur
			2310-2390	US276	RADIOLOCATION MOBILE Fixed G2	MOBILE
2655-2690 FIXED 762 763 764 MOBILE except aeronautical mobile BROADCASTING-SATELLITE 757 760 Earth Exploration-Satellite (Passive) Radio Astronomy Space Research (Passive) 758 759 765	2655-2690 FIXED 762 764 FIXED-SATELLITE (Earth-to-space) (Space-to-Earth) 761 MOBILE except aeronautical mobile BROADCASTING-SATELLITE 757 760 Earth Exploration-Satellite (Passive) Radio Astronomy Space Research (Passive) 765	2655-2690 FIXED 762 764 FIXED-SATELLITE (Earth-to-space) 761 MOBILE except aeronautical mobile BROADCASTING-SATELLITE 757 760 Earth Exploration-Satellite (Passive) Radio Astronomy Space Research (Passive) 765 766	2655-2690	US205 US269	Earth Exploration-Satellite (Passive) Radio Astronomy Space Research (Passive)	BROADCASTING-SATELLITE Earth Exploration-Satellite (Passive) Radio Astronomy Space Research (Passive) FIXED NG47 NG101 NG102
4500-4800 FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE 792			4500-4800	US245	FIXED MOBILE	FIXED-SATELLITE (Space-to-Earth)
8400-8500 FIXED MOBILE except aeronautical mobile SPACE RESEARCH (Space-to-Earth) 816 817			8450-8500		FIXED SPACE RESEARCH (Space-to-Earth)	SPACE RESEARCH (Space-to-Earth)

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
10.6-10.68 EARTH EXPLORATION-SATELLITE (Passive) FIXED MOBILE except aeronautical mobile RADIO ASTRONOMY SPACE RESEARCH (Passive) Radiolocation 831 832			10.6-10.68	US265 US277	EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)	FIXED EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)

GOVERNMENT AND NON-GOVERNMENT SHARED

TABLE 4. (Continued)

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
14.4-14.47	FIXED FIXED-SATELLITE (Earth-to-space)858 MOBILE except aeronautical mobile Space Research (Space-to-Earth) 859		14.4-14.5	US203 US234 US287 862	Mobile Fixed	FIXED-SATELLITE (Earth-to-space)
14.47-14.5	FIXED FIXED-SATELLITE (Earth-to-space)858 MOBILE except aeronautical mobile Radio Astronomy 859 862					

TABLE 5. ALLOCATIONS FOR GOVERNMENT AND NON-GOVERNMENT SHARED BANDS WHICH INCLUDE FIXED AND MOBILE (947 MHz - 17.7 GHz)

BAND	ALLOCATION Government	ALLOCATION Non-Government
1427 - 1429 MHz	FIXED MOBILE except Aeronautical Mobile SPACE OPERATION (Earth-to-space) (722, G30)	SPACE OPERATION (Earth-to-space) Land Mobile (Telemetering and telecommand) Fixed telemetering)
1429 - 1435 MHz	FIXED/MOBILE (722, G30)	Land Mobile (Telemetering and telecommand) Fixed (telemetering)
1435 - 1530 MHz	MOBILE (Aeronautical telemetering) (US78, 722)	MOBILE (Aeronautical telemetering)
1530 - 1535 MHz	MARITIME MOBILE SATELLITE (Space-to-Earth) Mobile (Aeronautical telemetering) (US272, 722, US78)	MARITIME MOBILE SATELLITE (Space-to-Earth) Mobile (Aeronautical telemetering)
1700 - 1710 MHz	FIXED METEOROLOGICAL SATELLITE (Space-to-Earth) (722, 671, G118)	Fixed METEOROLOGICAL SATELLITE (Space-to-Earth)
2290 - 2300 MHz	SPACE RESEARCH (Space-to-Earth) (Deep Space only) FIXED MOBILE (except Aeronautical Mobile)	SPACE RESEARCH (Space-to-Earth) (Deep Space only)
2300 - 2310 MHz	RADIOLOCATION Fixed/Mobile (US253, G2)	Amateur
2310 - 2390 MHz	RADIOLOCATION MOBILE Fixed (US276, G2)	MOBILE

TABLE 5. (Continued)

BAND	ALLOCATION	
	Government	Non-Government
4500 - 4800 MHz	FIXED/MOBILE (US245)	FIXED-SATELLITE
8450 - 8500 MHz	FIXED SPACE RESEARCH (Space-to-Earth)	SPACE RESEARCH (Space-to-Earth)
14.4 - 14.45 GHz	Mobile (US203, US234, US287, 862)	FIXED-SATELLITE (Earth-to-Space)

TABLE 6. FREQUENCY ASSIGNMENTS FOR GOVERNMENT RADIO SERVICES IN SHARED BANDS BETWEEN 947 MHz AND 17.7 GHz

Band	Agency	Number of Assignments	Total
1427 - 1429 MHz	Air Force	2	
	Army	8	
			10
1429 - 1530 MHz	Air Force	259	
	Army	83	
	Energy	36	
	Navy	281	
	NASA	30	
	NSF	5	
			694
1530 - 1535 MHz	Air Force	13	
	Army	3	
	Energy	4	
	Navy	5	
	NSF	1	
	NASA	1	
			27
1535 - 1559 MHz	Air Force	3	
	NASA	2	
			5
1626 - 1660 MHz	Air Force	1	
	Army	1	
	Commerce	1	
	Energy	1	
	Navy	5	
	NSF	1	
			10
1700 - 1710 MHz	Air Force	2	
	Commerce	2	
	NASA	1	
			5

TABLE 6. (Continued)

Band	Agency	Number of Assignments	Total
2290 - 2390 MHz	Air Force	28	
	Army	15	
	Energy	24	
	Navy	14	
	NASA	12	
	NSF	1	
			94
4500 - 4800 MHz	Air Force	227	
	Army	91	
	Energy	27	
	Navy	130	
	NASA	7	
			482
8450 - 8500 MHz	Air Force	3	
	Army	1	
	Coast Guard	3	
	Energy	2	
	Justice	8	
	Navy	2	
			19
10.6 - 10.68 GHz		0	
14.4 - 14.47 GHz	Air Force	6	
	Army	10	
	Energy	2	
	FAA	1	
	Justice	1	
	Navy	1	
	NASA	1	
			22
		TOTAL ASSIGNMENTS	1,368

NON-GOVERNMENT EXCLUSIVE
EXCERPTS FROM THE INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS
TABLE 7.

INTERNATIONAL			UNITED STATES			
Region 1 MHz	**Region 2** MHz	**Region 3** MHz	**Band** MHz 1	**National Provisions** 2	**Government Allocation** 3	**Non-Government Allocation** 4
942-960 FIXED MOBILE except aeronautical mobile BROADCASTING 703 699 704	942-960 FIXED Mobile 708	942-960 FIXED MOBILE BROADCASTING 701	947-960			FIXED NG9
1710-2290 FIXED Mobile 722 744 746 747 748 750	1710-2290 FIXED MOBILE 722 744 745 746 747 748 749 750		1850-1990			FIXED
			1990-2110	US90 US111 US219 US222		FIXED MOBILE NG23 NG118
			2110-2200	US111 US219 US222 US252		FIXED NG23
2450-2500 FIXED MOBILE Radiolocation 752 753	2450-2500 FIXED MOBILE RADIOLOCATION 752		2450-2500	US41 752		FIXED MOBILE Radiolocation
2500-2655 FIXED 762 763 764 MOBILE except aeronautical mobile BROADCASTING-SATELLITE 757 760 720 753 756 758 759	2500-2655 FIXED 762 764 FIXED-SATELLITE (Space-to-Earth) 761 MOBILE except aeronautical mobile BROADCASTING-SATELLITE 757 760 720 755	2500-2535 FIXED 762 764 FIXED-SATELLITE (Space-to-Earth) 761 MOBILE except aeronautical mobile BROADCASTING-SATELLITE 757 760 754 2535-2655 FIXED 762 764 MOBILE except aeronautical mobile BROADCASTING-SATELLITE 757 760 720	2500-2655	US205 US269 720		BROADCASTING-SATELLITE FIXED NG47 NG101 [illegible]
	3700-4200 FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile 787		3700-4200			FIXED FIXED-SATELLITE (Space-to-Earth) NG41

NON-GOVERNMENT EXCLUSIVE

TABLE 7. (Continued)

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
5925-7075	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE		5925-6425			FIXED FIXED-SATELLITE (Earth-to-space) NG41
			6425-6525	791 809		MOBILE FIXED-SATELLITE (Earth-to-space) NG122
			6525-6875	809		FIXED FIXED-SATELLITE (Earth-to-space)
	791 809		6875-7075	809		FIXED FIXED-SATELLITE (Earth-to-space) MOBILE NG118
7075-7250	FIXED MOBILE		7075-7125	809		FIXED MOBILE NG118

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
10.55-10.6	FIXED MOBILE except aeronautical mobile Radiolocation		10.55-10.6			FIXED
10.7-11.7 FIXED FIXED-SATELLITE (Space-to-Earth) (Earth-to-Space) 835 MOBILE except aeronautical mobile	10.7-11.7 FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile		10.7-11.7	US211		FIXED FIXED-SATELLITE (Space-to-Earth) NG41 NG104

NON-GOVERNMENT EXCLUSIVE

TABLE 7. (Continued)

<table>
<tr><th colspan="3">INTERNATIONAL</th><th colspan="4">UNITED STATES</th></tr>
<tr><th>Region 1
GHz</th><th>Region 2
GHz</th><th>Region 3
GHz</th><th>Band
GHz
1</th><th>National
Provisions
2</th><th>Government
Allocation
3</th><th>Non-Government
Allocation
4</th></tr>
<tr><td rowspan="2">11.7-12.5
FIXED
BROADCASTING
BROADCASTING-
SATELLITE
Mobile except
aeronautical
mobile

838 840</td><td>11.7-12.1
FIXED 837
FIXED-SATELLITE
(Space-to-Earth)
Mobile except
aeronautical
mobile
836 839 840</td><td>11.7-12.2
FIXED
MOBILE except
aeronautical
mobile
BROADCASTING
BROADCASTING-
SATELLITE
838 840</td><td>11.7-12.2</td><td>836
839
840</td><td></td><td>FIXED-SATELLITE
(Space-to-Earth)
Mobile except
aeronautical
mobile</td></tr>
<tr><td>12.1-12.3
FIXED 837
FIXED-SATELLITE
(Space-to-Earth)
MOBILE except
aeronautical
mobile
BROADCASTING
BROADCASTING-
SATELLITE
839 840 841
842 843 844</td><td>12.2-12.5
FIXED
MOBILE except
aeronautical
mobile
BROADCASTING

838 840 845</td><td rowspan="2">12.2-12.7</td><td rowspan="2">839
840
843
844</td><td rowspan="2"></td><td rowspan="2">FIXED
BROADCASTING-
SATELLITE

NG139</td></tr>
<tr><td></td><td>12.3-12.7
FIXED
MOBILE except
aeronautical
mobile
BROADCASTING
BROADCASTING-
SATELLITE
839 840 843
844 846</td><td></td></tr>
<tr><td>12.5-12.75
FIXED-SATELLITE
(Space-to-Earth)
(Earth-to-space)

840 848 849 850</td><td>12.7-12.75
FIXED
FIXED-SATELLITE
(Earth-to-space)
MOBILE except
aeronautical
mobile

840</td><td>12.5-12.75
FIXED
FIXED-SATELLITE
(Space-to-Earth)
MOBILE except
aeronautical
mobile
BROADCASTING-
SATELLITE 847
840</td><td>12.7-12.75</td><td>840</td><td></td><td>FIXED
FIXED-SATELLITE
(Earth-to-space)
MOBILE

NG53 NG118</td></tr>
<tr><td colspan="3">12.75-13.25
FIXED
FIXED-SATELLITE (Earth-to-space)
MOBILE
Space Research (Deep space)
(Space-to-Earth)</td><td>12.75-13.25</td><td>US251</td><td></td><td>FIXED
MOBILE
FIXED-SATELLITE
(Earth-to-space)

NG53 NG104
[illegible]</td></tr>
</table>

TABLE 8. FREQUENCY ALLOCATIONS FOR NON-GOVERNMENT EXCLUSIVE BANDS WHICH INCLUDE FIXED AND/OR MOBILE (947 MHz - 17.7 GHz)

BAND	RADIO SERVICE ALLOCATION
947 - 960 MHz	FIXED (NG 9)
1850 - 1990 MHz	FIXED
1990 - 2110 MHz	FIXED/MOBILE (NG23, NG118, US90, US111, US219, US222)
2110 - 2200 MHz	FIXED (Us111, US252, NG23)
2450 - 2500 MHz	FIXED/MOBILE Radiolocation (ISM 2450 ± 50 MHz) (752, US41)
2500 - 2655 MHz	BROADCASTING-SATELLITE FIXED (US205, 720, US269, NG47, NG101, NG102)
3700 - 4200 MHz	FIXED FIXED-SATELLITE (Space-to-Earth) (NG41)
5925 - 6425 MHz	FIXED FIXED-SATELLITE (Earth-to-space) (NG41)
6425 - 6525 MHz	MOBILE FIXED-SATELLITE (Earth-to-space) (791, 809, NG122)
6525 - 6875 MHz	FIXED FIXED-SATELLITE (Earth-to-space) (809)

TABLE 8. (Continued)

BAND	RADIO SERVICE ALLOCATION
6875 - 7075 MHz	FIXED/MOBILE FIXED-SATELLITE (Earth-to-space) (809, NG118)
7075 - 7125 MHz	FIXED/MOBILE (809, NG118)
10.55 - 10.6 GHz	FIXED
10.7 - 11.7 GHz	FIXED FIXED-SATELLITE (Space-to-Earth) (US211, NG41, NG104)
11.7 - 12.2 GHz	FIXED-SATELLITE (Space-to-Earth) Mobile (except Aeronautical Mobile) (836, 839, 940, NG143, NG145)
12.2 - 12.7 GHz	FIXED BROADCASTING-SATELLITE (839, 840, 843, 844, NG139)
12.7 - 12.75 GHz	FIXED/MOBILE FIXED-SATELLITE (Earth-to-space) (840, NG53, NG118)
12.75 - 13.25 GHz	FIXED/MOBILE FIXED-SATELLITE (Earth-to-space) (US251, NG53, NG104, NG118)

TABLE 9. FREQUENCY ASSIGNMENTS FOR GOVERNMENT RADIO SERVICES IN THE NON-GOVERNMENT EXCLUSIVE BANDS FROM 947 MHz TO 17.7 GHz

Band	Agency	Number of Assignments		Use
947-960 MHz	Air Force	3		Microwave links Dewline Tropo link Antenna Radiation pattern tests
1850-2200 MHz	Air Force	26		
	Army	2		
	Commerce	6		
	Interior	1		
	NASA	275		
			310	TDRSS Links Space Shuttle Links GOES Satellite ISEE 1, 2 & 3 satellites STS orbital operations Nimbus Satellites (6, 7, G) Head 2 Satellite IRAS Satellite Landsat D-Satellite Solar Max Satellite Space Telescope SOLAR MESOPHER Satellite NASA Deep Space Command IVS Galileo Jupiter Pioneer 6, 7, 8, 10, & 11 Helios 1 & 2 Voyager 1 & 2 Viking 1
2450-2655 MHz	Air Force	5		
	Interior	1		
	Navy	1		
			7	Vehicle traffic counters Radar test facilities Antenna test facilities
3700-4200 MHz	Air Force	10		
	Army	6		
	NASA	2		
			18	Antenna test facilities Prelaunch test of spacecraft avionics (INTELSAT V) MOLNIYA II Satellite downlink and tracking Down Link ATS-3, ATS-5 Satellite Evaluation of Air Target Fuses

TABLE 9. (Continued)

Band	Agency	Number of Assignments	Total	Use
5925-7125 MHz	Air Force	36		
	Army	1		
	Energy	19		
	Interior	3		
	Navy	2		
	Transportation	16		
			77	Prelaunch check on equipment on missiles and satellites Information transfer from and communication with WESTAR III Satellite Microwave links along Alaskan Highway Radar test facilities Antenna test facilities Test of airborne equipment B-1 Defense Subsystem and tests ECM R&D Control and operation of BPA power transmission system
10.5-13.25 GHz	Air Force	27		
	Army	1		
	Commerce	1		
	Interior	6		
	Navy	2		
	NASA	2		
			39	Antenna test facilities Prelaunch check of various satellites Calibration and test of shipborne equipment Video and control links for security systems University of Alaska for NASA contracts Samoan educational TV system
14.2-14.4 GHz	Air Force	3		
	FAA	1		
			4	Antenna test facilities Air traffic control (on ground) WESTAR command Prelaunch check of INTELSAT COMSAT Terrestrial Radiolink FAS Transmitter
		TOTAL	455	

TABLE 10. ALLOCATIONS FOR BANDS ADDRESSED BY FCC (947 MHz - 17.7 GHz)
(based on Ad Hoc 172 proposals)

	Band	Allocation
i)	1.99 - 2.11 GHz	Non-Government - Fixed/Mobile (NG2, NG118) (US90, 111, 219, 222)
ii)	6.525 - 6.875 GHz	Non-Government - FIXED/FIXED-SATELLITE Earth-to-space (809)
iii)	6.875 - 7.075 GHz	Non-Government - FIXED/FIXED-SATELLITE/MOBILE Earth-to-space (809, NG118)
iv)	7.075 - 7.125 GHz	Non-Government - FIXED/MOBILE (809, NG118)
v)	12.7 - 12.75 GHz	Non-Government - FIXED/FIXED-SATELLITE/MOBILE Earth-to-space (840, NG53, NG118)
vi)	12.75 - 13.25 GHz	Non-Government - FIXED/FIXED-SATELLITE/MOBILE Earth-to-space (US251, NG53, NG104, NG118)
vii)	17.7 - 17.8 GHz	Non-Government - FIXED/FIXED-SATELLITE/MOBILE Earth-to-space/Space-to-earth (US271)

TABLE 11. FREQUENCY ASSIGNMENTS FOR BANDS ADDRESSED BY FCC (947 MHz - 17.7 GHz)
(based on GMF)

	Band	Agency	Assignments	Total
i)	1.99 - 2.11 GHz	Air Force	15	
	(Non-Government)	Army	2	
		Commerce	6	
		NASA	164	
		Non-Government	4	191
ii)	6.525 - 7.125 GHz	Air Force	24	
	(Non-Government)	Army	1	
		Energy	4	
		Interior	4	
		Navy	1	
		Non-Government	1	35
iii)	12.7 - 13.25 GHz	Air Force	2	
	(Non-Government)	Interior	6	
		Non-Government	1	9

TABLE 12. NUMBER OF GOVERNMENT SYSTEMS CURRENTLY UNDER REVIEW OR LISTED IN THE SYSTEMS REVIEW FILE

Government Exclusive Bands	
1350 - 1400 MHz	13
1710 - 1850 MHz	41
2200 - 2290 MHz	48
4400 - 4500 MHz	19
4800 - 4990 MHz	17
7125 - 8450 MHz	36
14.5 - 15.35 GHz	17
	191
Shared Bands	
1427 - 1535 MHz	11
1700 - 1710 MHz	8
2290 - 2390 MHz	15
2655 - 2690 MHz	2
4500 - 4800 MHz	17
8450 - 8500 MHz	0
10.6 - 10.68 GHz	0
14.4 - 14.5 GHz	10
	61
Non-Government Exclusive Bands	
947 - 960 MHz	0
1850 - 2200 MHz	19
2450 - 2655 MHz	4
3700 - 4200 MHz	2
5925 - 7125 MHz	4
10.55- 10.6 GHz	0
10.7 - 13.25 GHz	2
	31

TOTAL: 283

TABLE 13. NUMBER, TYPE OF SYSTEM, AND STAGE OF REVIEW FROM SYSTEM REVIEW FILE
947 MHz - 17.7 GHz

TYPE OF SYSTEM	NUMBER OF SYSTEMS
Satellite Systems	85
Radar and Positioning System	100
Radio Communications	30
Missile and RPV Systems	11
Misc.	18
Ordnance Scoring System	8
Data and Command Control System	38
Space Shuttle	4
Telemetry	10
Microwave Landing System	7
Air Navigation Aids, Air Traffic Control	14
TOTAL:	325

STAGE OF REVIEW

0	Review not indicated	3
1	Conceptual	19
2	Experimental	41
3	Developmental	85
4	Operational	163
8	System was not reviewed	3
9	System is no longer functioning	11
	TOTAL:	325

RULES AND REGULATIONS

A summary of the pertinent rules and regulations in effect for the Fixed and Mobile Services in the bands between 947 MHz and 17.7 GHz is presented here. The principle references are the ITU Radio Regulations, the National Telecommunications and Information Administration (NTIA) Manual, and the International Radio Consultive Committee (CCIR) documents.

Allocations (ITU and NTIA) Tables 1 through 19 of this report contain an extract, of Article V of the ITU Table of Frequency Allocations covering the band from 942 MHz to 17.7 GHz, and of Chapter 4, Allocations, Allotments and Plans of the NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management. Note that the international (ITU) allocations are uniform worldwide in the 1427-1429 MHz, 1636.5-1660, 2550-2655, 4200-4990, 5925-8025, 8400-8500 MHz, 10.55-10.68 GHz, 10.7-10.95, 11.2-11.7, 12.75-13.25, and 14.4-15.35 GHz bands. Figure 7 (Government Exclusive Bands), Figure 8 (Government and non-Government Shared Bands), and Figure 9 (non-Government Exclusive Bands) are a graphic presentation of these allocations; the Fixed and Mobile bands relevant to this study and their footnotes are discussed below:

947-960 MHz Band: Nationally, this is a non-Government "Exclusive" band in the Fixed Service. Internationally, in Region 2 it is allocated on a primary basis to the Fixed and on a secondary basis to the Mobile Service.

There are two footnotes applicable to the United States and Region 2:

NG9--Aural broadcast intercity relay stations may be authorized to use the band 947-952 MHz on the condition that harmful interference will not be caused to other classes of stations operating in accordance with the Table of Frequency Allocations.

708--Different category of service: in the United States, the allocation of the bands 942-947 MHz and 952-960 MHz to the Mobile service is on a primary basis (see No. 425) and subject to agreement obtained under the procedure set forth in Article 14.

1350-1400 MHz Band: This is a Government band with primary allocation to the Radiolocation Service and secondary allocation to the Fixed (note that the Fixed and Mobile Services are limited to the military) and Mobile Services. Footnote G114 permitted a new service in the band, G114 states "... the frequency 1381.02 MHz with emissions limited to ± 12 MHz is also allocated to Fixed and Mobile Satellite Services (space-to-Earth) for the relay of nuclear burst data."

The lower adjacent band, 1300-1350 MHz, is allocated both nationally and internationally to the Aeronautical Radionavigation Service on a primary basis. The band 1300-1350 MHz is also reserved on a worldwide basis for the use of Radiolocation on a secondary basis. A summary of the International Table of Frequency Allocations, given in the Final Acts of WARC-79, is shown in Table 1.

In the subband 1350-1400 MHz, footnote G114 provides for the allocation of 1381.05 $\pm$ 12 MHz to Fixed and Mobile Satellite Services (space-to-Earth). This allocation is not stated in the international table. The changes in the international tables were in agreement with the U.S. proposals to the WARC-79. The effects of the revision, which was adopted by the WARC-79 in the 1350-1400 MHz band, were investigated by the United States during the WARC-79 preparation activities.

The upper adjacent band 1400-1427 MHz is allocated nationally and internationally to the Radio Astronomy Service on a primary basis. The national Government provisions (NTIA Manual) state that: " ... the Radio Astronomy Service shall be protected from extra-band radiation only to the extent that 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."

The footnotes in the 1350-1400 MHz band applicable to the United States are:

GS2--In the bands 216-225, 420-450 (except as provided by US217), 890-920, 928-942, 1300-1400, 2300-2450, 2700-2900, 5650-5925, and 9000-9200 MHz, the Government radiolocation is limited to the military services.

G27--The Fixed and Mobile Services are limited to the military services.

G114--In the band 1350-1400 MHz, the frequency 1381.05 MHz with emissions limited to ± 12 MHz is also allocated to Fixed and Mobile Satellite Services (space-to-Earth) for the relay of nuclear burst data.

714--Additional allocation: In Canada and the United States, the bands 1240-1300 MHz and 1350-1370 MHz are also allocated to the Aeronautical Radionavigation service on a primary basis.

718--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 from harmful interference in the band 1330-1400 MHz. Emissions from space or airborne stations can be particularly serious sources and interference to the radio astronomy service (see Nos. 343 and 344 and Article 36).

720--The bands 1370-1400 MHz, 2640-2655 MHz, 4950-4990 MHz, and 15.20-15.35 GHz are also allocated to the space research (passive) and earth exploration-satellite (passive) services on a secondary basis.

1427-1535 MHz Bands: There are four distinct Government and non-Government shared bands in this region of the spectrum: 1427-1429 MHz, which is shared on a primary basis between the Fixed, Mobile, and Space Operation with secondary allocations in the non-Government services for land mobile telemetering and fixed telemetering; 1429-1435 MHz, which is allocated on a primary basis to the Government for Fixed and Mobile Services, and on a secondary basis for fixed and land mobile telemetering in the non-Government area; and 1435-1530 MHz, allocated to both the Government and non-Government Mobile Service on a primary coequal basis for aeronautical telemetering purposes. The FCC presently has an ongoing rule making under General Docket 84-186 to revise use rules for aeronautical mobile telemetry in these bands. The 1530-1535 MHz band is allocated to Government and non-Government Maritime Mobile-Satellite Service as primary and to the Mobile Service (aeronautical telemetering) on a secondary basis.

Note (US272) that the Maritime Mobile-Satellite Service will not be effective until January 1, 1990. Until that date the Mobile Service will be primary in the 1530-1535 MHz band.

The footnotes that are relevant to the United States in the 1427-1535 MHz bands are:

G30--In the bands 138-144, 148-149.9, 150.05-150.8, 225-328.6, 335.4-399.9, 1427-1429, and 1429-1435 MHz, the fixed and mobile services are limited primarily to operations by the military services.

US78--In the band 1435-1535 MHz, the frequencies between 1435 and 1485 MHz will be assigned primarily for the flight testing of manned aircraft, or major components thereof; the frequencies between 1485 and 1535 MHz will be assigned primarily for the flight testing of unmanned aircraft and missiles or major components thereof. Included as permissible usage for aeronautical telemetering stations in the band 1435-1535 MHz is telemetry associated with launching and re-entry into the Earth's atmosphere, as well as any incidental orbiting prior to re-entry, of manned or unmanned objects undergoing flight tests. In the band 1530-1535 MHz the maritime mobile satellite service will be the only primary service after 1 January 1990.

US272--The allocation to the Maritime Mobile-Satellite service in the band 1530-1535 MHz shall be effective from 1 January 1990. Up to that date the allocation to the Mobile Service will be on a primary basis.

722--In the bands 1400-1727 MHz, 101-120 GHz and 197-220 GHz, passive research is being conducted by some countries in a programme for the search for intentional emissions of extraterrestrial origin.

<u>1700-1710 MHz Band</u>: This band is shared on a primary basis by the Fixed and Meteorological-Satellite Services in the Government allocations, but in the non-Government allocations the Fixed Service is secondary to the Meteorological-Satellite Service.

The footnotes that are applicable to the United States in the 1700-1710 MHz band are:

G118--Government fixed stations may be authorized in the band 1700-1710 MHz only if spectrum is not available in the band 1710-1850 MHz.

671--Earth exploration-satellite service applications, other than the meteorological-satellite service, may also be used in the bands 460-470 MHz and 1690-1710 MHz for space-to-Earth transmissions subject to not causing harmful interference to stations operating in accordance with the Table.

722--In the bands 1400-1727 MHz, 101-120 GHz and 197-220 GHz, passive research is being conducted by some countries in a programme for the search for intentional emissions of extraterrestrial origin.

1710-1850 MHz Band: Nationally, the 1710-1850 MHz band is allocated to Government Fixed and Mobile Services on a shared primary basis. The 1761-1842 MHz portion of the band is also allocated for Earth-to-space satellite control systems on a coequal basis. Table 1 includes excerpts from the U.S. National Table of Frequency Allocations (NTIA, 1982) for the 1710-1850 MHz and adjacent bands along with the footnotes applicable to the United States.

The U.S. Footnote US256 now provides that the needs of the Radio Astronomy service for measurements in the band 1720-1721 MHz be considered.

In addition to these specific allocation rules and regulations, the NTIA Manual identified frequency assignment procedures that are specifically applicable to this band. Paragraph 8.2.25 of the NTIA Manual limits the use of frequency diversity for line-of-sight fixed systems in the 1710-1850 MHz band. To employ frequency diversity for a new system, justification is required to show that the diversity will provide the required reliability. Paragraph 8.4.12 of the NTIA Manual establishes the coordination criteria for earth station frequency assignments. The coordination criterion is to assure that terrestrial stations within the coordination area will not receive interference. The coordination area for an earth station is calculated in accordance with Appendix 28 of the ITU Radio Regulations. The existing Earth-to-space stations in the 1710-1850 MHz band are listed below:

Transmitting Earth stations in the 1710-1850 MHz band

Band (MHz)	Location	Coordinates	
1761-1842	Anderson AFB, Guam	1337XXN	14451XXE
1761-1842	Kaena Pt., HI	2134XXN	15816XXW
1761-1842	New Boston, NH	4256XXN	07138XXW
1761-1842	Vandenberg AFB, CA	3444XXN	12032XXW
1761-1842	Fairchild, WA	4734XXN	11810XXW
1761-1842	Loring, ME	4700XXN	06810XXW
1761-1842	Buckley Field, CO	3493XXN	10446XXW
1761-1842	Fortune, ND	---	---

The footnotes that are applicable to the 1710-1850 MHz band are:

G42--Space command, control, range and range rate systems for Earth station transmission only (including installations on certain Navy ships) may be accommodated on a co-equal basis with the fixed and mobile services in the band 1761-1842 MHz. Specific frequencies required to be used at any location will be satisfied on a coordinated case-by-case basis.

US256--Radio astronomy observations may be made in the band 1717.8-1722.2 MHz on an unprotected basis. Agencies providing other services in this band in the geographic areas listed below should bear in mind that their operations may affect those observations, and those agencies are encouraged to minimize potential interference to the observations in so far as it is practicable.

National Astronomy and Ionosphere Center Arecibo, Puerto Rico	Rectangle between latitudes 17°20'N and 19°00'N and between longitudes 65°10'W and 68°00'W.
Haystack Radio Observatory Tyngsboro, Massachusetts	Rectangle between latitudes 41°00'N and 43°00'N and between longitudes 71°00'W and 73°00'W.
National Radio Astronomy Observatory Green Bank, West Virginia	Rectangle between latitudes 37°00'N and 39°15'N and between longitudes 78°30'W and 80°30'W.
National Radio Astronomy Observatory Socorro, New Mexico	Rectangle between latitudes 32°30'N and 35°30'N and between longitudes 106°00'W and 109°00'W.
Owens Valley Radio Observatory Big Pine, California	Two contiguous rectangles, one between latitudes 36°00'N and 37°00'N and between longitudes 117°40'W and 118°30'W and the second between latitudes 37°00'N and 38°00'N and longitudes 118°00'W and 118°50'W.
Hat Creek Observatory Hat Creek, California	Rectangle between latitudes 40°00'N and 42°00'N and between longitude 120°15'W and 122°15'W.

722--In the bands 1400-1727 MHz, 101-120 GHz and 197-220 GHz, passive research is being conducted by some countries in a programme for the search for intentional emissions of extra-terrestrial origin.

1850-2200 MHz Bands: There are three discrete assignment bands in this region of the spectrum: 1850-1990 MHz, which is allocated exclusively to the non-Government Fixed Service; 1990-2110 MHz, which is shared on a primary basis between the non-Government Fixed and Mobile Services with the exceptions noted below in US90, 111, 219, and 222 for Government Space Research and Earth Exploration-Satellite Services, and in NG23 and NG118 relating to international fixed public radio service and television translators relay stations; and 2110-2200 MHz, which is allocated exclusively to the non-Government Fixed Service with the exceptions noted in US111, 219, 222, 252, and NG23.

The footnotes that are relevant to this band are:

NG23--Frequencies in the band 2100-2200 MHz may also be assigned to stations in the international fixed public radio service located south of 25°30' north latitude in the State of Florida and in U. S. Possessions in the Caribbean area, provided, however, no new assignments in the band 2150-2162 MHz will be made to such stations after February 25, 1974.

NG118--Television translator relay stations may be authorized to use frequencies in this band on a secondary basis to stations operating in accordance with the Table of Frequency Allocations.

US90--In the band 2025-2110 MHz Earth-to-space and space-to-space transmissions may be authorized in the Space Research and earth exploration-satellite services subject to such conditions as may be applied on a case-by-case basis. Such transmission shall not cause harmful interference to non-Government stations operating in accordance with the Table of Frequency Allocations. All space-to-space transmission reaching the Earth's surface shall adhere to a power flux density of between -144 and -154 dBW/M^2/4 kHz depending on angle of arrival in accordance with ITU Radio Regulations, 2557 NE through 2560 NGA and shall not cause harmful interference to the other space services.

US111--In the band 1990-2120 MHz, Government space research earth stations may be authorized to use specific frequencies at specific locations for earth-to-space transmissions. Such authorizations shall be secondary to non-Government use of this band and subject to such other conditions as may be applied on a case-by-case basis.

Corpus Christi, Texas	27° 39' N 097° 23' W.
Fairbanks, Alaska	64° 59' N 147° 53' W.
Goldstone, California	35° 18' N 116° 54' W.
Greenbelt, Maryland	39° 18' N 076° 50' W.
Guam, Mariana Island	13° 19' N 144° 44' E.
Kauai, Hawaii	22° 08' N 159° 40' W.
Merritt Island, Florida	28° 29' N 080° 35' W.
Rosman, North Carolina	35° 12' N 082° 52' W.
Wallops Island, Virginia	37° 57' N 075° 28' W.

US219--In the band 2025-2120 MHz Government Earth Resources Satellite Earth Stations in the Earth Exploration-Satellite Service may be authorized to use the frequency 2106.4 MHz for earth-to-space transmissions for tracking, telemetry, and telecommand at the sites listed below. Such transmissions shall not cause harmful interference to non-Government operations:

Sioux Falls, South Dakota	43° 32' 03.1" N 96° 45' 42.8" W.
Fairbanks, Alaska	46° 58' 36.6" N 147°30' 54.2" W.

US222--In the band 2025-2035 MHz Geostationary Operational Environmental Satellite Earth stations in the Space Research and Earth Exploration-Satellite Services may be authorized on a co-equal basis to use the frequency band 2025-2035 MHz for Earth-to-space transmissions for tracking, telemetry, and telecommand at the sites listed below:

Wallops Island, Virginia	37° 50' 48" N	75° 27' 33" W.
Seattle, Washington	47° 34' 15" N	122° 33' 10" W.
Honolulu, Hawaii	21° 21' 12" N	157° 52' 36" W.

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.

2200-2300 MHz Bands: Nationally, the 2200-2300 MHz band is allocated to the Fixed, Mobile and Space Research (space-to-Earth) Services on a coequal primary basis. From 2200-2290 MHz the allocations are to Government use exclusively, while from 2290-2300 MHz the band is shared with non-Government Space Research. The Fixed and Mobile Services are restricted to the line-of-sight mode of propagation. The Mobile Service in the 2200-2290 MHz band includes aeronautical telemetry but excludes telemetry from manned aircraft. Aeronautical mobile stations are excluded between 2290-2300 MHz. The Space Research Service use of the 2290-2300 MHz band is further restricted to "deep space only" (mission distance equal to or greater than the distance between the Earth and Moon). Table 1 includes excerpts from the International and U.S. National Table of Frequency Allocations (NTIA, 1982) for the 2200-2300 MHz band, and adjacent bands along with the applicable footnotes.

Internationally, the allocations differ in that, from 2200-2290 MHz, the Space Research Service is not allocated in Region 1 but may be used in Regions 2 and 3, only by "agreement between the administrations concerned and those having services operating in accordance with the table which may be affected." Between 2290 and 2300 MHz, the Space Research Service is allocated for all ITU regions but is not limited to deep space. In addition, there is no exception taken to Aeronautical Mobile, nor are limitations placed on the Mobile Service except in Region 1 where the Mobile Service is limited to a secondary status.

The Final Acts of the WARC-79 called for several changes to the International Allocation Table. Those changes pertinent to this study are summarized in Table 1. The major change is the addition of the Space Operation, Space Research, and Earth-Exploration-Satellite Services for space-to-Earth and space-to-space transmission in a footnote (750) in the 2200-2290 MHz band in all regions. This change satisfies requirements for telemetry, tracking and operational control of satellites using common and standardized equipment. In support of the current requirements for data-relay-satellites (space-to-space), directional indicators were also added. The WARC allocated the band 2290-2300 MHz to the Space Research Service for deep space only, to provide increased protection for this function. The primary allocation to the Mobile Service is limited to other than Aeronautical Mobile, to protect the very sensitive deep-space systems from airborne transmission.

Additionally, WARC-79 changed the requirements for international coordination by the addition of new Article 14 (Conference Article N13A). This Article is applied to cases where a footnote in the Table of Frequency Allocations requires that an administration must obtain the agreement of any administration whose services may be affected before notifying the International Frequency Registration Board (IFRB) of a frequency assignment in one of the covered bands. This Article provides specific procedures rather than providing an open-ended opportunity for an administration to complain about interference. A time limit of 4 months has been applied. The definition of the term "administration" whose operations may be affected has been resolved by requiring an administration to send a request for coordination to the Board rather than to a specific administration. The Board is to publish these requests in a special section of the Weekly Circular for all to examine and the "administration," whose operation may be affected, then has 4 months to respond. Also, the coordination request may be initiated with either the data required by Appendix 3 or Appendix 4 and the coordination may be accomplished simultaneously with the procedures of advance publication and conventional coordination described in new Article 11.

In addition to these specific allocation rules and regulations, the NTIA Manual identified frequency assignment and coordination procedures that are specifically applicable to this band. Section 8.2.25 of the NTIA Manual limits the use of frequency diversity for line-of-sight fixed systems in the 2200-2290 MHz band. To employ frequency diversity for a new system, justification is required to show the necessity for the high reliability as well as an engineering evaluation to show that the diversity will provide the required reliability. Section 8.2.33 provides a guideline for the selection of sites and frequencies for Earth and terrestrial stations in the bands above 1 GHz shared with equal rights by terrestrial and space radiocommunication services. Section 8.2.36 of the NTIA Manual limits the power flux density at the Earth's surface from space stations in the Space Research Service operating in the 2200-2300 MHz frequency band. These limits are identical to the provisions 6055/470NE and 6059/4700NGA of the Final Acts of WARC-79. These are derived on the basis of protecting stations in the Fixed Service that employ line-of-sight communications. Sections 8.4.12, 8.4.13, and 8.4.14, of the NTIA Manual establish the coordination criteria for Earth-station frequency assignments. The purpose of the coordination criteria is to assure that terrestrial stations will not interfere with the Earth station and vice versa. The coordination area for an Earth station is calculated in accordance with Appendix 28 of the ITU Radio Regulations. The existing Earth stations listed in the NTIA Manual within the 2200-2300 MHz band are

Frequency MHz	Location	Coordinates Latitude	Coordinates Longitude	Agency
2200-2290	Goldstone, CA	35 20 30N	116 52 25W	NASA
	Greenbelt, MD	38 59 55N	076 50 34W	NASA
	Guam	31 83 33N	144 44 04E	NASA
	Kauai, HI	22 07 31N	159 40 03W	NASA
	Merritt Island, FL	28 30 30N	084 41 37W	NASA
	Rosman, NC	35 12 XXN	082 52 19W	NASA
	Fairbanks, AK	64 58 38N	147 30 54W	NASA
	Shirley Bay, Ontario	45 20 56N	075 53 23W	CANADA
2290-2300	Goldstone, CA	35 25 29N	116 53 24W	NASA
2200-2300	Andersen AFB, Guam	13 36 48N	144 51 12E	USAF
	Buckley Field, CO	39 43 XXN	104 46 XXW	USAF
	Cape Kennedy, FL	28 24 XXN	080 30 XXW	USAF
	Fairchild AFB, WA	47 30 XXN	118 10 XXW	USAF
2200-2300	Kaena Pt., HI	21 34 18N	158 16 34W	USAF
	Loring AFB, ME	47 00 XXN	068 01 XXW	USAF
	New Boston, NH	42 56 54N	071 38 24W	USAF
	Shemya, AK	52 43 XXN	174 07 XXE	USAF
	Vandenberg AFB, CA	34 29 24N	120 31 54W	USAF

The footnote that is applicable to the 2200-2300 MHz Bands is:

G101--In the band 2200-2290 MHz, space operations (Space-to-Earth) and (Space-to-space), and earth exploration-satellite (Space-to-Earth) and (Space-to-space) services, may be accommodated on a co-equal basis with fixed, mobile and space research service.

2300-2390 MHz Bands: There are two discrete assignment bands in this spectral region: 2300-2310, which is allocated to the Government Radiolocation Service on a primary basis and the Fixed and Mobile Services on a shared secondary basis with the Amateur Service; and 2310-2390 MHz which is allocated to the Government Radiolocation and Mobile Services shared with the non-Government Mobile Service, all on a primary coequal basis.

There is also a secondary allocation to the Government Fixed Service. The Mobile Service is limited to aeronautical telemetering and associated telecommand operations and all other mobile telemetering is secondary. The FCC has an ongoing rule making under General Docket 84-186 to implement use rules for aeronautical mobile telemetry in the 2310-2390 MHz band.

Internationally, the allocations differ in that, for Region 1, the Fixed Service is primary and the Amateur, Mobile and Radiolocation Services are allocated on a secondary basis. In Region 2 and 3, the allocations are identical to the National Table with the exception that the Fixed and Mobile Services are allocated across the entire band. The Final Acts of the WARC-79 adopted several changes to the International Allocation Table in this band. These changes were the upgrading of the Fixed and Mobile Services to a coequal shared primary allocation with the Radiolocation Service in Region 2 and 3, the addition of footnote 751, and the modification of footnotes 752 and 664 for all regions.

The addition of footnote 751 recognized the requirement in the United States for flight test telemetering in the band 2310-2390 MHz. A National Memorandum of Understanding NMOU that states that the band 2310-2390 MHz will be allocated on a coequal primary basis to Radiolocation and Mobile Services, with Fixed and Amateur Services secondary, has been agreed to within the United States. The only primary use of the Mobile Service is to be by aeronautical mobile telemetering stations. Further use of the band for aeronautical mobile purposes shall be coordinated as is now accomplished for the band 1435-1535 MHz.

In February 1980, an IRAC ad hoc committee (Ad Hoc-172) was established to provide recommendations to the IRAC containing allocation actions necessary for the Federal Government to implement the Final Acts of the WARC-79. These changes implement WARC-79 provisions to the extent indicated in TABLE 4. Government/non-Government allocations for the primary Mobile Services were added in the band 2310-2390 MHz and footnote US34 was suppressed to recognize this change to satisfy the need for flight-testing telemetering documented in the NMOU. Merging the 10 MHz from 2390-2400 MHz with the new band 2390-2450 MHz eliminates the Fixed and Mobile within this 10 MHz. Additionally, footnotes G29 and G55 were deleted, US253 was added, and G2 modified.

The footnotes that are relevant to the 2300-2390 MHz bands are:

US253--In the band 2300-2310 MHz, the fixed and mobile services shall not cause harmful interference to the amateur service.

US276--Use of the band 2310-2390 MHz by the mobile service is limited to aeronautical telemetering and associated telecommand operations. Exceptionally all other mobile telemetering uses shall secondary.

G2--In the bands 216-225, 420-450, 1300-1400, 2300-2450, 2700-2900, 5650-5925 and 9000-9200 MHz, the Government radiolocation is limited to the military service.

664--In the bands 435-438 MHz, 1260-1270 MHz, 2400-2450 MHz, 3400-3410 MHz (in Regions 2 and 3 only) and 5650-5670 MHz, the amateur-satellite service may operate subject to not causing harmful interference to other services operating in accordance with the Table (see No. 435). Administrations authorizing such use shall ensure that any harmful interference caused by emissions from a station in the amateur-satellite service is immediately eliminated in accordance with the provisions of No. 2741. The use of the bands 1260-1270 MHz and 5650-5670 MHz by the amateur-satellite service is limited to the Earth-to-space direction.

751--In Australia, the United States and Papua, New Guinea, the use of the band 2310-2390 MHz by the aeronautical mobile service for telemetry has priority over other uses by the mobile services.

752--The band 2400-2500 MHz (center frequency 2450 MHz) is designated for industrial, scientific and medical (ISM) applications. Radio 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.

2450-2655 MHz Bands: There are two discrete bands in this region: 2450-2500 MHz, which is allocated on a primary basis to the non-Government Fixed and Mobile Services, and on a secondary basis to Radiolocation; and the 2500-2655 MHz band is shared by the Broadcasting-Satellite and the Fixed Service on a primary basis.

The modifications of footnote 752 designate the band 2400-2500 MHz for ISM without exception for all ITU regions. No specific provision was made for a U.S. proposed satellite power system, but the CCIR was asked to study further the technical and other questions, including environmental aspects of such power systems, and to make appropriate recommendations (Conference Recommendation 3). Also, the CCIR and the next competent World Administrative Radio Conference were invited to resolve the problem of interference from ISM equipment to radiocommunication services (Conference Resolution 63).

The modification of footnote 664 (3644/320A) provides that the Amateur-Satellite Service may operate in the band 2400-2450 MHz (in Regions 2 and 3 only) subject to not causing harmful interference to the other allocated services and administrations, and to ensure that if interference occurs it be eliminated immediately.

In any general revision of Radio Regulations, the allocations, which are administered by the ITU, constitute an international framework within which governments establish their own national allocations. In the United States, the FCC following public notice, sets such allocations for non-Governmental use; NTIA sets such allocations for Government use, based on the advice of IRAC. National procedures are being modified to reflect the new WARC-79 procedures which are to be implemented January 1, 1982.

The footnotes that are applicable to the 2450-2500 MHz band are:

US41--The Government radiolocation service is permitted in the band 2450-2500 MHz on the condition that harmful interference is not caused to non-Government services.

752--The band 2400-2500 MHz (center frequency 2450 MHz) is designated for industrial, scientific and medical (ISM) applications. Radio 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.

The footnotes that apply to the 2500-2655 MHz band are:

US205--Tropospheric scatter systems are prohibited in the band 2500-2690 MHz.

US269--In the band 2500-2690 MHz, applicants for space station assignments are urged to take all practicable steps to protect radio astronomy observations in the adjacent band, 2690-2700 MHz, from harmful interference. Further, all applicants are urged to coordinate their proposed systems through the Electromagnetic Spectrum Management Unit, National Science Foundation, Washington, D.C. 20550, prior to systems development.

NG47--In the band 2500-2690 MHz, channels in 2500-2686 MHz and the corresponding response frequencies 2686.0625-2689.8125 MHz may be assigned to stations in the Instructional Television Fixed Service (Part 74 of this Chapter) CFR 47; channels in 2596-2644 MHz and response frequencies 2686.5625-2689.6875 MHz may be assigned to Multipoint Distribution Service stations (Part 21 of this Chapter); and channels 2650-2656 MHz, 2662-2668 MHz and 2674-2680 MHz and response frequencies 2686.9375 MHz, 2687.9375 MHz and 2688.9375 MHz may be assigned to stations in the Operational Fixed Service (Part 94 of this Chapter). In Alaska, however, frequencies within the band 2655-2690 MHz are not available for assignment to terrestrial stations.

NG101--The use of the band 2500-2690 MHz by the broadcasting-satellite service is limited to domestic and regional systems for community reception of educational television programming and public service information. Such use is subject to agreement among administrations concerned and those having services operating in accordance with the table, which may be affected. Unless such agreement includes the use of higher values, the power flux density at the earth's surface produced by emissions from a space station in this service shall not exceed those values set forth in Part 73 of the rules for this frequency band.

NG102--The frequency bands 2500-2655 MHz (space-to-earth) and 2655-2690 MHz (earth-to-space) are allocated for use in the fixed-satellite service as follows:

(a) For common carrier use in Alaska, for intra-Alaska service only, and, in the mid and western Pacific area including American Samoa, the Trust Territory of the Pacific Islands, Guam and Hawaii;

(b) For educational use in the contiguous United States, Alaska, and the mid and western Pacific area including American Samoa, the Trust Territory of the Pacific Islands, Guam and Hawaii.

Such use is subject to agreement with administrations having services operating in accordance with the table, which may be affected. In the band 2500-2655 MHz unless such agreement includes the use of higher values, the power flux density at the earth's surface produced by emissions from a space station in this service shall not exceed the values set forth in Part 25 of the rules for this frequency band.

720--The bands 1370 - 1400 MHz, 2640 - 2655 MHz, 4950 - 4990 MHz and 15.20 - 15.35 GHz are also allocated to the space research (passive) and earth exploration-satellite (passive) services on a secondary basis.

762--Administrations shall make all practicable efforts to avoid developing new tropospheric scatter systems in the band 2500 - 2690 MHz.

764--When planning new tropospheric scatter radio-relay links in the band 2500 - 2690 MHz, all possible measures shall be taken to avoid directing the antennae of these links towards the geostationary-satellite orbit.

3700-4200 MHz Band: Nationally, this band is shared by the non-Government Fixed-Satellite (space-to-Earth) and Fixed Services on a primary basis.

Internationally, the band is shared by Fixed, Fixed-Satellite, and Mobile (except Aeronautical Mobile) Services in Region 2.

There is only one footnote applicable to this band:

NG41--Frequencies in the bands 3700-4200 MHz, 5925-6425 MHz, and 10.7-11.7 GHz may also be assigned to stations in the international fixed public and international control services located in U.S. Possessions in the Caribbean area.

4400-4990 MHz Bands: There are three separate U.S. allocation bands in this region: 4400-4500 MHz, which is allocated exclusively to the Government Fixed and Mobile Service; 4500-4800 MHz, which is shared by the Government Fixed and Mobile Services and the non-Government Fixed-Satellite Service; and 4800-4990 MHz, which is allocated exclusively to the Government Fixed and Mobile Services.

The footnotes that are applicable to these bands are:

US203--Radio astronomy observations of the formaldehyde line frequencies 4825-4835 MHz and 14.470-14.500 GHz may be made at certain radio astronomy observatories as indicated below:

Bands to be observed		
4 GHz	14 GHz	Observatory
X		National Astronomy and Ionosphere Center Arecibo, Puerto Rico
X	X	National Radio Astronomy Observatory Green Bank, W. Va.
X	X	National Radio Astronomy Observatory Socorro, New Mexico
X	X	Hat Creek Observatory (U. of Calif.) Hat Creek, California
X	X	Haystack Radio Observatory (MIT-Lincoln Lab) Tyngsboro, Mass.
X	X	Owens Valley Radio Observatory (Cal. Tech.) Big Pine, California
	X	Five College Radio Astronomy Observatory, Quabbin Reservoir (near Amherst) Massachusetts

Every practicable effort will be made to avoid the assignment of frequencies to stations in the Fixed or Mobile Services in these bands. Should such assignments result in harmful interference to these observations, the situation will be remedied to the extent practicable.

US245--The Fixed-Satellite Service is limited to International inter-Continental systems and subject to case-by-case electromagnetic compatibility analysis.

US257--Radio astronomy observations may be made in the 4950-4990 MHz band at certain Radio Astronomy Observatories indicated below:

Hat Creek Observatory Hat Creek, California	Rectangle between latitude 40°00'N and 42°00'N and between longitude 120°15'W and 122°15'W.
Owens Valley Radio Observatory Big Pine, California	Two contiguous rectangles, one between latitudes 36°00'N and 37°00'N and longitudes 117°40'W and 118°30'W and the second between latitudes 37°00'N and 38°00'N and longitudes 118°00'W and 118°50'W.
Haystack Radio Observatory Tyngsboro, Massachusetts and Five College Radio Astronomy Observatory Quabbin Reservoir (near Amherst, MA)	Rectangle between latitudes 41°00'N and 43°00'N and between longitudes 71°00'W and 73°00'W.

720--The bands 1370 - 1400 MHz, 2640 - 2655 MHz, 4950 - 4990 MHz and 15.20 - 15.35 GHz are also allocated to the space research (passive) and earth exploration-satellite (passive) services on a secondary basis.

<u>5925-7125 MHz Bands</u>: Nationally, this region of the spectrum is divided into five distinct bands of non-Government allocation: 5925-6425 MHz, which is allocated to the Fixed and Fixed-Satellite (Earth-to-space) Services; 6425-6525 MHz, allocated to the Mobile and Fixed-Satellite (Earth-to-space) Services; 6525-6875 MHz, allocated to the Fixed and Fixed-Satellite (Earth-to-space) Services; 6875-7075 MHz, allocated to the Fixed, Fixed-Satellite, and Mobile Services; and 7075-7125 MHz, which is allocated to the Fixed and Mobile Services on a coequal basis.

Internationally, the WARC-79 added footnote 809, which allows passive microwave sensor measurements in the 6425-7075 MHz region by Earth Exploration-Satellite and Space Research Services; and footnote 810 makes the band 7125-7155 MHz available for Earth-to-space transmission in the Space Operation Service.

The footnotes relevant to the 5925-7125 MHz bands are:

791--The standard frequency and time signal-satellite service may be authorized to use the frequency 4202 MHz for space-to-Earth transmissions and the frequency 6427 MHz for Earth-to-space transmissions. Such transmission shall be confined within the limits of ± 2 MHz of these frequencies and shall be subject to agreement obtained under the procedure set forth in Article 14.

809--In the band 6425 - 7075 MHz, passive microwave sensor measurements are carried out over the oceans. In the band 7075 - 7250 MHz, passive microwave sensor measurements are carried out. Administrations should bear in mind the needs of the earth exploration-satellite (passive) and space research (passive) services in their future planning of this band.

810--Subject to agreement obtained under the procedure set forth in Article 14, in Region 2, the band 7125 - 7155 MHz may be used for Earth-to-space transmission in the space operation service.

811--Subject to agreement obtained under the procedure set forth in Article 14, the band 7145 - 7235 MHz may be used for Earth-to-space transmissions in the space research service. The use of the band 7145 - 7190 MHz is restricted to deep space; no emissions to deep space shall be effected in the band 7190 - 7235 MHz.

NG41--Frequencies in the bands 3700-4200 MHz, 5925-6425 MHz, and 10.7-11.7 GHz may also be assigned to stations in the international fixed public and international control services located in U.S. Possessions in the Caribbean area.

NG118--Television translator relay stations may be authorized to use frequencies in this band on a secondary basis to stations operating in accordance with the table of frequency allocations.

NG122--Television Pickup stations may be authorized in the 6425-6525 MHz band on a secondary basis to stations operating in accordance with the Table of Frequency Allocations.

7125-8500 MHz Bands: The majority of these bands have been allocated, on a shared basis, to both satellite communications and fixed and mobile terrestrial communications, primarily microwave radio relay systems. There are 14 distinct Government allocation bands in this region: (1) 7152-7190 MHz, which is allocated to the Fixed Service, but is also allocated to the Space Operations Service on a limited number of sites for Earth-to-space transmission; (2) 7190-7235 MHz, allocated to the Fixed and Space Research (Earth-to-space) Services; (3) 7235-7250 MHz, allocated exclusively to the Fixed Service; (4) 7250-7300 MHz, allocated on a primary basis to the military Fixed-Satellite and Mobile-Satellite, and the Fixed on a secondary basis; (5) 7300-7450 MHz, allocated on a primary basis to the military Fixed-Satellite and Government Fixed Service, with the military Mobile-Satellite shared on a secondary basis; (6) 7450-7550 MHz, shared on a coequal basis by Government Fixed, military Fixed-Satellite and Meteorological Satellite, with the military Mobile-Satellite allocated on a secondary basis; (7) 7550-7750 MHz, allocated on a primary basis to the Government Fixed and military Fixed-Satellite and on a secondary basis with the military Mobile-Satellite; (8) 7750-7900 MHz, allocated on an exclusive basis to the Government Fixed Service; (9) 7900-8025 MHz, allocated on a primary basis to the military Fixed-Satellite and Mobile-Satellite, with the Government Fixed on a secondary basis; (10) 8025-8175 MHz, shared on a primary basis by the Government Earth Exploration-Satellite and Fixed, with the military Fixed-Satellite and the military Mobile-Satellite (Earth-to-space, and no airborne transmissions) on a secondary basis; (11) 8175-8215 MHz, shared on a primary basis by the Government Fixed, Earth Exploration-Satellite, and Meteorological-Satellite, and with the military Mobile-Satellite on a secondary basis; (12) 8215-8400 MHz, shared on a primary basis by the Government Fixed, Earth Exploration Satellite, and Meteorological-Satellite, and on a secondary basis with the military Mobile Satellite; (13) 8400-8450 MHz, allocated on a coequal primary basis to the Government Fixed and Space Research (Space-to-Earth) (Deep space only) Services; and (14) 8450-8500 MHz, which is shared on a primary basis by the Government Fixed and Space Research which is shared with the non-Government Space Research.

The footnotes that are applicable to these bands are:

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

G116--The band 7125-7155 MHz is also allocated for Earth-to-space transmission in the Space Operations Service at a limited number of sites (not to exceed two), subject to established coordination procedures.

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.

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

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

809--In the band 6425 - 7075 MHz, passive microwave sensor measurements are carried out over the oceans. In the band 7075 - 7250 MHz, passive microwave sensor measurements are carried out. Administrations should bear in mind the needs of the earth exploration-satellite (passive) and space research (passive) services in their future planning of this band.

<u>10.55-10.6 GHz Band</u>: Nationally, the 10.55-10.6 GHz band is allocated exclusively to the non-Government Fixed Service.

Internationally, it is shared on a coequal primary basis by the Fixed and Mobile (except Aeronautical Mobile) Services worldwide with Radiolocation as a secondary service.

<u>10.6-10.68 MHz Band</u>: This band is shared by the Government Earth Exploration-Satellite (passive) and Space Research (passive), with the non-Government Fixed, Space Research (passive) and Earth Exploration-Satellite (passive) Services.

Internationally, the Fixed Service is allocated worldwide on a primary basis with the Earth Exploration Satellite (passive), Space Research (passive), Mobile (except Aeronautical Mobile) and Radio Astronomy. Radiolocation is also assigned on a secondary basis worldwide.

There are two footnotes applicable to this band:

US265--In the band 10.6-10.68 GHz, the fixed service shall be limited to a maximum equivalent isotropically radiated power of 40 dBW and the power delivered to the antenna shall not exceed -3 dBW, per 250 kHz.

US277--The band 10.6-10.68 GHz is also allocated on a primary basis to the radio astronomy service. However, the radio astronomy service shall not receive protection from stations in the Fixed Service which are licensed to operate in the one hundred most populous urbanized areas as defined by the U.S. Census Bureau. The following radio astronomy sites have been coordinated for observations in this band: National Radio Astronomy Observatory, Green Bank, West Virginia; National Radio Astronomy Observatory, Socorro, New Mexico; Harvard Radio Astronomy Station, Fort Davis, Texas; Hat Creek Observatory, Hat Creek, California; Owens Valley Radio Observatory, Big Pine, California; Naval Research Laboratory, Maryland Point, Maryland.

10.7-11.7 GHz Bands: Nationally, this band is assigned to the non-Government Fixed, and Fixed-Satellite (space-to-Earth) Services on a coequal basis.

Internationally, the Fixed, and Fixed-Satellite Services are shared with Mobile (except Aeronautical Mobile) Services in Region 2 and 3.

The footnotes that apply to this band are:

NG41--Frequencies in the bands 3700-4200 MHz, 5925-6425 MHz, and 10.7-11.7 GHz may also be assigned to stations in the international fixed public and international control services located in U.S. Possessions in the Caribbean area.

NG104--The use of the band 10.7-11.7 GHz and 12.75-13.25 GHz in the fixed-satellite service is limited to international systems, i.e., other than domestic systems.

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.

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.

11.7-13.25 GHz Bands: There are four distinct non-Government bands in this region of the spectrum: 11.7-12.2 GHz, which is allocated to the Fixed-Satellite (space-to-Earth) Service on a primary basis, and the Mobile (except Aeronautical Mobile) Service on a secondary basis; 12.2-12.7 GHz, allocated to the Fixed and Broadcasting-Satellite Services on a coequal primary basis; 12.7-12.75 GHz, allocated to the Fixed, Mobile and Fixed-Satellite (Earth-to-space) Services on a shared primary basis; and 12.75-13.25 GHz, which is allocated on a primary basis to the Fixed, Mobile, and Fixed-Satellite (Earth-to-space) Services.

As one of the proposals for the WARC-79, the United States proposed to move the allocation of the Broadcasting-Satellite Service from the band 11.7-12.2 GHz to the band 12.2-12.7 GHz for Region 2 in the International Frequency Allocation Table (ITU, 1976); these changes are shown in Table 7.

The U.S. preparatory effort for the WARC-79 of the ITU has concluded that the existing shared allocation of the band 11.7-12.2 GHz between the Broadcasting-Satellite Service and Fixed-Satellite Service (space-to-Earth) in the ITU Region 2 is insufficient to meet the demands of these services (FCC, 1978). The United States has, therefore, proposed that the allocations for the Broadcasting-Satellite Service and Fixed-Satellite Service (space-to-Earth) in the band 11.7-12.2 GHz in Region 2 be separated in such a way that the Fixed-Satellite Service (space-to-Earth) is retained in the band 11.7-12.2 GHz and the Broadcasting-Satellite Service is moved to the band 12.2-12.7 GHz. This separation of the two space services should provide a greatly increased capacity for each of the services.

Since the 12.2-12.7 GHz band has been allocated to BSS by the 1983 RARC and it is anticipated that several BSS systems will be in operation by 1988, continued use of this band for terrestrial operations will only be possible on a secondary basis after September 9, 1988. Although various aspects of such sharing have been discussed in several studies (CCIR, 1978 a, b, c; COMSAT, 1978; SPS, 1978; Western Union, 1978; Lee et al., 1979), each study is not necessarily complete enough to give a clear picture of sharing between the Broadcasting-Satellite Service and the Fixed Service. As shown in Appendix B, some conclusions of these studies even contradict each other (Akima, 1980).

The U.S. proposal to the RARC 1983 recommends that the Conference to provide additional Broadcasting-Satellite Service divide the band 12.1-12.3 GHz at 12.2 GHz with the present allocation at 11.7-12.1 GHz expanded to include the subband 12.1-12.2; and the allocation of 12.3-12.7 GHz be expanded to include the subband 12.2-12.3 GHz. The details of this proposal are given in APPENDIX C.

The footnotes that are relevant to this band are:

US251--The band 12.75-13.25 GHz is also allocated to the Space Research Service (Deep Space) (Space-to-Earth) for reception only at Goldstone, California. 35° 18' N - 116° 54' W.

NG53--In the band 12.7-13.15 GHz, television pickup stations and CARS pickup stations shall be assigned channels on a co-equal basis and shall operate on a secondary basis to fixed stations operating in accordance with the Table of Frequency Allocations. In the 13.15-13.20 GHz band television pickup stations and CARS pickup stations shall be assigned on an exclusive basis in the top one hundred markets, as set out in Section 76.51.

NG104--The use of the band 10.7-11:7 GHz and 12.75-13.25 GHz in the fixed-satellite service is limited to international systems, i.e., other than domestic systems.

NG118--Television translator relay stations may be authorized to use frequencies in this band on a secondary basis to stations operating in accordance with the table of frequency allocations.

NG139--Pending adopting of further specific rules concerning usage of the band 12.2-12.7 GHz by the fixed and broadcasting-satellite services, systems in these services may be authorized 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.

836--In Region 2, in the band 11.7-12.1 GHz, transponders on space stations in the fixed-satellite service may be used additionally for transmissions in the broadcasting-satellite service, provided that such transmissions do not have a maximum e.i.r.p. greater than 53 dBW per television channel and do not cause greater interference or require more protection from interference than the coordinated fixed-satellite service frequency assignments. With respect to the space services, this band shall be used principally for the fixed-satellite service. The upper limit of this band shall be modified in accordance with the decision of the 1983 regional administrative radio conference for Region 2 (see No. 841).

837--Different category of service: in Canada, Mexico and the United States, the allocation of the band 11.7-12.2 GHz to the fixed service is on a secondary basis (see No. 424).

838--In the band 11.7-12.5 GHz in Regions 1 and 3, the fixed, fixed-satellite, mobile, except aeronautical mobile, and broadcasting services, in accordance with their respective allocations, shall not cause harmful interference to broadcasting-satellite stations operating in accordance with the provisions of Appendix 30.

839--The use of the band 11.7-12.7 GHz in Region 2 by the fixed-satellite and broadcasting-satellite services is limited to national and sub-regional systems and is subject to previous agreement between the administrations concerned and those having services, operating or planned to operate in accordance with the Table, which may be affected (see Articles 11, 13 and 14 and Resolution 33).

840--For the use of the band 11.7-12.75 GHz in Regions 1, 2 and 3, see Resolutions 31, 34, 504, 700 and 701.

841--The 1983 regional administrative radio conferences for Region 2 will divide the band 12.1-12.3 GHz into two sub-bands. It will allocate the lower sub-band to the fixed-satellite service and the upper sub-band to the broadcasting-satellite, broadcasting, mobile except aeronautical mobile, and fixed services, all being on a primary basis.

842--Additional allocation: the bands 12.1-12.3 GHz in Brazil and Peru, and 12.2-12.3 GHz in the United States, are also allocated to the fixed service on a primary basis.

843--In the band 12.1-12.7 GHz, the Region 2 space services, existing or planned before the 1983 regional administrative radio conference for Region 2, shall not impose restrictions on the elaboration of the plan for the broadcasting-satellite service in Region 2 and shall be operated under the conditions set forth by that conference.

844--In Region 2, in the band 12.1-12.7 GHz, existing and future terrestrial radiocommunication services shall not cause harmful interference to the space services operating in accordance with the broadcasting-satellite plan to be prepared at the 1983 regional administrative radio conference for Region 2, and shall not impose restrictions on the elaboration of such a plan. The lower limit of this band shall be modified in accordance with the decisions of that conference for Region 2 (see No. 841).

846--In Region 2, in the band 12.3-12.7 GHz, assignments to stations of the broadcasting-satellite service made available in the plan to be established by the 1983 regional administrative radio conference for Region 2 may also be used for transmissions in the fixed-satellite service (space-to-Earth), provided that such transmissions do not cause more interference or require more protection from interference than the broadcasting-satellite service transmissions operating in accordance with that plan. With respect to the space services, this band shall be used principally for the broadcasting-satellite service. The lower limit of this band shall be modified in accordance with the decisions of that conference for Region 2 (see No. 841).

<u>14.4-14.5 GHz Band</u>: Nationally, this band is shared by the non-Government Fixed-Satellite (Earth-to-space) on a primary basis, with the Government Fixed and Mobile on a secondary basis.

Internationally, this band is broken up into two subbands: 14.4-14.47 GHz, which is assigned to the Fixed, Fixed-Satellite and Mobile (except Aeronautical Mobile) Services on a primary basis, and to the Space Research (space-to-Earth) Service on a secondary basis; and 14.47-14.5 GHz, assigned to the Fixed, Fixed-Satellite (Earth-to-space) and Mobile (except Aeronautical Mobile) Services on a primary basis, and with Radio Astronomy on a secondary basis.

The footnotes that are relevant to this band are:

US287--The band 14-14.5 GHz is also allocated to the non-Government land mobile-satellite service (Earth-to-space) on a secondary basis.

US234--In the band 14.4-14.5 GHz, all Government fixed and mobile stations, effective December 31, 1981, shall be on a secondary basis to stations in the non-Government fixed-satellite service. Exceptionally, the Government operations listed below, which were in existence on December 31, 1981, may continue to operate on a coequal primary basis with stations in the non-Government fixed-satellite service until December 31, 1986.

Operation	Points of Communication
Point Mugu, CA	From 34° 07' N 119° 07' W to 34° 00' N 119° 38' W
Fort Bragg, NC	From 35° 08' N 79° 05' W to 35° 10' N 79° 01' W
Vandenberg, CA	Transportable terminals within 25 km radius of 34° 44' N 120° 35' W
Bolling AFB, DC	Transportable Terminals within 25 km radius of 38° 50' N, 77° 01' W

US203--Radio astronomy observations of the formaldehyde line frequencies 4825-4835 MHz and 14.470-14.500 GHz may be made at certain radio astronomy observatories as indicated below:

Bands to be observed 4 GHz	14 GHz	Observatory
X		National Astronomy and Ionosphere Center Arecibo, Puerto Rico
X	X	National Radio Astronomy Observatory Green Bank, W. Va.
X	X	National Radio Astronomy Observatory Socorro, New Mexico
X	X	Hat Creek Observatory (U. of Calif.) Hat Creek, California
X	X	Haystack Radio Observatory (MIT-Lincoln Lab) Tyngsboro, Mass.
X	X	Owens Valley Radio Observatory (Cal. Tech.) Big Pine, California
	X	Five College Radio Astronomy Observatory, Quabbin Reservoir (near Amherst) Massachusetts

Every practicable effort will be made to avoid the assignment of frequencies to stations in the fixed or mobile services in these bands. Should such assignments result in harmful interference to these observations, the situation will be remedied to the extent practicable.

862--In making assignments to stations of other services to which the band 14.47-14.5 GHz is allocated, administrations are urged to take all practicable steps to protect spectral line observations of 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 and Article 36).

14.5-15.35 GHz Bands: Nationally, this region of the spectrum is subdivided into three discrete Government bands: 14.5-14.7145 GHz, which is allocated to the Fixed Service on a primary basis and to the Mobile and Space Research Services on a secondary basis; 14.7145-15.1365 GHz, allocated on a primary basis to the Mobile Service, and on a secondary basis to the Fixed and Space Research Services; and 15.1365-15.35 GHz, allocated on a primary basis to the Fixed Service and on a secondary basis to the Mobile and Space Research Services.

Internationally, this region is divided into two bands assigned worldwide: 14.5-14.8 GHz, allocated to the Fixed, Fixed-Satellite (Earth-to-space), and Mobile Services on a primary co-equal basis and to Space Research on a secondary basis; and 14.8-15.35 GHz, which is allocated to the Fixed and Mobile Services on a coequal primary basis, and on a secondary basis to the Space Research Service.

The footnotes that are applicable to these bands are:

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.

720--The bands 1370 - 1400 MHz, 2640 - 2655 MHz, 4950 - 4990 MHz and 15.20-15.35 GHz are also allocated to the space research (passive) and earth exploration-satellite (passive) services on a secondary basis.

Detailed Summary of Government Exclusive Bands by Band

THE 1350-1400 MHz BAND

INTRODUCTION

This 1350-1400 MHz band is a Government exclusive band used mainly for military radars. A Spectrum Resource Assessment was printed in September 1981 (Farrar, 1981) for the 1215-1400 MHz band which covered this 1350-1400 MHz portion. Excerpts from that report are included in the following sections. This band is also allocated to the Fixed and Mobile Services on a secondary basis (noninterfering to primary allocated services) which qualifies it as a band for study in this report.

ALLOCATIONS, RULES AND REGULATIONS

The 1350-1400 MHz frequencies are allocated as shown in Table 14 to Government Radiolocation Services on a primary basis and to Government Fixed and Mobile Services on a secondary basis. This is not only a Government exclusive band but by footnote G2 and G27 all services are limited to use by the military. By footnote G114 the frequency 1381.05 ± 12 MHz is allocated to the Fixed and Mobile Satellite Services (space-to-Earth) for the relay of nuclear burst data. International footnote 714 also allocates the 1350-1370 MHz portion of the band to the Aeronautical Radionavigation Service on a primary coequal basis. By international footnote 720 the 1370-1400 MHz portion is also allocated to the Space Research (passive) and Earth Exploration-Satellite (passive) Services on a secondary basis. Provisions of footnote 718 provide for the use of the Radio Astronomy Service for spectral line observations in the band 1330-1400 MHz and should be protected where possible.

The lower adjacent band 1300-1350 MHz is allocated internationally and nationally to the Aeronautical Radionavigation Service on a primary basis and is shared with the non-Government. The Radiolocation Service is also allocated on a secondary noninterfering basis to the military services.

The upper adjacent band 1400-1427 MHz is allocated nationally and internationally to the Radio Astronomy Service on a primary basis. The national Government provisions (US 74) state that: "... the radio astronomy service shall be protected from extra-band radiation only to the extent that 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." Footnote US246 provides additional protection for radio astronomy by prohibiting authorization of transmission to any station in this and certain other radio astronomy frequency bands. In the United States the information on radio astronomy frequencies monitored by the observatories is published and updated when necessary in a booklet distributed by the Committee on Radio Frequencies of the National Academy of Sciences. This booklet is available to Government agencies in order to keep them informed of the frequencies being used by the U. S. observatories.

TABLE 14

INTERNATIONAL AND U. S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS FOR THE 1350-1400 MHz FREQUENCY BAND

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
1300-1350 AERONAUTICAL RADIONAVIGATION 717 Radiolocation 715 716 718			1300-1350	717 718	AERONAUTICAL RADIONAVIGATION Radiolocation G2	AERONAUTICAL RADIONAVIGATION
1350-1400 FIXED MOBILE RADIOLOCATION 718 719 720	1350-1400 RADIOLOCATION 714 718 720		1350-1400	714 718 720	RADIOLOCATION Fixed Mobile G2 G27 G114	
1400-1427 EARTH EXPLORATION-SATELLITE (Passive) RADIO ASTRONOMY SPACE RESEARCH (Passive) 721 722			1400-1427	US74 US246 722	RADIO ASTRONOMY EARTH EXPLORA-TION-SATELLITE (Passive) SPACE RESEARCH (Passive)	RADIO ASTRONOMY EARTH EXPLORA-TION-SATELLITE (Passive) SPACE RESEARCH (Passive)

SPECTRUM USAGE AND SYSTEM DESCRIPTIONS

There are 97 assignments in the 50 MHz between 1350 and 1400 MHz used by 4 Government agencies. There are seven assignments to non-Government companies to support Government research and development of systems in the band. Table 15 shows agency usage by station class and number of assignments. Army has the largest number of assignments with 62, Navy has 21, Air Force has 13, and the National Security Agency has 1. With the 7 non-Government assignments there are a total of 104.

There are also 43 assignments listed in the 1215-1240 MHz band which are used by systems that range tune into the 1350-1400 MHz band. These are mainly radar systems that can tune from 1200-1400 MHz. There are 14 systems involved and the assignments are allocated to the various Government agencies as given in Table 16.

Frequency assignment does not indicate actual usage; there may be any number of equipments or systems that are assigned the same frequency. Data presented in Table 15 show the greatest usage to be Radiolocation and Radionavigation Services. Frequency assignment distributions are shown in Figure 8. The growth trends in the 1350-1400 MHz band are shown in Figure 9. The 3 years between January 1980 and January 1983 show an increase from 69 to 104 assignments. This represents about a 50% growth over the 3-year period.

TABLE 15

FREQUENCY ASSIGNMENTS BY AGENCY
FOR THE 1350-1400 MHz BAND

STATION CLASS	REMARKS	AGENCY	NUMBER OF ASSIGNMENTS
FL - Land Station:	A station in the Mobile Service not intended to be used while in motion.	Army	2
FX - Fixed Station:	A station in the Fixed Service.	Army	9
LR - Radiolocation Land Station:	A station in the Radiolocation Service not intended to be used while in motion.	Army Air Force	15 1

TABLE 15. (Continued)

STATION CLASS	REMARKS	AGENCY	NUMBER OF ASSIGNMENTS
MR - Radiolocation Mobile Station:	A station in the Radiolocation Service intended to be used while in motion or during halts at unspecified points.	Army	22
RL - Radionavigation Land Station:	A station in the Radionavigation Service not intended to be used while in motion.	Navy	3
TR - Space Telemetering Earth Station:	An Earth station which receives emissions used for space telemetering.	Navy	2
XC - Experimental Contract Developmental	An experimental station used for the evaluation or testing under Government contract of electronics equipment or systems in a design or development stage.	Air Force Non-Government	4 4
XD - Experimental Development Station:	An experimental station used for evaluation or testing of electronics equipment or systems in a design or development stage.	Navy Army Non-Government	10 1 1
XE - Experimental Export Station:	An experimental station intended for export and used for the evaluation or testing of electronics equipment or systems in a design or development stage.	Non-Government	1
XR - Experimental Research Station:	An experimental station used in basic studies concerning scientific investigation looking toward the improvement of the art of radiocommunications.	Army Non-Government NS	1 1 1
XT - Experimental Testing Station:	An experimental station used for the evaluation or testing of electronics equipment or systems, including site selection and transmission path surveys, which have been developed for operational use.	Air Force Army Navy	8 12 5
		TOTAL ASSIGNMENTS:	104

TABLE 16

RANGE TUNED ASSIGNMENTS

Air Force	LR	2
	XC	3
	XM	1
	XT	2
Army	LR	1
	XC	1
	MR	9
	XD	2
	XT	4
Navy	LR	1
	MR	3
	RL	8
Non-Government	XC	1
	XR	5
		43

There are presently 13 systems in the NTIA Systems Review File that are in various stages of development. Included in these systems are the following: (6 classified systems not shown)

STAGE OF DEVELOPMENT*	SYSTEM
8	AN/FPS-108 (RADAR)
9	SEEK FROST RADAR
3	NUCLEAR DETONATION DETECTION SYSTEM
3	E-3A DISPLAY REMOTING CAPABILITY
3	MODIFIED VEGA 316L TRANSPONDER SYSTEM
4	NUDET EARTH STATIONS
3	TRANSPONDER POSITION LOCATION SYSTEM

*Stage 1 Conceptual
2 Experimental
3 Development
4 Operational
8 System was not reviewed
9 System is no longer functioning

The transmitting and receiving systems in the 1350-1400 MHz band are geographically located as shown on the map of Figure 10. This map does not include the 43 range tuned systems from lower bands that can tune into the 1350-1400 MHz band. There are 25 stations with no assignments in this band. There may be a possibility of Fixed and Mobile Services on a secondary basis for those areas far removed from the high power radars in the band. Some of the radars are mobile and in case of national emergency or wartime basis the radars could be moved anywhere in CONUS, which means any other uses of the band would have to be secondary. There are only 17 assignments designated as fixed stations or experimental fixed and only 2 mobile.

Table 17 shows the nomenclatures and types of major equipment used in the band. As would be expected since the primary allocation is to radiolocation the, major equipment are radars. There are eight classified systems not listed.

The U.S. military services use the 1350-1400 MHz band for radio communications using multichannel, land-based, transportable and mobile equipment. The transmitter power for such equipment is approximately 15 to 30 watts and the antenna gains are typically from 10-20 dBi. The nomenclatures for the military communication systems with assignments in the band are the AN/GRC-50 and the AN/GRC-103. The assignments for these systems are on a secondary basis and, if necessary, these systems are capable of tuning to frequencies outside the 1350-1400 MHz band. The AN/GRC-103

TABLE 17

NOMENCLATURE AND EQUIPMENT TYPE, OF MAJOR UNCLASSIFIED SYSTEMS OPERATING IN THE 1350-1400 MHz BAND

NOMENCLATURE	SYSTEM TYPE
AN/FPS-19	AERONAUTICAL RADIONAVIGATION RADAR
AN/FPS-20	RADAR
AN/FPS-108	RADAR
AN/FPS-117	RADAR
AN/GRC-50	RADIO COMMUNICATION LINK
AN/GRC-103	MOBILE TACTICAL RADIO RELAY EQUIPMENT
AN/MPQ-50	MOBILE RADAR
AN/TPS-63	GROUND TRANSPORTABLE SEARCH RADAR
AN/UPS-1	GENERAL USE SEARCH RADAR
LSPL	RADAR
RAT SCAT	RADAR
RAY LCAR	RADAR TEST FACILITY
REI L3T	GROUND TEST EQUIPMENT FOR NUDET SYS LINK
VEGA 371L,372L	TRANSPONDER

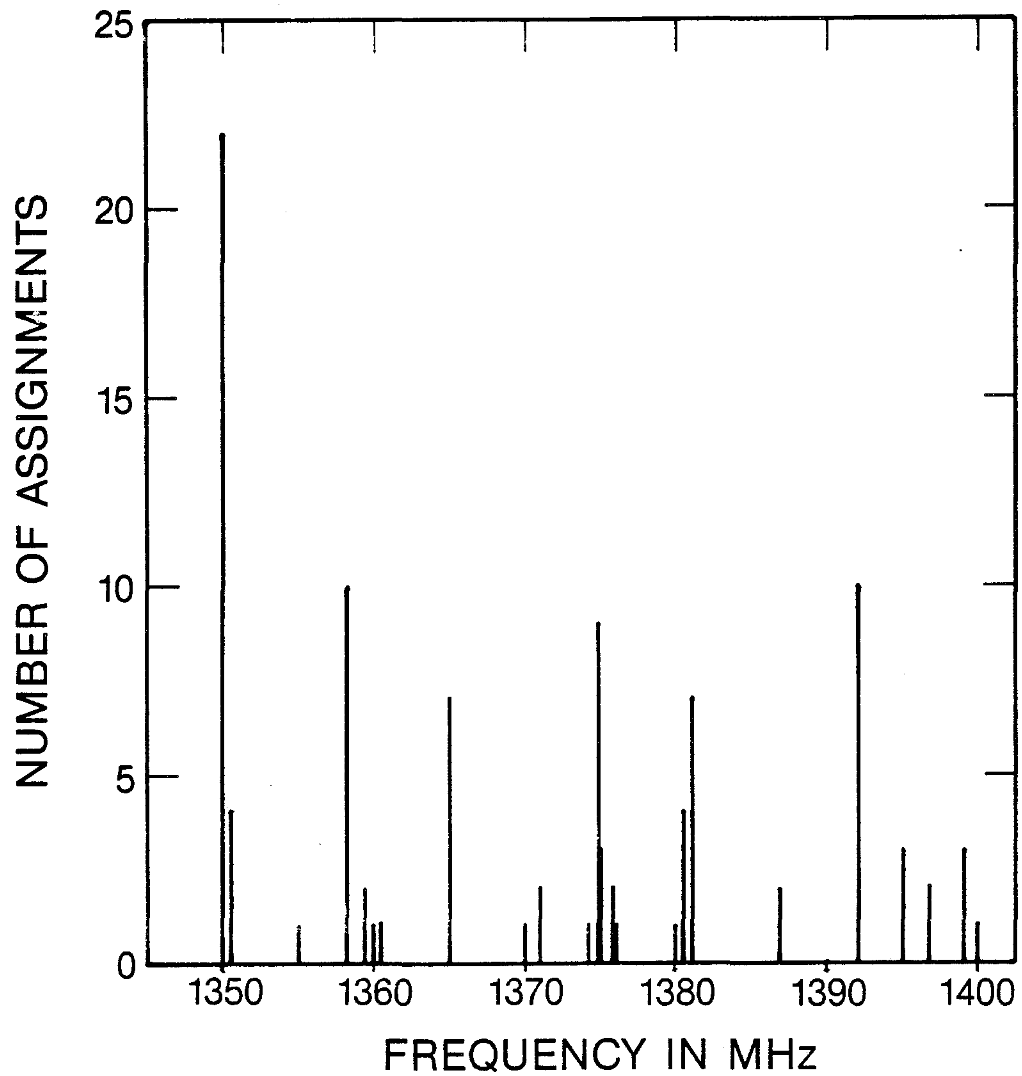


Figure 8. Frequency Assignment Distribution for the 1350-1400 MHz Band.

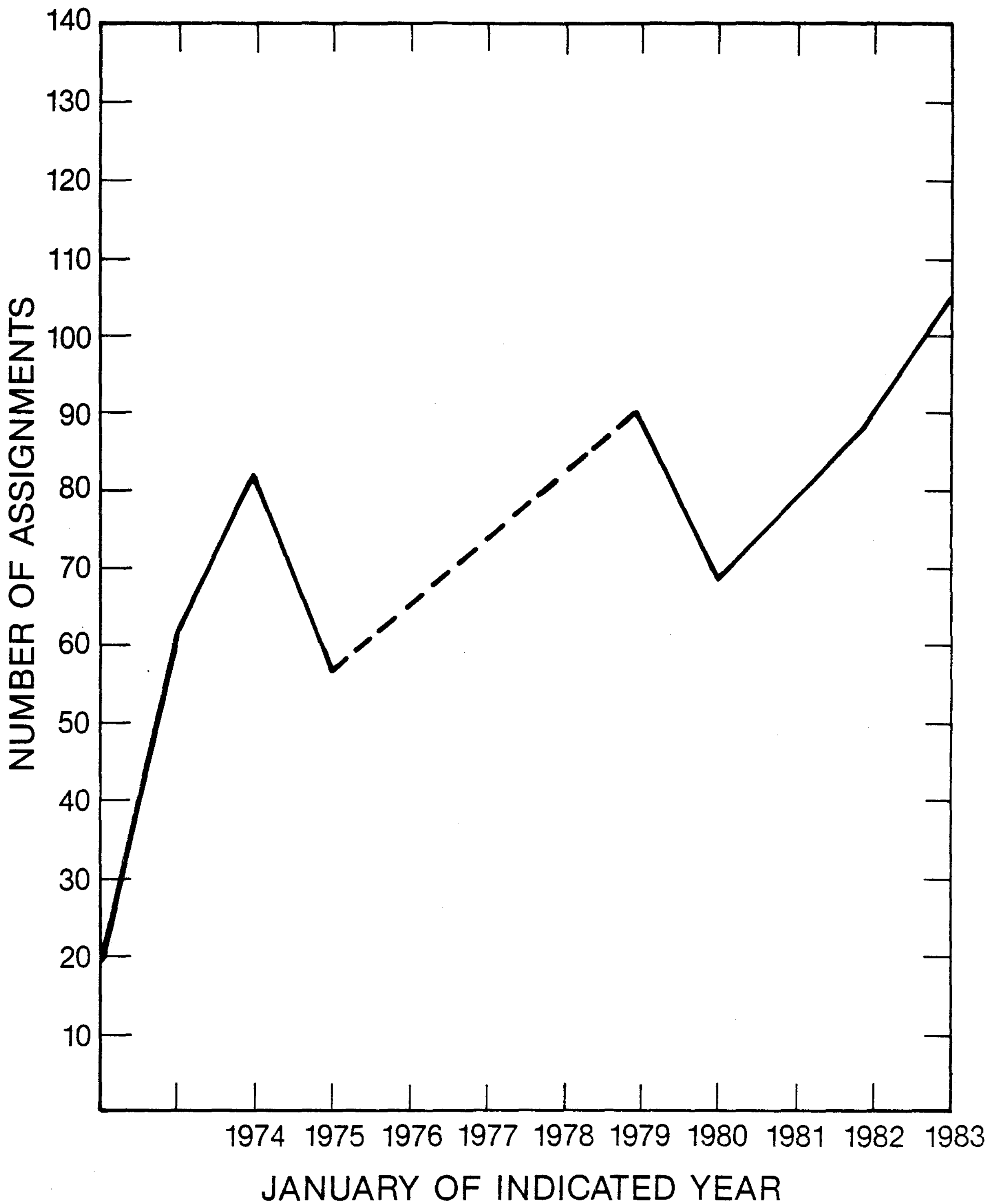


Figure 9. Growth Trend for the 1350-1400 MHz Band.

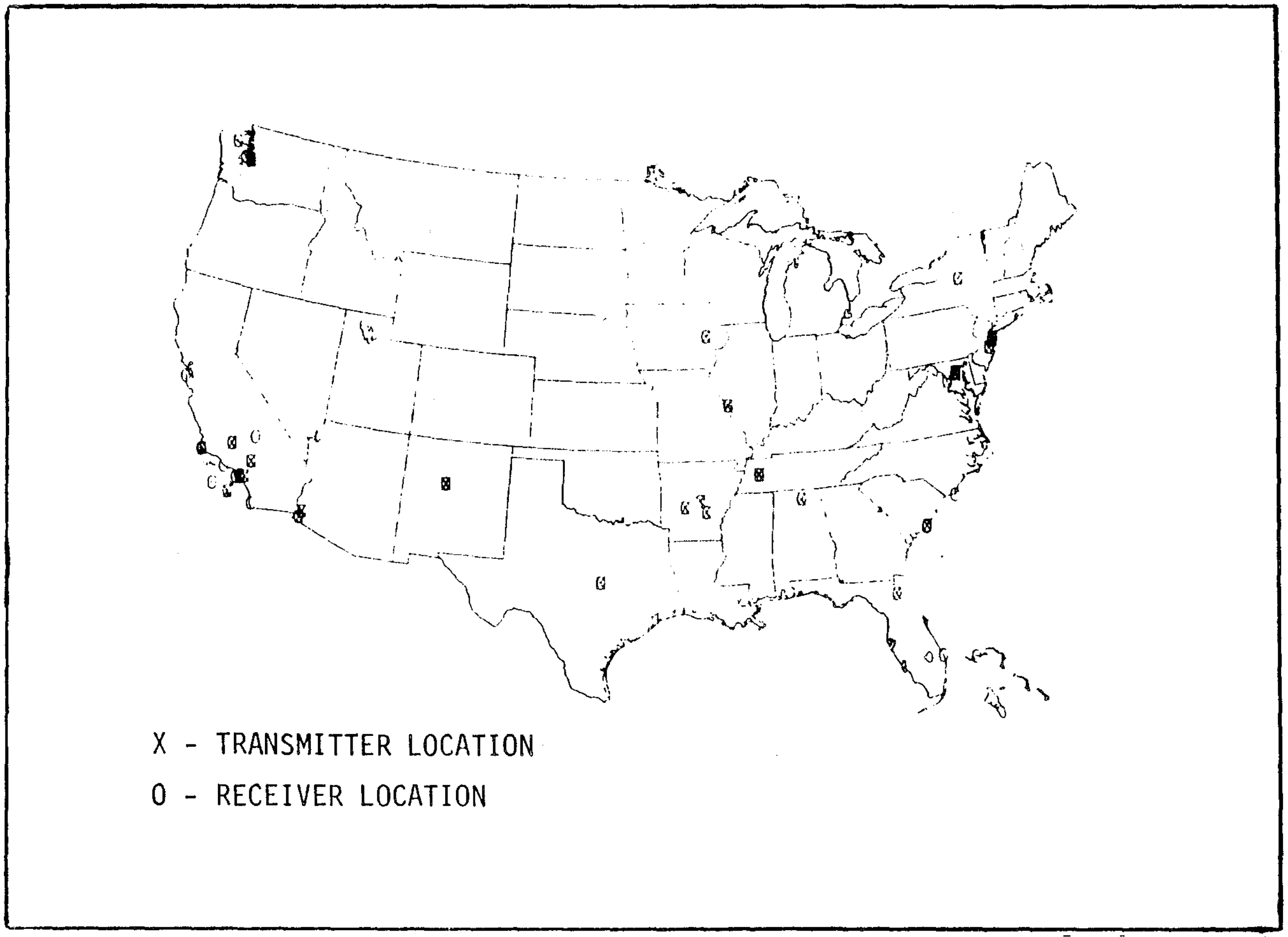


Figure 10. Transmitter and Receiver Locations for the 1350-1400 MHz Band.

for example can tune from 220 to 1850 MHz in 5 different bands. The frequency 1381.05 MHz with emission limited to ± 12 MHz is also allocated to Fixed and Mobile Satellite Service (space-to-Earth) for the relay of nuclear burst data. The major systems in the band are radars and Table 18 gives some basic characteristics of typical radars in the band. There are also some basic characteristics of the AN/GRC-50 and AN/GRC-103 given in this table.

CONCLUSIONS

Since Fixed and Mobile Services are of primary concern in this investigation, it is concluded after researching the use of the 1350-1400 MHz band that this is not a band where these services could be accommodated much above present use. The high power (> 1 MW) radars in the band are important to the national defense and should remain the primary service. There are 25 states which do not have present assignments in the band which could support a limited Fixed and Mobile Service on a secondary basis.

TABLE 18.

CHARACTERISTICS OF SOME TYPICAL SYSTEMS IN THE 1350-1400 MHz BAND

Nomenclature	ANTENNA Type	ANTENNA Gain	Function	Peak Power (kw)	Pulse Width μs/PRF	Sensitivity (dBm)	Emission Bandwidth (MHz)
AN/FPS-19	Parab.	36 dBi	Search Radar	170	6/400		
AN/FPS-20	Parab.	35	Search Radar	2000	6/360	-114	.15 (- 3) .14 (-60)
AN/FPS-108	Phased Array	47.9	Search Radar	16,800	1000/30	- 99	200 (- 3) 340 (-60)
AN/TPS-63	Parab.	33	Search Radar	100	39/773		
AN/UPS-1	Parab.	27	Search Radar	1400	1.4/800 4.2/367	-105	.45(- 3) or 1.5 (- 3)
AN/GRC-50	Dipole	17	Radio Communications	.03		-100	.6 (- 3)
AN/GRC-103	Corner Reflector or Parab.	11-14 19	Tactical Radio Relay	.02-.03 .015		-100	

THE 1710 - 1850 MHz BAND

INTRODUCTION

The 1710-1850 MHz band is a Government exclusive band. There has been a comprehensive study accomplished in this band and published in two reports (Hurt and Crandall, 1979 and Hurt and Crandall, 1980). Excerpts from these two reports will be used extensively in the following summary of band usage. There are 2437 assignments in the band according to the November 1983 GMF with the major use by the Fixed Services which has 1,879 assignments (80%). There are 41 systems listed for the band in the systems review file. This is one of the heaviest used bands in the Government for Fixed and Mobile use in the 947 MHz to 17.7 GHz portion of the radio frequency spectrum.

RULES AND REGULATIONS

Nationally, the 1710-1850 MHz band is allocated to Government Fixed and Mobile Services on a shared primary basis. Table 19 is an excerpt from the U.S. Table of Frequency Allocations (NTIA, 1983) for the 1710-1850 MHz and adjacent bands along with footnotes applicable to the U.S. Footnote G42 allocates the 1761-1842 MHZ portion of the band for Earth-to-space satellite control systems on a coequal basis with Fixed and Mobile Services. In Chapter 4 of the NTIA Manual there is also a frequency allotment to this band as follows:

> 4.2.2 <u>Allotments in the Band 1710-1850 MHz for Fixed Security Surveillance Systems</u>
>
> The frequencies 1720, 1740, 1760, 1780, and 1800 MHz are allotted for use in fixed security surveillance systems, on a secondary basis to other stations operating in accordance with the Government Table of Frequency Allocations.

Paragraph 8.2.25 of the NTIA Manual limits the use of frequency diversity for line-of-sight fixed systems in the 1710-1850 MHz band. To employ frequency diversity for a new system, justification is required to show the necessity for the high reliability as well as an engineering evaluation to show that the diversity will provide the required reliability. Paragraph 8.4.12 of the NTIA Manual establishes the coordination criteria for Earth-station frequency assignments. The coordination criteria are to assure that terrestrial stations within the coordination area will not receive interference. The coordination area for an Earth station is calculated in accordance with Appendix 28 of the ITU Radio Regulations.

The band 1718.8 -1727.2 MHz is used by the Radio Astronomy Service in certain geographical areas specified in U.S. Footnote 256.

TABLE 19

EXCERPTS FROM THE INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS
FOR THE 1710-1850 MHz BAND

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
1700-1710 FIXED METEOROLOGICAL- SATELLITE (Space-to-Earth) Mobile except aeronautical mobile 671 722	1700-1710 FIXED METEOROLOGICAL-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile 671 722 743		1700-1710	671 722	FIXED METEOROLOGICAL- SATELLITE (Space-to-Earth) G118	Fixed METEOROLOGICAL- SATELLITE (Space-to-Earth)
1710-2290 FIXED Mobile	1710-2290 FIXED MOBILE		1710-1850	US256 722	FIXED MOBILE G42	
			1850-1990			FIXED

722 - In the bands 1400-1727 MHz, 101-120 GHz, and 197-220 GHz, passive research is being conducted by some countries in a program for the search for international emissions of extra-terrestrial origin.

US256 - Radio astronomy observations may be made in the band 1718.8 - 1722.2 MHz on an unprotected basis. Agencies providing other services in this band in the geographic areas listed below (not listed here) should bear in mind that their operations may affect those observations, and those agencies are encouraged to minimize potential interference to the observations in so far as practicable.

G42 - Space command, control, range and range rate systems for earth station transmission only (including installations on certain Navy ships) may be accommodated on a co-equal basis with the fixed and mobile services in the band 1761-1842 MHz. Specific frequencies required to be used at any location will be satisfied on a coordinated case-by-case basis.

SPECTRUM USAGE AND MAJOR SYSTEMS

SPECTRUM USAGE

Table 20 shows the assignments (June 1983) in the 1710-1850 MHz band by agency and station class. There are 2437 assignments in the 140 MHz between 1710-1850 MHz. The fixed assignments make up approximately 80% of the total assignments in the band. The Department of Agriculture (DOA) has the largest number of assignments with 606 used mainly in the protection and management of the many national forests of the country. Figure 11 shows the geographic distribution of assignments in the band. There are many areas of the United States where the frequency assignments in the band show an apparent congested condition. It is interesting to compare the geographic distribution map of Figure 12 which is an excerpt from the 1980 Phase II report on the 1710-1850 MHz band with the present map of Figure 12. The growth of assignments in the band and the increase in congested areas is apparent.

Figure 13 shows the growth trend between 1972 and 1983 (no data between 1975 and 1979). From January of 1979 to January of 1983 there was a 94% growth in band assignments. This is statistically one of the fastest growth bands in the 947 MHz - 17.7 GHz study. Figure 14 shows the number of assignments plotted in 2 MHz segments across the 1710-1850 MHz band.

From the results of the Phase I assessment of the 1710-1850 MHz band (Hurt and Crandall 1979) there are four general areas where more detailed study was deemed necessary. These studies were carried out in the Phase II report (Hurt and Crandall, 1980) the results of which are too voluminous to reprint here. The four areas of detailed study were as follows:

1. Sharing between Fixed and Aeronautical Mobile Services.
2. Coordination of Earth stations.
3. Accommodation of the Packet Radio System.
4. Examination of congested geographic areas.

TABLE 20

GOVERNMENT AND NON-GOVERNMENT ASSIGNMENT IN THE 1710-1850 MHz GOVERNMENT EXCLUSIVE BAND BY AGENCY AND STATION CLASS

	FA	FL	FLD	FLEA	FLEB	FLEC	FX	FXE	MA	MAD	ML	MO	MOD	MOEA	MOEB	TD/TR	XC	XD	XM	XR	XT
Agriculture							606														
Air Force	8	2			7	7	94	14	10	10				10	7	158	21	1	3		67
Army			2				311		4		15		2	4							25
Energy							269	9	1				1								
Navy				16			94		36			1		26	18						49
Interior							166	2													
Coast Guard							86														
TVA							80														
FAA							48														
NASA			1				9							1	6					2	11
Transportation						1	28														
Justice							18														
FEMA							17														
Treasury							16														
GSA							14														
NG							9														
Commerce							6														
HHS							6														
NS							2														
TOTAL	8	2	3	16	7	8	1879	25	51	10	15	1	3	41	31	158	21	1	3	2	152

1710 - 1850 MHz

Table 20 (Continued)

FA - Aeronautical Station: A land station in the Aeronautical Mobile Service. In certain instances, an aeronautical station may be located, for example, on board a ship or on a platform at sea.

FL - Land Station: A station in the Mobile Service not intended to be used while in motion.

FLD - Telecommand Land Station: A Land Station, the emissions of which are used for terrestrial telecommand.

FLEA - Aeronautical Telemetering Land Station: A telemetering land station used in the flight testing of manned or unmanned aircraft, missiles, or major components thereof.

FLEB - Flight Telemetering Land Station: A telemetering land station. The emissions of which are used for telemetering to a balloon; to a booster or rocket, excluding a booster or rocket in orbit about the Earth or in deep space; or to an aircraft, excluding a station used in the flight testing of an aircraft.

FLEC - Surface Telemetering Land Station: A telemetering land station, the omissions of which are intended to be received on the surface of the Earth.

FX - Fixed Station: A station in the Fixed Service.

FXE - Telemetering Fixed Station: A fixed station, the emissions of which are used for telemetering.

MA - Aircraft Station: A mobile station in the Aeronautical Mobile Service other than a survival craft station, located on board an aircraft.

ML - Land Mobile Station: A mobile station in the Land Mobile Service capable of surface movement within the geographical limits of a country or continent.

MO - Mobile Station: A station in the Mobile Service intended to be used while in motion or during halts at unspecified points.

MOD - Telecommand Mobile Station: A mobile station, the emissions of which are used for terrestrial telecommand.

MOEA - Aeronautical Telemetering Mobile Station: A telemetering mobile station used in the flight testing of manner or unmanned aircraft, missiles, or major components thereof.

MOEB - Flight Telemetering Mobile Station: A telemetering mobile station the emissions of which are used for telemetering from a balloon; from a booster or rocket, excluding a booster or rocket in orbit about the Earth or in deep space; or from an aircraft, excluding a station used in the flight testing of an aircraft.

TD - Space Telecommand Earth Station: An Earth station, the emissions of which are used for space telecommand.

XC - Experimental Contract Developmental Station: An experimental station used for the evaluation or testing under Government contract of electronics equipment or systems in a design or development stage.

XD - Experimental Development Station: An experimental station used for evaluation or testing of electronics equipment or systems in a design or development stage.

XM - Experimental Composite Station: An experimental station used in experimental operations of a complex nature not readily specified or used in an operation which is a composite of two or more of the established experimental categories.

XR - Experimental Research Station: An experimental station used in basic studies concerning scientific investigation looking toward the improvement of the art of radiocommunications.

XT - Experimental Testing Station: An experimental station used for the evaluation or testing of electronics equipment or systems, including site selection and transmission path surveys, which have been developed for operational use.

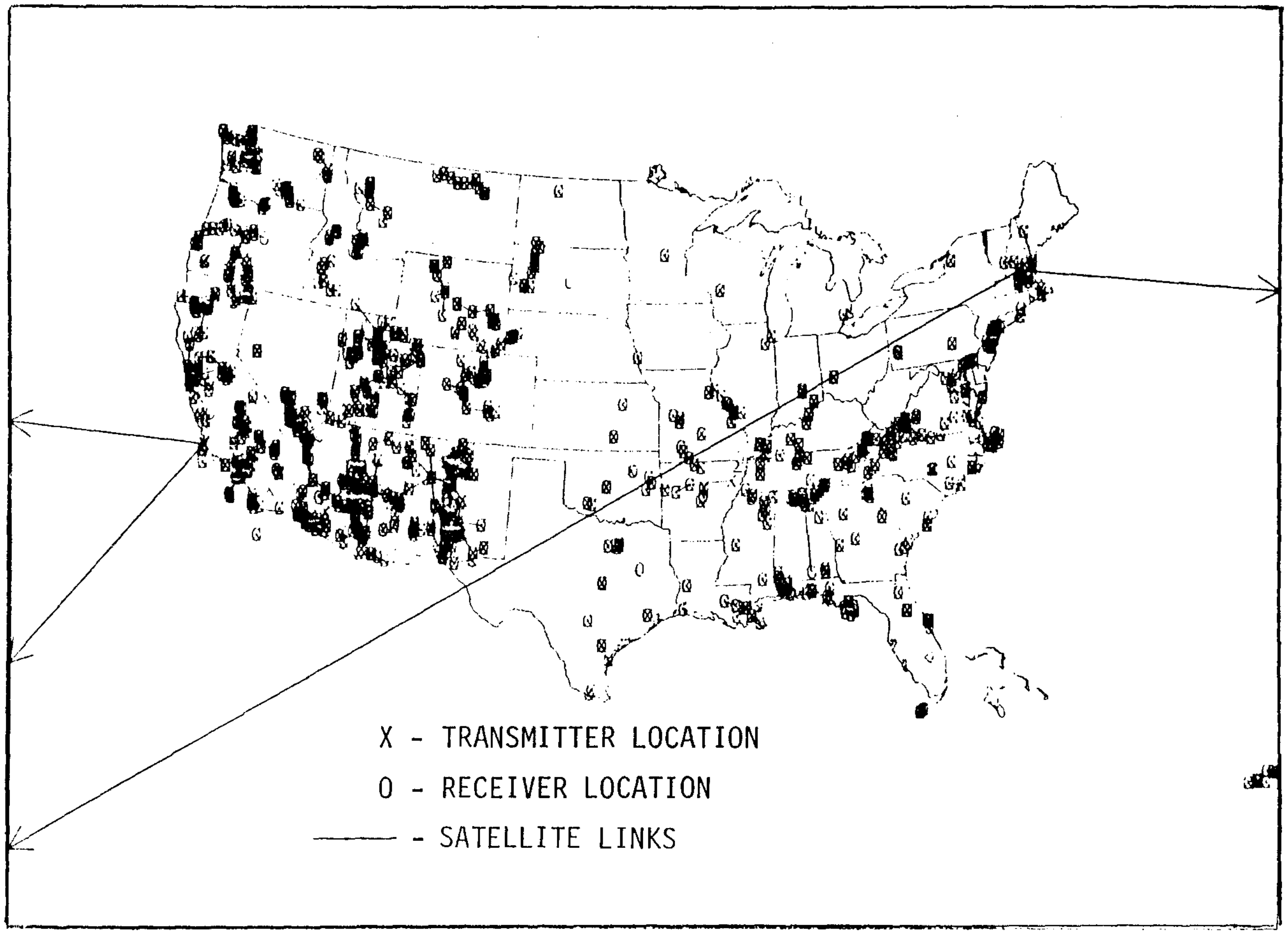


Figure 11. Geographic Distribution of Government Assignments in the 1710-1850 MHz Band, 1983.

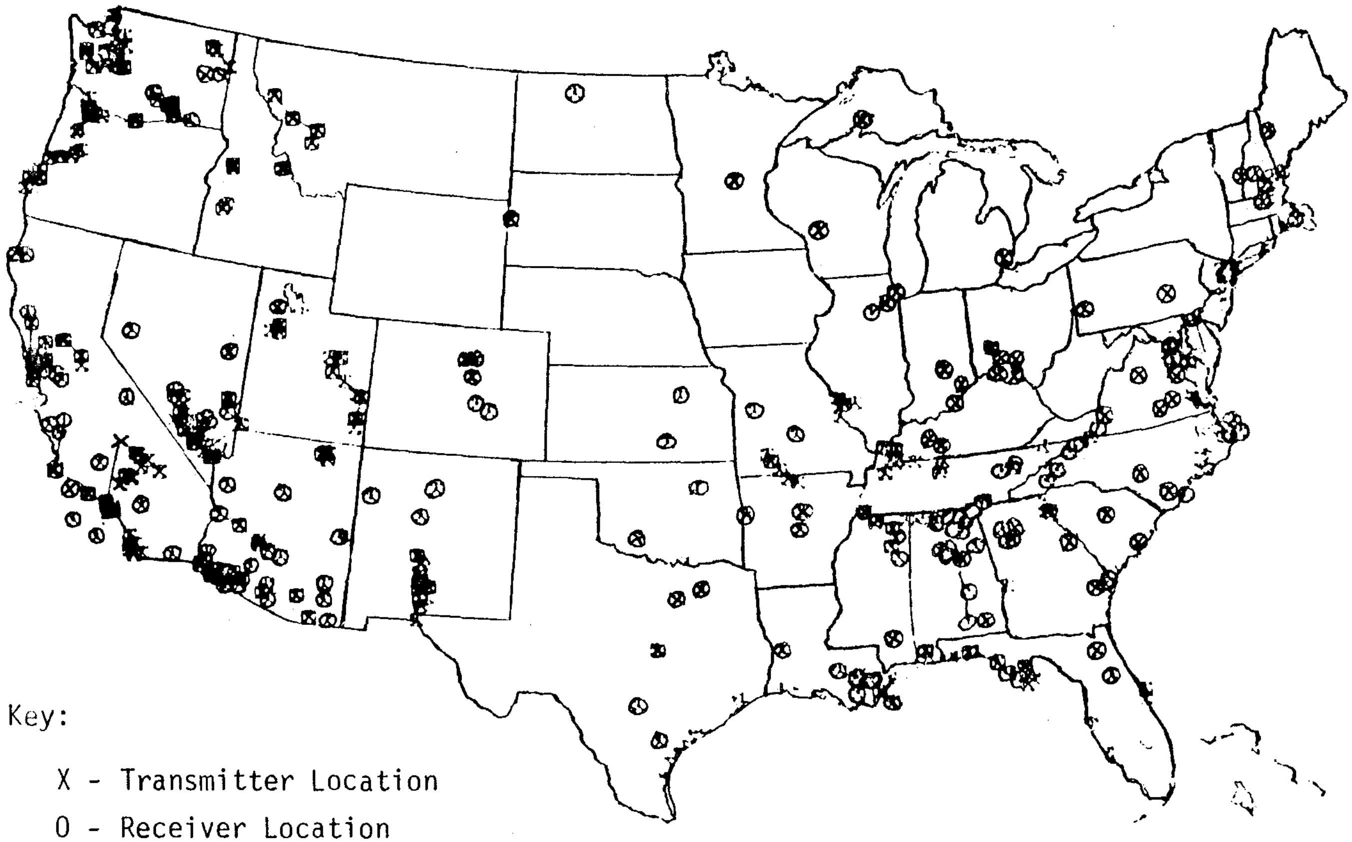


Figure 12. Geographic Distribution of Assignments in the 1710-1850 MHz Band, 1980.

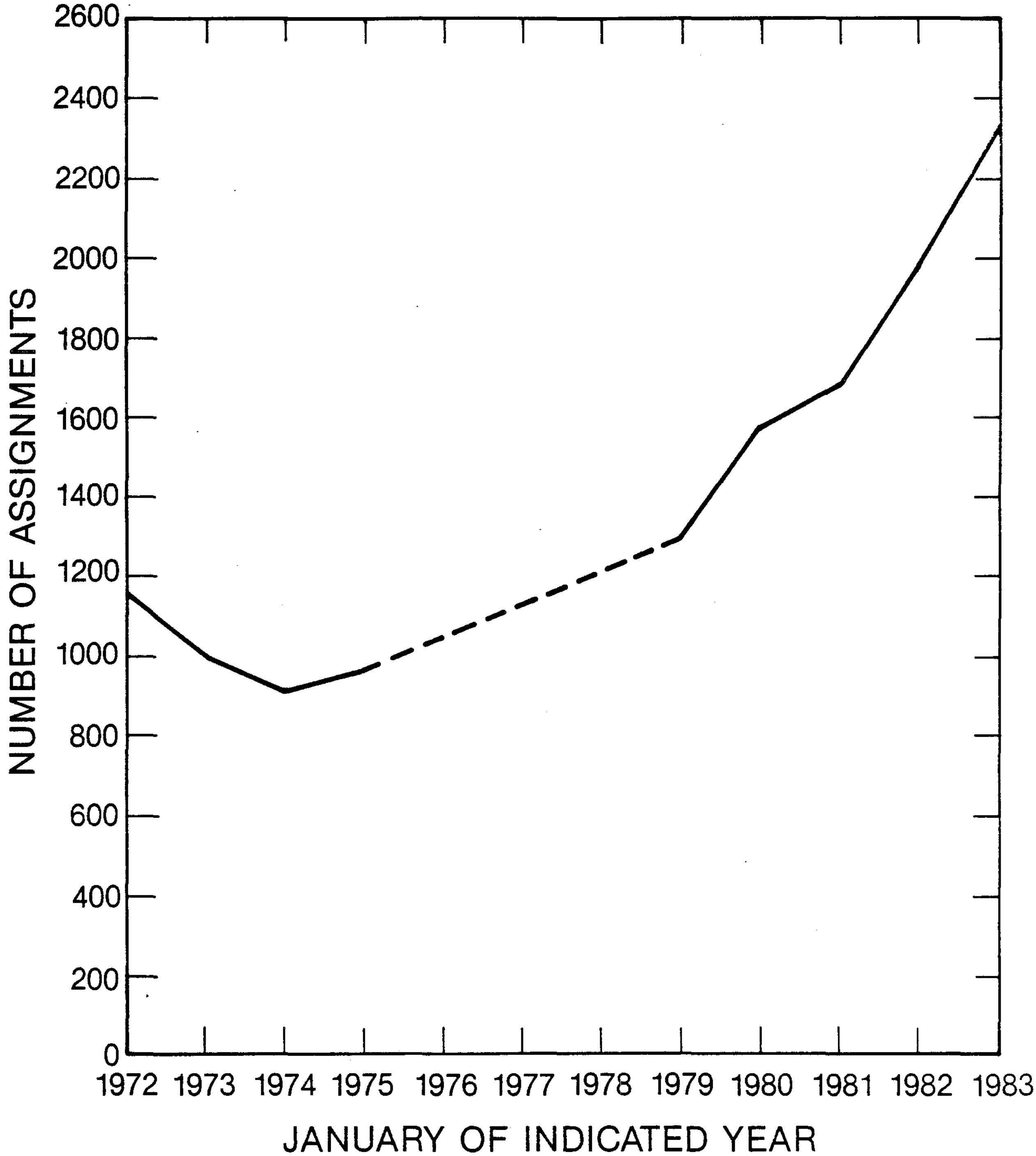


Figure 13. Growth Trend for the 1710-1850 MHz Band Between 1972 and 1983.

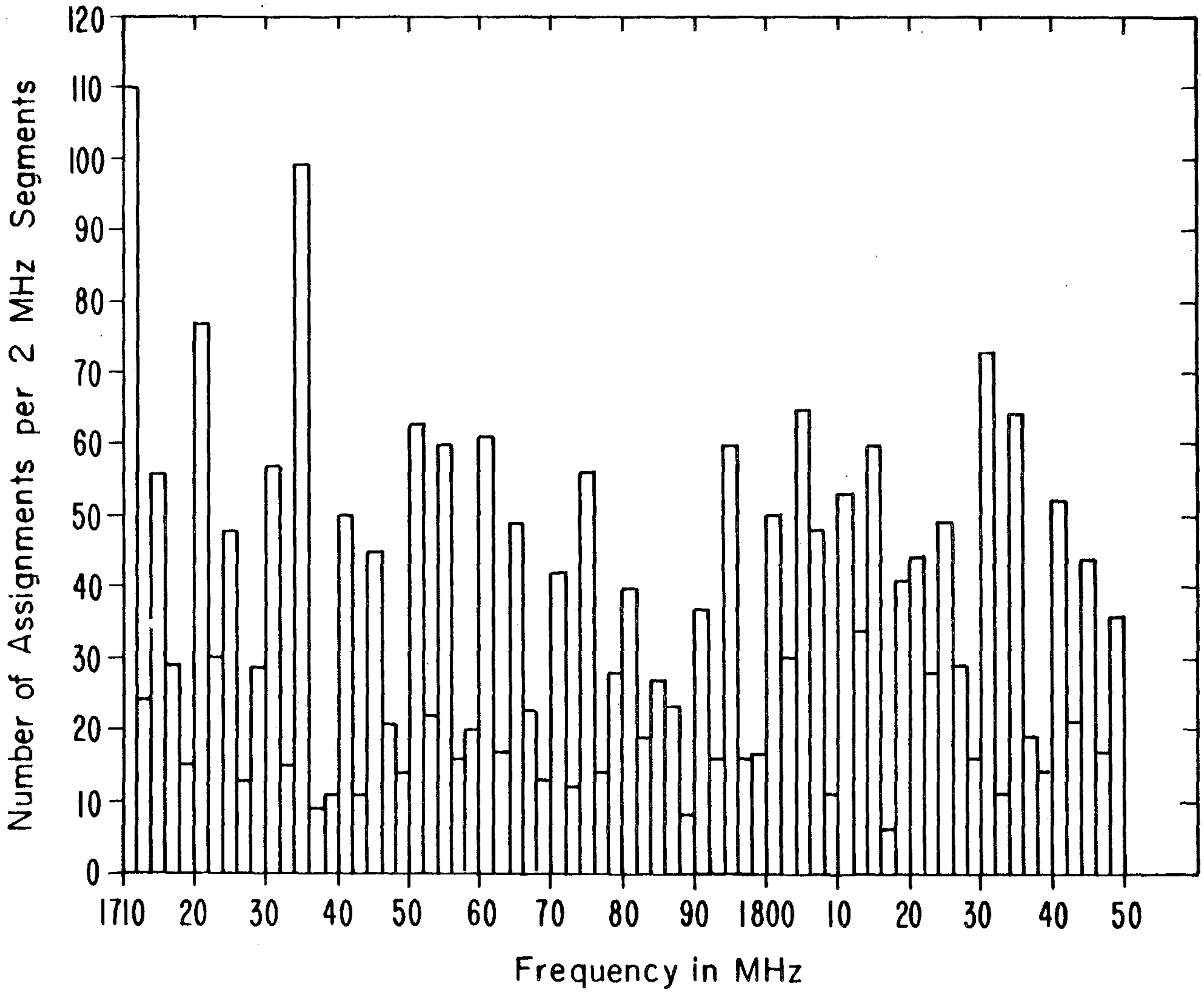


Figure 14. Frequency Assignment Distribution for the 1710-1850 MHz Band

MAJOR SYSTEMS

Tables 21 and 22 summarize the major systems operating in the band along with typical parameters. A pictorial representation of these systems is given in Figure 15. A short synopsis is given below of the major systems in the band which are important from a spectrum management standpoint.

Space Systems. The major space system in the band is the Air Force Space Ground Link Subsystem. Its function is to provide tracking, telemetry, and control for Department of Defense orbiting satellites. Both geostationary and nongeostationary satellites are serviced from four Satellite Control Facility ground stations located in Guam, Hawaii, New Hampshire, and California. The rf links in this band are up-paths in the band 1761-1842. The down-paths are in the 2200-2900 MHz band.

Fixed (line-of-sight). The dominant fixed systems in the band are for medium capacity FDM/FM point-to-point communications. Channel capacities typically vary from 24 to 600 channel with bandwidths from 0.5 to 10 MHz. Applications include law-enforcement networks, backbone trunking systems, and control links for various power, land, water, and energy management systems. Commercial off-the-shelf equipment is normally used. Other specialized fixed links include video/data relay and timing distribution signals.

Land Mobile. The Department of Defense Advanced Research Projects Agency (ARPA) has developed several packet radio systems to test the feasibility of new techniques and concepts for a network of fixed and mobile digital data terminals. The concept extends the ARPANET packet switching technology to radio communications. Both 20 MHz and 140 MHz spread spectrum bandwidth versions have been built for experimentation.

Aeronautical Mobile. A number of air-to-ground links are used in this band for video communications. These are primarily used to provide real-time television displays from airborne cameras for ground reception. Functions include testing of remotely piloted vehicles and drones, flight testing of new aircraft, and airborne monitoring of civil disturbances. More limited aeronautical mobile functions include air-to-ground data relay, telemetry, and telecommand.

Figure 16 shows the tuning range capabilities of the major systems in the band. Since many of the systems can tune either across the whole band or large portions of it coupled with the growth rate of assignments and geographic distribution, a potential for conflicts among these systems is becoming greater each year.

TABLE 21

SUMMARY OF MAJOR SYSTEMS IN THE 1710-1850 MHz BAND

1. SPACE SYSTEMS
   a. Space Ground Link Subsystems (SGLS)
   b. Space Shuttle
   c. Other Satellite Links

2. FIXED
   a. Line-of-Sight, Point-to-Point
      (1) Vessel Traffic System
      (2) Corps of Engr. District Comm.
      (3) Tennessee Valley Auth.
      (4) Bonneville Power Admin.
      (5) U.S. Park Service
      (6) Bureau of Land Management
      (7) Dept. of Energy Nevada Test Site
      (8) Test Ranging Timing Distribution Systems
      (9) Numerous Others
   b. Transhorizon
   c. Tactical and Training Radio Relay
   d. Air Combat Maneuvering Systems

3. RADIOLOCATION
   a. Scoring Systems
      (1) AN/DKT-30
      (2) AN/DRQ-4
      (3) AN/DSQ-007
      (4) AN/DSQ-24
      (5) AN/DSQ-37
      (6) AN/DSQ-40
      (7) AN/USQ-35
      (8) Others
   b. Distance Measuring Equipment
   c. Security Systems

4. LAND MOBILE
   a. ARPA Packet Radio

5. AERONAUTICAL MOBILE
   a. Tactical Weapon Systems
   b. SEEK SKYHOOK
   c. Air-Ground Video Links
   d. Air Combat Maneuvering Systems

6. RADIO ASTRONOMY

7. EXPERIMENTAL
   a. Design or Development of New Systems
   b. Basic Research
   c. Testing of Operational Systems

8. UPPER ADJACENT BAND
   a. Non-Government Fixed

9. LOWER ADJACENT BAND
   a. Meteorological Satellite

TABLE 22

SUMMARY OF KEY SYSTEM PARAMETERS IN THE 1710-1850 MHz BAND

System	Agen.	Frequency (MHz)	Environment	PWR (Watts)	G_T (dBi)	G_R (dBi)	Emission
SGLS	AF	1761-1842	NH, CA, HA, GUM Space	10K	43	3	M5F9
Space Shuttle	NASA AF	1761-1842	Space → Space				M5F9
Fixed, L-O-S	A	1710-1850	US & P	1-40	24-33	24-33	800F9 - M8F9
Tactical & Training	Army	1350-1850	Army Bases & Nat'l Guard Units	20-120	19	19	M1.2F9
AMCI/ACMR	AF Navy	1779-1840	AF & Navy Air Bases & at Sea	1-20	0-26	0-26	600F9, M3F9
MDI Scoring Systems	Navy	1710-1850	CA	1-5	--	--	M1F9, M2F3
VMDI Scoring System	AF	1750-1850	Gulf of Mexico & WSMR	40-225	3	3	M115P0, M20P0
BHI Scoring System	AF	1750 or 1775	Gulf of Mexico & WSMR	1-5	0-4	0-4	M350P9
DME	DOE	1710,1721,1742		50	--	--	M1
Security Systems	AF	1720,1740,1760	AZ,AR,KS	2	12	--	1F0
ARPA Packet Radio	Navy	1710-1850	San Francisco, CA	10	--	--	M15.36F9 - M140F9
SEEK SKYHOOK	AF	1755,1820	Florida Keys	2	7	20	M60F9
Air/Grd Video Links	AF Navy	1710-1850	US & P (Mostly Test Ranges)	2-20	3	30	M16F9
Radio Astronomy	NSF	1718-1722	Radio Astronomy Fac., US&P	--	--	--	--
Experimental	A	1710-1850	US & P	--	--	--	--
METSAT	C	1695-1710	Space → VA, AK & Worldwide	5	4	47	M3F9
Non-Gov't Fixed	FCC	1850-1990	US & P	2-5	24-33	24-33	800F9 - M8F9

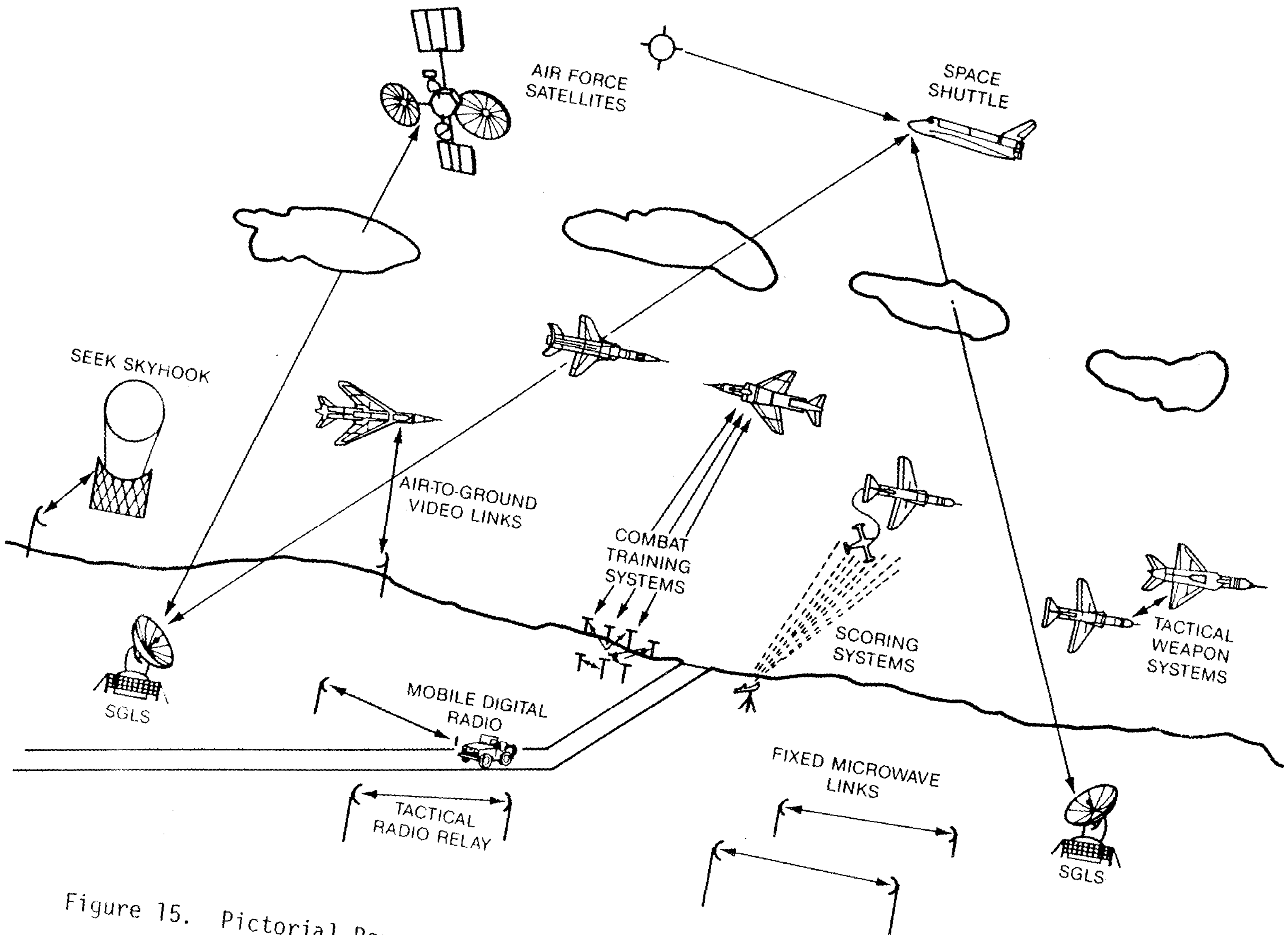


Figure 15. Pictorial Representation of Major Systems in the 1710-1850 MHz Band.

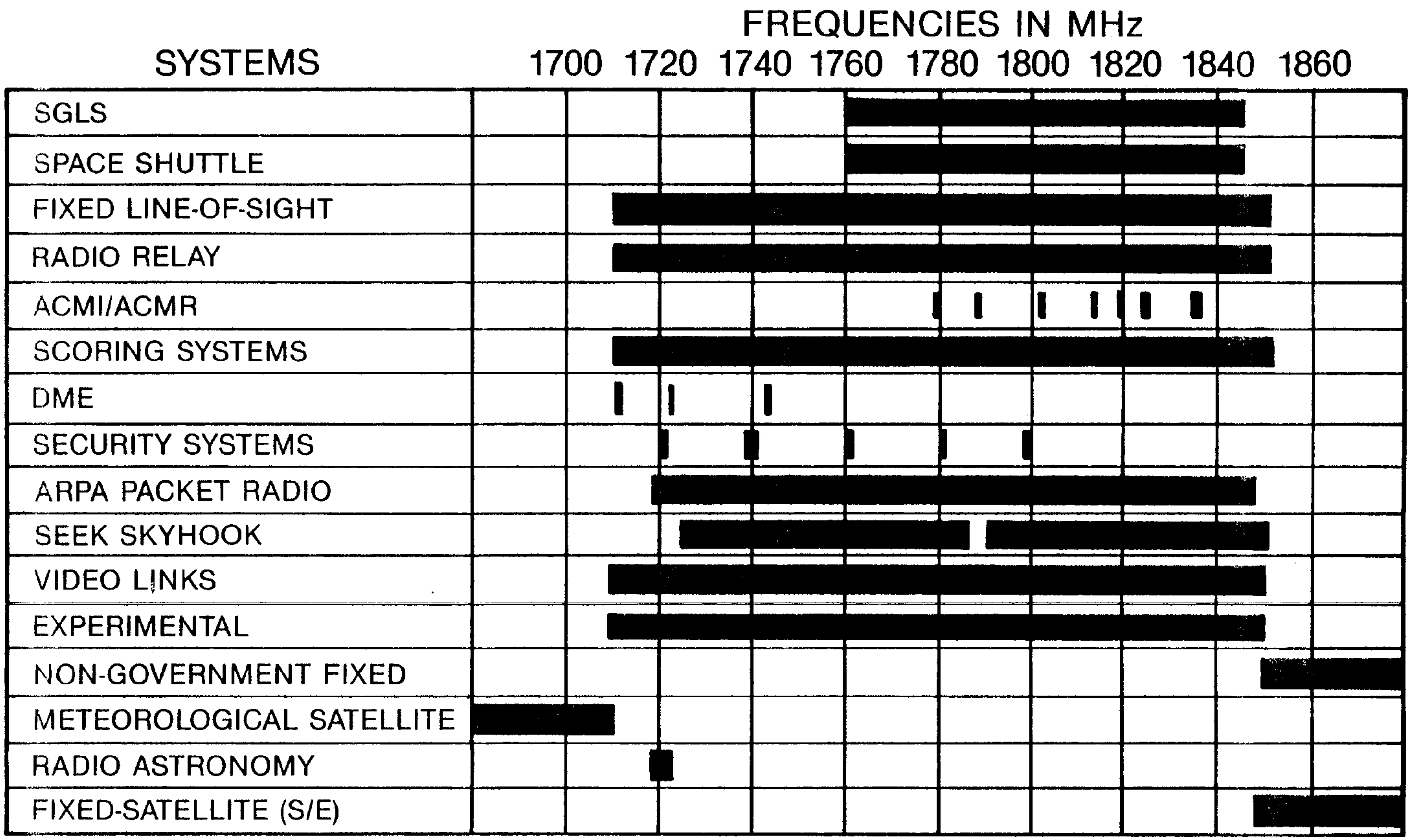


Figure 16. Tuning Range Capabilities of Major Systems (1710-1850 MHz).

The systems listed in Table 23 are sponsored by 9 different Federal agencies with Air Force sponsoring the most with 18. These systems are representative of both the variety of uses in the 1710-1850 MHz band and the potential growth of the band.

TABLE 23

SYSTEMS IN THE SYSTEMS REVIEW FILE FOR THE 1710 - 1850 MHz BAND AS OF 6/83

SYSTEMS	NUMBER
RPV Systems	3
Guided Weapon Systems	1
Tethered Balloon Systems	2
Upgraded Packet Radio	1
AN/AXQ-14	1
Transportable/Mobile Ground Stations	1
CCD Seeker Systems	1
Air Combat Maneuvering Range	1
AN/GRC-103(V) Tactical Radio Relay	1
Vessel Traffic System (4 sites)	1
Bullet Hit Indicator	1
VECTOR Miss Distance Indicator	1
INS Enforcement Land Mobile Radio Sys.	1
Artillery Launched TV Target Location Systems	1
Space Systems	11
Fixed Microwave Systems	13

In the following portions of this section the spectrum planning process for this band is examined. The first discussion that follows addresses the major functions used in the band. Insight is given as to how these functions are accommodated in the band and what, if any, alternatives (e.g., other bands) are possible to satisfy those needs. Recommendations are offered in instances where improved management of the band would result. The second addresses the adoption of a channel plan for this band.

System Functions

Line-of-Sight Fixed Links. The 1710-1850 MHz band is the major Government band for accommodating medium channel capacity (or medium bandwidth) point-to-point microwave links. For multichannel telephony, typical capacity varies from 24 to 600 channel with most necessary bandwidths being in the range from 0.5 to 10 MHz. In general, microwave links with bandwidths considerably greater than 10 MHz can be better accommodated in portions of the 7.12-8.5 GHz and 14.4-15.35 GHz bands. The increased spectrum generally available in these bands is more conducive to accommodating the wider bandwidth systems.

Similarly, low capacity (or narrow bandwidth) links are often better accommodated in lower frequency bands such as 406.1-420 MHz or in the vicinity of 902-928 MHz. This follows the fact that few commercial microwave receivers in the 1710-1850 MHz band employ bandwidths commensurate with narrowband emissions less than approximately 0.5 MHz. It is recognized that the use of the lower bands is not without problems. In the 406.1-420 MHz band, the multichannel links would be competing for spectrum space with the rapidly expanding use of single channel fixed and mobile stations. In the 902-928 MHz band, the Fixed Service is currently on a secondary basis and is the subject of a separate study (Bulawka, 1980).

For the medium capacity link bandwidths, in the range of 0.5-10 MHz, few alternatives exist to the 1710-1850 MHz band. For example, the 2200-2300 MHz band is allocated to the Fixed and Mobile Service but is presently dominated by the Mobile Service. This also is the subject of a separate study (Flynn, 1980b). The 4400-4990 MHz band is also allocated to the Fixed and Mobile Service, but is not currently used to a great extent by nonmilitary Government operations (private communication).

Tropospheric Scatter. Tropospheric scatter communications is a technique that takes advantage of scattering of radio waves from irregularities and disturbances in the lower troposphere. When sufficient power, antenna gains, and receiver sensitivity are employed, the high troposcatter propagation losses can be overcome to achieve point-to-point communications for distances of 400 km or more. Thus, up to 10 line-of-sight microwave hops could be replaced by 1 tropospheric scatter link. This proves to be an advantage in certain military tactical and other situations where maintenance of intervening line-of-sight stations may be impractical. The disadvantages are the significant increase in overall system costs as well as the consumption of a large amount of spectrum space.

For line-of-sight links, potential interference paths are nearly always limited to free-space or diffraction-mode propagation mechanisms resulting in relatively short interference distances. Because of the high power and gain used for the troposcatter link, tropospheric scatter propagation can become significant for potential interference paths as well. Thus, much larger interference distances are involved. Also, troposcatter links often employ frequency diversity and high frequency deviation ratios in the modulation in order to achieve acceptable reliability further adding to spectrum consumption.

In view of the large consumption of spectrum space and high interference potential, the decision has been previously made to exclude tropospheric scatter communications from the similarly allocated 2200-2300 MHz band. This was accomplished by adding a "line-of-sight only" restriction directly into the national allocation tables. An argument could be advanced for a similar restriction in the 1710-1850 MHz band. Both the 1710-1850 MHz and 2200-2300 MHz bands are allocated to the Fixed and Mobile Service and both are used for many of the same types of functions, albeit in different distributions. Presently, there are very few tropospheric scatter links and no current plans are known for any new tropospheric scatter communications systems for this band. The adoption of a line-of-sight only restriction for this band would preclude this possibility.

Tactical Radio Relay. A number of military radio relay equipments are assigned and operated in this band for tactical and training use. While some of these links are assigned specific frequencies and locations, many are class assignments which authorize their use but provide for the selection of specific locations and frequencies by field level frequency coordinators. Most of these equipments have field tuning capabilities over the 1350-1850 MHz or 1700-2400 MHz bands. The 1710-1850 MHz band is the principal band available over these ranges that can accommodate Fixed Service operations on a primary basis. This field coordination of frequencies has apparently worked satisfactorily with few problems.

Air-to-Ground and Air-to-Air Video/Data Links. The 1710-1850 MHz band supports a number of assignments for air-to-ground or air-to-air video/data links for testing, training, and limited operational links. The test and training applications are predominately for video information used for such purposes as munitions targeting, aerial reconnaissance, and vehicle testing. Bandwidths are commonly between 10 and 20 MHz.

The SPS (private communication) has identified two frequency bands that were recommended for supporting these types of functions to be 4400-4990 MHz as well as 1710-1850 MHz. While the higher band is available and used, some penalty is paid in system performance. For example, many of these links use omnidirectional (or hemispheric coverage) antennas in the airborne components and tracking antennas on the ground on the order of 4 to 6 feet in diameter. The use of the higher frequency band introduces additional path losses that cannot be easily compensated by increased antenna gains. The latter results from the tracking requirements. Thus, increased transmitter power would be required at increased cost. Also, commonality of equipments with the associated telemetry, tracking and/or command functions, which operate in the 1400-2300 MHz range, is often desirable. This is easily achieved in the 1710-1850 MHz band but not in the 4400-4990 MHz band. In general, these types of systems operate on an intermittent basis with some uses being reported as few as several hours per week. In such cases time sharing among these systems is practical, and the same frequency may be assigned to several users in the same area. Coordination of the planned transmission periods with the local frequency coordinator can assure compatible operations. Thus, continued accommodation of this type of function appears warranted in this band.

One specific class of air-to-ground data link that becomes difficult to accommodate in the band includes systems that are very wideband and operate on a continuous or long duration basis. One example is the SEEK SKYHOOK system identified in the Phase I study (Hurt, 1979). The links in this band (two 60 MHz channels are used for relaying wide-band radar data from a tethered balloon to a ground receiver. Because of its continuous transmission and airborne operation, both time and geographic sharing with other band users becomes very limited. To assure protection from interference to other users, a distance separation of 100 to 200 miles may be required. Future systems of this type, which consume a large portion of the band and have limited sharing possibilities with other systems, should be considered for assignment in other more appropriate bands. One such possibility is 14.7144 to 15.1365 GHz.

Telemetry and Telecommand. A limited number of Aeronautical Mobile stations are assigned in this band for telemetry purposes. Such use would be permitted under the overall Mobile Service allocation for the band. Accommodation of a limited number of these systems into the band has been accomplished in the past with minimal difficulty. As the band usage continues to grow, difficulty in coordinating the use of this airborne function will likewise grow, because of larger required distance separations between airborne and land-based systems. These large required distances follow from the resulting altitude dependent line-of-sight ranges of typically 100 to 200 miles.

It is observed that alternative bands are available for use which have been specifically designated for flight testing and aeronautical telemetry, namely 1435-1535 MHz and 2200-2290 MHz. In a separate study [Flynn, 1980], the 2200-2290 MHz band is examined and the telemetry usage is discussed along with the extensive coordination procedures presently employed in that band to assure compatible operation. Using real-time regional frequency management, with time sharing used as required, spectrum efficiency is optimized for these intermittent operations. Similar time sharing among intermittent telemetry functions is also accomplished in the 1435-1535 MHz band in accordance with procedures given in Annex D of the NTIA Manual. With the adoption of the 2310-2390 MHz band for telemetry functions, as a result of WARC-79 action, additional spectrum is available to support these needs. The latter band is expected to be implemented in the United States flight testing telemetry.

In the 1710-1850 MHz band, extensive real-time coordination of these intermittent operations is not currently practiced nor planned. While time sharing among these intermittent airborne operations can result in relatively efficient use of the spectrum, sharing between fixed and aeronautical mobile operations tend to be less efficient. This follows from the inability of continuously operating Fixed stations to time share, and the reduced possibility for geographic sharing because of large required distance separations from airborne transmissions.

In view of the growing usage in the 1710-1850 MHz band the more suitable alternative bands available for flight testing telemetry, exclusion of future flight testing telemetry operations in the 1710-1850 MHz band would appear to be a feasible and attractive policy option.

Similarly, some limited telecommand stations are assigned in the band. The SPS (private communication) has previously noted that the 1427-1435 MHz band is recommended for supporting these functions. Since telecommand is inherently a relatively narrowband function the 8 MHz available should, in general, be adequate to support this function.

One specific example is the ACMI/ACMR system used by the Air Force and Navy which was discussed in the Phase I report. This system is used to monitor aircraft engaged in simulated air combat. It is composed of multiple fixed links, an air-to ground, and a ground-to-air link. The fixed links which are nominally of 1 MHz bandwidth are appropriate for assignment in the 1710-1850 MHz band. The two airborne links serve telemetry and telecommand functions with a closed loop cw ranging function also provided. These functions could be accommodated in the 1427-1435 and 1435-1535 MHz bands for the command and telemetry respectively. The tracking function essentially rides on top of the command and telemetry signal and would not normally require a separate and distinct station class indicator. Assignment of future functions of this type in other more appropriate bands would further ease potential congestion in the 1710-1850 MHz band.

A proposed modification to the NTIA Manual to effect such a policy to exclude further telemetry and telecommand functions in this band was proposed in the NTIA Phase II report for this band.

Packet Radio Systems

Packet Radio is a system developed by the Defense Advanced Research Projects Agency (DARPA) as a test-bed for various packet switching communication studies. Packet switching is a technology that was developed for digital networks of point-to-point communication links. Common carrier telephone networks were designed for voice traffic and are not ideally suited for digital data transmission, especially computer originated. Packet switching, on the other hand, is a natural mode of communication for computers. Computer generated traffic is characterized by a very low-duty cycle in which a short burst of data is sent or received followed by a longer quiescent interval after which additional traffic will again be present. With this low-duty cycle, multiple users could time share a single communications channel efficiently. Packet Radio extends this packet switching technology to the domain of radio communications. Packet Radio employs a communications architecture whereby a number of geographically distributed users can communicate among themselves by packets of digital information. The basic structure consists of randomly distributed mobile user terminals and one or more central stations (usually fixed). The functions of a central station are associated with management of the radio net. The central station determines the route to each of the radios in the net and plays an active role in initializing, organizing, and maintaining the operational network. Using a common wide-band channel and spread spectrum multiple access techniques, the system attempts to demonstrate an overall increase in spectrum efficiency as well as end-to-end survivability of information. The Packet Radio concept and its capabilities are still primarily in the research stage, but significant progress has already been achieved in the development of three systems: the Experimental Packet Radio (EPR), the Improved Packet Radio (IPR), and the Upgraded Packet Radio (UPR).

The Packet Radio technology is undergoing continuing research and development. This technology and the capability inherent to packet switching provides for many of the future tactical needs of the military. Secure and reliable voice and digital communications and survivability due to packet switching are two important capabilities of the Packet Radio. Some examples of future applications are found in numerous publications. Of particular interest is the potential checkerboard deployment described in an article in Aviation Week and Space Technology [Klass, 1979] and the potential airborne deployment described in this and other articles [Fossum and Cerf, 1979]. The checkerboard deployment of the Packet Radio would involve the installation of 5,000 to 10,000 small Packet Radio repeater stations throughout the continental U.S., spaced within line-of-sight range, roughly 32 km from one another. The philosophy behind this deployment is to provide survivability of communications in a wartime environment. Even if many communication repeaters were destroyed or incapacitated by nuclear missile attack, there would still be many surviving radios that could by circuitous routing maintain connectivity across the U.S. The concern here is that if the Packet Radio is deployed in the 1710-1850 MHz band, a Packet Radio transmitter will be well within the protection area of many receivers identified in the previous EMC studies, such as to cause severe degradation to these other services. Many of these other services, such as the fixed microwave links for dam control or tactical weapon systems are vital in a wartime environment. Thus, a checkerboard deployment of the Packet Radio cannot be accommodated in this band as proposed. Accommodation could be made by the deployment of a limited number of Packet Radios around military bases in conjunction with either packet-switched land lines or point-to-point communications to complete the checkerboard network. Also, using only the narrowband Packet Radios or the provision of a narrowband mode on the UPR could be used to obtain frequency separation as well as distance separation to avoid interference to the other users in the 1710-1850 MHz band.

Airborne Spread Spectrum. The need is recognized for certain military applications to employ band spreading, or spread spectrum, techniques to assure adequate antijam margins in a hostile environment. In the future, possible non-military applications may also come into use as a potentially more efficient use of the spectrum as compared to conventional narrowband techniques. The use of a spread spectrum system in the band in a fixed and mobile application has been discussed by Crandall (1980). The use of spread spectrum in airborne application has not, at present, been proposed for this band. However, to provide a technical evaluation prior to any proposal for such an application in the 1710-1850 MHz band, calculations were made on spread spectrum systems based on hypothetical parameters in the NTIA Phase II report and the conclusions were ... "it is clear that the coordination of airborne spread spectrum systems in this band would become difficult. Time sharing with fixed systems is impractical for obvious reasons. Frequency sharing, i.e., designating a specific portion of the band for the airborne spread spectrum system, would not assist in the solution because of the typically wide bandwidths used. And finally, geographic sharing would require relatively large distance separations as indicated. In view of these difficulties, widespread use of airborne spread spectrum systems in this band would not be possible in many areas of the country. In a given geographic area, the use of one system that effectively excludes all other band users from the same area cannot be considered as effective use of the band. Any such planned use could only be permitted on a secondary non-interference basis, and would be limited to specific geographical areas as determined on a case-by-case basis. Such use should not limit the introduction or expansion of other conventional systems in the same area."

Space Systems

In the NTIA Manual, Government Footnote 42 of the National Table of Frequency Allocations, provides for certain space functions in the 1710-1850 MHz band.

This footnote accommodates the Air Force Space Ground Link Subsystem (SGLS) which employs up-paths in this band and down-paths in the 2200-2290 MHz band. This system is used to provide tracking, telemetry, and command services to a wide variety of geostationary and non-geostationary military satellites.

At present, the SGLS and related test systems are the only space assignments in the 1710-1850 MHz band. The DoD/NASA Space Shuttle vehicle includes an SGLS compatible transmitter/receiver and is considered a part of the overall SGLS system.

Satellite Control Facility (SCF) stations are located at four sites within the United States and possessions. The SGLS processes various combinations of up-path to develop the baseband components and modulation indices required in the rf up-path to the SGLS-instrumented spacecraft.

Based on analysis of the 1710-1850 MHz Phase II report, if a suggested channel plan were used in the 1710-1850 MHz band compatible operation with Fixed and Mobile Services in the band could be achieved. Analysis of SGLS earth station transmitter to terrestrial receiver systems interactions would be somewhat complex and must be accomplished on a case-by-case basis. If, however, the proposed channel plan were adopted, the analysis and coordination of such interactions would be greatly simplified and conflicts more easily identified.

From the Phase II report, ... "A channel plan for this band would significantly improve the utilization of the band to more effectively accommodate the various needs of the band users. At the same time the potential spectrum available for future radiocommunication needs for the band will be maximized."

CONCLUSIONS

Based on the NTIA Spectrum Resource Assessment of this band and the growth pattern now evident by the statistics given in this report, no sharing of this band with non-Government Services is feasible for the foreseeable future. The coordination between all the various types of systems presently operating in the band, as given in Table 21, is fairly difficult. Even closer coordination and increased spectrum planning will have to be accomplished to accommodate planned future growth by Federal agencies using the 1710-1850 MHz band.

THE 2200-2290 MHz BAND

INTRODUCTION

The 2200-2290 MHz band is a Government exclusive band with 1,588 assignments. Fixed, Mobile and Space Research are the primary allocations with mobile assignments as the largest user with 929 used mainly for telemetry purposes. An NTIA spectrum resource assessment was published in September 1980 (Flynn, 1980b) for the 2200-2300 MHz band. Much of the material in the following section include excerpts from that report. The largest number of new systems in the band (from the Systems Review File) are those connected with space systems and space research (with 28) and it is expected that this trend will continue in the near future.

Allocations, Rules and Regulations

Nationally, the 2200-2290 MHz band is allocated to the Fixed, Mobile and Space Research (space-to-Earth) Services on a co-equal primary basis. The Fixed and Mobile Services are restricted to the line-of-sight mode of propagation. The Mobile service in the 2200-2290 MHz band includes aeronautical telemetry but excludes telemetry from manned aircraft. Table 24 includes excerpts from the International and U.S. National Table of Frequency Allocations [NTIA, 1982] for the 2200-2290 MHz band, and adjacent bands along with the applicable footnotes.

The Final Acts of the WARC-79 called for several changes to the International Allocation Table. The major change is the addition of the Space Operation, Space Research, and Earth Exploration-Satellite Services for space-to-Earth and space-to-space transmission in a footnote (750) in the 2200-2290 MHz band in all regions. This change satisfies requirements for telemetry, tracking, and operational control of satellites using common and standardized equipment.

Additionally, WARC-79 changed the requirements for international coordination by the addition of new Article 14. This article is applied to cases where a footnote in the Table of Frequency Allocations requires an agreement with an administration, such as footnote 750. The article requires that an administration must obtain the agreement of any administration whose services may be affected before notifying the International Frequency Registration Board (IFRB) of a frequency assignment in one of the covered bands. This article provides specific procedures rather than providing an open-ended opportunity for an administration to complain about interference. A time limit of 4 months has been applied. The definition of the term "administration" whose operations may be affected has been resolved by requiring an administration to send a request for coordination to the Board rather than to a specific administration. The Board is to publish these requests in a special section of the Weekly Circular for all to examine and the "administration" whose operation may be affected then has 4 months to respond. Also, the coordination request may be initiated with either the data required by Appendix 3 or Appendix 4 and the coordination may be accomplished simultaneously with the procedures of advance publication and conventional coordination described in new Article 11.

In addition to these specific allocation rules and regulations, the NTIA Manual identified frequency assignment and coordination procedures that are

TABLE 24

EXCERPTS FROM THE INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
1710-2290 FIXED Mobile 722 744 746 747 748 750	1710-2290 FIXED MOBILE 722 744 745 746 747 748 749 750		2200-2290		FIXED (LOS* only) MOBILE (LOS only including aeronautical telemetering, but excluding flight testing of manned aircraft) SPACE RESEARCH (Space-to-Earth) (Space-to-space) G101	
2290-2300 FIXED SPACE RESEARCH (Deep Space) (Space-to-Earth) Mobile except aeronautical mobile	2290-2300 FIXED MOBILE except aeronautical mobile SPACE RESEARCH (Deep Space) (Space-to-Earth)		2290-2300		SPACE RESEARCH (Space-to-Earth) (Deep Space Only) FIXED MOBILE except aeronautical mobile	SPACE RESEARCH (Space-to-Earth) (Deep Space Only)

*LOS only

G101 - In the band 2200-2290 MHz, space operations (space-to-Earth) and (space-to-space), and earth exploration-satellite (space-to-Earth) and (space-to-space) services, may be accommodated on a co-equal basis with fixed, mobile and space research services.

specifically applicable to this band. Section 8.2.25 of the NTIA Manual limits the use of frequency diversity for line-of-sight fixed systems in the 2200-2290 MHz band. To employ frequency diversity for a new system, justification is required to show the necessity for the high reliability as well as an engineering evaluation to show that the diversity will provide the required reliability. Section 8.2.33 provides a guideline for the selection of sites and frequencies for earth and terrestrial stations in the bands above 1 GHz shared with equal rights by terrestrial and space radiocommunication services. Section 8.2.36 of the NTIA Manual limits the power flux density at the Earth's surface from space stations in the Space Research Service operating in the 2200-2300 MHz frequency band. These limits are identical to the provisions of the Final Acts of WARC-79. These are derived on the basis of protecting stations in the Fixed Service which employ line-of-sight communications. Sections 8.4.12, 8.4.13, and 8.4.14, of the NTIA Manual establishes the coordination criteria for earth station frequency assignments. The purpose of the coordination criteria is to assure that terrestrial stations will not interfere with the earth station and vice versa. The coordination area for an earth station is calculated in accordance with Appendix 28 of the ITU Radio Regulations. The existing earth stations listed in the NTIA Manual within the 2200-2300 MHZ band are:

Frequency MHz	Location	Coordinates		Agency
		Latitude	Longitude	
2200-2290	Goldstone, CA	35 20 30N	116 52 25W	NASA
	Greenbelt, MD	38 59 55N	076 50 34W	NASA
	Guam	13 83 33N	144 44 04E	NASA
	Kauai, HI	22 07 31N	159 40 03W	NASA
	Merritt Island, FL	28 30 30N	084 41 37W	NASA
	Fairbanks, AK	64 58 38N	147 30 54W	NASA
	Shirley Bay, Ontario	45 20 56N	075 53 23W	CANADA
2200-2300	Andersen AFB, Guam	13 36 48N	144 51 12E	USAF
	Buckley Field, CO	39 43 XXN	104 46 XXW	USAF
	Cape Kennedy, FL	28 24 XXN	080 30 XXW	USAF
	Fairchild AFB, WA	47 30 XXN	118 10 XXW	USAF
2200-2300	Kaena Pt., HI	21 34 18N	158 16 34W	USAF
	Loring AFB, ME	47 00 XXN	068 01 XXW	USAF
	New Boston, NH	42 56 54N	071 38 24W	USAF
	Shemya, AK	52 43 XXN	174 07 XXE	USAF
	Vandenberg AFB, CA	34 29 24N	120 31 54W	USAF
2290-2300	Goldstone, CA	35 25 29N	116 53 24W	NASA

Technical Standards for the 2200-2290 MHz band are given in Appendix F. There is a channeling plan for this band given in Chapter 4 of the NTIA Manual as follows:

In the band 2200-2290 MHz, ninety 1-MHz narrowband channels are designated, centered on 2200.5 MHz and each 1-MHz increment thereafter, through and including 2289.5 MHz. The use of emission bandwidths greater than 1 MHz is permitted, provided the assigned frequencies are centered on the center frequencies of narrowband channels. These channels are available for a) telemetering from space research space stations irrespective of their trajectories and b) aeronautical telemetering, including telemetry associated with launch vehicles, missiles, and upper atmosphere research rockets. Such use is on a coequal shared basis with fixed and mobile line-of-sight operations in the band conducted in accordance with the Government Table of Frequency Allocations. No provision is made in this band for the flight testing of manned aircraft. In the band 2290-2300 MHz, no specific channels have been established.

SPECTRUM USAGE AND SYSTEM DESCRIPTIONS

SPECTRUM USAGE

The spectrum allocation rules and regulations permit a wide variety of systems to operate in the 2200-2290 MHz band, including systems in the Fixed, Mobile, and Space Research Services. In addition to those specifically permitted by the allocation tables, a number of experimental stations also operate in this band. For this report, the sources of data to identify the various band users are primarily the GMF, NGMF, the Systems Review Documentation, and other IRAC sources, as well as contact with agency personnel.

In order to present a concise summary, the data have been categorized by terrestrial, space, and experimental radiocommunications systems. The frequency assignments have then been further subdivided into the various services and individual station classes within these services. This method helps to highlight overall trends for the band. Table 25 gives a summary of the assignments in the GMF grouped by service using agency and station class.

The distribution of the total number of frequency assignments in the 2200-2290 MHz band is given in Figure 17 (GMF, June 1983). It should be noted that the distribution does not necessarily include the total number of equipments represented by these assignments, nor does it include consideration of the emission bandwidth of the assignments.

There are presently (GMF, June 1983) 1,588 assignments in the band with a geographic distribution as shown in Figure 18. The lines represent the direction of broadcast for satellite systems. The growth trends for the 2200-2290 MHz band are shown in Figure 19. Here it can be seen that great growth in band usage occurred between 1977 and 1981. There has been a decline in assignments since 1981 to present with a peak in assignments of 1,876 in July 1981 to the 1,588 assignments in June 1983. These declines are mainly due to systems used by Air Force and Navy which are being phased out of this band. The number of assignments should show an upward trend in the next few years as systems which are still in the developmental stages become operational.

TABLE 25

SUMMARY OF ASSIGNMENTS IN THE 2200-2290 MHz BAND
(June, 1983)

SPACE RADIOCOMMUNICATIONS		AGENCY	NUMBER OF ASSIGNMENTS
EH	Space research space station	NASA	5
EK	Space tracking space station	AF	4
		NASA	1
ER	Space telemetering space station	AF	77
		N	5
		NASA	6
ET	Space operation space station	NASA	1
EHER	Space telemetering space station in the Space Research Service	NASA	6
EMEK	Space tracking space station in the Meteorological-Satellite Service	NASA	1
EMER	Space telemetering space station in the Meteorological-Satellite Service	C	1
		NASA	4
ETEK	Space tracking space station in the Space Operation Service	NASA	3
TH	Space research earth station	NASA	5
THTR	Space telemetering earth station in the Space Research Service	NASA	1

TERRESTRIAL RADIOCOMMUNICATIONS

FIXED SERVICE

	AGENCY	NUMBER OF ASSIGNMENTS
FX - Fixed Station	AF	5
	AR	52
	CIA	4
	CG	22
	DOE	10
	FAA	2
	FEMA	8
	N	18
	TRAN	10
FXE - Telemetering Fixed Station	AF	1
	AR	2
	DOE	30
	N	3
	NASA	6
FXD - Telecommand Fixed Station	NASA	1
	N	1

TABLE 25 (continued)

MOBILE SERVICE	AGENCY	NUMBER OF ASSIGNMENTS
FA - Aeronuatical Land Station	AR	5
FLEA - Aeronautical Telemetering Land Station	AR	14
FLEC - Surface Telemetering land station	AR	2
	DOE	22
MOD - Telecommand Mobile Station	N	9
MOE - Telemetering Mobile Station	AF	3
	AR	3
	DOE	15
	N	57
	NASA	7
MOEA - Aeronatical Telemetering Mobile Station	AF	126
	AR	71
	DOE	35
	N	205
	NASA	3
MOEB - Flight Telemetering Mobile Station	AF	106
	AR	47
	C	2
	DOE	68
	N	22
	NASA	13
MOEC - Surface Telemetering Mobile Station	AF	1
	AR	7
	DOE	60
	N	10
MA - Aircraft Station	N	4
ML - Land Mobile Station	AR	2
MS - Ship Station	N	10
EXPERIMENTAL ASSIGNMENTS		
XC - Experimental Contract (development)	AF	19
	AR	6
	NG	4
XD - Experimental Developmental Station	AR	4
	NG	1
XE - Experimental Export Station	NG	4
XM - Experimental Composite Station	AF	3
	NASA	3
XR - Experimental Research Station	AF	4
	NASA	37
	NG	3
XT - Experimental Testing Station	AF	144
	AR	14
	DOE	2
	N	90
	NASA	26
		1,588

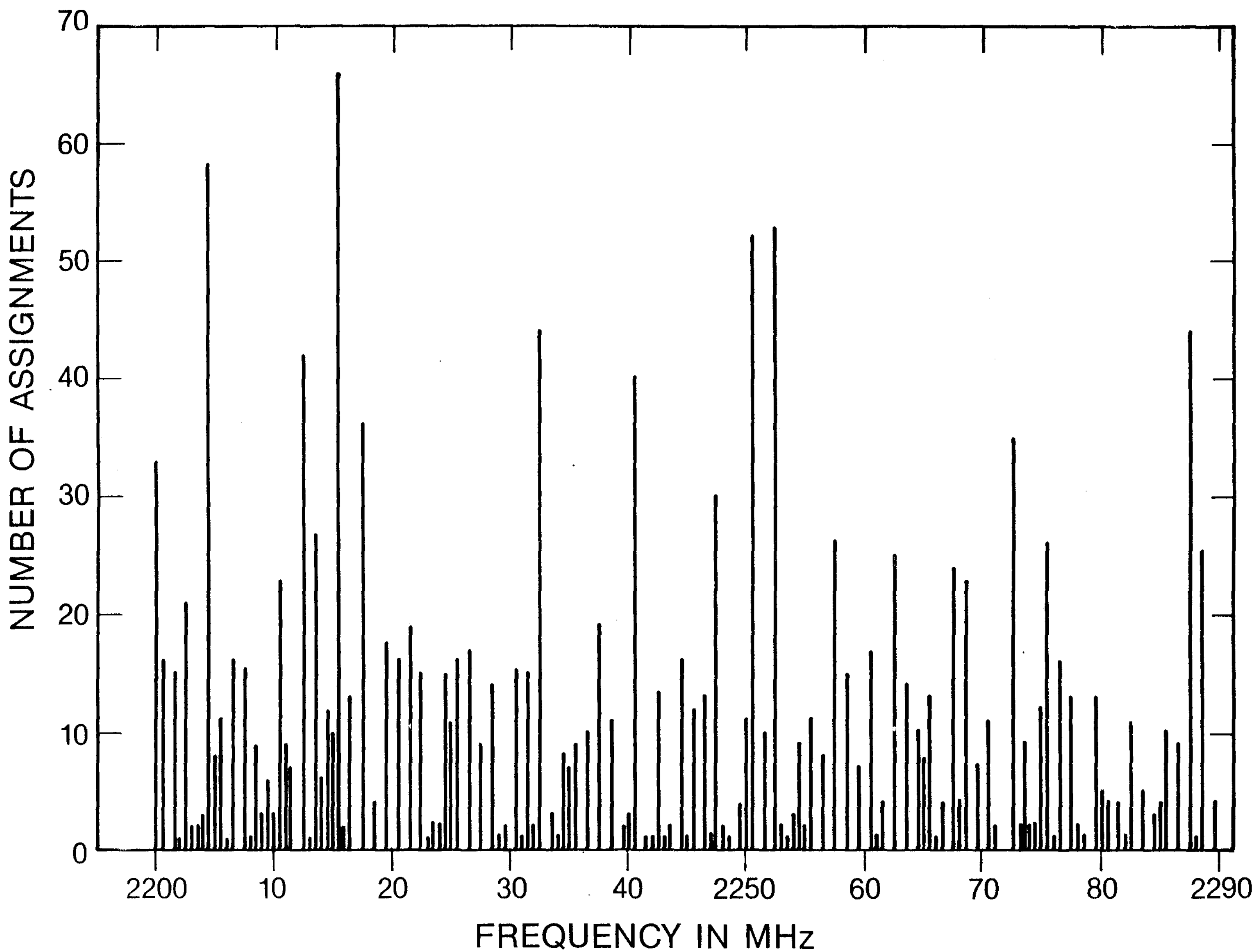


Figure 17. The Distribution of the Total Number of Assignments in the 2200-2290 MHz Band.

X - TRANSMITTER LOCATION

O - RECEIVER LOCATION

———— - SATELLITE LINKS

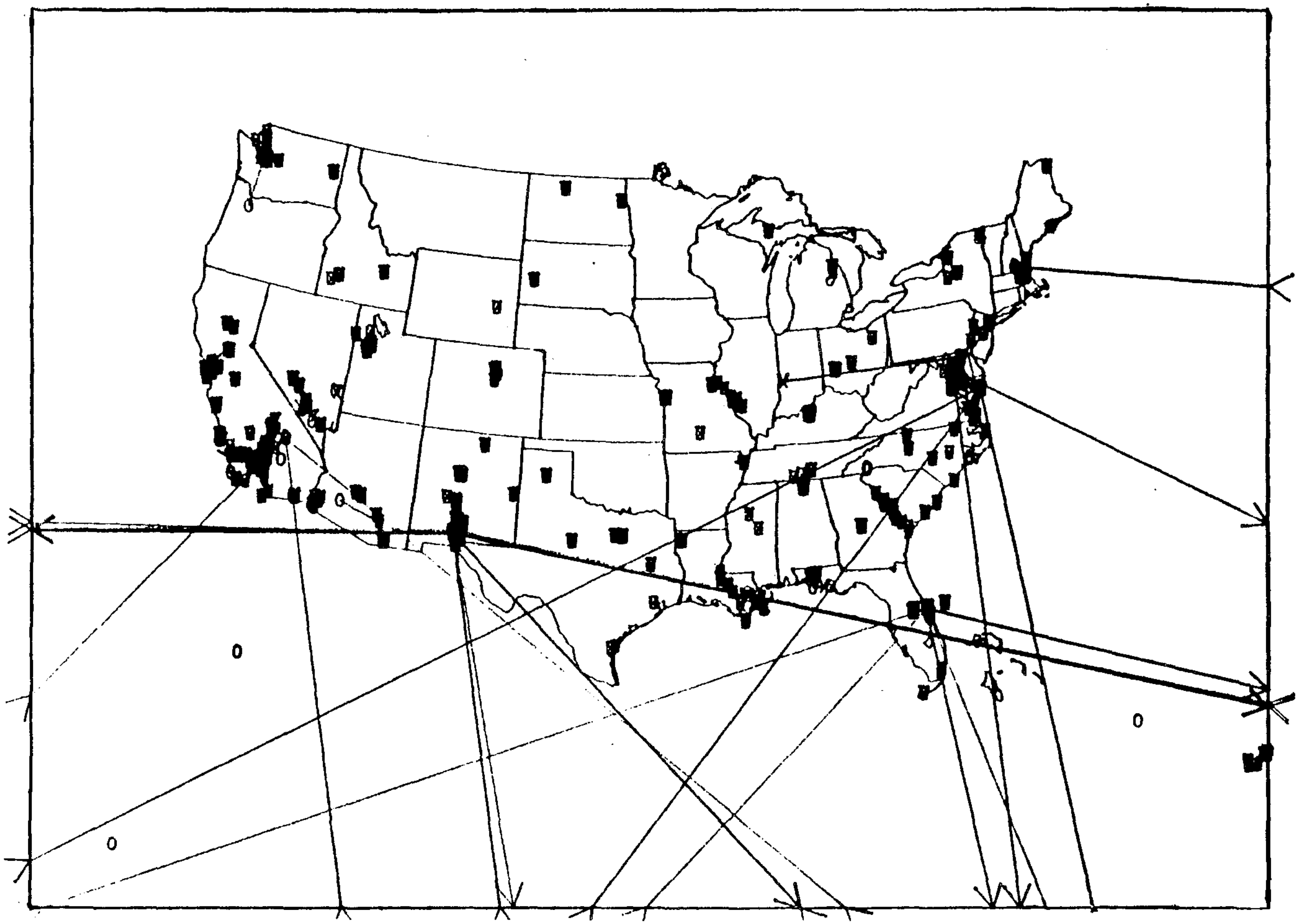


Figure 18. Geographic Distribution of Assignments in the 2200-2290 MHz Band.

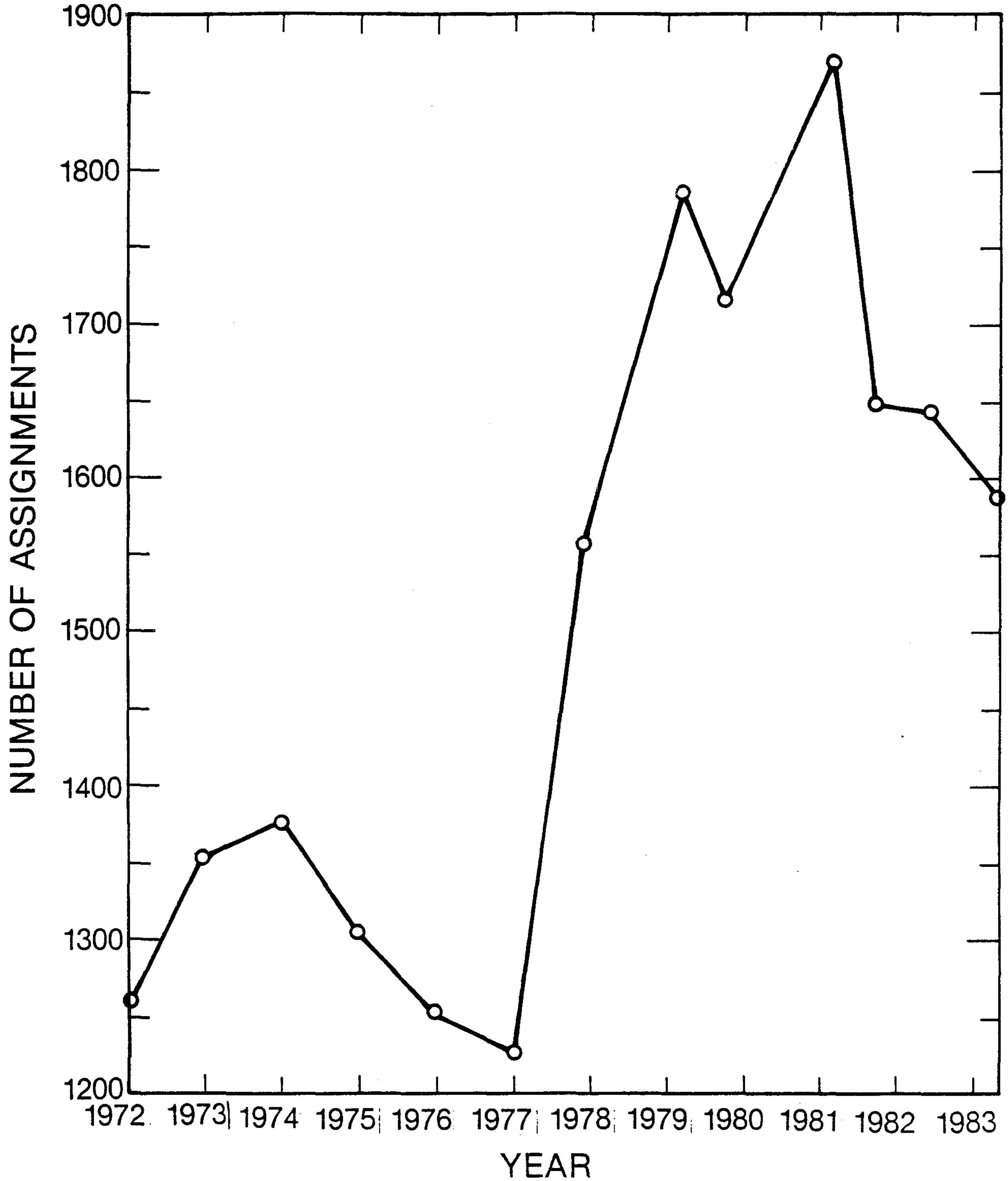


Figure 19. Growth Trend for the 2200-2290 MHz Band.

There are 48 systems in the systems review process as of the June 1983 systems review file. These are categorized as follows:

Space Systems	28
Mobile Systems	4
Fixed Systems	5
Tethered Balloon Systems	2
RPV/Missile Systems	4
Misc. Systems (Bullet Hit indicator, etc)	5
	48

The space systems are the most significant in number and in potential interference problems.

SYSTEM DESCRIPTIONS

SPACE SYSTEMS

General

The space usage in the 2200-2290 MHz frequency band is limited to systems operated by the U.S. Air Force and NASA with one assignment to the Department of Commerce for Meteorological-Satellite Service. The Space Ground Link Subsystem (SGLS) under the direction of the Air Force Satellite Control Facility (AFSCF) is used to support spacecraft requiring downlink telemetry. The Spaceflight Tracking and Data Network (STDN), is under the system management and technical direction of the Goddard Space Flight Center. Its function is to support manned and unmanned Earth-orbiting and lunar scientific and advanced technology satellites.

Security restraints on the mission of many military satellites prohibit the publication of systems or equipment characteristics. An estimate, however, of the space-to-ground frequency utilization of NASA and DoD programs in the 2200-2290 MHz band has been provided by AFSCF.

NTIA established policy indicates that all space systems should undergo the System Review Procedure outlined in Part 8.3 of the NTIA Manual. All space systems with nonexperimental use of the frequency spectrum are expected to be reviewed at the stage 4 (preprocurement level). This requirement includes telemetry operations on otherwise experimental or scientific research satellites. Similarly, NTIA established policy is to advance publish, coordinate with other administration as appropriate, and modify frequency assignments to the IFRB for insertion in the International Frequency List (IFL) for all space systems.

Space Ground Link Subsystem (SGLS)

The SGLS is an Air Force system providing tracking, telemetry, and control for the DoD satellites. Both geostationary and nongeostationary satellites are serviced from four Satellite Control Facility (SCF) ground stations located in Guam, Hawaii, New Hampshire, and California. The rf links include command up-paths in the 1761-1842 MHz band and telemetry down-paths in the 2200-2290 MHz band. Tracking is accomplished by the use of narrow-beam ground station antennas, combined with ranging, using phase comparison techniques between the up-path signal, and the return from the satellite borne transponders. The SGLS system may provide two down-path carriers that can be received simultaneously at a ground station and be processed to recover range and range rate data, satellite telemetry, and payload data. The two signals are called Carrier 1 and Carrier 2, with Carrier 1 being the pilot signal for normal antenna auto tracking, range rate tracking and low-speed PCM or analog telemetry. Carrier 2 is always at a fixed frequency offset (5 MHz) below the frequency of Carrier 1, and is used to carry one digital bit stream at rates from 128 KB/S to 1.024 MB/S using PSK suppressed carrier modulation.

Spaceflight Tracking and Data Network (STDN)

NASA maintains a worldwide system of ground tracking stations to provide tracking, telemetry, and command to all authorized user spacecraft missions. The set of ground stations presently supporting the low Earth-orbiting spacecraft and the high, eccentric, or synchronous orbit spacecraft, together with the communication links connecting NASA centers with the ground stations, is referred to as the STDN.

With the addition of the Tracking and Data Relay Satellite System (TDRSS) the STDN is capable of providing the increased support required by user missions. Also, the addition of the TDRSS allows the closure of some current STDN ground station sites. A key benefit of the STDN in the TDRSS era is that data flow between mission spacecraft and user ground facilities is real-time. The TDRSS is used as the primary communications path for low Earth orbiting spacecraft, replacing the one that goes via a STDN ground station. The remaining STDN ground stations will be known as the Ground-Based STDN (GSTDN).

Three of the GSTDN ground stations, those located at Goldstone, CA, Madrid, Spain, and Canberra, Australia, provide primary support for high and synchronous orbit spacecraft and for the eccentric orbit spacecraft. A fourth GSTDN ground station at Fairbanks, AK, will support existing Earth orbiting spacecraft that are not compatible with TDRSS. Launch support facilities will be located at Merritt Island, FL, with down-range facilities at Bermuda for east coast launches. The Vandenberg facility will be operated by the USAF for west coast launches.

Space Shuttle

The Space Shuttle is a joint NASA and DoD program under development to reduce the cost of manned space operations and to support a wide range of scientific, defense, commercial, and international interests. At present, a fleet of five reusable orbital vehicles is planned with flights that began in late 1980. The communication links for the Space Shuttle are shown in Figure 20. The primary paths of interest in the 2200-2290 MHz band are the SGLS tracking and telemetry downpaths from the Shuttle, AF Payload, and the NASA Payload telemetry links.

In order to be able to permit payload communications with minimum interference, two in-band assignments, designated "high" and "low", are used for the 2200-2290 MHz Space Shuttle links. The high network channels, centered at the Shuttle transmit frequency of 2287.5 MHz will be used if a payload is to receive the signals from STDN in the lower portion of the band, 2200 MHz to approximately 2250 MHz. The low network channel, centered at a transmit frequency of 2217.5 MHz, will be used if a payload is to receive the signals from the STDN in the high portion of the band, 2250-2300 MHz. When the Shuttle payload subsystem is to receive data from a Shuttle payload, the STDN network receiver is configured to either the high or low band depending on whether the payload is in the low or high band, respectively. The channel selection is governed by whether the transmission originates from a DoD or NASA payload.

Tracking and Data Relay Satellite System (TDRSS)

The TDRSS is a NASA program under development to reduce the cost and improve the efficiency of returning spacecraft gathered scientific data to Earth. In addition, real-time coverage of the low-orbit satellite can be provided on a more complete basis, as compared to the current network of U.S. earth stations that can support a given space research mission for about 15 percent of the time due to visibility constraints. TDRSS will consist of a ground station at White Sands, NM, and two operational Tracking and Data Relay Satellites separated by approximately 130°(41° and 171° West Longitude). The primary paths of interest in the 2200-2290 MHz bands are the multiple access transmission (space-to-space) relaying data from up to 20 low-orbit user spacecraft operating at 2287.5 MHz and a contingency telemetry link (space-to-Earth) operating at 2211 MHz. This system has the potential of reducing the loading on the 2200-2290 MHz for space-to-Earth transmissions. One off-setting factor to the loading reduction, however, will be the fact that the back-up direct telemetry link (space-to-Earth) may be required and will have to be exercised regularly.

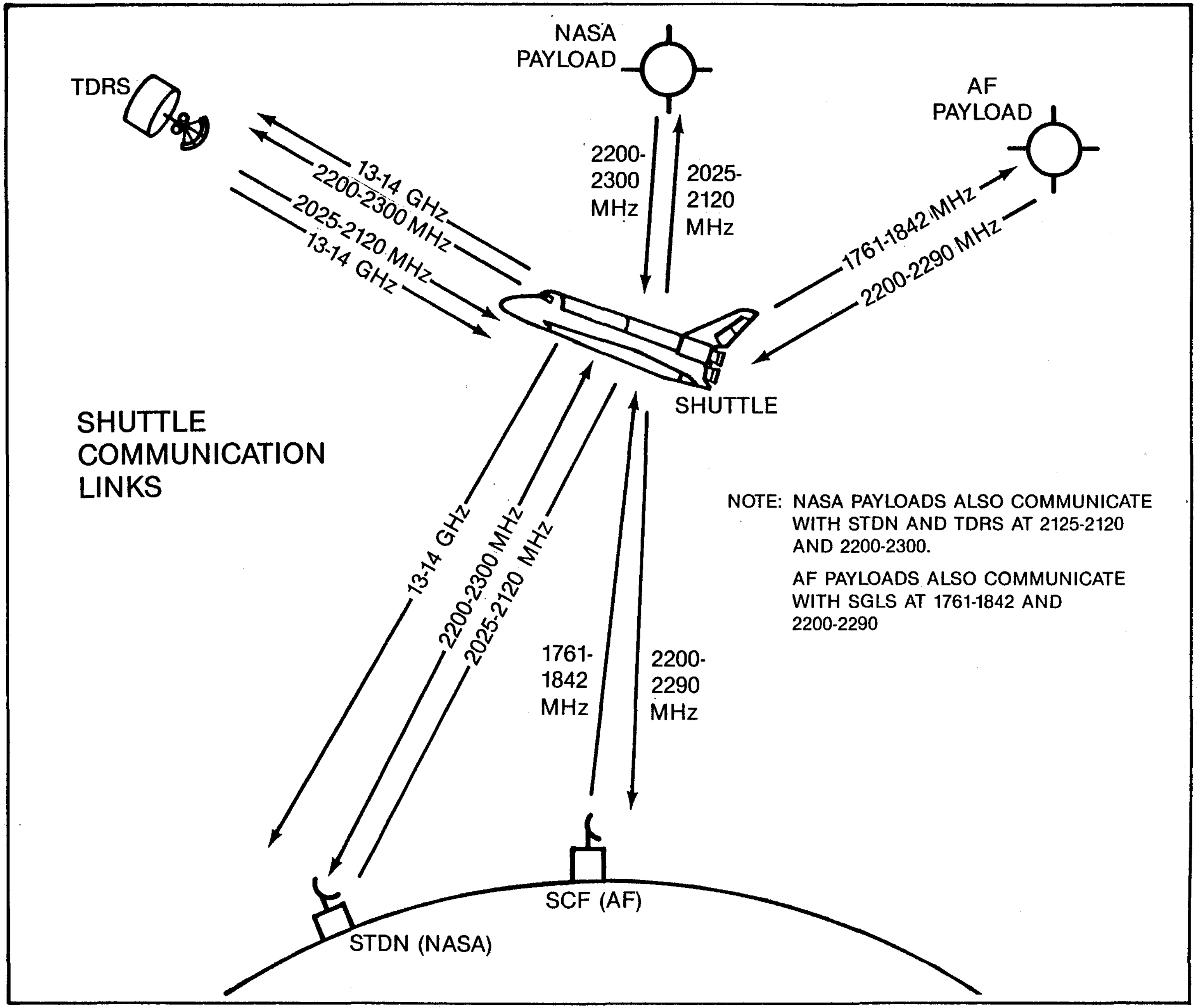


Figure 20. The Communication Links for the Space Shuttle.

TERRESTRIAL SYSTEMS

FIXED SERVICE SYSTEMS

Point-to-Point (Line-of-Sight). For this class of system, the GMF portrays a relatively accurate picture of the actual usage. These assignments are recognized from the file by the following parameters: station class equal to FX, power less than 20 W, directional antennas on each end of the path, and coordinates for each end point uniquely identified. There are 11 assignments located outside CONUS. The Army operates a microwave network in Alaska with four assignments at 2275 MHz with an emission designation of M30F9 and the Coast Guard (CG) operates six microwave circuits in Puerto Rico with an emission designator of 800F9. The Department of Transportation (DoT) operates a microwave link for use on The Alaska Railroad system with an emission designator of M1.6F9. From the total number of assignments, the apparent use in CONUS of this band by the Government for point-to-point radiocommunications is increasing having gone from 50 assignments in 1980 to 164 assignments in 1983 (approximately 50 assignments). Bands that are available to Government agencies to support point-to-point communications are as follows:

Low Capacity (212 channels)	406.1420 MHz 902-928 MHz (Secondary basis)
Medium Capacity	1710-1850 MHz 2200-2300 MHz
High Capacity	7125-8500 MHz 14.4-15.35 GHz

The Army is the predominant user with 52 assignments in the 2200-2290 MHz band.

Telecommand System. There are only two assignments in the GMF for this station class (FXD): one at 2206.5 MHz for digital command from a U.S. Navy shore station in North Carolina to a platform to release stored data, and the other for the NASA at 2215.5 MHz required for ground testing of equipment for use in the Solar pointing aerobee rocket control system at the Goddard Space Flight Center.

Telemetering Fixed System. The majority of assignments (30) are used at the Nuclear Test Site (NTS) by DoE. These telemetry systems are used for transmission from devices or equipment to a central controller. These assignments FXE are indicated by relatively low power levels (less than 4 W) with emission bandwidths of 500F9, M2F9, and M3F9. This system might well be described as transportable. NASA has six assignments for telemetering of stress, vibration, and shock data during high-G drop tests of booster system components at Huntsville, AL. There are six frequencies used between 2247.5 and 2277.5 MHz with a power level of 10 W and emission designator of 500F9.

Land Mobile

Records for land stations in the Mobile Service are relatively few in number. The Army operates a telemetry system for the SAM-D missile program used throughout the U. S. at U. S. Army bases. This system operates at 5 W and emission designator of M1.10F9.

Telemetering Mobile Systems

This functional class of systems represents the largest group of assignments, approximately 900, in this band. This band has become one of the principal bands supporting telemetering for military operations since the closing of the 225-400 MHz band for this function. These systems primarily provide real-time data from remotely piloted vehicles, drones, and missiles. Locations of these systems are somewhat diverse but the majority are on military test ranges in the Southwest United States and on the East Coast. The majority use low gain or omnidirectional antennas and power levels of less than 20 W. The U.S. Navy, however, does operate a system with a power level of 100 W for drones and aircraft that operate within a 322 km (200 mi) radius of Pt. Mugu, CA.

The overall usage of each of these systems at any location is quite fluid as systems are moved in and out of the military test ranges. Spectrum usage has been enhanced by the coordination of activity in those environments where there is a high probability of interference. The fact that tests can be scheduled and persist for a relatively short time allows coordination procedures to be a useful tool in the management of this band. The report by ECAC (White, 1977) documents the frequency management techniques that are presently used for coordination at the eastern and western test ranges.

EXPERIMENTAL

There are approximately 364 assignments listed in the GMF for equipment operating in the band in the experimental services. Of these assignments the majority (designated XR or XT) are for stations used in basic research or in the evaluation or testing of electronics equipment or systems which are being developed for operational use. The latter category includes such activities as factory testing, system checkout, and telemetry system calibration. A second class of experimental assignments (designated XC or XD) is for stations used in the evaluation or testing of electronic equipments or systems in a design or development stage. A third class of experimental assignments (designated XM), which represents a composite of two or more experimental categories, is used for experiments in radar cross section and transmission of video data. These assignments are all on a secondary basis and have a specified expiration date.

SYSTEM INTERACTIONS

An examination was made of the interactions among the major systems identified in this band. For purposes of discussion, these are ordered by the various receiver types interacting with the representative environment in the 2200-2290 MHz band as shown in Figure 21.

Earth Station Receiver Systems (2200-2290 MHz)

The earth station receiver system is comprised of directive antennas and low noise temperature receivers. For example, the SGLS receiver system has antenna gains ranging from 33.5 to 48.2 dBi and system noise temperatures from 220 to 376 Kelvin. Because of these parameters, the potential of interference from the various classes of transmitters found in the 2200-2290 MHz band is significant. Each of these transmitters is discussed in the following paragraphs.

Space Transmitters. With the exception of geostationary satellites, a satellite is within view of any one earth station only part of the time. The precise periods of time that it is in view of the earth station, as well as the period of time between viewings, are a function of the orbital parameters of the satellite and the location of the earth station. Typically, a nongeosynchronous satellite is within view of a ground station only a small fraction of the time between successive viewings. As a result, it is possible for several satellites in the same or different orbits to operate in a time-shared mode on the same frequency, and communicate with the same ground station without interference, if they are suitably spaced in orbit. Interference between the telemetry channels of two satellites occurs when they are operating on the same or nearby frequencies and the paths to the satellites fall within a certain angle of each other, assuming both satellites are transmitting signals simultaneously. The magnitude of this critical angle is largely a function of the earth station antenna directivity, receiver sensitivity and selectivity, and the relative effective radiated power (ERP) transmitted by each satellite. Because of these variables, the probability of interference is a function of the individual orbital and radiative characteristics of the satellites. The mission requirements always dictate the orbital parameters and satellite ERP.

Presently, a computer analysis model is in active use at AFSCF to control time-sharing of the earth stations. The precise periods of interference between two or more satellites can be forecast and the probability of interference can be obtained. This capability has often been used on military satellite interference problems and occasionally has been used to forecast interference probability between NASA and military satellites. Because of the effectiveness of this real-time frequency coordination network, potential interference at these sites is manageable.

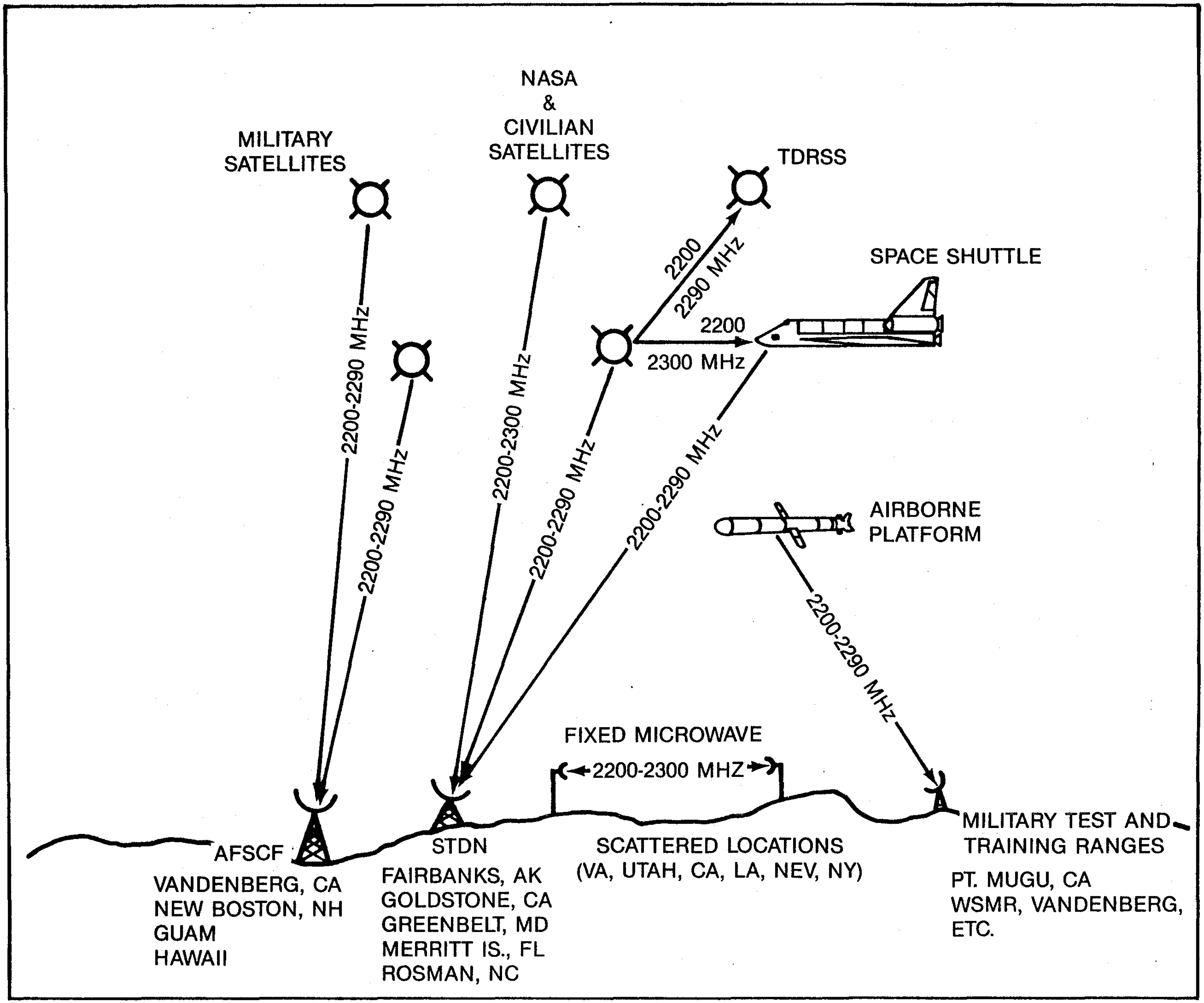


Figure 21. Representation of the Environment for the 2200-2290 MHz Band.

Fixed Transmitters. In frequency bands shared by terrestrial radio relay systems and earth stations, the potential for interference must be carefully examined to assure compatible operation. The potential interference radius around an earth station may range as high as several thousand kilometers, depending on terrain factors and relative orientation. Although there is little need for sophistication in the calculation of microwave path losses within the horizon, the matter of path losses at ranges beyond the horizon is much more complicated. As a result, the problem of coordination between earth stations and terrestrial systems sharing the same bands is rather complex.

Appendix 28 of the ITU Radio Regulations defines the procedure for determination of the coordination area around an earth station in frequency bands shared between space and terrestrial radiocommunication services. It must be emphasized that the presence of installations of a terrestrial station within the coordination area of an earth station would not necessarily preclude the successful operation of either the earth station or the terrestrial station.

Part 8.4 of the NTIA Manual defines the coordination procedures to be followed for a new frequency assignment or a new radio station for which protection is required. Also included are the special coordination procedures and standards to be applied between terrestrial stations and earth stations. The NTIA Manual also contains coordination contours of the existing earth station for CONUS. The coordination process for these interactions is thus well documented.

Mobile Telemetry Transmitters. The Mobile Services in the 2200-2290 MHz band include aeronautical telemetry, but exclude telemetry from manned aircraft. Because of the high mobility and potential mainbeam coupling, significant interference interactions are possible. Presently, an extensive real-time coordination network among major users in the Southwest United States and on the East Coast is in use. In the past, this network has been sufficient to mitigate the potential interference conflicts.

Earth station receivers and airborne telemetry transmitters are fundamentally incompatible when operation is simultaneous, co-channel, and in the same environment. Up to the present time, the management of this conflict has been possible because of the loading of the earth stations with the timing of the operations of the mobile systems. With the need for increasing use of the band by space research radiocommunication, serious problems may arise in the future. For example, the SGLS earth station operating at Vandenberg AFB is in an environment that can produce interactions from airborne transmitters in the 2200-2290 MHz frequency band. California has a very high population of mobile and experimental assignments and if the trend of increasing assignments in this area continues, the day-to-day operations of this system may be affected. The operations at Vandenberg are so critical that a heavily automated around-the-clock frequency organization is in place to protect the space operations at Vandenberg AFB from interbase and intrabase interference.

The Vandenberg AFB area has the highest probability of interference problems between mobile telemetry transmitters and earth station receivers. The automated frequency coordination process in operation at Vandenberg has been effective in protecting these operations (White, 1977). The major concern is the continued growth in the usage of these services. Higher usage results in more stringent time scheduling and could cause delays in equipment usage because of potential time/frequency conflicts. A potential conflict between an aeronautical mobile telemetry operation and a space telemetry operation would generally give priority to the space telemetry. Thus, the mobile telemetry operations will likely be the most heavily impacted as overall usage requirements increase.

If usage of the Mobile Service increases in the future, other areas of the country where earth stations are located may also experience conflicting requirements between space and terrestrial telemetry systems. For those areas, the coordination network in place at Vandenberg AFB and the surrounding area should be examined as a model.

Fixed (Line-of-Sight Only) Receivers (2200-2300 MHz)

These systems are very vulnerable to interference because of their general requirement for high reliability of service (up to 99.99 percent or more). In general, these systems have difficulty sharing with other services in the same environment on the same frequency. The frequency band of 2200-2290 MHz, however, has few Fixed Service assignments resulting in few interactions.

Space Transmitters. The power flux density (PFD) at the surface of the Earth for space transmitters in this band is specified in Section 8.2.36 of the NTIA Manual. This power level varies from -154 dBW/m/4 kHz to -144 dBW/m/4 kHz as a function of the angle of arrival of the signal from space, and was developed on the basis of protecting the Fixed Service equipments using line-of-sight techniques. For systems in the Fixed Service using tropospheric scatter techniques, and where there is insufficient frequency separation, there must be sufficient angular separation between the direction to the space station and the direction of maximum radiation of the antenna of the receiving station of the Fixed Service. This angular separation should ensure that the interference power at the receiver input of the station of the Fixed Service does not exceed -168 dBW in any 4 kHz band (see ITU No. 6058/470 NGA). However, only line-of-sight (LOS) fixed and mobile systems are allocated in the 2200-2290 MHz frequency band. Also, for their own protection, receiving stations in the Fixed and Mobile Services operating in bands shared with Space Research Services (space-to-Earth) should avoid directing their antennas towards the geostationary satellite orbit if their sensitivity is sufficiently high that interference from space station transmission may be significant. Annex B of the NTIA Manual can be used as a guide for azimuths to be avoided for the Fixed and Mobile Services. Using these existing procedures, the problems associated with space transmitters are manageable.

Fixed Transmitters. The NTIA Manual in Section 9.2.4 lists special instructions concerning application for frequency assignments for fixed stations in the 2200-2290 MHz band. This procedure shall be used in the processing of applications for new systems and for changes to existing systems that would increase the probability of harmful interference. Using the instruction and existing coordination procedures, the interaction of fixed systems is manageable.

Mobile Telemetry Transmitters. The largest number of assignments in the 2200-2290 MHz band are to DoD stations in the Mobile Service. While it has been shown that time sharing among airborne operations can result in the relative efficient use of the spectrum, sharing between Aeronautical Mobile and Fixed operations tends to be less efficient. This follows from the inability of continuously operating fixed stations to time share, and the reduced possibility for geographic sharing because of the relatively large separation distance required to provide interference-free operations.

Mobile Telemetry Receiver (2200-2290 MHz)

The same general configuration of facilities is used for aeronautical mobile telemetry tracking as is used for space telemetry tracking. The detailed equipment characteristics vary to meet the telemetry standards, signal levels, and mission requirements, but the general configuration and operational concepts remain the same. Like earth station receivers, interference to the telemetry link is possible from numerous other sources and these transmitters are discussed in the following paragraphs:

Space Transmitters. As in the case of earth stations, the only time interference from space transmitters can occur to mobile telemetry receivers is when the spacecraft and mobile telemetry receivers (which may be immobile) are in view of each other and operating simultaneously on the same frequency. The probability of this interference is a function of the orbital and radiation characteristics of the satellite. For nongeosynchronous satellites, the period of interference varies cyclically and allows some time window where interference-free operation is possible. Time coordination is possible and effectively reduces this problem to a manageable problem.

Fixed Transmitters. In general, the use of high-gain antennas by the telemetry receivers, which are elevated above the horizon (i.e., tracking) tends to offer significant protection from ground-based transmitters resulting in minimal separation requirements between these systems. The judicious placement of telemetry receivers can be an effective method for reducing any potential interference with potential interference problems from ground-based transmitters. For this reason, problems associated with potential interference from fixed transmitters appear manageable with the existing spectrum management procedures.

Mobile Telemetry Transmitters. The majority of these transmitters are operated intermittently (e.g., tracking of drones, missiles, tanks, and testing of periodic status of on-board equipment) and scheduling with other mobile systems is feasible. Although interference is possible, a time coordination process allows the problem to be manageable. However, the southwestern portion of the United States has numerous military test and training operations and day-to-day activities can become frustrating and costly because of delays in scheduling due to the growth of activity in this area.

Both of the propagation loss and receiver antenna gain in the direction of the telemetry transmitter are dependent on height and orientation. Table 26 gives calculations of slant range at which interference becomes unacceptable for

TABLE 27

REQUIRED DISTANCE SEPARATION BETWEEN HYPOTHETICAL
AIRBORNE TELEMETRY TRANSMITTER AND FIXED MICROWAVE SYSTEM

Required Distance Separation (Kilometers)

Fixed Antenna *	Maximum Altitude (Meters)				
Discrimination Angle	300	600	1500	3000	6000
0	107 Km	138 Km	209 Km	257 Km	354 Km
10	97	128	180	241	330
30	84	113	154	154	154
90	82	109	145	145	145
180	82	109	145	145	145

*Azimuth angle between the fixed receiver antenna boresite and the direction to the airborne transmitter.

various conditions. In these calculations, the path loss is based on computer derived values [Integrated Propagation Systems, (IPS), Smooth Earth Model] for smooth terrain conditions. The off-axis antenna gain is based on the reference radiation patterns given by CCIR (1978) where the off-axis gain (dBi) is equal to 38 -25 log θ for $\theta \leq 35°$ and 0 for $35° \leq \theta \leq 180°$. It must be noted that distances indicated are for one single interfering source at its closest distance to the microwave link. For multiple interference sources, the interfering powers tend to be directly additive, thus increasing the distance separation requirements. Specific scenarios would be necessary to fully examine the case of multiple interference.

While the values given are based on hypothetical (but representative) parameters, it is clear that coordination of airborne transmitters with point-to-point microwave receivers is difficult. Time sharing with fixed systems is impractical because of the high reliability requirement and continuous operations. Frequency sharing, i.e., designating a specific portion of the band for airborne systems, would not assist in the solution because of the limited amount of spectrum available (90 MHz) and finally, geographic sharing would require relatively large distance separation to provide for compatibility.

However, the areas where the majority of mobile assignments are located are at the military test ranges. This fact has permitted the judicious placement of a few fixed point-to-point microwave relay systems in CONUS.

CONCLUSIONS

With the growth in space research earth stations and expanding Government Fixed Service it would not seem feasible at this time to open the 2200-2290 MHz band to a shared band with the non-Government Fixed Service. The coordination effort would have to be considerable and at best new fixed systems would have to be on a secondary basis. There may be a possibility of some expansion of the Government Fixed Service in the Northern Midwest and Rocky Mountain States since there are 10 states in those areas with no assignments or just one assignment.

THE 4400-4500 MHz BAND

INTRODUCTION

The 4400-4500 MHz band is a Government exclusive band allocated to Fixed and Mobile Services on a primary coequal basis. Currently there are 245 assignments 75% of which are in the Fixed Service, 14% are to the experimental services and 11% to Mobile Service. An NTIA Spectrum Resource Assessment covering the 4400-4900 MHz band was published by NG (1981). Portions of the following sections will include excerpts from that NTIA report. There are currently 17 systems for this band in the Systems Review File. Of the 17, 11 systems would be classified in the Mobile Service and 6 in the Fixed Service.

RULES AND REGULATIONS

The national allocations [NTIA, 1982] for the 4400-4500 MHz and adjacent bands are shown in Table 27. Nationally, as mentioned above, the allocations are to the Government Fixed and Mobile Services on a primary coequal basis. The national allocations for this band were not affected by WARC-79 changes.

The technical standards, minimum performance requirements and design objectives applicable to transmitters, receivers, and antennas used by Government radio stations are contained in Chapter 5 of the NTIA Manual (NTIA, 1982). The Manual also stipulates that if technical criteria are not specified, the appropriate provisions of the ITU Radio Regulations normally should apply, or the current CCIR Recommendations should be used as guidelines.

A synopsis of the Government Technical Standards (Part 5.10 of the NTIA Manual) for fixed systems employing line-of-sight, point-to-point, and transportable type equipments (except for systems designed to use scatter techniques) using the band 4400-4500 MHz is given in Appendix E. In addition to these minimum standards, the use of frequency diversity for line-of-sight (LOS) transmissions is permitted provided that such use is justified.

TABLE 27

EXCERPTS FROM POST WARC-79 INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS FOR THE 4400-4500 MHz BAND

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
4200-4400	AERONAUTICAL RADIONAVIGATION 789 788 790 791		4200-4400	US261 791	AERONAUTICAL RADIONAVIGATION	AERONAUTICAL RADIONAVIGATION
4400-4500	FIXED MOBILE		4400-4500		FIXED MOBILE	
4500-4800	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE 792		4500-4800	US245	FIXED MOBILE	FIXED-SATELLITE (Space-to-Earth)
4800-4990	FIXED MOBILE 793 Radio Astronomy 720 778 794		4800-4990	US203 US257 720 778	FIXED MOBILE	

SPECTRUM USAGE AND MAJOR SYSTEMS

Introduction

This section provides a general description of the national frequency spectrum usage and typical equipment characteristics for operating systems in the band 4400-4500 MHz. The usage is summarized according to the information contained in the GMF, NGMF, IRAC/SPS Systems Review File, and the various Government agency inputs through their IRAC representatives.

Spectrum Usage

Within the United States, the military agencies are the major users of the 4400-4500 MHz band. The systems authorized to operate in the band typically have a tuning capability from 4400 to 4990 MHz. At the present time there are 69 assignments that have this cabability. Figure 22 shows the assignment trend of the 4400-4990 MHz band from January 1972 to January 1983, which includes the band of interest here. The statistics in past years have been kept over this total band (4400-4990 MHz) and the long-term trend for the 4400-4500 MHz band cannot be separated out. The graph shows an apparent decrease in assignments over the long run, however, if Navy assignments are taken out as shown in the lower curve the assignments show a slight increase over the past 5 years. The Navy assignments show a decrease because of systems that have been deleted from Navy inventory for this band. (No statistics on number of assignments are available for the period shown by the dashed line in Figure 22.)

As of June 1983, the Government Master File (GMF) lists 245 frequency assignments for this 4400-4500 MHz band. Table 28 shows the assignments by agency and station class. Army has the greatest number of assignments with 109 and the Fixed Service has the most assignments with 179.

Table 28

FREQUENCY ASSIGNMENT DISTRIBUTION FOR THE 4400-4500 MHz BAND

	FX	FXE	FL	FLEC	MA	MAD	MO	MOD	MOEA	XC	XD	XR	XT	TOT
AF	53						1			1			10	65
AR	100		3		2	1			1		2			109
DOE	8	5												13
NASA	1													1
N	18		2	3		5		7			17		2	54
NG										2		1		3

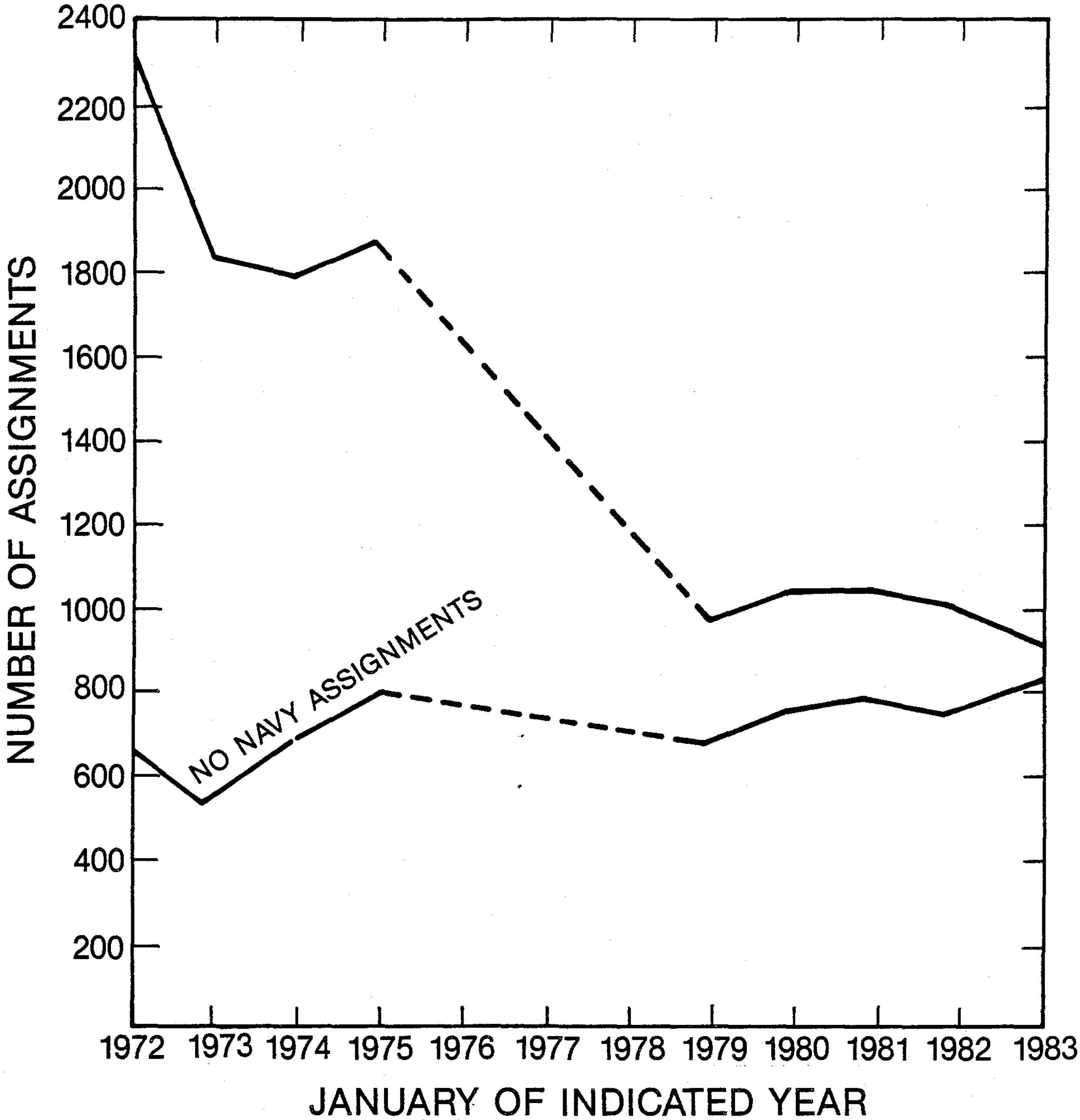


Figure 22. Assignment Trends of the 4400-4990 MHz Band from January 1972 to January 1983.

The CONUS geographical distribution of assignments in the 4400-4500 MHz band is shown in Figure 23. There are an additional 21 assignments not plotted due to no specific coordinates given in the GMF. There are 20 states with either no assignments or only one. However, since many of these systems are portable, in time of actual national emergency they could be used anywhere the need arises in CONUS.

Many of the military assignments have a GMF record note S189 and/or S362. Note S189 is designated for use as a "Tactical and Training" assignment, which indicates that the frequency is being used to train operators in the use of the equipment; such training normally takes place during military exercises. Note S362 indicates the frequency is designated for transportable equipment. The radius of operation of these transportable equipments is specified by the Code "RAD" in the GMF. This provision provides the description of an area of operation as a mileage radius extending from the given transmitter and receiver antenna locations.

Figure 24 shows the frequency assignment distribution for the 4400-4500 MHz band. There would seem to be a possibility of expansion of the fixed and mobile assignments in this band. However, the military tactical communications in the band must be protected and have priority in time of national disaster or war. Any new assignments should be well coordinated as they now are.

The usage of the Fixed and Mobile Services in the 4500-4800 MHz band by Government agencies can be grouped into the following categories:

FIXED SERVICE

Line-of-Sight (LOS) Radio Relay

Fixed and transportable point-to-point LOS radio-relay equipments operating in this band are characterized by moderate transmitter power, high gain directional antenna, low capacity, and moderate receiver sensitivity. The radius of operation of the transportable equipments identified in the GMF varies from 8 km to 480 km.

The technical characteristics of representative equipment are summarized in Table 29. A few of the common LOS systems are highlighted in the following paragraphs.

Table 29

TYPICAL LINE-OF-SIGHT RADIO RELAY EQUIPMENT IN THE BAND 4400-4500 MHz

	Transmitter			Receiver	
Equipment Nomenclature	Power (Watts)	Antenna Gain (dBi)	Emission Bandwidth (MHz)	Noise Figure (dB)	Antenna Gain (dBi)
AN/TRC-97	15.0	38.0	1.0F9	5.0	38.0
AN/GRC-144	2.0	33.0	4.1F9	11.0	33.0
AN/TRC-027	3.0	30.0	10.0P9	13.0	30.0
AN/GSQ-120	0.5	37.0	1.0F9	---	37.0
TER/TCM 602	1.0	33.0	36.0F9	8.5	33.0
AN/TRC-144	0.1	33.0	3.0F9	---	33.0

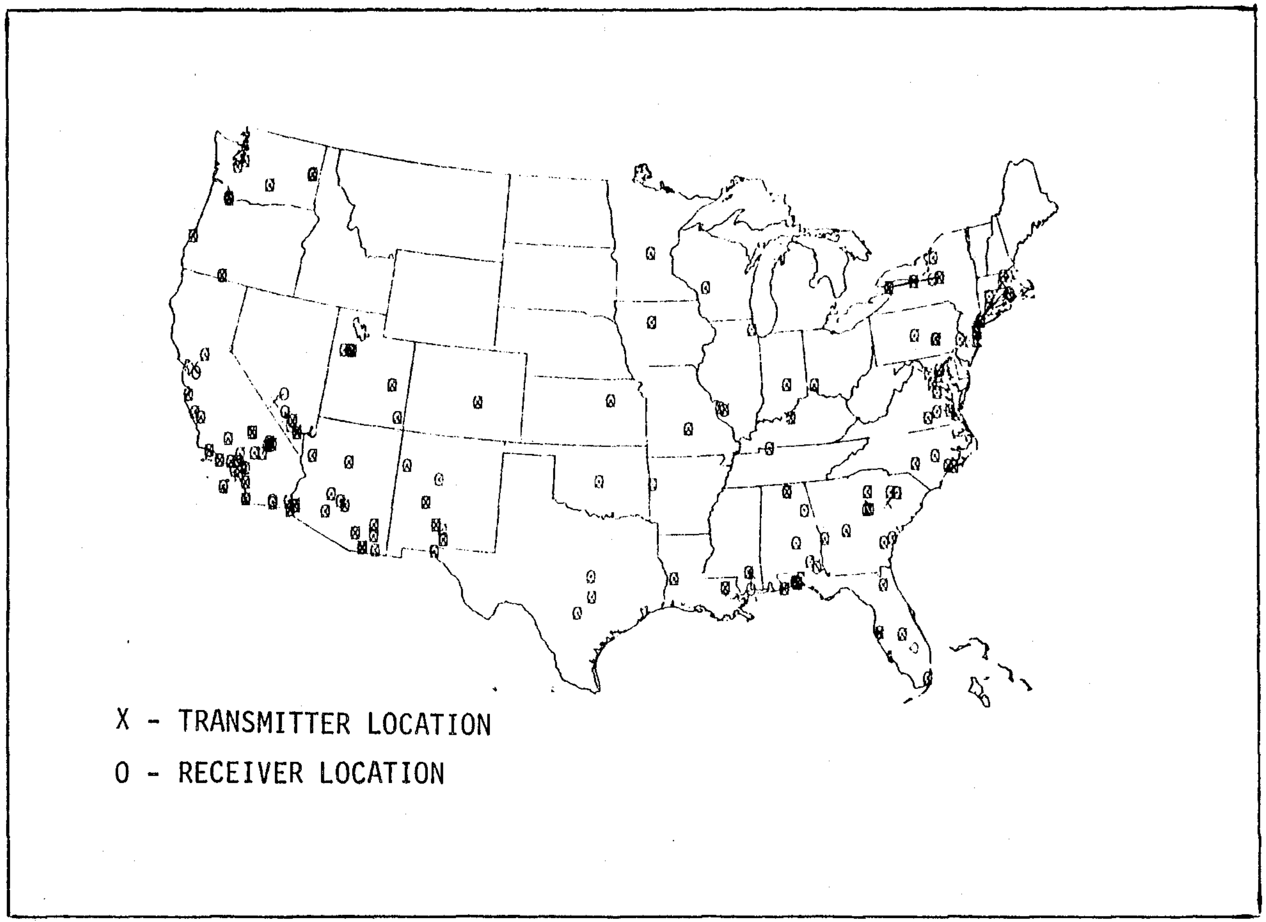


Figure 23. Geographic Distribution of Assignments in the 4400-4500 MHz Band.

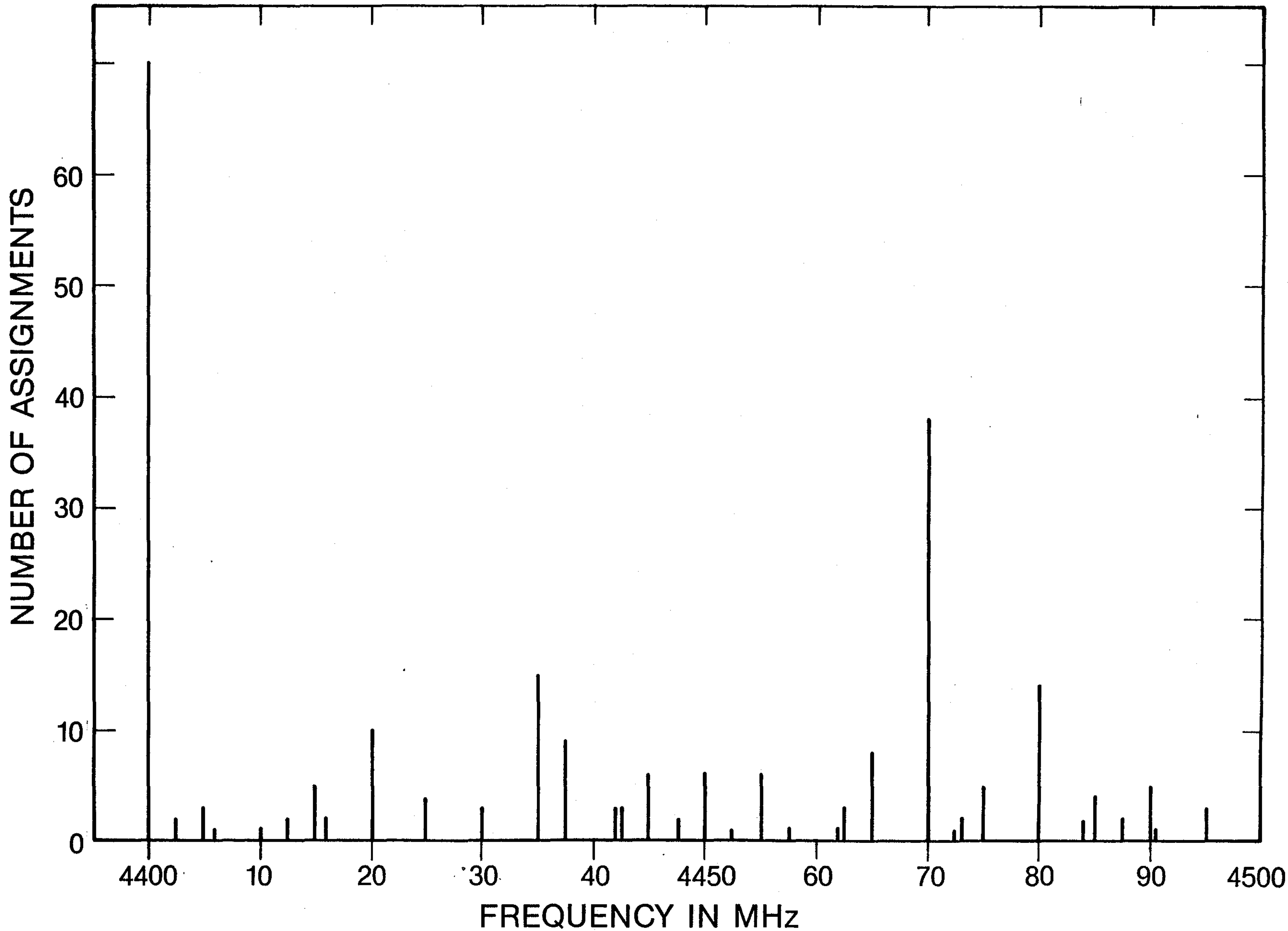


Figure 24. Frequency Assignment Distribution for the 4400-4500 MHz Band.

The AN/TR-C97 is a fixed or transportable tactical radio set capable of providing 24-voice channels or 23-voice channels plus 16 teletype channels over a few kilometers in the LOS mode. It has a low power transmitter, two complete receivers and two identical 2.4 meter parabolic antennas. The system is capable of operating either in a nondiversity or a dual space diversity configuration.

The AN/GSQ-120 is a radar data transfer system and provides data transfer links for the 407 L system. Radar data is time-division multiplexed on an FM carrier for remoting the data to a central site.

The AN/TRC-27 is a tactical LOS set designed primarily for operating in a forward area. It may be used in a radio relay net configuration with the stations spaced 15 km or more apart. The system is a 24-voice channel equipment with 30 rf channels in 20 MHz increments.

Tropospheric Scatter (TROPO) Radio Relay

Fixed and transportable TROPO communications systems are being used extensively in this band to provide reliable multichannel circuits when the use of LOS systems is not feasible or desirable. A typical TROPO link spans a distance between 80 and 480 km. The transmitter power is normally between 1 kW and 10 kW and the receiver has a noise figure as low as 3 dB. The antenna varies from transportable parabolic to fixed-billboard type antenna with typical gains ranging from 38 to 50 dBi. The system reliability is attained through the use of space, angle, and/or frequency-diversity techniques. Typical equipments are listed in Table 30 and three typical systems are discussed in the following paragraphs.

Table 30

TYPICAL TROPOSPHERIC SCATTER EQUIPMENT IN THE BAND 4400-4500 MHz

	Transmitter			Receiver	
Equipment Nomenclature	Power (kW)	Antenna Gain (dBi)	Emission Bandwidth (MHz)	Noise Figure (dB)	Antenna Gain (dBi)
AN/TRC-97 (·)	1.0	38.0	1.0F9	5.0	38.0
AN/TRC-132A	10.0	49.0	5.0F9	9.0	49.0
AN/GRC-143	1.0	40.0	2.3F9	4.0	40.0
AN/TRC-170(V1)	6.6	45.0	3.5P9	3.0	45.0
-170(V2)	1.85	41.0	3.5P9	3.0	41.0
-170(V3)	2.0/0.65	41.0	3.5P9	3.0	41.0

The AN/TRC-97 (·) is a transportable or fixed-tactical TROPO set that has similar characteristics to the LOS version, except the transmitter has a 1 kW power amplifier. This family of systems was developed by the U.S. Air Force and has been operating since 1963.

The AN/TRC-132 (A) is a heavy-route TROPO system. It has two complete transmitters and four receivers. Hence, it has the capability of operating in either dual-space-diversity mode or quad-diversity (space and frequency) mode. This family of systems is designed for use over long distances, typically 320 to 480 km.

The AN/TRC-170 family of tactical TROPO terminals is presently under full-scale development by the Tri-Service Tactical Communication Program (TRI-TAC) under the guidance of USAF/ESD. This equipment employs digital transmission techniques and is intended as a replacement for the present AN/TRC-97. The nominal range capability and the diversity mode for the AN/TRC-170 family is given as follows:

Equipment	Diversity Mode	Nominal Range (km)
AN/TRC-170 V1	Quad (frequency and space)	321 (200 miles)
AN/TRC-170 V2	Quad (frequency and space)	241 (150 miles)
AN/TRC-170 V3	Dual (frequency or space)	161 (100 miles)

These nominal range capabilities are under typical deployment, but substantially greater ranges could be achieved depending on the combination of terrain features and the channel capacity. The digital transmission capabilities are from 128 kbps to 2048 kbps. The low-noise amplifier is a thermoelectric cooled FET device that provides 27 dB gain with a noise figure of 1.8 dB.

The AN/TRC-170 has undergone a System Review under the provisions of Part 8.3 of the NTIA Manual. The System Review indicated that this system meets the applicable specifications of Chapter 5 of the NTIA Manual for frequency tolerance and spurious emission levels. The System Review indicated that all three versions of the AN/TRC-170 are capable of producing field intensity levels in excess of those specified in 29 CFR 1910.97 as the safe exposure limit for personnel. The maximum power density expected for each configuration of the AN/TRC-170 and the distance out from the antenna where the 10 mW/cm^2 will be exceeded within the mainbeam are as follows:

AN/TRC-170	Maximum Power Density (mW/cm^2)	Safe Distance (meters)
V1	160	384
V2	121	133
V3	121	133
V3 (LO-PWR)	37	73

MOBILE SERVICE

Radio Command and Drone Control

This band has been designated by the Military Communications Electronics Board (MCEB) for radio drone control operations. The Integrated Target Control System (ITCS) is a radio drone control system now being used in this band. The ITCS integrates the functions of command, control, tracking, and telemetry into a single system. Basically, the ground control station transmits ranging and command data and the transponder on the target simultaneously transmits telemetry data for tracking and performance monitoring by the control station. The technical characteristics of the equipment components of the ITCS system are summarized in Table 31. The radius of operation for this system is typically between 130 and 400 km.

Table 31

TYPICAL CHARACTERISTICS OF THE ITCS COMPONENTS

Transmitter					Receiver	
Component Nomenclature	Function	Power (Watts)	Antenna Gain (dBi)	Emission Bandwidth (MHz)	Sensitivity (dBW)	Antenna Gain (dBi)
AN/TFW-9 & AN/TSW-10	Transportable Control Station	250 800	35.5 33.0	1.0F9 1.0F9	-132 -132	35.5 33.0
AN/PSW-1	Portable Control Station	250	25.0	1.0F9	-138	25.0
AN/DKW-1	Target Drone Transponder	2.5	-3.0	1.0F9	-123	-3.0

A similar system designed to provide command, via relay pods carried aboard an aircraft, to a remotely piloted vehicle (RPV) is also operating in the 4500-4800 MHz band. The telemetry and video information from the RPV also operate in this band.

At the present time, a stage 4 (operational) system review has been granted to the U.S. Army for its MQM-33C Command Control System (SPS5029). This system is intended to be used for control of pilotless drone aircraft. The transmitter is located on the ground while the receiver is located in the drone. The System Review indicated that the MQM33C conforms to all applicable standards given in Section 5.2.3 of the NTIA Manual and the transmitters are not expected to produce power density in excess of 10 mV/cm^2.

Television Ordnance Scoring System (TOSS)

The TOSS is an ordnance scoring system that locates the impact point of ordnance dropped from aircraft in a training or operational test environment.

Experimental

The number of assignments for experimental stations for each agency was given previously in Table 28. Three of these assignments are for "XC" stations used for evaluation or testing under Government contract of electronic equipments or systems in a design or development stage. A second class of experimental assignments (designated XR or XT) are indicative of stations used in basic research or for evaluation or testing of electronic equipment or systems that have been developed for operational use. This latter category includes such activities as site selection, transmission path surveys, predelivery factory checkout and antenna calibration, and includes 3 assignments to non-Government companies to support Government research and development.

Following is a list of the unclassified systems in the Systems Review File for the 4400-4500 MHz band. (There are three classified systems which, if described here, would not particularly add to the conclusions made in this report so are not included).

SYSTEM	SPONSORING AGENCY	REVIEW* STAGE
Integrated Target Control Systems (ITCS)	NA	0
Television Ordnance Scoring System (TOSS)	AF	4
Space Transportation System (Space Shuttle)	NASA	4
Remotely Piloted Vehicle System (RPV)	AR	2
Video Mirowave Link	DOE	4
COMPASS COPE	AF	1
Airborne RPV Radar Telecommand and Data Relay	AF	2
Integrated Communications and Navigation System (ICNS)	AR	2
Nuclear Emergency Search Team	DOE	4
Digital Radio and Multiplex Acquisition Systems	AR	4
AN/TRC-170	AF	4
MQM-33C Command Control System	AR	4
AN/GRC-144	AR	4
Vega 6156/6157 Target Control System	N	3
Nevada Test Site Backbone Microwave System	DOE	4
Digital Microwave Radio	AR	1

The basic requirements, spectrum use and powers for these systems are not much different than existing systems in the 4400-4990 MHz band.

* - Review Stage Status
0 - Stage of review was not indicated
1 - Conceptual
2 - Experimental
3 - Developmental
4 - Operational

CONCLUSIONS

The 4400-4500 MHz band is not highly saturated with assignments. There are a few areas such as southern California and the northeastern seaboard where tight management by Government area frequency control personnel is necessary. Because the systems in the band include military tactical radio communication links, many which are portable, any increased use of the band would have to be well coordinated with the various military agencies involved and would of necessity be secondary to their needs. As seen from the Systems Review File there are many new systems coming into the band. This trend appears to be continuing for the foreseeable future.

Since so many of the other Government exclusive bands which are allocated on a primary basis to Fixed and Mobile Services (1710-1850 MHz, 2220-2290 MHz, 7125-8450 MHz) are becoming very crowded, the 4400-4990 MHz band will most likely see much greater growth in the next 10 to 20 years than it has in the past 10 years. Because of important military test facilities and tactical troposcatter communication systems in the band, it would be very difficult to coordinate usage with non-Government entities.

THE 4800-4990 MHz BAND

INTRODUCTION

The 4800-4990 MHz band is a Government exclusive band with primary allocations to the Fixed and Mobile Services. There are 305 assignments in the band but this does not reflect 69 range tuned assignments listed in the 4400-4500 MHz band which tune from 4400 to 4990 MHz. The majority of assignments (58%) are to the Fixed Service. An NTIA Spectrum Resource Assessment for the 4400-4990 MHz band was completed in 1981 (Ng, 1981). Much of the material presented here will be excerpts or summaries from that report. New systems coming into the band are functionally state-of-the-art versions similar to systems presently being used in the band.

RULES AND REGULATIONS

Nationally, the 4800-4990 MHz band is allocated to the Fixed and Mobile Services on a coequal primary basis. The only changes to this band as a result of WARC 79 were the addition of footnotes 720, 778, and US257. Table 32 includes excerpts from the International and U.S. National Table of Frequency Allocations (May, 1983). Table 33 shows the allocations for the 4800-4990 MHz band, and adjacent bands along with the applicable footnotes. Three of the footnotes deal with the sharing and protection of the Radio Astronomy Services in portions of the band. International footnote 720 allocates the 4950-4990 MHz portion of the band to the Space Research and Earth Exploration-Satellite (both passive) Services on a secondary basis, which constitutes sharing by footnote.

TABLE 32

EXCERPTS FROM THE INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS FOR THE 4800-4990 MHz BAND

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
4500-4800 FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE 792			4500-4800	US245	FIXED MOBILE	FIXED-SATELLITE (Space-to-Earth)
4800-4990 FIXED MOBILE 793 Radio Astronomy 720 778 794			4800-4990	US203 US257 720 778	FIXED MOBILE	
4990-5000 FIXED MOBILE except aeronautical mobile RADIO ASTRONOMY Space Research (Passive) 795			4990-5000	US74 US246	RADIO ASTRONOMY Space Research (Passive)	RADIO ASTRONOMY Space Research (Passive)

International Footnotes:

720 - The bands 1 370 -- 1 400 MHz, 2 640 -- 2 655 MHz, 4 950 -- 4 990 MHz and 15.20 -- 1535 GHz are also allocated to the space research (passive) and earth exploration-satellite (passive) services on a secondary basis.

778 - In making assignments to stations of other service, administrations are urged to take all practicable steps to protect the spectral line observations of the radio astronomy service from harmful interference in the bands 3 260 -- 3 267 MHz, 3 332 -- 3 339 MHz, 3 345.8 -- 3 352.5 MHz and 4 825 -- 4 835 MHz. 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).

U.S. Footnotes:

US 203 - Radio astronomy observations of the formaldehyde line frequencies 4825-4835 MHz and 14.470-14.500 GHz may be made at certain radio astronomy observations as indicated below:

Table 32 (Continued)

Bands to be observed 4 GHz	14 GHz	Observatory
X		National Astronomy and Ionosphere Center Arecibo, Puerto Rico
X	X	National Radio Astronomy Observatory Green Bank, W. Va.
X	X	National Radio Astronomy Observatory Socorro, New Mexico
X	X	Hat Creek Observatory (U. of Calif.) Hat Creek, Cal.
X	X	Haystack Radio Observatory (MIT-Lincoln Lab) Tyngsboro, Mass.
X	X	Owens Valley Radio Observatory (Cal. Tech.) Big Pine, Cal.
	X	Five College Radio Astronomy Observatory Quabbin Reservoir (near Amherst) Massachusetts

Every practicable effort will be made to avoid the assignment of frequencies to stations in the fixed or mobile services in these bands. Should such assignments result in harmful interference to these observations, the situation will be remedied to the extent practicable.

US257 - Radio astronomy observations may be made in the 4950-4990 MHz band at certain Radio Astronomy Observatories indicated below:

Hat Creek Observatory Hat Creek, California	Rectangle between latitudes 40° 00' N and 42° 00' N and between longitudes 120° 15' W and 122° 15' W
Owens Valley Radio Observatory Big Pine, California	Two continguous rectangles, one between latitudes 36° 11' N and 37° 00' N and longitudes 117° 40' W and 118° 30' W and the second between latitudes 38° 00' N and longitudes 118° 00' W and 118° 50' W.
Haystack Radio Observatory Tyngsboro, Massachusetts and Five College Radio Astronomy Observatory Quabbin Reservoir (near Amherst, MA).	Rectangle between latitudes 41° 00' N and 43° 00' N and between longitudes 71° 00' and 73° 00' W.

Table 32 (Continued)

National Astronomy and Ionosphere Center Arecibo, Puerto Rico	Rectangle between latitudes 17° 30' N and 19° 00' N and between longitudes 65° 10' W and 68° 00' W.
National Radio Astronomy Observatory Socorro, New Mexico	Rectangle between latitudes 32° 30' N and 35° 30' N and longitudes 106° 00' W and 109° 00' W.
National Radio Astronomy Observatory Green Bank, West Virginia	Rectangle between latitudes 37° 30' N and 39° 15' N and between longitudes 78° 30' W and 80° 30' W.

Every practicable effort will be made to avoid the assignment of frequencies in the band 4950-4990 MHz to stations in the Fixed and Mobile Services within the geographic areas given above. In addition, every practicable effort will be made to avoid the assignment of frequencies in this band to stations in the Aeronautical Mobile Service that operate outside those geographic areas, but which may cause harmful interference to the listed observatories. Should such assignments result in harmful interference to these observatories, the situation will be remedied to the extent practicable.

The technical standards, minimum performance requirements, and design objectives applicable to transmitters, receivers, and antennas used by Government radio stations are contained in Chapter 5 of the NTIA Manual (NTIA, 1982). The Manual also stipulates that if technical criteria are not specified, the appropriate provisions of the ITU Radio Regulations normally should apply, or the current CCIR Recommendations should be used as guidelines.

A synopsis of the Government technical standards (Part 5.10 of the NTIA Manual) for fixed systems employing line-of-sight, point-to-point and transportable type equipments (except for systems designed to use scatter techniques) using the band 4800-4990 MHz is given in Appendix F. In addition to these minimum standards the use of frequency diversity for line-of-sight (LOS) transmissions is permitted provided that such use is justified.

MAJOR SYSTEMS AND SPECTRUM USAGE

INTRODUCTION

This section provides a general description of the national frequency spectrum usage, and typical characteristics of equipment operating in the band 4800-4990 MHz. The usage is summarized according to the information contained in the GMF, NGMF, IRAC/SPS System Review File, inputs from the IRAC representatives of the various Government agencies, and previously published reports.

Within the United States, the military agencies are the major users of the 4800-4990 MHz band. The systems authorized to operate in this band typically have a tuning capability over the 4400-4990 MHz band. At the present time, there are 70 assignments that have this capacity. Figure 25 shows the assignment trend of the 4400-4990 MHz band from January 1972 to January 1983 which includes the band of interest here. The statistics in past years have been kept over this total band (4400-4990 MHz) and the long-term trend for the 4800-4990 MHz band cannot be separated. The graph shows an apparent decrease in assignments over the long run; however, if Navy assignments are taken out as shown in the lower curve, the assignments show a slight increase over the past 5 years. The Navy assignments show a decrease based on the phasing out of certain equipment in the band. (No statistics on number of assignments are available for the period shown by dashed line in Figure 25.)

As of June, 1983, the GMF contained 305 frequency assignments in the 4800-4990 MHz band which are used by five Government agencies. The agencies and the number of assignments for each is tabulated in Table 33. A percentage distribution of assignments for the stations is also shown in this table. The CONUS geographical distribution of assignments in the 4800-4990 MHz band is shown in Figure 26. In addition, there are 41 transmitter and 41 receiver locations not plotted due to no specific coordinates in the GMF.

Half of the military assignments have a GMF record note S189 and/or S362. Note S189 is designated for use as a "Tactical and Training" assignment that indicates the frequency is being used to train operators in the use of the equipment; such training normally takes place during military exercises. Note S362 indicates the frequency is designated for transportable equipment. The radius of operation of this transportable equipment is specified by the Code "RAD" in the GMF. This provision provides the description of an area of operation as a mileage radius extending from the given transmitter and receiver antenna locations.

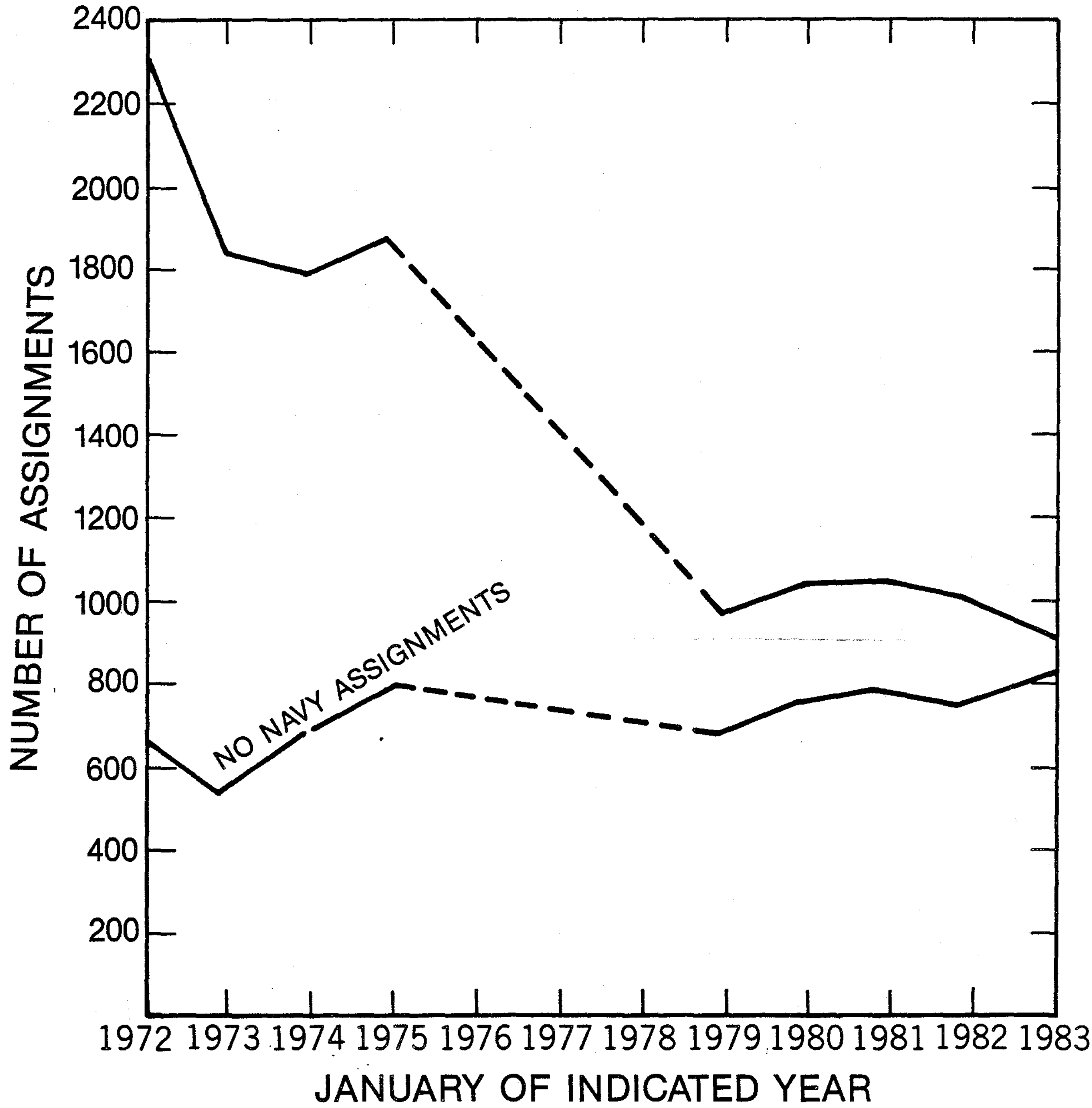


Figure 25. Growth Trends for the 4400-4990 MHz Band from 1972 to 1983.

TABLE 33

GOVERNMENT ASSIGNMENTS BY AGENCY AND STATION CLASS IN THE 4800-4990 MHz BAND

AGENCY/ SERVICE	STATION CLASS										NUMBER OF OF ASSIGNMENTS	PERCENTAGE OF ASSIGNMENTS
	FLD	FX	FXE	LR	MA	MOD	MOEA	XC	XD	XT		
AIR FORCE		96		1			1	1		36	135	44.2%
ARMY	15	38			7	3			2	3	68	22.3%
DOE		5	10								15	5.0%
NASA		1									1	0.3%
NAVY		28				18			36	4	86	28.2%
NUMBER OF ASSIGNMENTS	15	168	10	1	7	21	1	1	38	43	TOTAL 305	
PERCENTAGE OF ASSIGNMENTS	5%	55%	3.2%	0.3%	2.3%	7%	0.3%	0.3%	12.5%	14.1%		

FLD - Telecommand Land Station

FX - Fixed Station

FXE - Telemetering Fixed Station

LR - Radiolocation Land Station

MA - Aircraft Station

MOD - Telecommand Mobile Station

MOEA - Aeronautical Telemetering Mobile Station

XC - Experimental Contract Development Station

XD - Experimental Development Station

XT - Experimental Testing Station

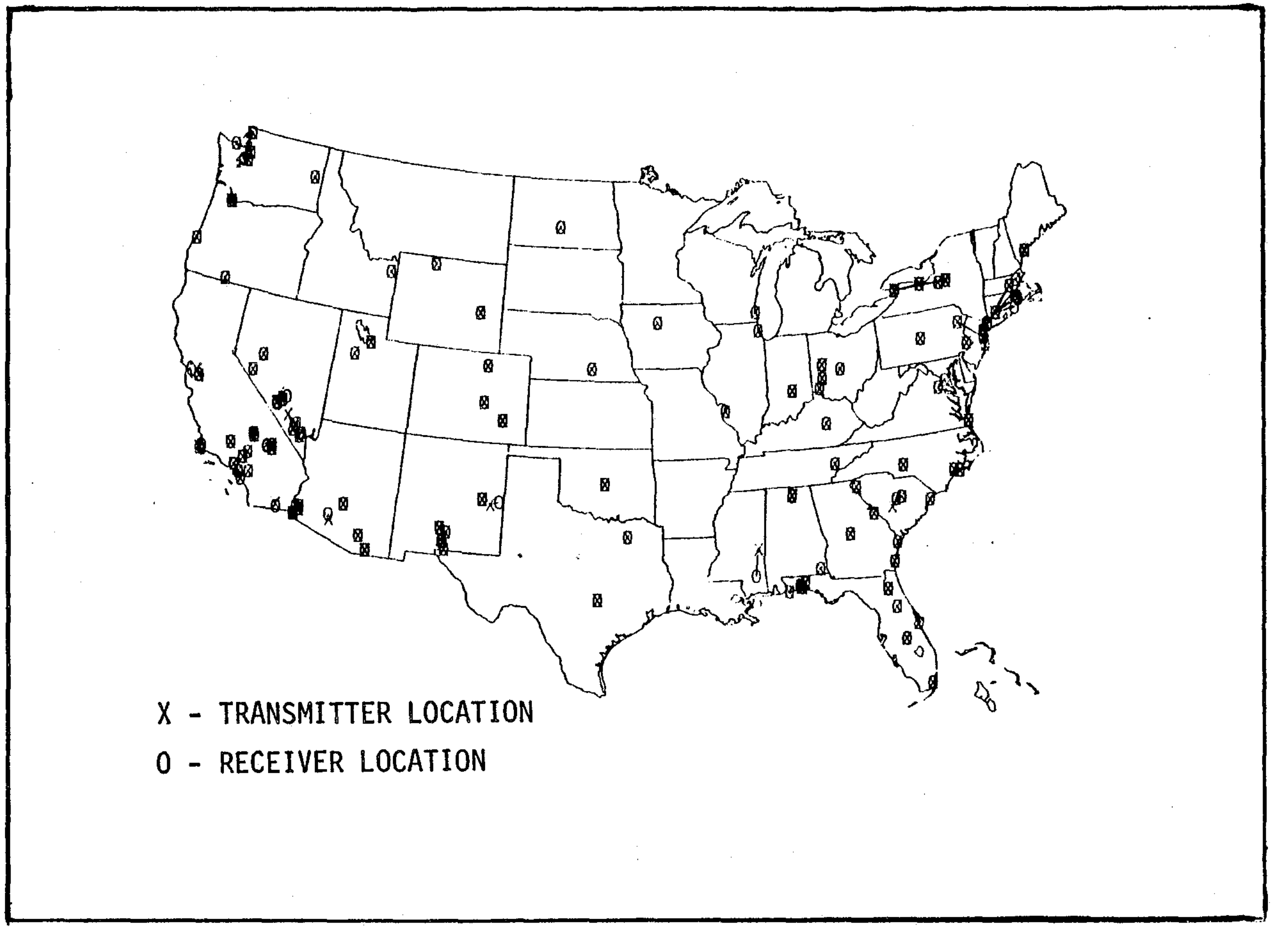


Figure 26. Geographic Distribution of Assignments in the 4800-4990 MHz Band.

Figure 27 shows the frequency assignment distribution for the 4800-4990 MHz band. There would seem to be a possibility of expansion of the fixed and mobile assignments in this band. However, the military tactical communications in the band must be protected and have priority in time of national disaster or war. Any new assignments should be well coordinated as they now are.

The usage of the Fixed and Mobile Services in the 4800-4990 MHz band by Government agencies can be grouped into the following categories:

FIXED SERVICE

Line-of-Sight (LOS) Radio Relay

Fixed and transportable point-to-point LOS radio-relay equipments operating in this band are characterized by moderate transmitter power, high gain directional antenna, low capacity, and moderate receiver sensitivity. The radius of operation of the transportable equipments identified in the GMF varies from 8 km to 480 km.

The technical characteristics of representative equipment are summarized in Table 34. A few of the common LOS systems are highlighted in the following paragraphs.

Table 34

TYPICAL LINE-OF-SIGHT RADIO RELAY EQUIPMENT IN THE BAND 4400-4500 MHz

	Transmitter			Receiver	
Equipment Nomenclature	Power (Watts)	Antenna Gain (dBi)	Emission Bandwidth (MHz)	Noise Figure (dB)	Antenna Gain (dBi)
AN/TRC-97	15.0	38.0	1.0F9	5.0	38.0
AN/GRC-144	2.0	33.0	4.1F9	11.0	33.0
AN/TRC-027	3.0	30.0	10.0P9	13.0	30.0
AN/GSQ-120	0.5	37.0	1.0F9	---	37.0
TER/TCM 602	1.0	33.0	36.0F9	8.5	33.0
AN/TRC-144	0.1	33.0	3.0F9	---	33.0

The AN/TRC-97 is a fixed or transportable tactical radio set capable of providing 24-voice channels or 23-voice channels plus 16 teletype channels over a few kilometers in the LOS mode. It has a low power transmitter, two complete receivers, and two identical 2.4 meter parabolic antennas. The system is capable of operating either in a nondiversity or a dual space diversity configuration.

The AN/GSQ-120 is a radar data transfer system and provides data transfer links for the 407 L system. Radar data is time division multiplexed on an FM carrier for remoting the data to a central site.

The AN/TRC-27 is a tactical LOS set which was designed primarily for operating in a forward area. It may be used in a radio relay net configuration with the stations spaced 15 km or more apart. The system is a 24 voice channel equipment with 30 rf channels in 20 MHz increments.

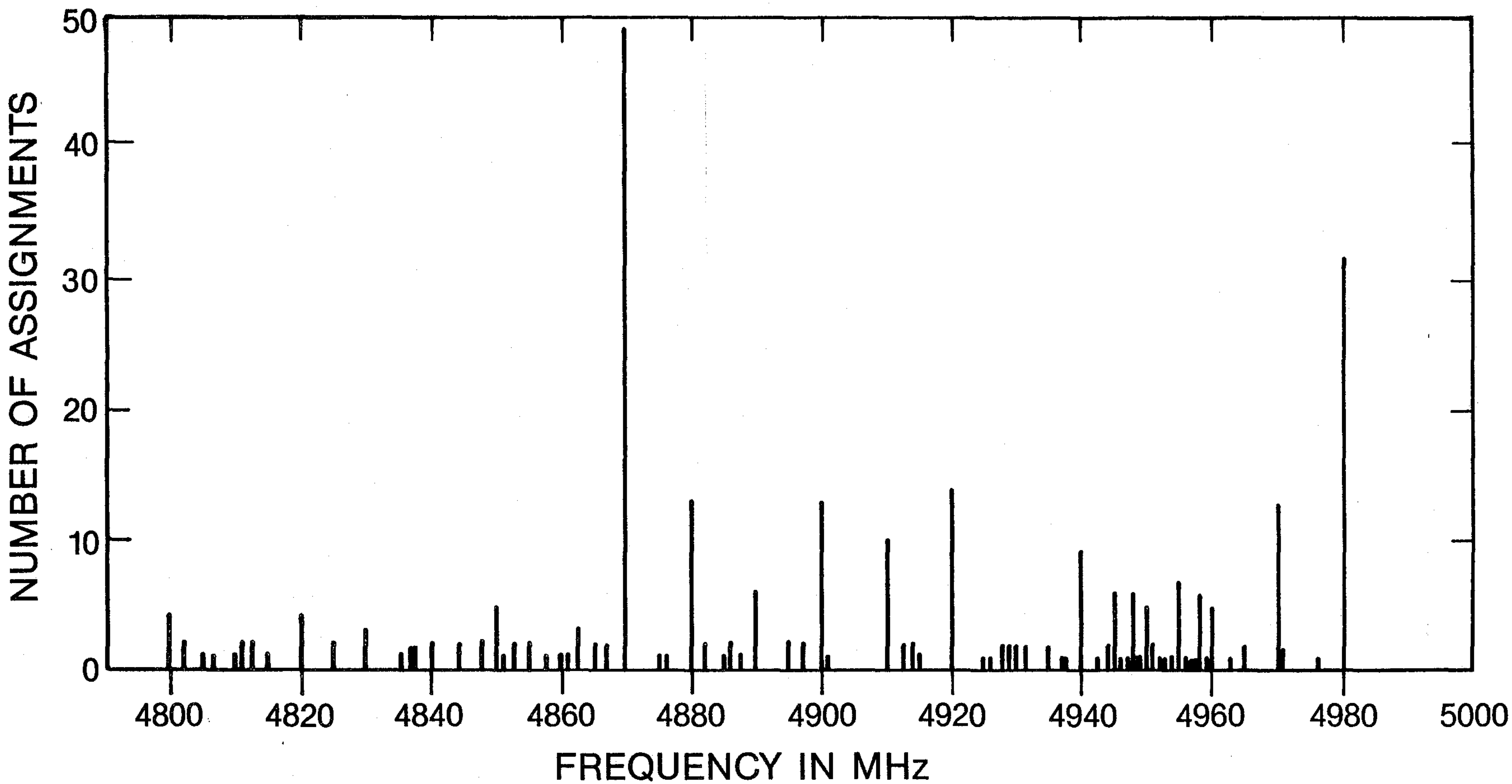


Figure 27. Frequency Assignment Distribution for the 4800-4990 MHz Band.

Tropospheric Scatter (TROPO) Radio Relay

Fixed and transportable TROPO communications systems are being used extensively in this band to provide reliable multichannel circuits when the use of LOS systems is not feasible or desirable. A typical TROPO link spans a distance between 80 and 480 km. The transmitter power is normally between 1 kW and 10 kW and the receiver has a noise figure as low as 3 dB. The antenna varies from transportable parabolic to fixed-billboard type antenna with typical gains ranging from 38 to 50 dBi. The system reliability is attained through the use of space, angle and/or frequency-diversity techniques. Typical equipments are listed in Table 35 and three typical systems are discussed in the following paragraphs.

Table 35

TYPICAL TROPOSPHERIC SCATTER EQUIPMENT IN THE BAND 4400-4500 MHz

	Transmitter			Receiver	
Equipment Nomenclature	Power (kW)	Antenna Gain (dBi)	Emission Bandwidth (MHz)	Noise Figure (dB)	Antenna Gain (dBi)
AN/TRC-97 (·)	1.0	38.0	1.0F9	5.0	38.0
AN/TRC-132A	10.0	49.0	5.0F9	9.0	49.0
AN/GRC-143	1.0	40.0	2.3F9	4.0	40.0
AN/TRC-170(V1)	6.6	45.0	3.5P9	3.0	45.0
-170(V2)	1.85	41.0	3.5P9	3.0	41.0
-170(V3)	2.0/0.65	41.0	3.5P9	3.0	41.0

The AN/TRC-97 (·) is a transportable or fixed-tactical TROPO set that has similar characteristics to the LOS version, except the transmitter has a 1 kW power amplifier. This family of systems was developed by the U.S. Air Force and has been operating since 1963.

The AN/TRC-132 (A) is a heavy-route TROPO system. It has two complete transmitters and four receivers. Hence, it has the capability of operating in either dual-space-diversity mode or quad-diversity (space and frequency) mode. This family of systems is designed for use over long distances, typically 320 to 480 km.

The AN/TRC-170 family of tactical TROPO terminals is presently under full-scale development by the Tri-Service Tactical Communication Program (TRI-TAC) under the guidance of USAF/ESD. This equipment employs digital transmission techniques and is intended as a replacement for the present AN/TRC-97. The nominal range capability and the diversity mode for the AN/TRC-170 family is given as follows:

Equipment	Diversity Mode	Nominal Range (km)
AN/TRC-170 V1	Quad (frequency and space)	321 (200 miles)
AN/TRC-170 V2	Quad (frequency and space)	241 (150 miles)
AN/TRC-170 V3	Dual (frequency or space)	161 (100 miles)

These nominal range capabilities are under typical deployment, but substantially greater ranges could be achieved depending on the combination of terrain features and the channel capacity. The digital transmission capabilities are from 128 kbps to 2048 kbps. The low-noise amplifier is a thermoelectric cooled FET device which provides 27 dB gain with a noise figure of 1.8 dB.

The AN/TRC-170 has undergone a System Review under the provisions of Part 8.3 of the NTIA Manual. The System Review indicated that this system meets the applicable specifications of Chapter 5 of the NTIA Manual for frequency tolerance and spurious emission levels. The System Review indicated that all three versions of the AN/TRC-170 are capable of producing field intensity levels in excess of the mW/cm^2 specified in 29 CFR 1910.97 as the safe exposure limit for personnel. The maximum power density expected for each configuration of the AN/TRC-170 and the distance out from the antenna where the 10 mW/cm^2 will be exceeded within the mainbeam are as follows:

AN/TRC-170	Maximum Power Density (mW/cm^2)	Safe Distance (meters)
V1	160	384
V2	121	133
V3	121	133
V3 (LO-PWR)	37	73

MOBILE SERVICE

Radio Command and Drone Control

This band has been designated by the Military Communications Electronics Board (MCEB) for radio drone control operations. The Integrated Target Control System (ITCS) is a radio drone control system now being used in this band. The ITCS integrates the functions of command, control, tracking, and telemetry into a single system. Basically, the ground control station transmits ranging and command data and the transponder on the target simultaneously transmits telemetry data for tracking and performance monitoring by the control station. The technical characteristics of the equipment components of the ITCS system are summarized in Table 36. The radius of operation for this system is typically between 130 and 400 km.

Table 36

TYPICAL CHARACTERISTICS OF THE ITCS COMPONENTS

		Transmitter			Receiver	
Component Nomenclature	Function	Power (Watts)	Antenna Gain (dBi)	Emission Bandwidth (MHz)	Sensitivity (dBW)	Antenna Gain (dBi)
AN/TFW-9 & AN/TSW-10	Transportable Control Station	250 800	35.5 33.0	1.0F9 1.0F9	-132 -132	35.5 33.0
AN/PSW-1	Portable Control Station	250	25.0	1.0F9	-138	25.0
AN/DKW-1	Target Drone Transponder	2.5	-3.0	1.0F9	-123	-3.0

A similar system designed to provide command, via relay pods carried aboard an aircraft, to a remotely piloted vehicle (RPV) is also operating in the 4500-4800 MHz band. The telemetry and video information from the RPV also operate in this band.

At the present time, a stage 4 (operational) system review has been granted to the Army for its MQM-33C Command Control System (SPS-5029). This system is intended to be used for control of pilotless drone aircraft. The transmitter is located on the ground while the receiver is located in the drone. The System Review indicated that the MQM-33C conforms to all applicable standards given in Section 5.2.3 of the NTIA Manual and the transmitters are not expected to produce power density in excess of 10 mV/cm^2.

Television Ordnance Scoring System (TOSS)

The TOSS is an ordnance scoring system that locates the impact point of ordnance dropped from aircraft in a training or operational test environment.

Experimental

The number of assignment for experimental stations for each agency was given previously in Table 33. Three of these assignments are for "XC" stations used for evaluation or testing under Government contract of electronic equipments or systems in a design or development stage. A second class of experimental assignments (designated XD or XT) is indicative of stations used in basic research and development or for evaluation or testing of electronic equipment or systems which have been developed for operational use. This latter category includes such activities as site selection, transmission path surveys, predelivery factory checkout and antenna calibration.

Following is a list of the unclassified systems in the Systems Review File for the 4800-4990 MHz band. (There are three classified systems that are not included).

SYSTEM	SPONSORING AGENCY	REVIEW* STAGE
Integrated Target Control System (ITCS)	NA	0
Television Ordnance Scoring System (TOSS)	AF	4
Remotely Piloted Vehicle System (RPV)	AR	2
Video Mirowave Link	DOE	4
COMPASS COPE	AF	1
Airborne RPV Radar Telecommand and Data Relay	AF	2
Integrated Communications and Navigation System (ICNS)	AR	2
Nuclear Emergency Search Team	DOE	4
Digital Radio and Multiplex Acquisition Systems	AR	4
AN/TRC-170	AF	4
MQM-33C Command Control System	AR	4
AN/GRC-144	AR	4
Nevada Test Site Backbone Microwave System	DOE	4
Digital Microwave Radio	AR	1

The basic requirements, spectrum use, and powers for these systems are not much different than existing systems in the 4400-4990 MHz band.

* - Review Stage Status
0 - Stage of review was not indicated
1 - Conceptual
2 - Experimental
3 - Developmental
4 - Operational

CONCLUSIONS

The 4800-4990 MHz band is not highly saturated with assignments. There are a few areas such as southern California and the northeastern seaboard where tight management by Government area frequency control personnel is necessary. Because the systems in the band include military tactical radio communication links, many which are portable, any increased use of the band would have to be well coordinated with the various military agencies involved and would of necessity be secondary to their needs. As seen from the Systems Review File there are many new systems coming into the band. This trend appears to be continuing for the foreseeable future.

Since so many of the other Government exclusive bands that are primarily allocated to Fixed and Mobile Services (1710-1850 MHz, 2200-2280 MHz, 7125-8450 MHz) are becoming very crowded, the 4400-4990 MHz band will most likely see much greater growth in the next 10 to 20 years than it has in the past 10 years. Careful planning and good spectrum management must be accomplished in the growth of this important band to assure the national security. Because of the importance of this band to military test facilities and the use of high power troposcatter communication systems in the band, private sector use, is not recommended at this time.

THE 7125-8450 MHz BAND

INTRODUCTION

The 7125-8450 MHz band is a Government exclusive band, however, there are a number of bands that are shared with non-Government users by footnote, i.e. see U.S. footnote 258. The band is divided into 13 subbands that contain the Fixed Service either alone (3 subbands) or shared with other Government services (10 subbands). The Fixed Service predominates with 6,706 assignments out of a total of 7,716 (87%). The FAA is the largest user of the band with 3,593 assignments (47%). The FAA use is mainly for the nation's air traffic control network for fixed microwave links that transmit radar, beacon, and control information from a remote radar site to an air traffic control center with command and control signals back to the radar. This is a very heavily used band and is critical to many Government operations, both military and civilian. Twenty-one Government departments, agencies, and services have assignments in this band.

ALLOCATIONS, RULES AND REGULATIONS

The present allocation table (NTIA 1983) for the 7125-8450 MHz portion of the spectrum is shown in Table 37. There were some major changes to the allocation tables as a result of WARC-79. Table 38 shows the pre-WARC-79 allocation table for this band. The old 7125-7250 MHz band which was allocated to the Fixed and Mobile Services on a primary coequal basis was divided into three bands, 7125-7190 and 7235-7250 MHz allocated exclusively to the Fixed Service and 7190-7235 MHz allocated to Fixed and Space Research (Earth-to-space) on a coequal primary basis. The old 7250-7300 MHz band, which had been allocated to the Fixed-Satellite Service exclusively, is now shared on a coequal primary basis with the Mobile-Satellite Service and with the Fixed Service secondary. Actually, Fixed Service assignments predominate in this subband with 245 of the 359 assignments. Footnote G117 states that the Government Fixed-Satellite and Mobile-Satellite Services are limited to military systems. The 7300-7450 MHz subband still has Fixed and Fixed-Satellite Services as primary coequal but the Mobile Service have been dropped and Mobile-Satellite (space-to-Earth) added as a secondary service. Again, the satellite services are limited to military systems.

TABLE 37

EXCERPTS FROM PRESENT (MAY, 1983) INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
7075-7250	FIXED MOBILE		7075-7125	809		FIXED MOBILE NG118
			7125-7190	US252 809	FIXED G116	
			7190-7235	809	FIXED SPACE RESEARCH (Earth-to-space)	
	809 810 811		7235-7250	809	FIXED	
7250-7300	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE 812		7250-7300		FIXED-SATELLITE (Space-to-Earth) MOBILE-SATELLITE (Space-to-Earth) Fixed G117	
7300-7450	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile 812		7300-7450		FIXED FIXED-SATELLITE (Space-to-Earth) Mobile-Satellite (Space-to-Earth) G117	
7450-7550	FIXED FIXED-SATELLITE (Space-to-Earth) METEOROLOGICAL-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile		7450-7550		FIXED FIXED-SATELLITE (Space-to-Earth) METEOROLOGICAL- SATELLITE (Space-to-Earth) Mobile-Satellite (Space-to-Earth) G104 G117	
7550-7750	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile		7550-7750		FIXED FIXED-SATELLITE (Space-to-Earth) Mobile-Satellite (Space-to-Earth) G117	
7750-7900	FIXED MOBILE except aeronautical mobile		7750-7900		FIXED	
7900-7975	FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE 812		7900-8025		Fixed FIXED-SATELLITE (Earth-to-Space) MOBILE-SATELLITE (Earth-to-Space)	

TABLE 37 (Continued)

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
7975-8025	FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE 812				G117	
8025-8175 FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE Earth Explora- tion-Satellite (Space-to-Earth) 813 815	8025-8175 EARTH EXPLORA- TION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE 814	8025-8175 FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE Earth Exploration- Satellite (Space-to-Earth) 813 815	8025-8175	US258	EARTH EXPLORA- TION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-Space) Mobile-Satellite (Earth-to-Space) (No Airborne Transmission) G117	
8175-8215 FIXED FIXED-SATELLITE (Earth-to-Space) METEOROLOGICAL- SATELLITE (Earth-to-Space) MOBILE Earth Explora- tion-Satellite (Space-to-Earth) 813 815	8175-8215 EARTH EXPLORA- TION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-Space) METEOROLOGICAL- SATELLITE (Earth-to-Space) MOBILE 814	8175-8215 FIXED FIXED-SATELLITE (Earth-to-Space) METEOROLOGICAL- SATELLITE (Earth-to-Space) MOBILE Earth Exploration- Satellite (Space-to-Earth) 813 815	8175-8215	US258	EARTH EXPLORA- TION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-Space) METEOROLOGICAL- SATELLITE (Earth-to-Space) Mobile-Satellite (Earth-to-Space) (No Airborne Transmissions) G104 G117	
8215-8400 FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE Earth Explora- tion (Space-to-Earth) 813 815	8215-8400 EARTH EXPLORA- TION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE 814	8215-8400 FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE Earth Exploration- Satellite (Space-to-Earth) 813 815	8215-8400	US258	EARTH EXPLORA- TION-SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-Space) Mobile-Satellite (Earth-to-Space) (No Airborne Transmissions) G117	
8400-8500	FIXED MOBILE except aeronautical mobile SPACE RESEARCH (Space-to-Earth) 816 817 818	8400-8450	8400-8450		FIXED SPACE RESEARCH (Space-to-Earth) (Deep Space Only)	
			8450-8500		FIXED SPACE RESEARCH (Space-to-Earth)	SPACE RESEARCH (Space-to-Earth)

TABLE 37 Footnotes

809 - In the band 7075-7250 MHz, passive microwave sensor measurements are carried out. Administrations should bear in mind the needs of the earth exploration-satellite (passive) and Space Research (passive) services in their future planning of this band.

US252 - The band 7145-7190 is also allocated for Earth-to-space transmissions in the Space Research Service, limited to deep space communications of Goldstone, California.

G116 - The band 7125-7155 MHz is also allocated for Earth-to-space transmissions in the Space Operations Service at a limited number of sites (not to exceed two), subject to established coordination procedures.

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.

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

US258 - In the band 8024-8400 MHz, the non-Government earth exploration-satellite service (space-to-Earth) is allocated on a primary basis. Authorizations are subject to a case-by-case electromagnetic compatibility analysis.

TABLE 38

EXCERPTS FROM PRE-WARC-79 TABLE OF FREQUENCY ALLOCATIONS

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
6425-7250	FIXED MOBILE		7125-7250	G 392B	FIXED MOBILE	
7250-7300	FIXED-SATELLITE (Space-to-Earth) 392D 392G		7250-7300	G 392D US100	FIXED-SATELLITE (Space-to-Earth) G107	
7300-7450	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE 392D		7300-7450	G 392D	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE G107 G108	
7450-7550	FIXED FIXED-SATELLITE (Space-to-Earth) METEOROLOGICAL-SATELLITE (Space-to-Earth) MOBILE 392D		7450-7550	G 392D	FIXED FIXED-SATELLITE (Space-to-Earth) METEOROLOGICAL- SATELLITE (Space-to-Earth) G104 G107 G108	
7550-7750	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE 392D		7550-7750	G 392D	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE G107 G108	
7550-7900	FIXED MOBILE		7550-7900	G	FIXED MOBILE	
7900-7975	FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE		7900-7975	G	FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE G107 G108	
7975-8025	FIXED-SATELLITE (Earth-to-Space) 392H		7975-8025	G US100	FIXED-SATELLITE (Earth-to-Space) G107	
8025-8175 FIXED FIXED- SATELLITE (Earth-to- Space) MOBILE Earth Exploration- Satellite (Space-to- Earth) 394B	7025-8175 EARTH EXPLORATION SATELLITE (Space-to- Earth) FIXED FIXED-SATELLITE (Earth-to- Space) MOBILE	8025-8175 FIXED FIXED-SATELLITE (Earth-to- Space) MOBILE Earth Exploration- Satellite (Space-to- Earth)	8025-8175	G	EARTH EXPLORATION- SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE G102 G107 G108	

TABLE 38 (Continued)

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
8175-8215 FIXED FIXED- SATELLITE (Earth-to- Space) METEOROLOGI- CAL- SATELLITE (Earth-to- Space) MOBILE Earth Exploration- Satellite (Space-to- Earth) 394B	8175-8215 EARTH EXPLORATION SATELLITE (Space-to- Earth) FIXED FIXED- SATELLITE (Earth-to- Space) METEOROLOGI- CAL- SATELLITE (Earth-to- Space) MOBILE	8175-8215 FIXED FIXED-SATELLITE (Earth-to-Space) METEOROLOGICAL- SATELLITE (Earth-to-Space) MOBILE Earth Exploration- Satellite (Space-to-Earth)	8175-8215	G	EARTH EXPLORATION- SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-Space) METEOROLOGICAL- SATELLITE (Earth-to-Space) MOBILE G102 G103 G104 G107 G108	
8215-8400 FIXED FIXED- SATELLITE (Earth-to- Space) MOBILE Earth Exploration- Satellite (Space-to- Earth) 392 394B	8215-8400 EARTH EXPLORATION- SATELLITE (Space-to- Earth) FIXED FIXED- SATELLITE (Earth-to- Space) MOBILE	8215-8400 FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE Earth Exploration- Satellite (Space-to-Earth) 394	8215-8400	G	EARTH EXPLORATION SATELLITE (Space-to-Earth) FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE G102 G107 G108	
8400-8500	FIXED MOBILE SPACE RESEARCH (Space-to- Earth) 394A, 394D		8400-8500	G, NG	FIXED MOBILE SPACE RESEARCH (Space-to-Earth)	SPACE RESEARCH (Space-to-Earth)

The 7450-7550 MHz subband allocations remained the same except that the Mobile allocation was dropped and Mobile-Satellite (space-to-Earth) was added as a secondary allocation. The footnote G117 applies and G104 states that military space radio communications systems and meteorological-satellite installations will take whatever steps are necessary to assure compatible operations. The 7550-7750 MHz subband has the same allocation scheme as the 7300-7450 MHz subband with Mobile allocations dropped and the Mobile-Satellite Service added on a secondary basis. The 7750-7900 MHz subband now has the Fixed Service as the exclusive primary service with Mobile allocations being dropped. This does not propose any problem since there are presently no mobile assignments in this subband.

The 7900-8025 MHz subbands, which prior to post-WARC-79 allocations had shown Fixed, Fixed-Satellite, and Mobile Services as primary coequal, now show Fixed-Satellite (Earth-to-space) and Mobile-Satellite (Earth-to-space) on a coequal primary basis with the Fixed Service secondary and no Mobile allocation. There are now 416 assignments out of the total of 569 assignments that are designated by the various user agencies as in the Fixed Service. This band will see considerable growth in the use of the Government satellite communication services in the future. Again footnote G117 restricts Government use of Fixed and Mobile-Satellite allocations to the military systems.

In the subband 8025-8175 MHz the post-WARC-79 allocation remained the same for Earth Exploration-Satellite (space-to-Earth), Fixed, and Fixed-Satellite (Earth-to-space) Services. The Mobile Service was dropped and the Mobile-Satellite (Earth-to-space) Service was added on a secondary, noninterference basis. Added to the new allocation listing is the statement, "no airborne transmissions are allowed." The U.S. Footnote 258 applies in this band which allows the non-Government Earth Exploration-Satellite service (space-to-Earth) on a primary basis subject to case-by-case EMC analysis from 8024-8400 MHz. There are 772 assignments in the band and 638 (83%) are in the Fixed Service. The FAA has the largest number of assignments with 327 (42%) followed by Air Force with 117 (15%). Fourteen Government departments, agencies, and services have assignments in this subband. Footnote G117 is applicable to this subband.

The 8175-8215 MHz subband is essentially the same as the Pre-WARC-79 allocation table with Earth Exploration-Satellite (space-to-Earth), Fixed, Fixed-Satellite (Earth-to-space), Meteorological-Satellite (Earth-to-space) all primary on a coequal basis. However, the Mobile Service was dropped and the Mobile-Satellite Service added on a secondary basis. Again there can be no airborne transmissions and G117 applies. Also, Footnote G104 which calls for the military space radio communication services and Meteorological-Satellite Service to coordinate their sites for EMC purposes applies in this band. The U.S. Footnote 258 applies which allows non-Government Earth exploration-satellite stations on a primary basis subject to case-by-case EMC analysis. There are 242 assignments in this subband with 215 (89%) to the Fixed Service. Again FAA has the most assignments with 109 (45%) followed by DOE with 38 (16%). There are 12 various Government agencies with assignments in the 8175-8215 MHz subband.

The 8215-8400 MHz subband had the same pre-WARC-79 and has the same post-WARC allocations as the 8025-8175 MHz subband (see above). There are 916 assignments in this subband with 717 (78%) assigned to the Fixed Service. The FAA leads users again with 336 (37%) assignments followed by Army with 148 (16%) assignments. Footnotes G117 and US258 apply to this band.

The 8400-8450 MHz subband was shown as the 8400-8500 MHz subband prior to WARC-79. The band at that time was a Government/non-Government shared band with Government allocations to Fixed, Mobile and Space Research (space-to-Earth) on a primary coequal basis. This was shared with the non-Government Space Research Service (space-to-Earth) which also had primary, coequal status. Present allocations show the band split in two parts 8400-8450 MHz and 8450-8500 MHz. The 8400-8450 MHz portion became an exclusive Government band allocated to Fixed and Space Research (space-to-Earth) with the additional restraint of "deep space only." The 8450-8500 MHz portion remained a shared band with Government allocations to Fixed and Space Research Services on a primary coequal basis with non-Government Space Research assignments. There are no national footnotes for this subband. There are only 26 assignments in the subband divided among 8 Government agencies. NASA has the most assignments with eight. The Fixed Services have 10 of the 26 assignments.

The technical standards, minimum performance requirements, and design objectives applicable to transmitters, receivers, and antennas used by Government radio stations are contained in Chapter 5 of the NTIA Manual (NTIA, 1983). The Manual also stipulates that if technical criteria are not specified, the appropriate provisions of the ITU Radio Regulations (RR) normally should apply, or the current CCIR Recommendations should be used as guidelines.

A synopsis of the Government technical standards (Part 5.10 of the NTIA Manual) for fixed systems employing line-of-sight, point-to-point and transportable type equipments using the band 7125-8450 MHz is given in Appendix E.

SPECTRUM USAGE AND MAJOR SYSTEMS

SPECTRUM USAGE

The 7125-8450 MHz band has 7716 assignments in the 13 subbands. Table 39 gives a summary of assignments by government department or agency and subband. The FAA is by far the largest user with 3593 (46.6%) assignments. There are 21 departments and agencies that have assignments in the band. Tables 40 through 45 show the assignments by subbands, agency and station class. Table 46 gives a summary of assignments in the 7125-8450 MHz band by the service, station class and frequency subband. This table also shows the percentage of use per service, the Fixed service predominating with 87% of the band usage. Space Services have 10% of the band usage and experimental 3%. Mobile use is negligible with only two assignments. Figure 28 shows the frequency assignment distribution in 2 MHz segments through the 7125-8450 MHz band (except for 8400-8450 MHz where assignments per MHz are few).

The growth trend in the 7125-8450 MHz band is shown in Figure 29. As can be seen, the band usage has remained fairly stable over the past 10 years with a peak assignment of 7740 in 1973 and the lowest numbers down only around 470 assignments from that peak. At present, there are 7716 assignments in 1983 up from 7274 in 1981. None of these statistics given so far in this band actually reflect equipment counts. There is often a wide gap between the actual frequency assignment and the number of systems or equipments which use those assignments. The Phase II report, which is a follow-on to this Phase I, study is intended to include equipment counts, more detailed present usage, and future usage by all Government agencies involved in the use of this spectrum.

Figures 30 through 42 are the geographic distributions of transmitter and receiver systems for the 13 subbands which make up the 7125-8450 MHz band. As can be seen from the large number of locations, all assignments on one map for the total band would have been unreadable. The lines that extend from sites on CONUS to the edge of the map represent direction of transmission for satellite systems. Unlike many of the bands in the 947 MHz-17.7 GHz portion of the spectrum where assignments are grouped on particular geographic areas such as the southwest and northeast United States, the assignments in the 7125-8450 MHz band tend to cover most of the country. Only an area from mid-Montana to its eastern border, North and South Dakota, Minnesota, Wisconsin, Iowa, and northern Nebraska have few, if any, assignments.

Figure 43 shows only the Department of Energy (DOE) transmitter/receiver sites for CONUS. The major assignments in the 7125-8450 MHz band are to the various Federal hydroelectric projects. This includes the Colorado River Storage Project which supplies electrical power to areas in Colorado, Wyoming, Utah, New Mexico, and Arizona. Also included are the Western Area Power Authority with assignments in Wyoming and Colorado, and the Bonneville Power Authority which provides electrical power for portions of Oregon, Washington, Montana, and Idaho. These microwave links are used for the supervisory control, [data acquisition, security alarms, and protection of the power transmission systems.]

TABLE 39

SUMMARY OF FREQUENCY ASSIGNMENT DISTRIBUTION BY AGENCY AND SUBBAND
FOR THE 7125-8450 MHz BAND

	7125 7190	7190 7235	7235 7250	7350 7300	7300 7450	7450 7550	7550 7750	7750 7900	7900 8025	8025 8175	8175 8215	8215 8400	8400 8450	TOTAL	% OF ASSIGN-MENTS
AF	60	37	9	31	143	69	119	81	72	117	12	87	3	840	10.9
AR	23	15	11	13	63	73	87	89	58	71	32	148		683	8.85
CIA	4	3			7	4	5		3	1	3	2		32	0.4
C	2	7			2		13	6	7	4	3	10		54	0.69
CG	6	3			9	8	22	16	3	6	3	15	1	92	1.2
DOE	61	32	9		99	103	177	111	55	90	38	124	1	900	11.7
FAA	272	173	19	239	526	438	641	284	229	327	109	336		3593	46.6
FEMA	1				1	1	1	1						5	.06
GSA	2	1	1		1	3		4						12	.16
I	2	2	1		3	2	5	4		1				20	.26
J	1		1							1		4	3	10	.13
N	52	30	8	72	140	115	109	78	116	95	28	129	3	975	12.6
NASA	5	3	1		7	5	8	8	5	9	3	11	8	73	0.9
NG	2	1		2	1	3	3	1	7	2	1	2	3	28	.36
NS				2	7	4	15	4	5	12	3	12		64	0.8
NSF								2				1		3	.04
T													4	4	.05
TVA	11	10	2		35	29	47	23	9	36	7	35		244	3.2
USIA	6	4	4		16	7	15							52	0.7
VA	5	3	1				12	11						32	0.4
	515	324	67	359	1060	864	1279	723	569	772	242	916	26	7716	100 %
NUMBER OF ASSIGN-MENT PER MHz	7.9	7.2	4.5	7.2	7.1	8.6	6.5	4.8	4.5	5.1	6	5	0.5		

TABLE 40

FREQUENCY ASSIGNMENT DISTRIBUTION BY AGENCY, FREQUENCY BAND AND STATION CLASS
FOR THE 7125-7250 MHz BANDS

DEPARTMENT OR AGENCY	7125-7190 MHz BAND							7190-7235 MHz BAND			7235-7250 MHz BAND
	FX	FXE	FL	MO	XM	XT	TOTAL	FX	XT	TOTAL	FX
AIR FORCE	56		1		1	2	60	33	4	37	9
ARMY	23						23	15		15	11
CIA	4						4	3		3	
COAST GUARD	6						6	3		3	
COMMERCE	2						6			0	
DOE	59		2				61	39		39	9
FAA	272						272	173		173	19
FEMA	1						1			0	
GSA	2						2	1		1	1
INTERIOR	2						2	2		2	1
JUSTICE	1						1			0	1
NAVY	50					2	52	30		30	8
NASA	3			1		1	5	3		3	1
NG	2						2	1		1	
TVA	11						11	10		10	2
USIA	6						6	4		4	4
VA	5						5	3		4	1
TOTALS	505	2	1	1	1	5	515	320	4	324	67

TABLE 41

FREQUENCY ASSIGNMENT DISTRIBUTION BY AGENCY, FREQUENCY BAND, AND STATION CLASS
FOR THE 7250-7450 MHz BANDS

DEPARTMENT OR AGENCY	7250-7300 MHz BAND									7300-7450 MHz BAND						
	FX	EC	EG	EJ	XC	XD	XR	XT	TOTAL	FX	FXE	EC	EJ	EK	XT	TOTAL
AIR FORCE		11		15	1			4	31	102		27	6		8	143
ARMY		13							13	43		20				63
CIA										7						7
COAST GUARD										9						9
COMMERCE										2						2
DOE										96	3					99
FAA	239								239	526						526
FEMA										1						1
GSA										1						1
INTERIOR										3						3
NAVY	6	34	2					30	72	80		58		2		140
NASA										7						7
NG						1	1		2	1						1
NS		2							2			7				7
TVA										35						35
USIA										16						16
TOTALS	245	60	2	15	1	1	1	34	359	929	3	112	6	2	8	1060

TABLE 42

FREQUENCY ASSIGNMENT DISTRIBUTION BY AGENCY, FREQUENCY BAND, AND STATION CLASS
FOR THE 7450-7750 MHz BANDS

DEPARTMENT OR AGENCY	7450-7550 MHz BAND									7550-7750 MHz BAND						
	FX	FXE	EC	EJ	EU	ML	XR	XT	TOTAL	FX	FXE	EC	XC	XR	XT	TOTAL
AIR FORCE	55		7	6				1	69	104		11	1		1	119
ARMY	32		38		2			1	73	64		19			4	87
CIA	4								4	5						5
COAST GUARD	8								8	22						22
COMMERCE										13						13
DOE	102	1							103	171	6					177
FAA	438								438	641						641
FEMA	1								1	1						1
GSA	3								3							
INTERIOR	2								2	5						5
NAVY	63		51			1			115	95	10				4	109
NASA	5								5	8						8
NG	2						1		3	2				1		3
NS			4						4			14		1		15
TVA	29								29	47						47
USIA	7								7	15						15
VA										12						12
TOTALS	751	1	100	6	2	1	1	2	864	1205	16	44	1	2	11	1279

TABLE 43

FREQUENCY ASSIGNMENT DISTRIBUTION BY AGENCY, FREQUENCY BAND, AND STATION CLASS
FOR THE 7750-8025 MHz BANDS

DEPARTMENT OR	7750-7900 MHz BAND						7900-8025 MHz BAND								
	FX	FXE	XC	XR	XT	TOTAL	FX	TC	TG	TJ	XC	XD	XR	XT	TOTAL
AIR FORCE	73		1		7	81	29	17		15	5			6	72
ARMY	70				19	89	42	13						3	58
CIA						0	1	2							3
COAST GUARD	16					16	3								3
COMMERCE	6					6	7								7
DOE	110	1				111	55								55
FAA	284					284	229								229
FEMA	1					1									0
GSA	4					4									0
INTERIOR	4					4									0
NAVY	70	4			4	78	36	41	4					35	116
NASA	8					8	5								5
NG				1		1					3	2	2		7
NSF	2					2									0
NS	2			2		4		5							5
TVA	23					23	9								9
VA	11					11									0
TOTALS	684	5	1	3	30	723	416	78	4	15	8	2	2	44	569

TABLE 44

FREQUENCY ASSIGNMENT DISTRIBUTION BY AGENCY, FREQUENCY BAND, AND STATION CLASS
FOR THE 8025-8215 MHz BANDS

DEPARTMENT OR AGENCY	8025-8175 MHz BAND										8175-8215 MHz BAND				
	FX	FXE	TC	TCS	TG	TB	XC	XR	XT	TOTAL	FX	TC	XC	XT	TOTAL
AIR FORCE	53		26			28	1		9	117	8		1	3	12
ARMY	48		16						7	71	25	3		4	32
CIA	1									1	3				3
COAST GUARD	6									6	3				3
COMMERCE	4									4	3				3
DOE	88	2								90	38				38
FAA	327									327	109				109
INTERIOR	1									1	1				0
JUSTICE	1									1					0
NAVY	60		30	2	1				2	95	16	2		10	28
NASA	9									9	1			2	3
NG							1	1		2			1		1
NS	2		9		1					12	3	1			3
TVA	36									36	7				7
TOTALS	636	2	81	2	2	28	2	1	18	772	215	6	2	19	242

TABLE 45

FREQUENCY ASSIGNMENT DISTRIBUTION BY AGENCY, FREQUENCY BAND, AND STATION CLASS
FOR THE 8215-8450 MHz BANDS

DEPARTMENT OR AGENCY	8215-8400 MHz BAND								8400-8450 MHz BAND						
	FX	TB	TC	TY	XC	XR	XT	TOTAL	FX	EHER	XC	XD	XR	XT	TOTAL
AIR FORCE	47	28	8				4	87						3	3
ARMY	65		50	3			30	148							
CIA	2							2							
COAST GUARD	15							15	1						1
COMMERCE	10							10							
DOE	124							124	1						1
FAA	336							336							
JUSTICE	4							4	3						3
NAVY	67		55				7	129	1			1		1	3
NASA	11							11		4			4		8
NG					1	1		2			2		1		3
NS			11			1		12							
NSF	1							1							
TVA	35							35							
TREASURY								0	4						4
TOTALS	717	28	124	3	1	2	41	916	10	4	2	1	5	4	26

TABLE 46

SUMMARY OF ASSIGNMENTS IN THE 7125-8450 MHz BAND BY SERVICE, STATION CLASS, AND FREQUENCY SUBBAND

STATION CLASS	7125-7190 MHz	7190-7235 MHz	7235-7250 MHz	7250-7300 MHz	7300-7450 MHz	7450-7550 MHz	7550-7750 MHz	7750-7900 MHz	7900-8025 MHz	8025-8175 MHz	8175-8215 MHz	8215-8400 MHz	8400-8450 MHz	TOTALS	% OF ASSIGN-MENTS
FIXED															
FX	505	320	67	245	929	751	1205	684	416	636	215	717	10	6700	
FXE	2				3	1	16	5		2				29	
														6729	87%
SPACE STATIONS															
EC				60	112	100	44							316	
EG				2										2	
EHER													4	4	
EJ				15	6	6								27	
EK					2									2	
EU						2								2	
														353	5%
MOBILE															
FL	1													1	
MO	1													1	
ML						1								1	
SATELLITE EARTH STATIONS															
TB										28		28		56	
TC									78	81	6	124		289	
TCS										2				2	
TG									4	2				6	
TJ												3		3	
														371	5%
EXPERIMENTAL															
XC				1			1	1	8	2	2	1	2	18	
XD				1					2				1	4	
XM	1													1	
XR				1		1	2	3	2	1		2	5	17	
XT	5	4		34	8	2	11	30	44	18	19	41	4	220	
														260	3%
TOTALS	515	324	67	359	1060	864	1279	723	569	772	242	916	26	7716	
%	7%	4%	1%	5%	14%	11%	17%	9%	7%	10%	3%	12%	>1%		

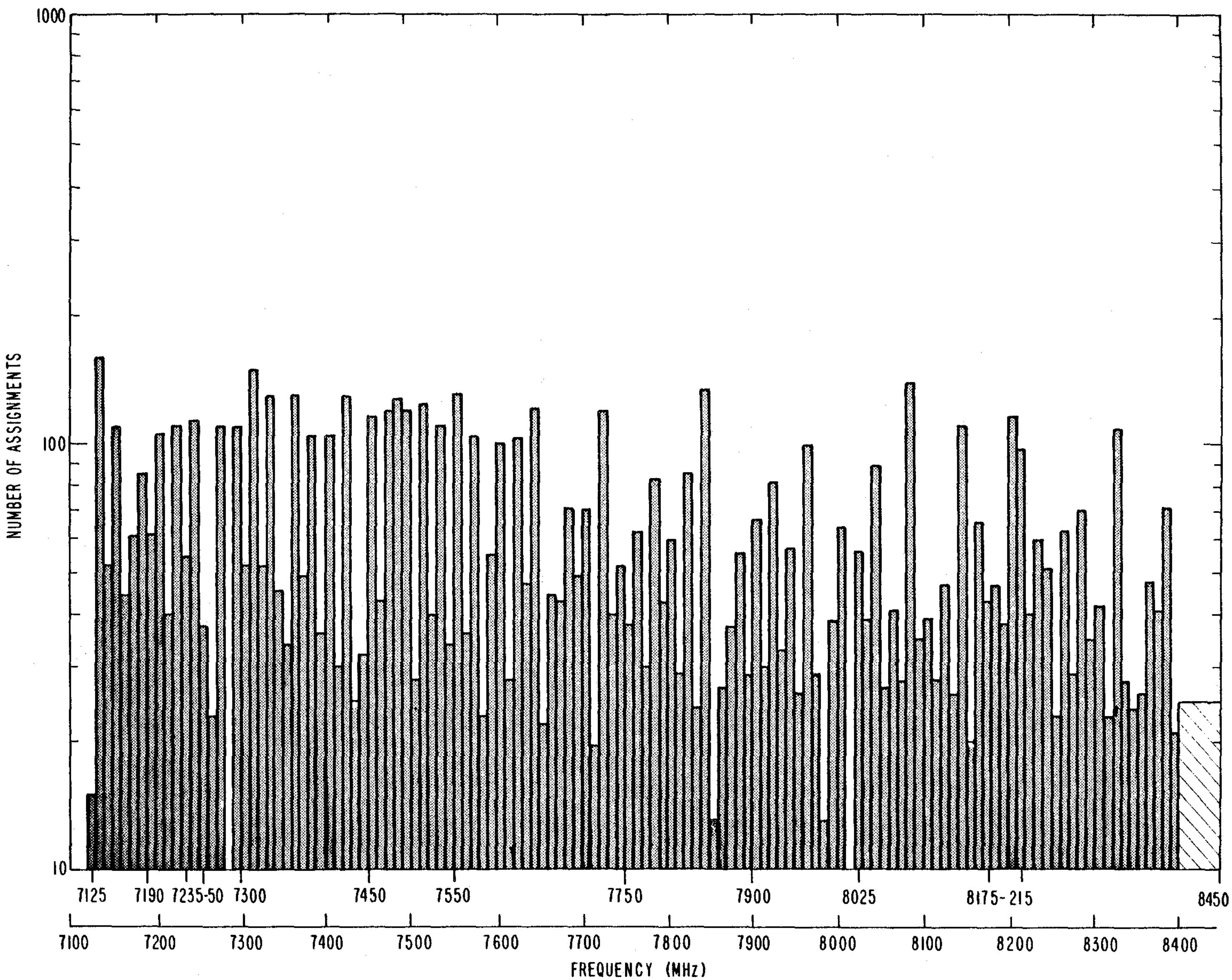


Figure 28. Frequency Assignment Distribution in 2 MHz Segments through the 7125-8450 MHz Band.

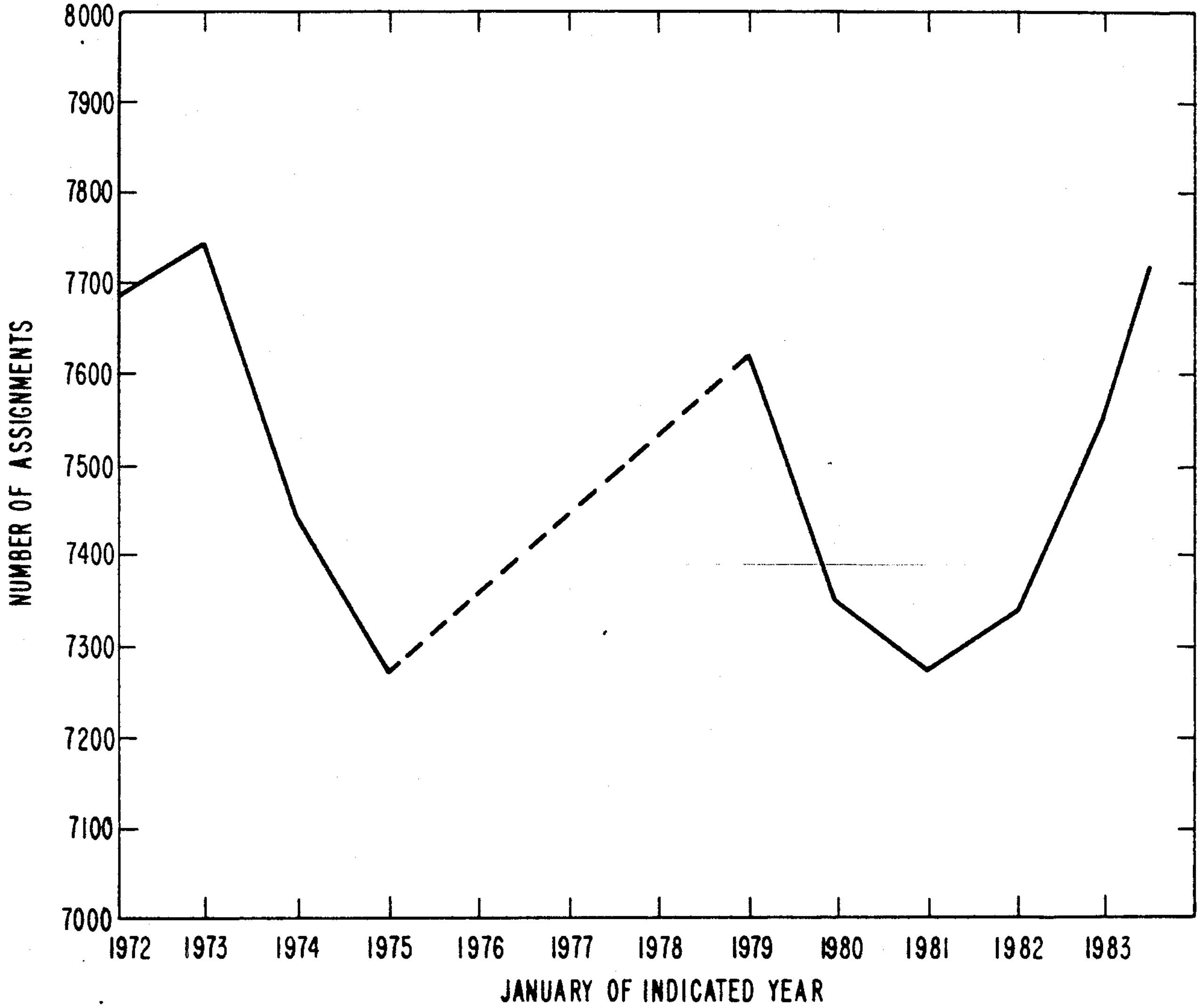


Figure 29. Growth Trend for the 7125-8450 MHz Band from January 1972 to January 1983.

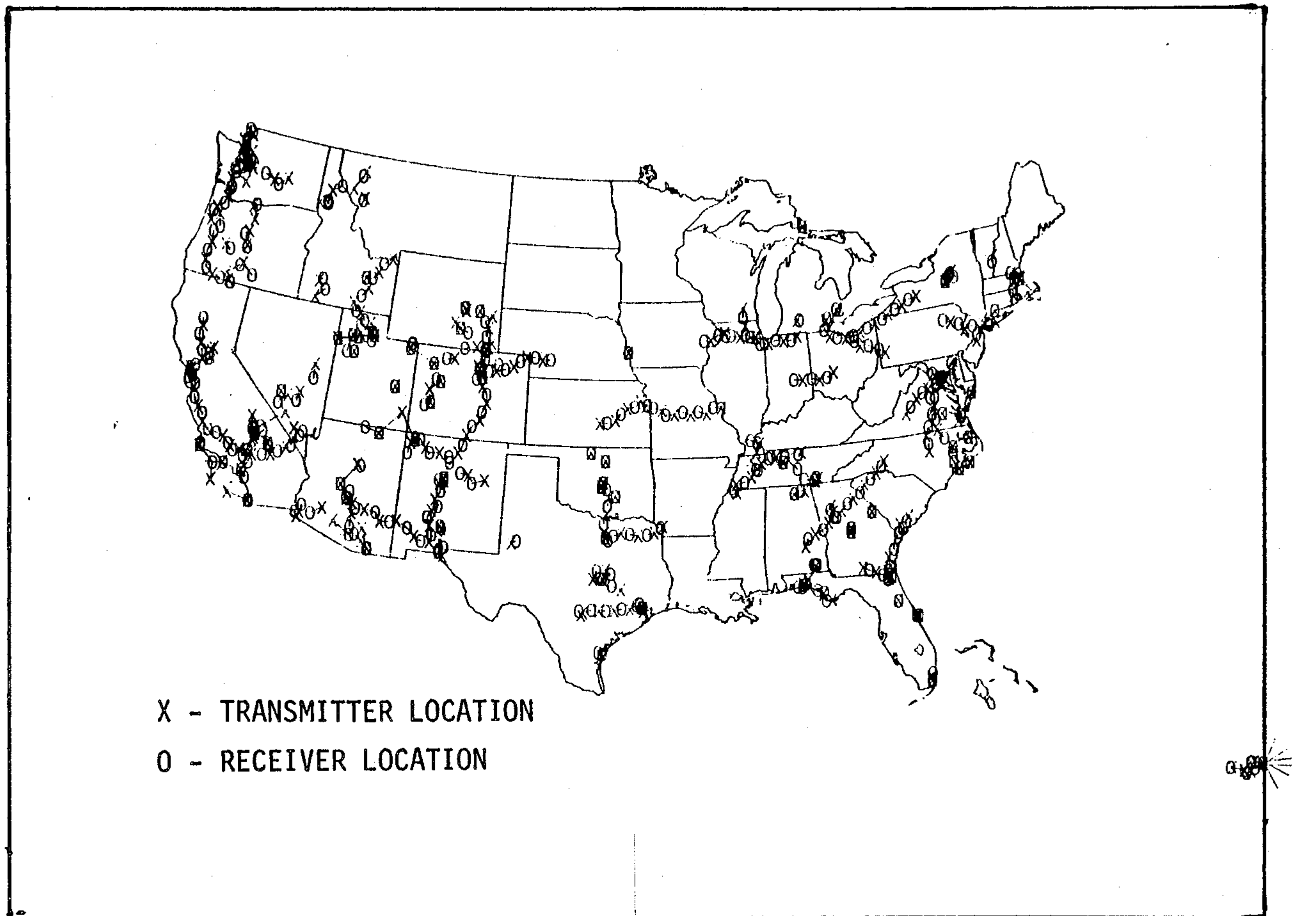


Figure 30. Geographic Distribution of Assignments in the 7125-7190 MHz Subband.

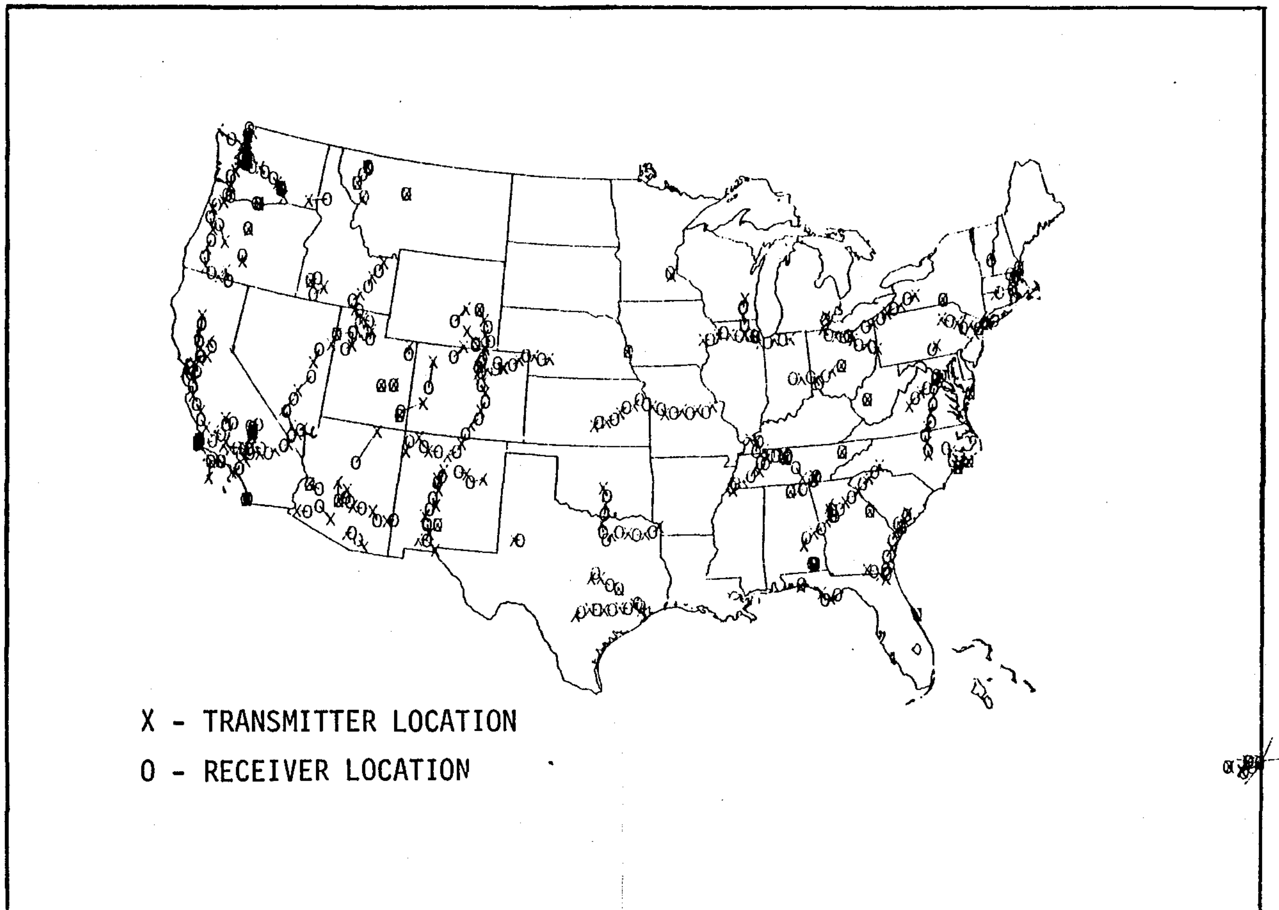


Figure 31. Geographic Distribution of Assignments in the 7190-7235 MHz Subband.

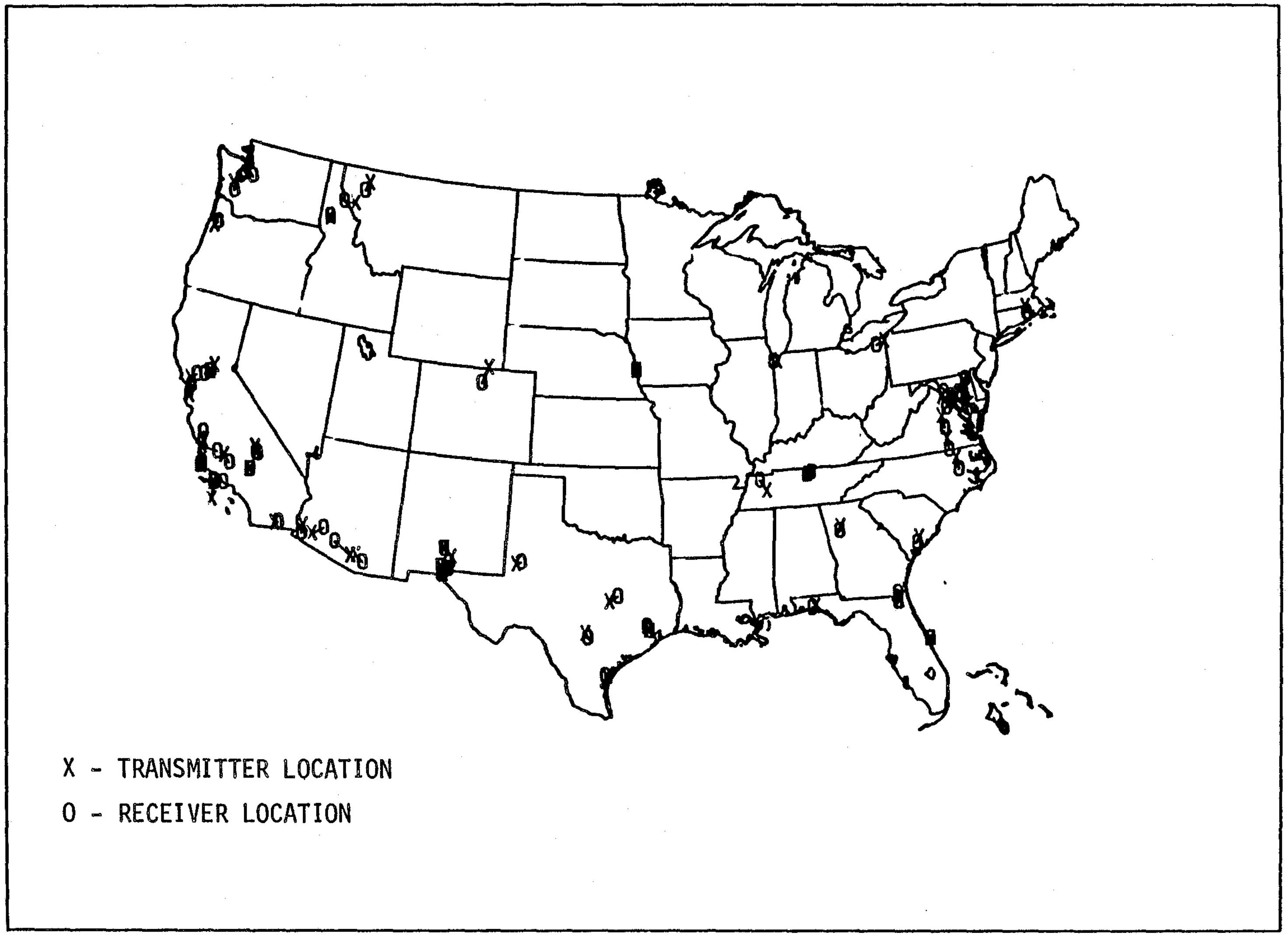


Figure 32. Geographic Distribution of Assignments in the 7235-7250 MHz Subband.

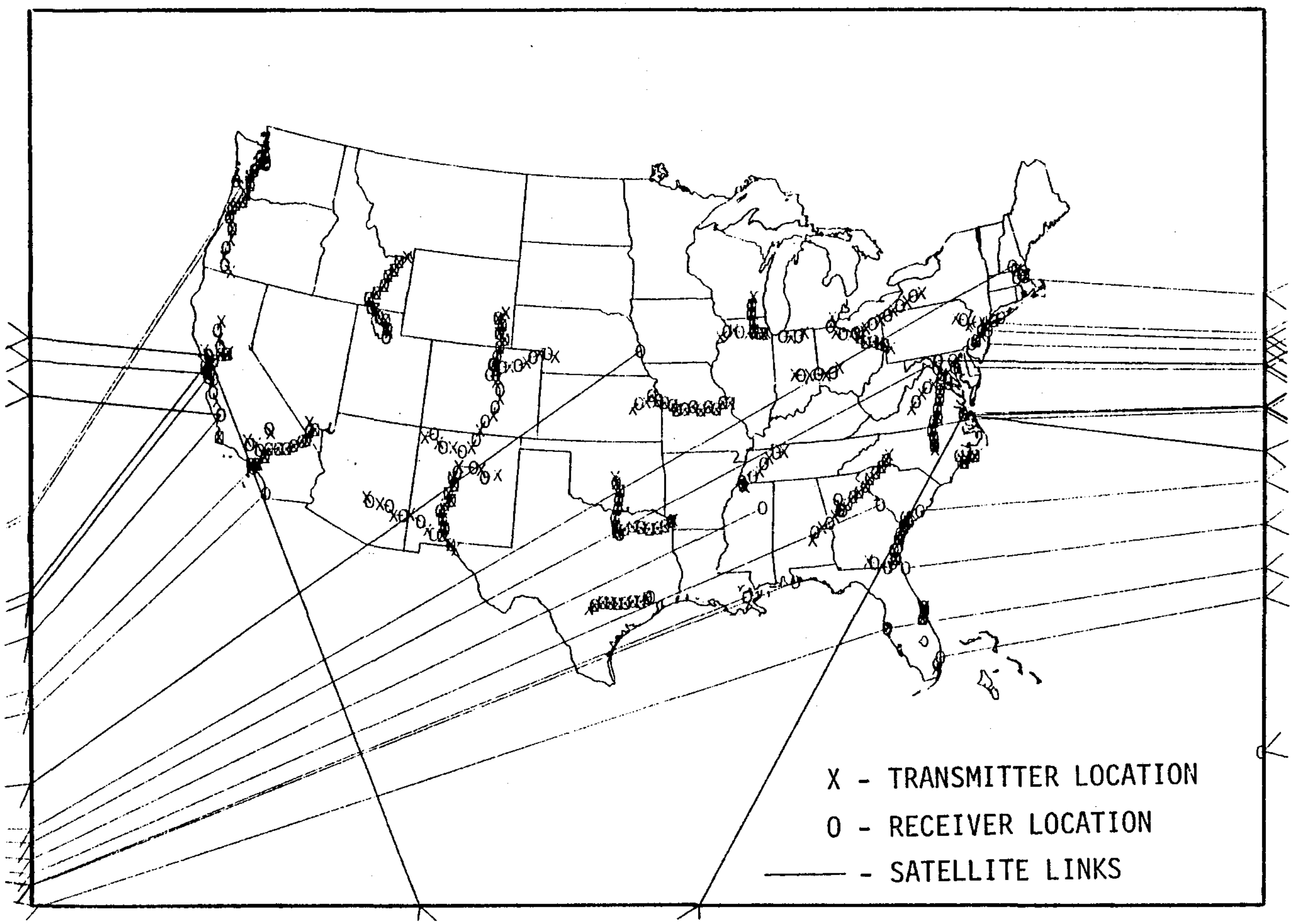


Figure 33. Geographic Distribution of Assignments in the 7250-7300 MHz Subband.

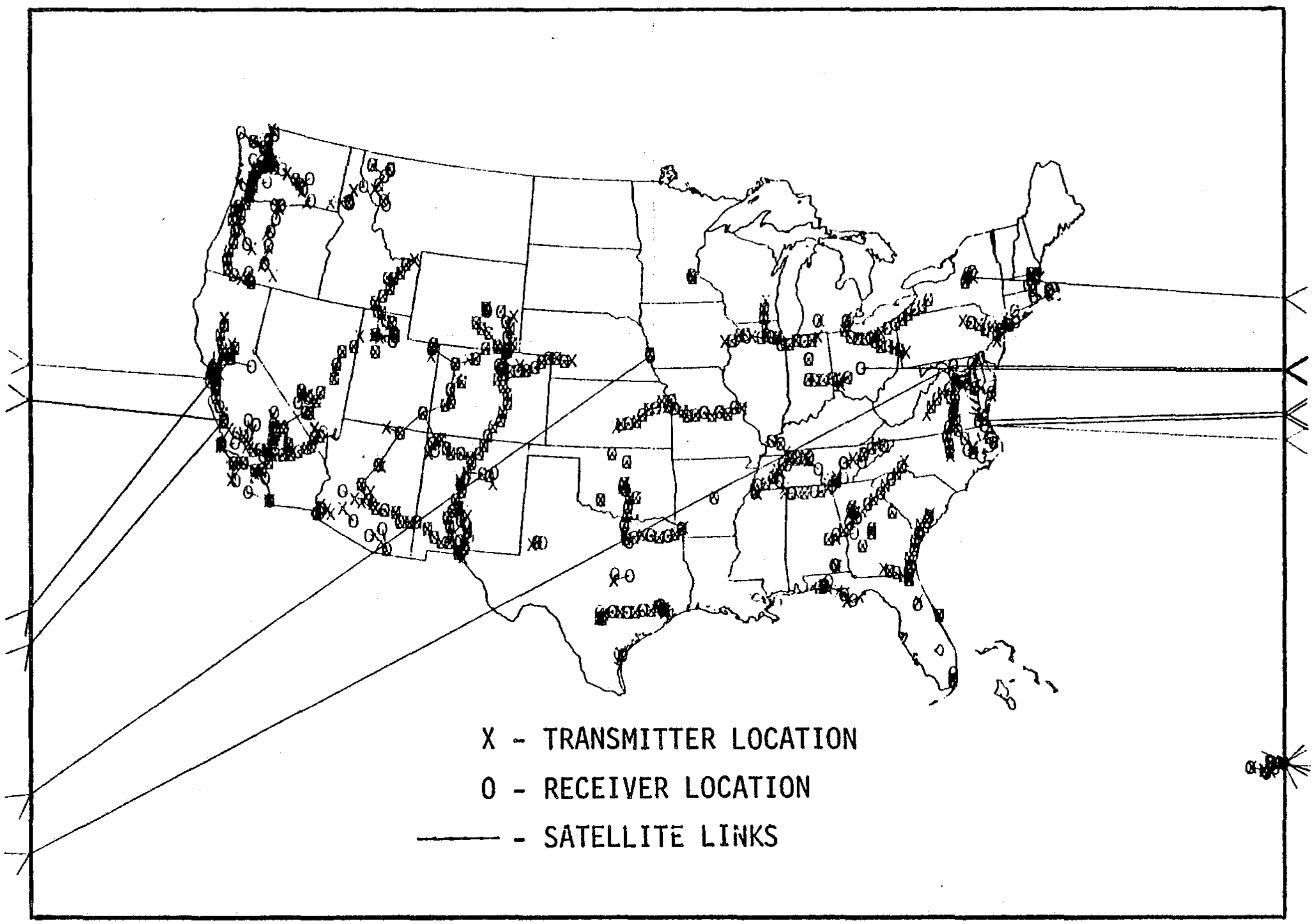


Figure 34. Geographic Distribution of Assignments in the 7300-7450 MHz Subband.

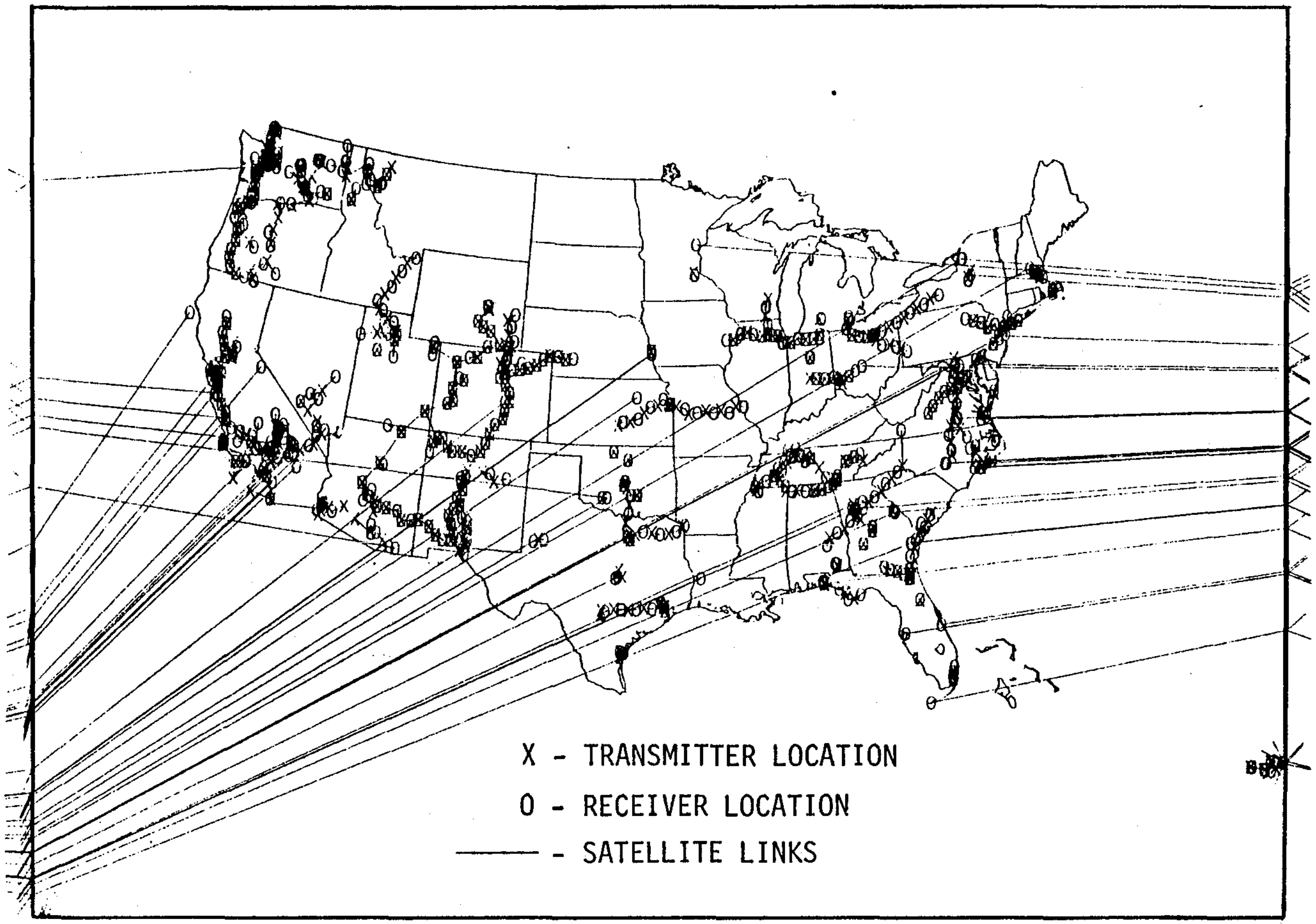


Figure 35. Geographic Distribution of Assignments in the 7450-7550 MHz Subband.

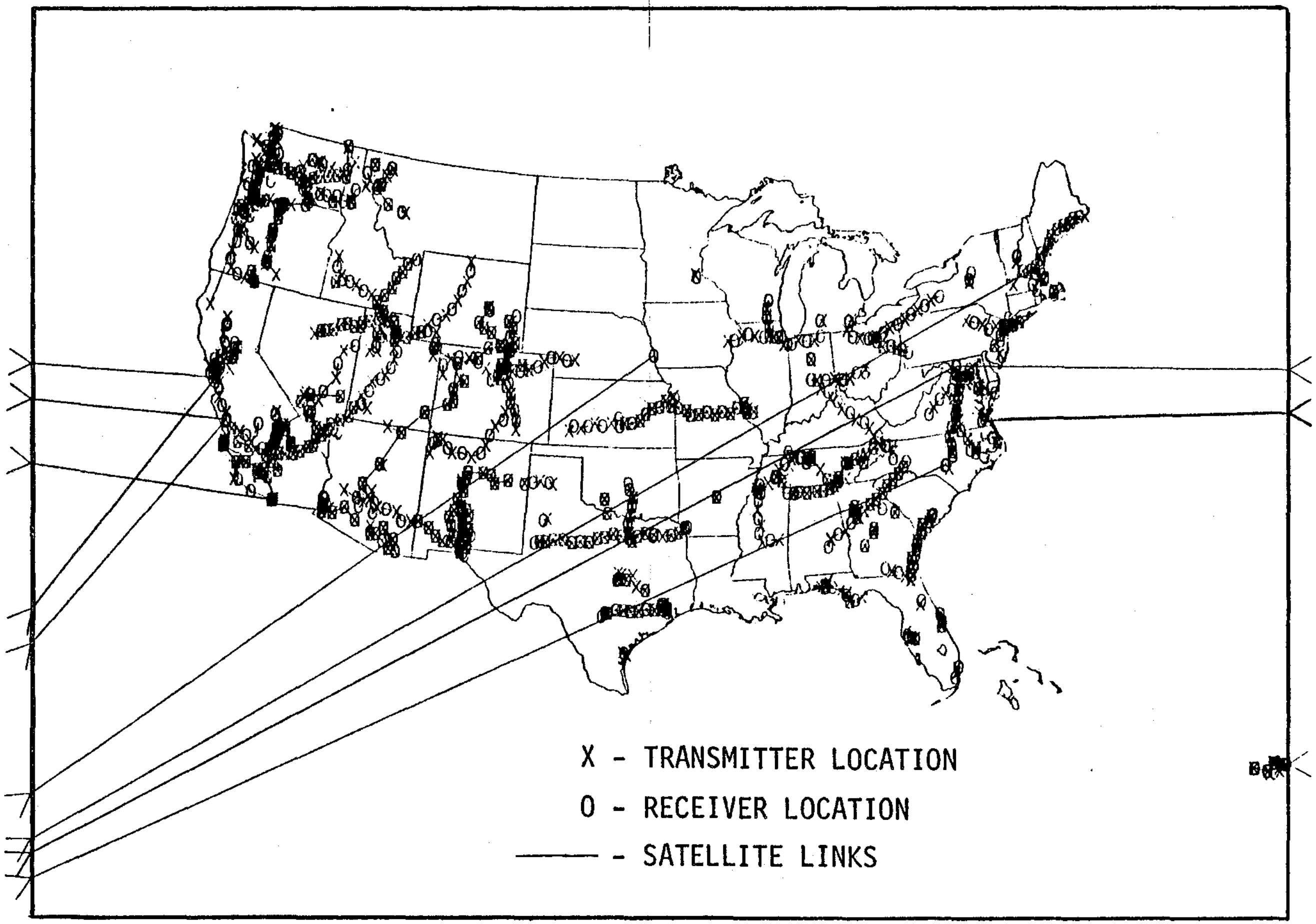


Figure 36. Geographic Distribution of Assignments in the 7550-7750 MHz Subband.

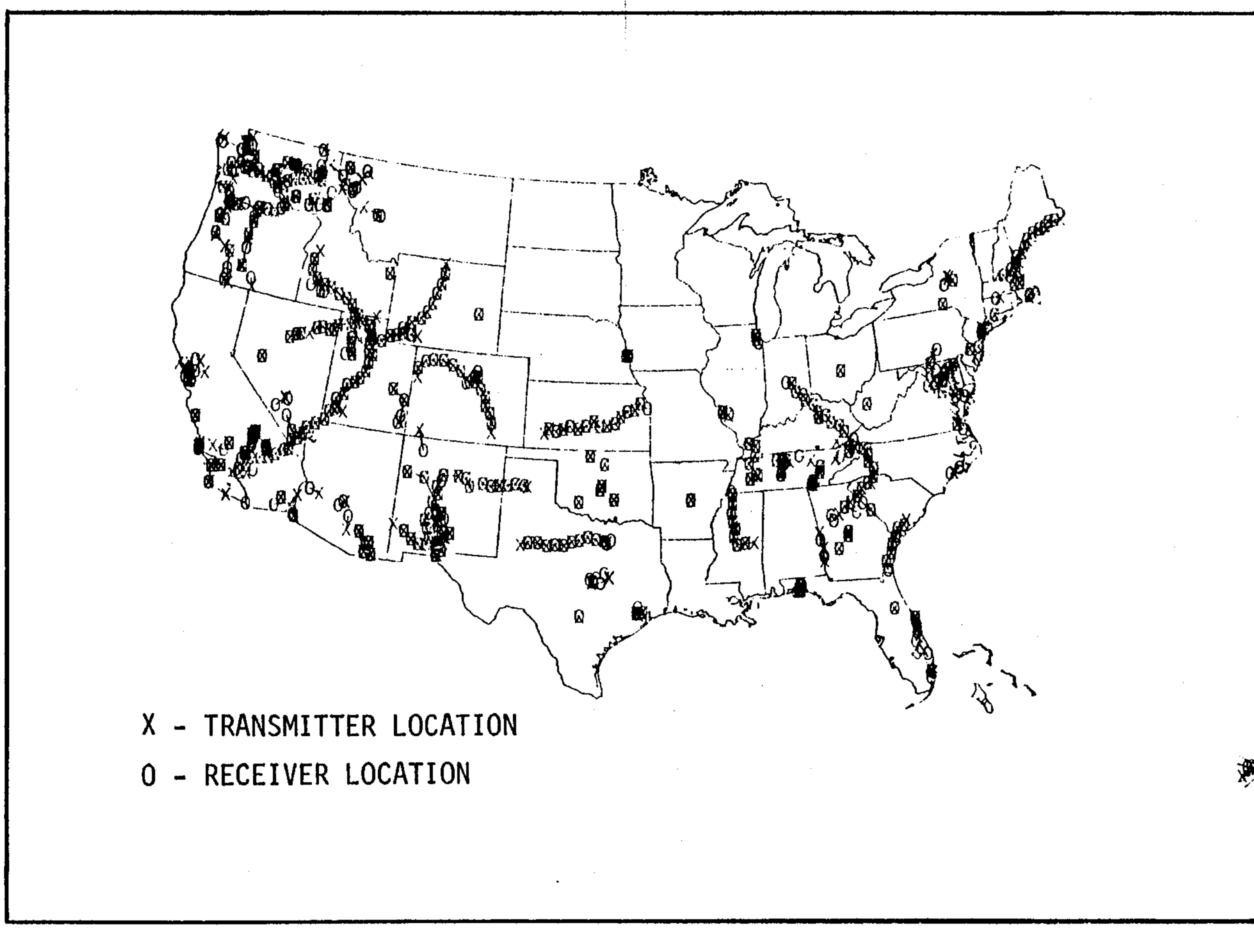


Figure 37. Geographic Distribution of Assignments in the 7750-7900 MHz Subband.

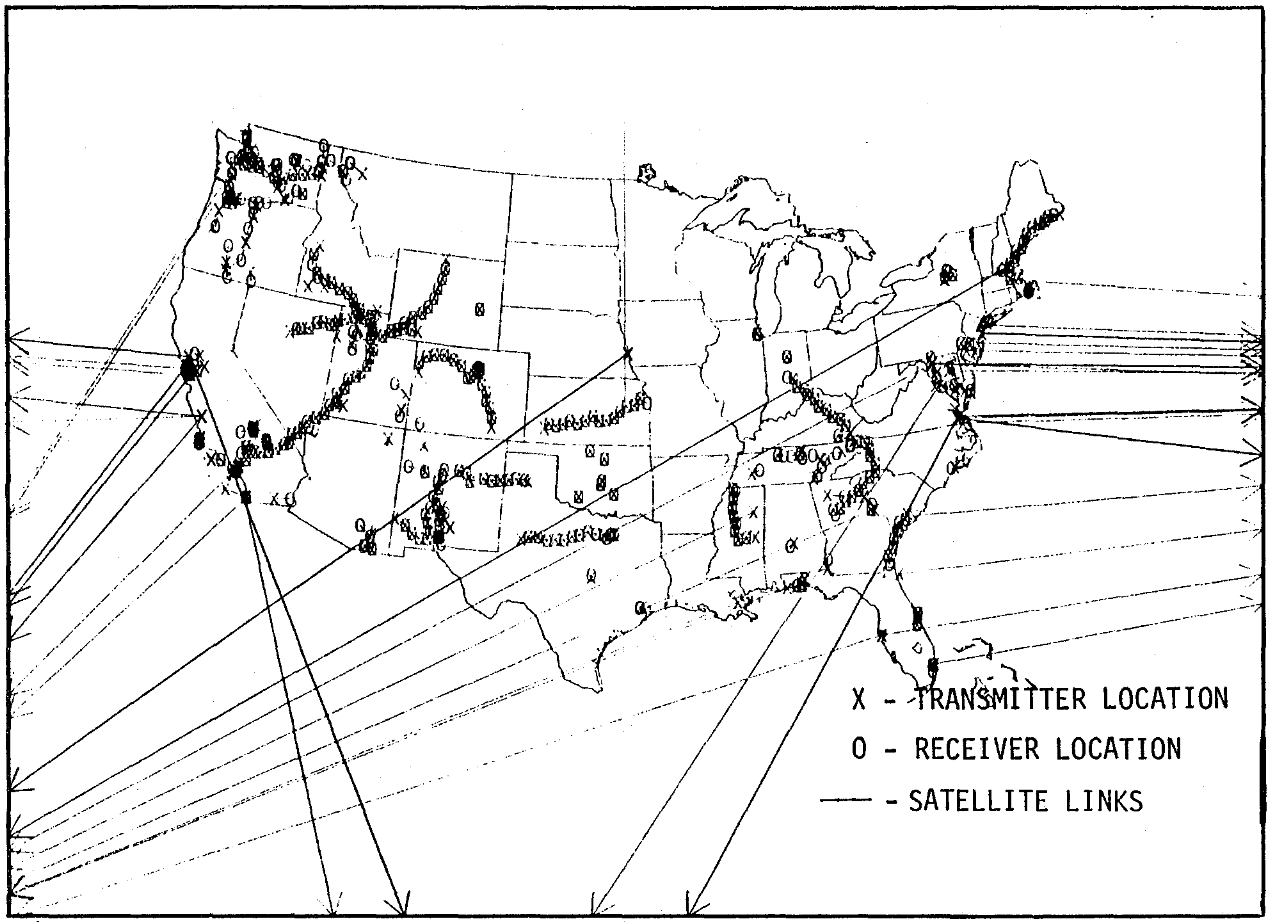


Figure 38. Geographic Distribution of Assignments in the 7900-8025 MHz Subband.

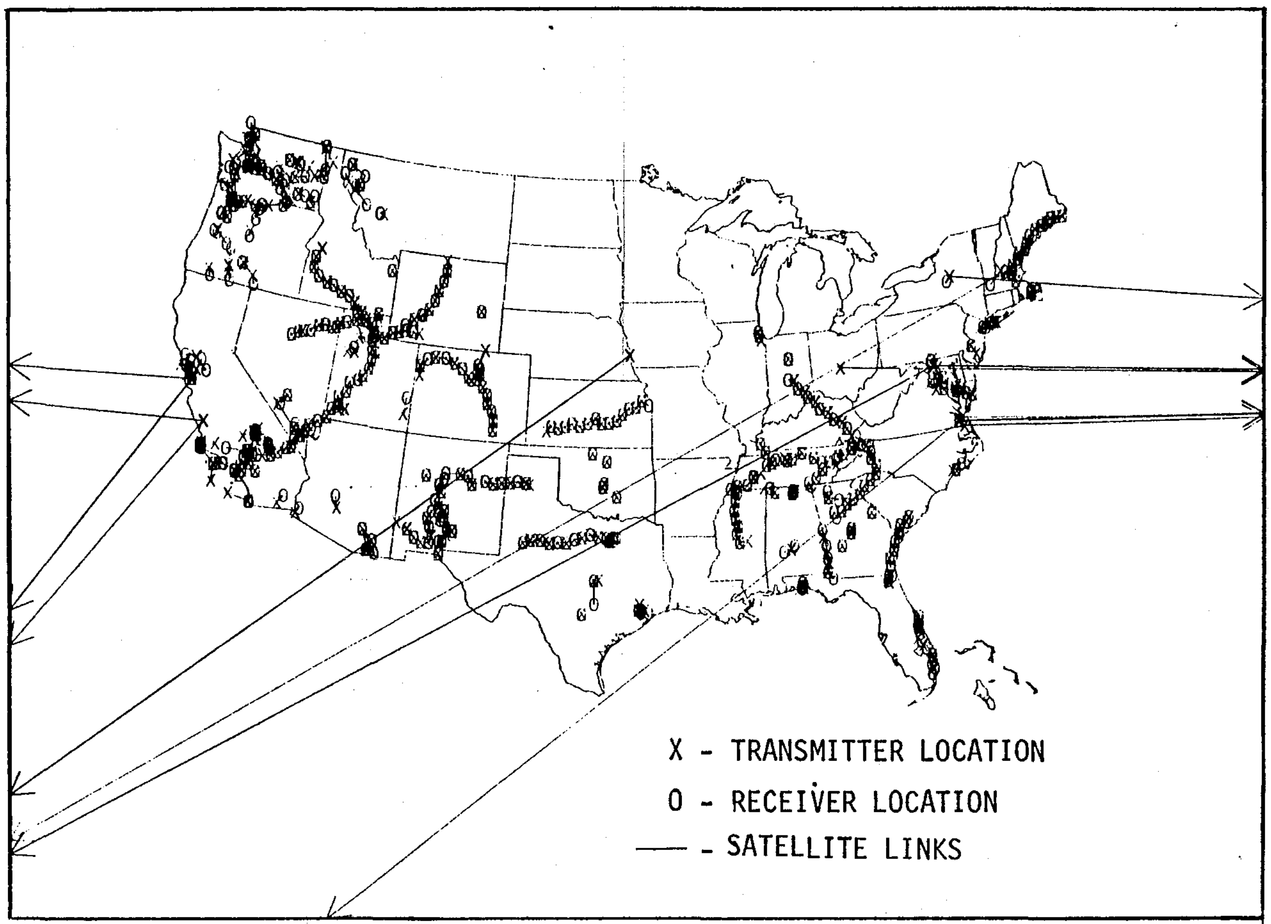


Figure 39. Geographic Distribution of Assignments in the 8025-8175 MHz Subband.

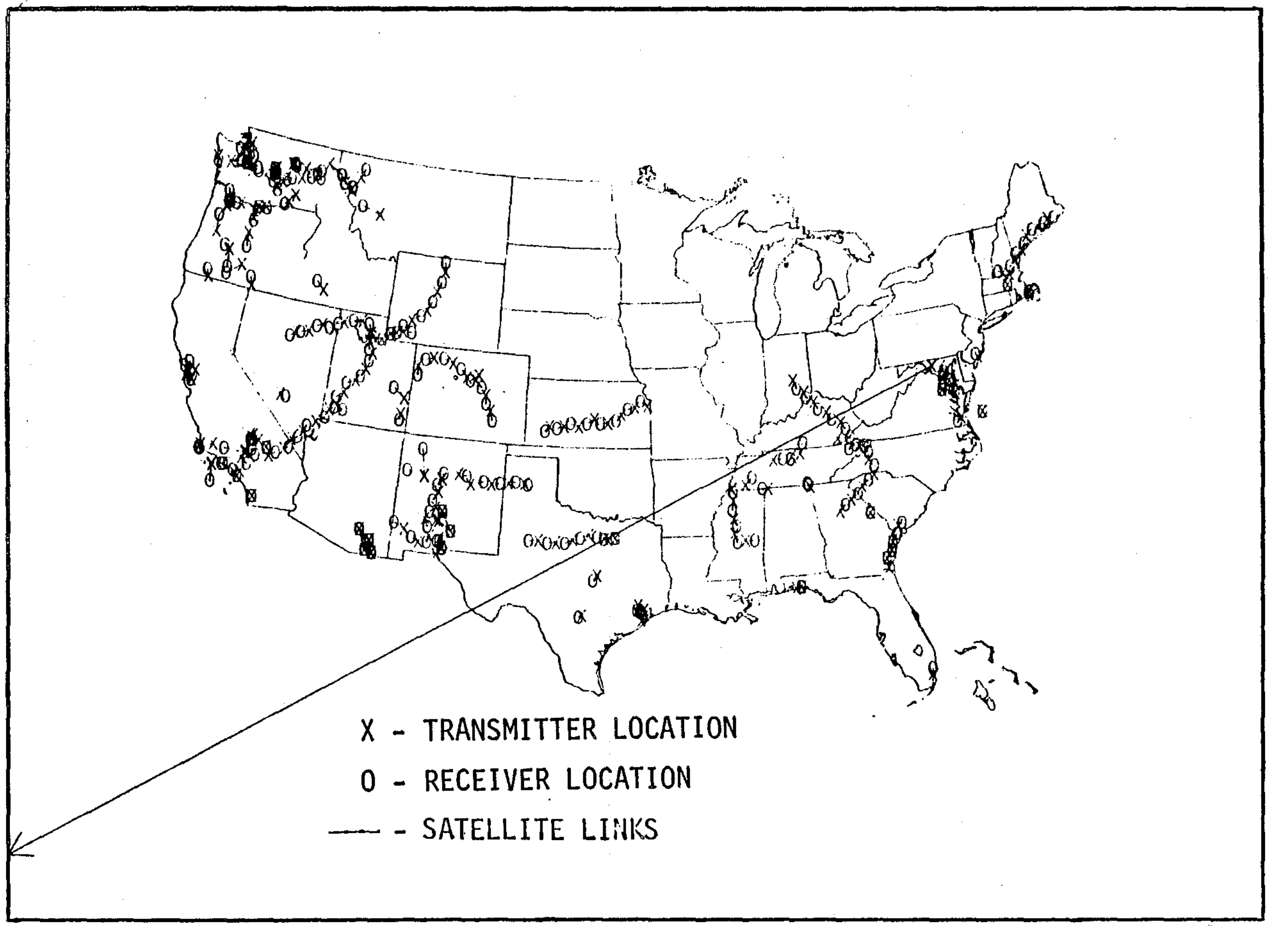


Figure 40. Geographic Distribution of Assignments in the 8175-8215 MHz Subband.

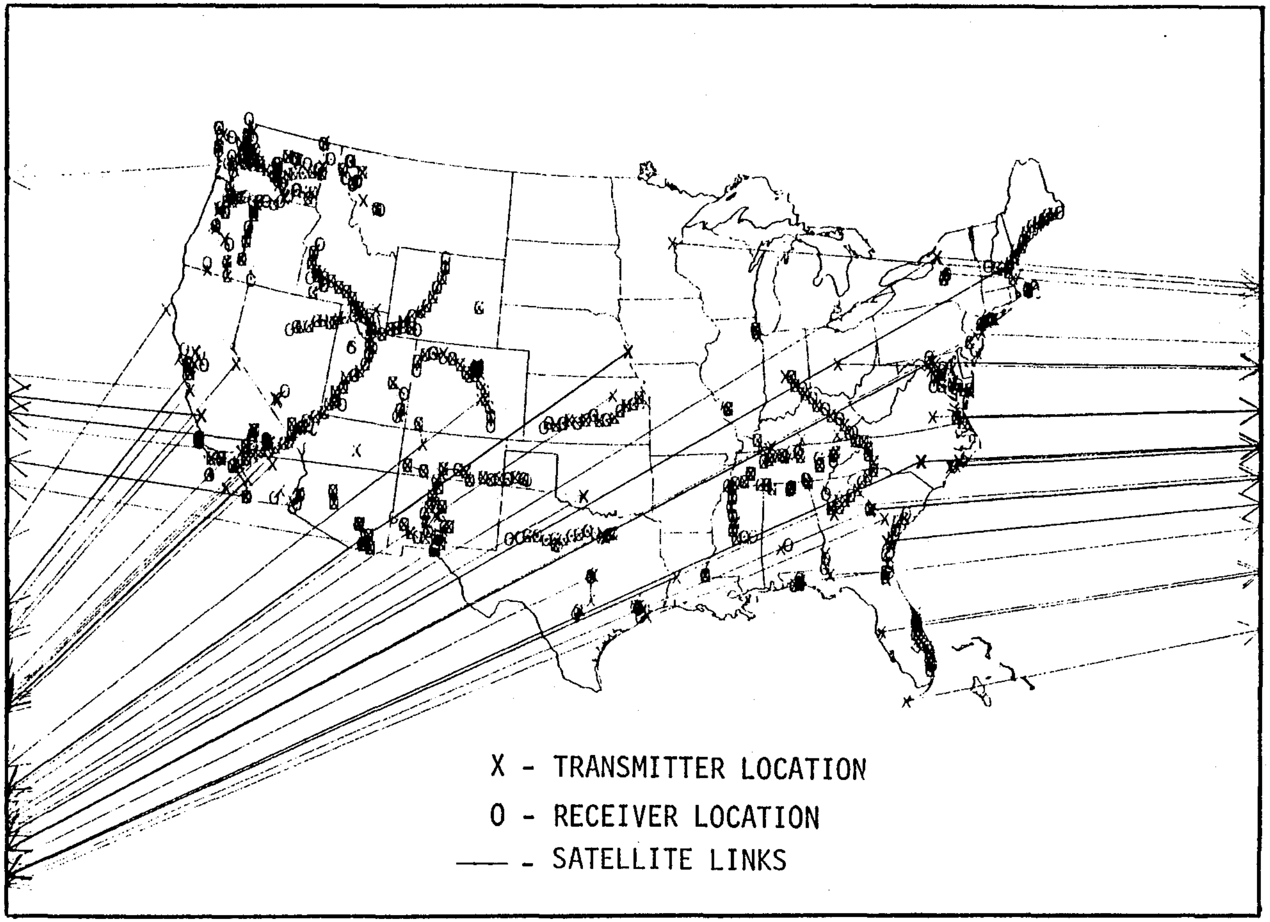


Figure 41. Geographic Distribution of Assignments in the 8215-8400 MHz Subband.

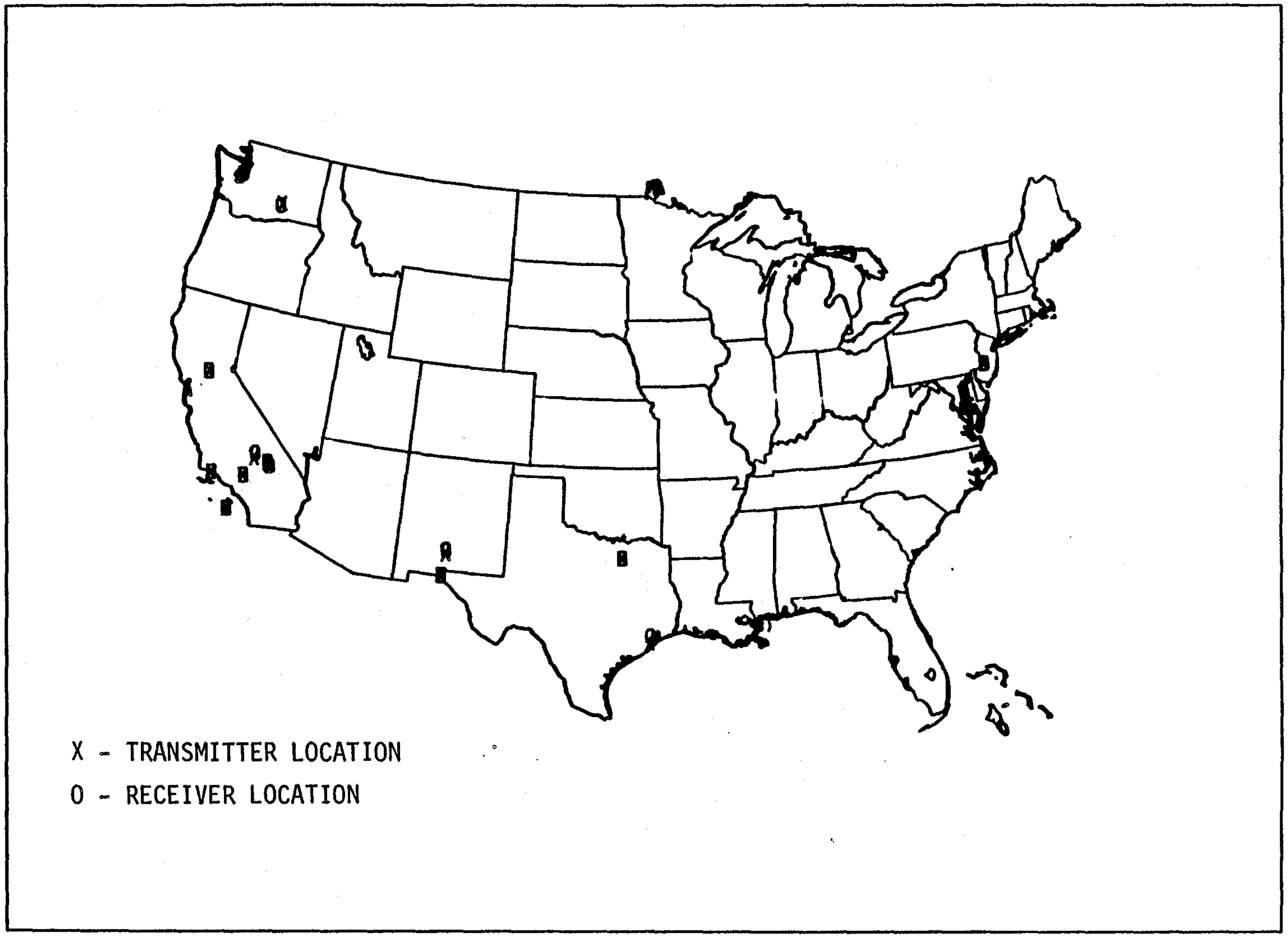


Figure 42. Geographic Distribution of Assignments in the 8400-8450 MHz Subband.

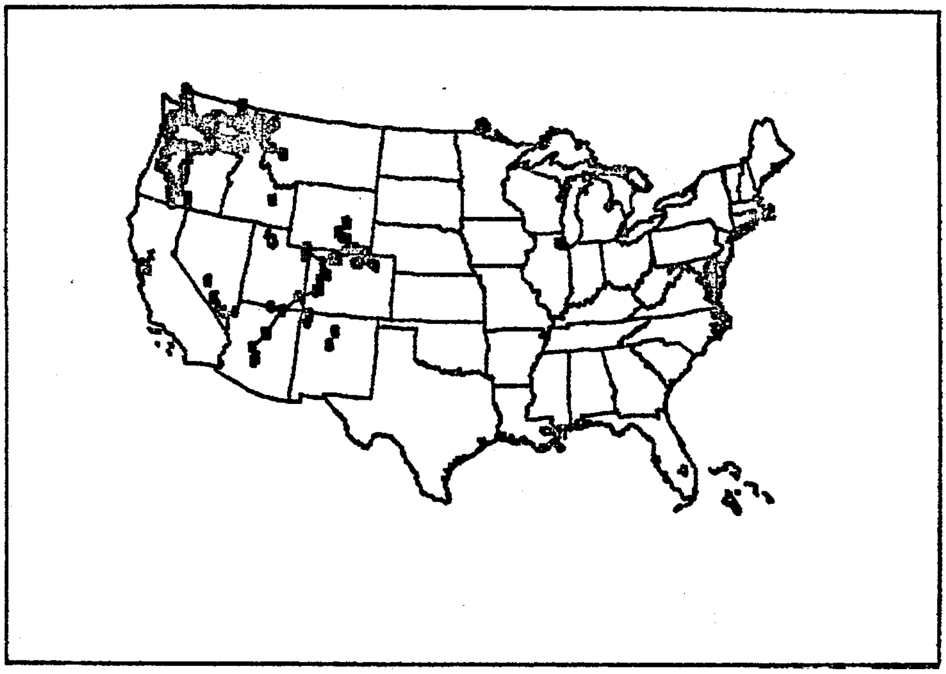


Figure 43. DOE Transmitter and Receiver Locations for the 7125-8450 MHz Band.

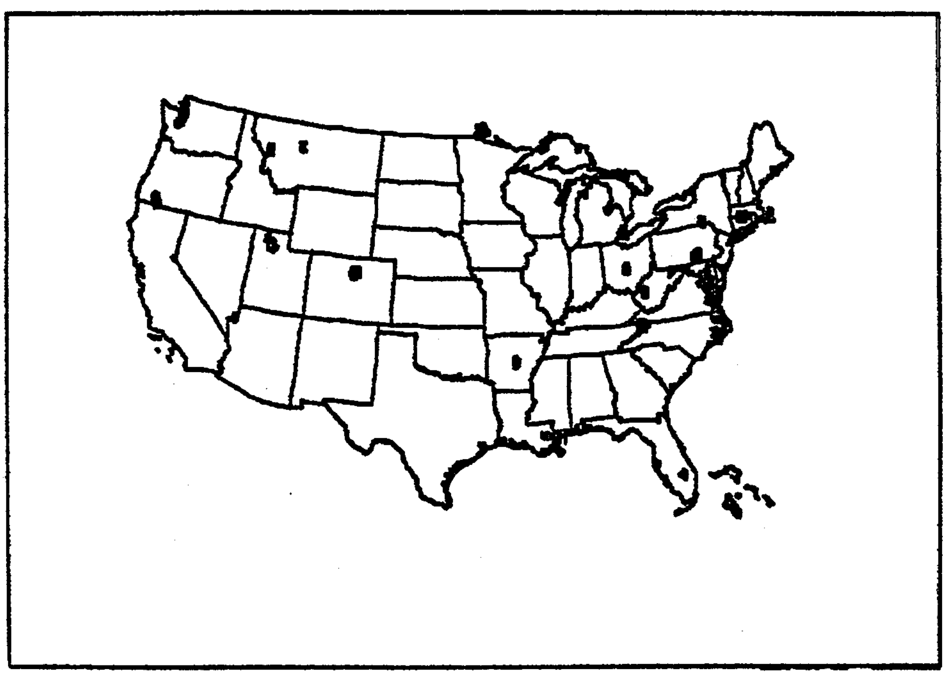


Figure 44. DOC Transmitter and Receiver Locations for the 7125-8450 MHz Band.

Because of the need for high reliability, these links use frequency diversity which almost doubles the use of DOE assignments in the 7125-8450 MHz band. Other DOE use of this band includes assignments at the Nevada Test Site (NTS) and the Tonopah test range to support nuclear and national security efforts. Other DOE microwave systems at NTS are used for relaying data from forward areas to the central control facility, closed circuit TV links to view remote rocket launches, and to support other range test projects. Other DOE assignments are at Los Alamos, NM for data links between research buildings and the main computers at Albuquerque, NM. There are video security and surveillance links, at Inell, Idaho, and Bataria, IL, has communications and data links between research labs. Lawrence Livermore Lab in California has microwave links between various lab sites and the University at California along with CCTV security systems. There are CCTV surveillance systems in conjunction with DOE buildings in Las Vegas, NV, all which use frequencies in the 7125-8450 MHz band.

Figure 44 shows the Department of Commerce transmitters and receivers that operate in the 7125-8450 MHz band. Most assignments are to the National Weather Service (NWS) for microwave links between remote weather radars and a central data collection and analysis facilities. The National Environmental Satellite Service has microwave links in Maryland which transmit GOES satellite data between various sites. The National Bureau of Standards (NBS) has a microwave link in Boulder, CO, used for transmission of voice and data to support Boulder research activities. The NBS also has distance measurement systems used in earthquake prediction studies at various sites in Colorado.

Figure 45 shows the microwave links used in the 7125-8450 MHz band by the Tennessee Valley Authority (TVA) for the control, protection, and operation of its electric power generation and distribution network. The TVA supplies electric power to portions of Alabama, Georgia, Kentucky, Mississippi, and Tennessee. The use of frequency diversity to achieve the high reliability necessary for these links considerably increases the number of assignments. The TVA presently has 244 assignments in this band.

Figure 46 shows the geographic distribution of transmitter/receiver sites used by the Coast Guard in the 7125-8450 MHz band. The majority of assignments are to the Vessel Traffic System (VTS) for communications and remote control of radar sites in support of harbor radar advisory ship control. Figure 47 shows the Coast Guard Vessel Traffic System at New York as a representative network showing the interconnection of the various capacity links. Those links between 7125-8450 MHz being the high capacity links. The Coast Guard also has assignments in this band at Puerto Rico, the Virgin Islands, and the Hawaiian Islands used for microwave links for remote control of VHF-FM equipment, etc., dealing with distress, alerting and search and rescue information. There are a number of remote CCTV surveillance sites such as the Merrimack River bar which use frequencies in the 7125-8450 MHz band for microwave links to transmit data to some central control station and receive command and control information at the remote site from the control center.

The greatest variety of use for the 7125-8450 MHz band is found in the military services. The Navy with the second highest number of assignments (975) behind FAA has intersite microwave links in Puerto Rico to support the weapons training facility operations and a link between Puerto Rico and St. Thomas Island (Virgin Island group). The Navy also operates the Hawaii digital microwave system,

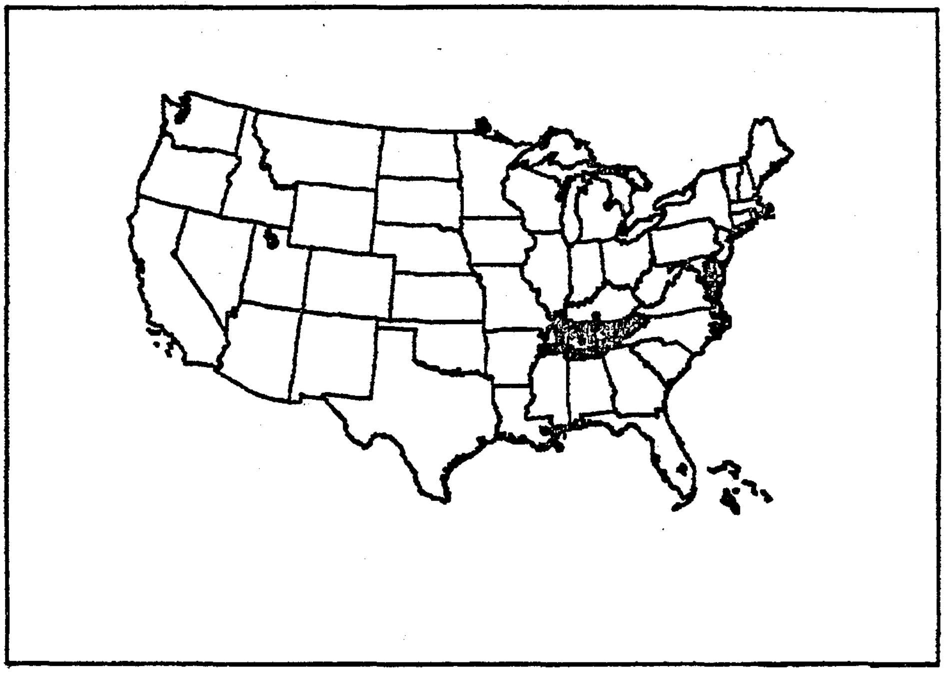


Figure 45. TVA Transmitter and Receiver Sites for the 7125-8450 MHz Band.

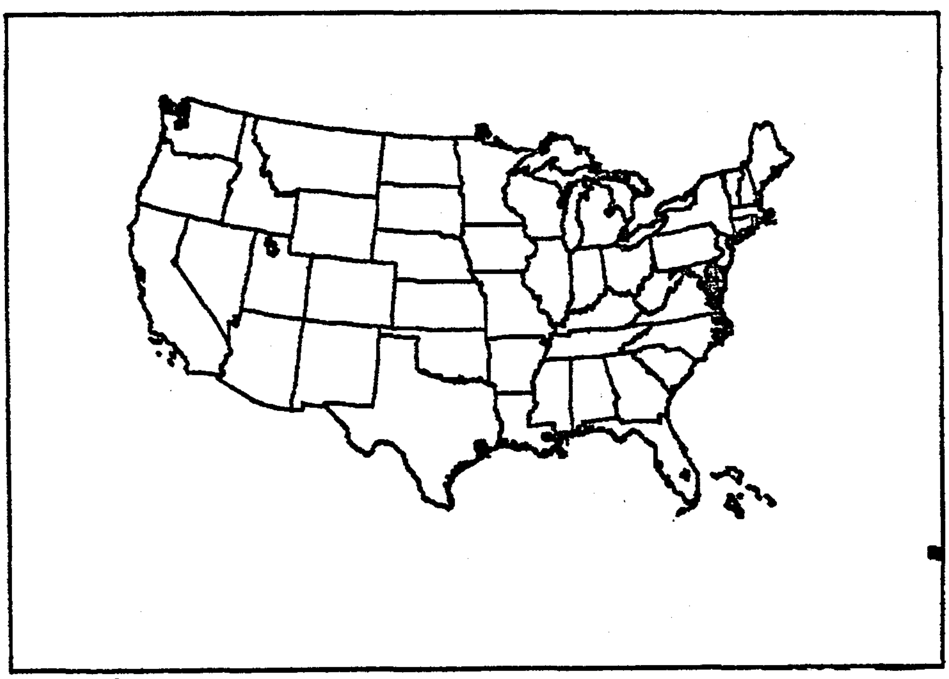
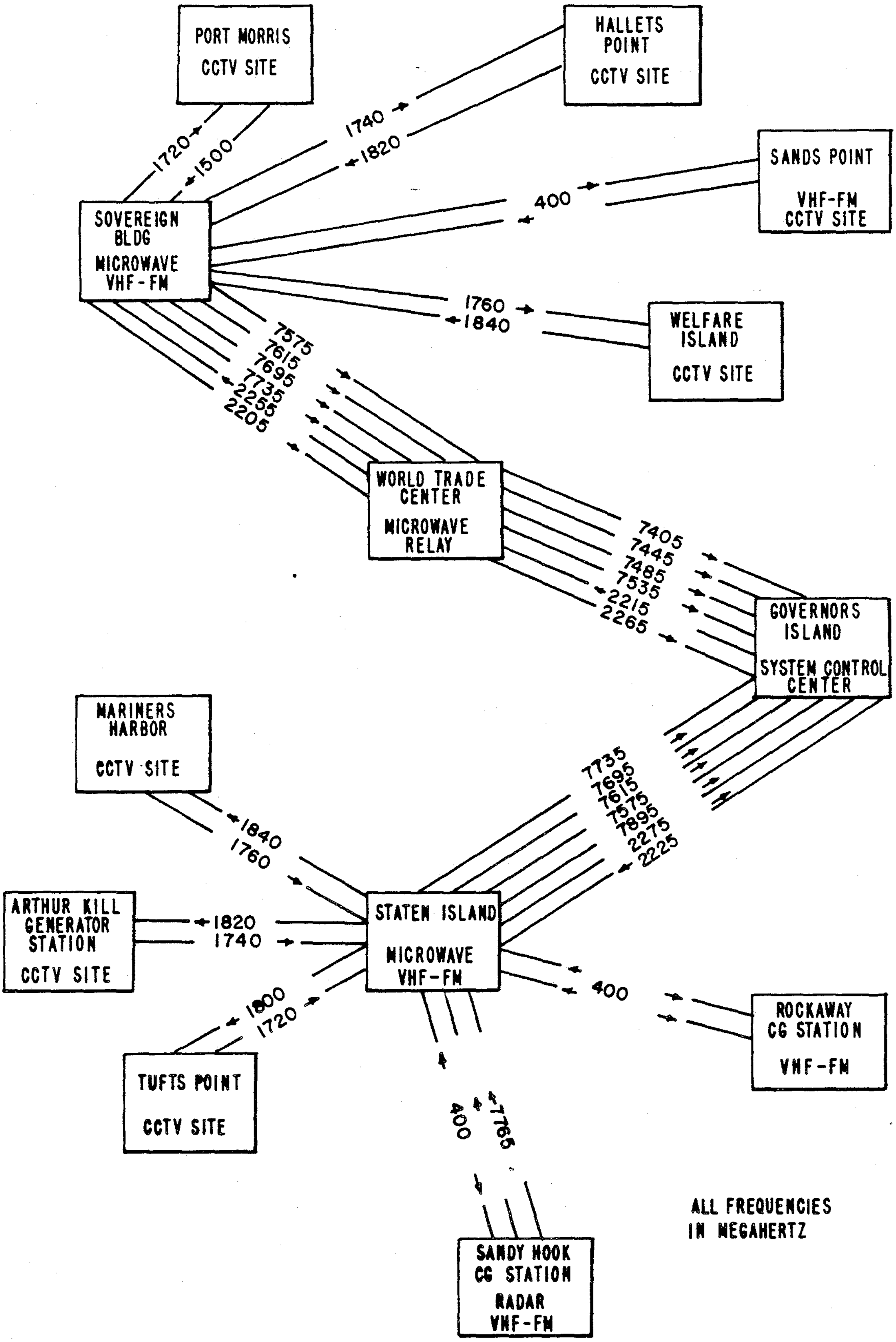


Figure 46. Coast Guard Transmitter and Receiver Sites for the 7125-8450 MHz Band.



NEW YORK VESSEL TRAFFIC SYSTEM

Figure 47. The Coast Guard Vessel Traffic System at New York showing the Interconnection of the Various Capacity Links.

which ties various Navy installations together for communications and data transfer purposes. Other uses are for Defense Communication System (DCS) microwave links, air traffic control radar data links, various test range communication support, various bombing range communications and data link support, and various security systems with remoting capability.

The Air Force has microwave links that support data and communications networks at various test ranges such as Vandenberg, CA, Eglin, FL, Nellis AFB, NV, Kennedy Space Flight Center, FL, Edwards AFB, CA, etc. These links are used for such purposes as mobile coverage of space shuttle launches and landings, transmitting video data from missile launch sites to central control for coordination of range operations, and data links between buildings and computers. The Air Force has microwave links which support tactical training of its personnel, air defense networks, air traffic control networks for remoting radars, and relay links between ranges such as Edward AFB, CA, and Wendover, UT. Other uses in the band are for the Defense Satellite Communication Systems (DSCS) and other satellite systems both Earth-to-space and space-to-Earth.

The Army uses microwave links in the 7125-8450 MHz band to support research efforts at facilities such as the electronic proving ground in Texas and the Aberdeen proving ground. These are communication and data links between test sites and command centers. Other uses of microwave links in the band are computer-to-computer data links such as the one at Hunter Liggitt, air traffic control networks for remoting radars, tactical training for army personnel in use of various communications, and data links, the Army Wide Area Communication System, ARTRAC Net, TARS, Net, FIESTA Net, use by the Army Corps of Engineers for supervisory control of power plants, dam flood gate control, and for CCTV remote links and security systems. The Army also has assignments for DSCS and other satellite systems.

The uses given here are by no means exhaustive but give a general overview of major Government spectrum usage in the 7125-8450 MHz bands.

MAJOR SYSTEMS

There are a variety of types of terrestrial microwave systems currently operating in the 7125-8450 MHz bands. These systems vary considerably in both technical characteristics and use. Table 47 lists some of the major systems used by the military. There are over 30 types of commercial equipment used by the various Government agencies, mainly for point-to-point microwave links. Table 48 lists the 36 systems presently in the IRAC Systems Review File. As shown there, the greater percentage of new systems are space related.

As given earlier, the FAA has approximately 47% of the assignments in the band and these are used mainly for radar microwave links (RML) that relay radar information from remote sites to air traffic control centers (ARTCC). Figure 48 shows a block diagram of a typical air traffic control radar beacon systems including the microwave link which carries the information to the control center. The characteristics of the FAA microwave links are similar in many ways to many of the other microwave systems operating in the band [Pratt, 1977].

TABLE 47

MAJOR SYSTEMS IN THE 7125-8450 MHz BAND

SYSTEMS	USE
AN/FRC-84	Terrestrial Microwave Link
AN/FRC-105	" " "
AN/FRC-109	" " "
AN/FRC-127	" " "
AN/FRC-149	" " "
AN/FRC-153	" " "
AN/FRC-158	" " "
AN/FRC-159	" " "
AN/FRC-162	" " "
AN/FRC-165	" " "
AN/FRC-171	" " "
AN/GRC-169V	" " "
AN/GSQ-120	" " "
AN/FRQ-11	" " "
AN/FSC-9	DSCS Earth Terminal
AN/FSC-78	" " "
AN/TSC-54	" " "
AN/TSC-85	" " "
AN/TSC-86	" " "
AN/MSC-46	" " "
AN/MSQ	" " "
AN/WSC-6	Fleet Command Satellite Terminal
AN/ASC-24	Airborne Satellite Terminal
AN/SLQ-32	Shipborne Countermeasures
AN/TXQ-3	Data Link
RML 1A, 2, 3, 4, 5, & 6	Command, Control and Data Link Between Remote Radars and Control Point.

Over 30 Types of Commercial Equipment--Mainly Point-to-Point Microwave Links

TABLE 48

UNCLASSIFIED SYSTEMS IN THE SYSTEMS REVIEW FILE FOR THE 7125-8450 MHz BAND (June 1983)

SYSTEM (No. of Systems)	SPONSOR	STAGE OF DEVELOPMENT*
Space Systems		
Integrated Medical and Behavioral Lab. Measurement System	HEW	4
Fleet SATCOM	N	4
LANDSAT D	NASA	3
Deep Space Net	NASA	0
SOLAR POLAR Sat	NASA	1
NATO SATCOM III	AF	0
GPS Command Upline	AF	1
Deep Space Telecommand	NASA	1
Satellite Earth Station	AR	4
WDX Dual Earth Terminal	NS	4
NATO-3A (2)	NS	4
NATO-3B (4)	AF	4
AN/ASC-24	AF	4
AN/ASC-28	AF	2
AN/GSC-49	AR	4
AN/MSC-59	AR	2
AN/TSC-85	AR	4
AN/TSC-86	AR	4
AN/YSC-93	AR	4
AN/TSC-94	AR	4
AN/WSC-6	N	4
Terrestrial Systems		
TVA Microwave Link	I	4
WAPA Microwave Link	DOE	4
Data Acquisition and Transmission System	AF	4
BPA Microwave Links (3)	DOE	4
VTS,VTCS (4)	CG	4
Digital Microwave System	AF	3
MDR-8-5 Microwave System	AF	4
TCM 604 Microwave Link	AF	4
Telemetry Acquisition & Relay System	AR	4

*STAGE
1. Conceptual
2. Experimental
3. Development
4. Operational
0. Not reviewed

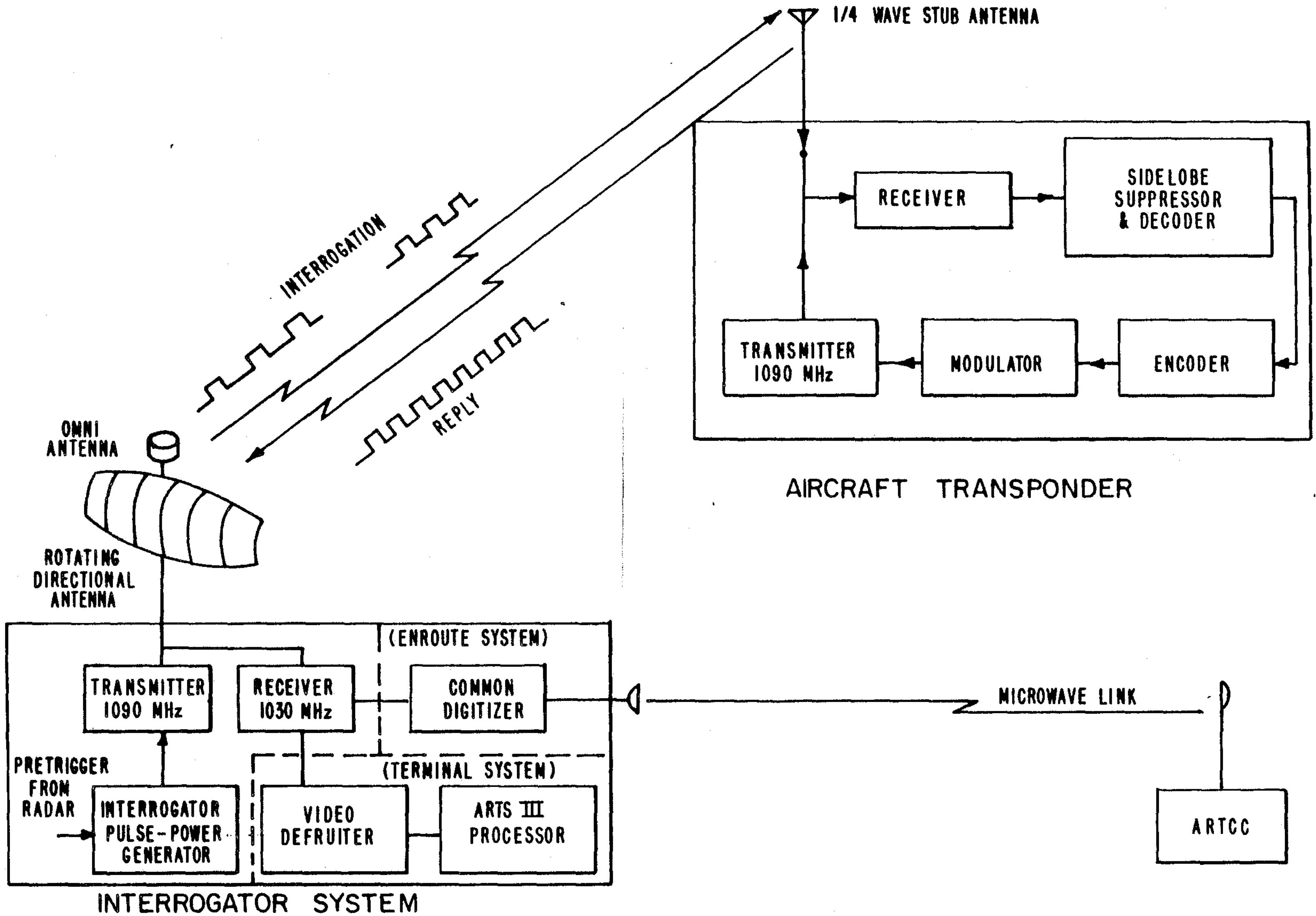


Figure 48. Block Diagram of a Typical Air Traffic Control Radar Beacon System.

Most of the FAA's links are of the RML-4 type. The RML-4 system transmits four channels of radar, beacon, and control information from the remote radar site to the "indicator" site, located at the air traffic control center. Similarly, two channels of information are transmitted from the indicator site back to the radar to enable control and monitoring in the reverse direction. The transmission is line-of-sight and often requires six or more relays along the path to redirect and amplify the signal.

A general block diagram of the RML-4 at the radar terminal is shown in Figure 49. Basically, this diagram shows four channels of information each being set via separate transmitters with two channels of information received. Each channel sends an FM modulated signal that occupies a bandwidth of 16 MHz. A general block diagram of the indicator side of the link is shown in Figure 50.

A few of the pertinent system parameters for the RML-4 are listed in the following table.

TABLE 49

SYSTEM PARAMETERS FOR THE RML-4
MICROWAVE LINK (RADAR TERMINAL)

Number of Channels	4
Modulation	FM
Power Output per Channel	-10 dBm
Bandwidth per Channel	15 MHz
IF Frequency	70 MHz
Channel Deviation Ratio	0.5
Antenna	
Type	Periscope
Polarization	Horizontal or Vertical
Gain	39.4-45.3 dBi
Receiver Noise Figure	14 dB
Frequency	7.125-8.4 GHz

The FAA also uses an RML-6 link at a few locations where ASR-7 radars have been installed. This system differs in a number of aspects from the RML-4. One of the major differences is that the RML-6 transmits all radar-to-indicator information in one wide-band channel as opposed to three channels in the other systems. A general block diagram of the RML-6 at the radar is shown in Figure 51. As can be seen, radar, video, triggers, and control signals are sent to both the A and B multiplexers where they are multiplexed into 0-16 MHz baseband signals. After multiplexing, the signal is sent to both the A and B FM generators which produce two 70 MHz frequency modulated signals. One of these signals is selected by a remotely controlled switch and is then simultaneously sent to two up-converters which translate it to the 7.125 to 8.4 GHz frequency band. The signal is subsequently amplified in a traveling wave tube (TWT) amplifier, and the output of desired TWT amplifier is connected to the proper antenna through a circular-switch arrangement. A similar reverse link exists for monitor and control purposes.

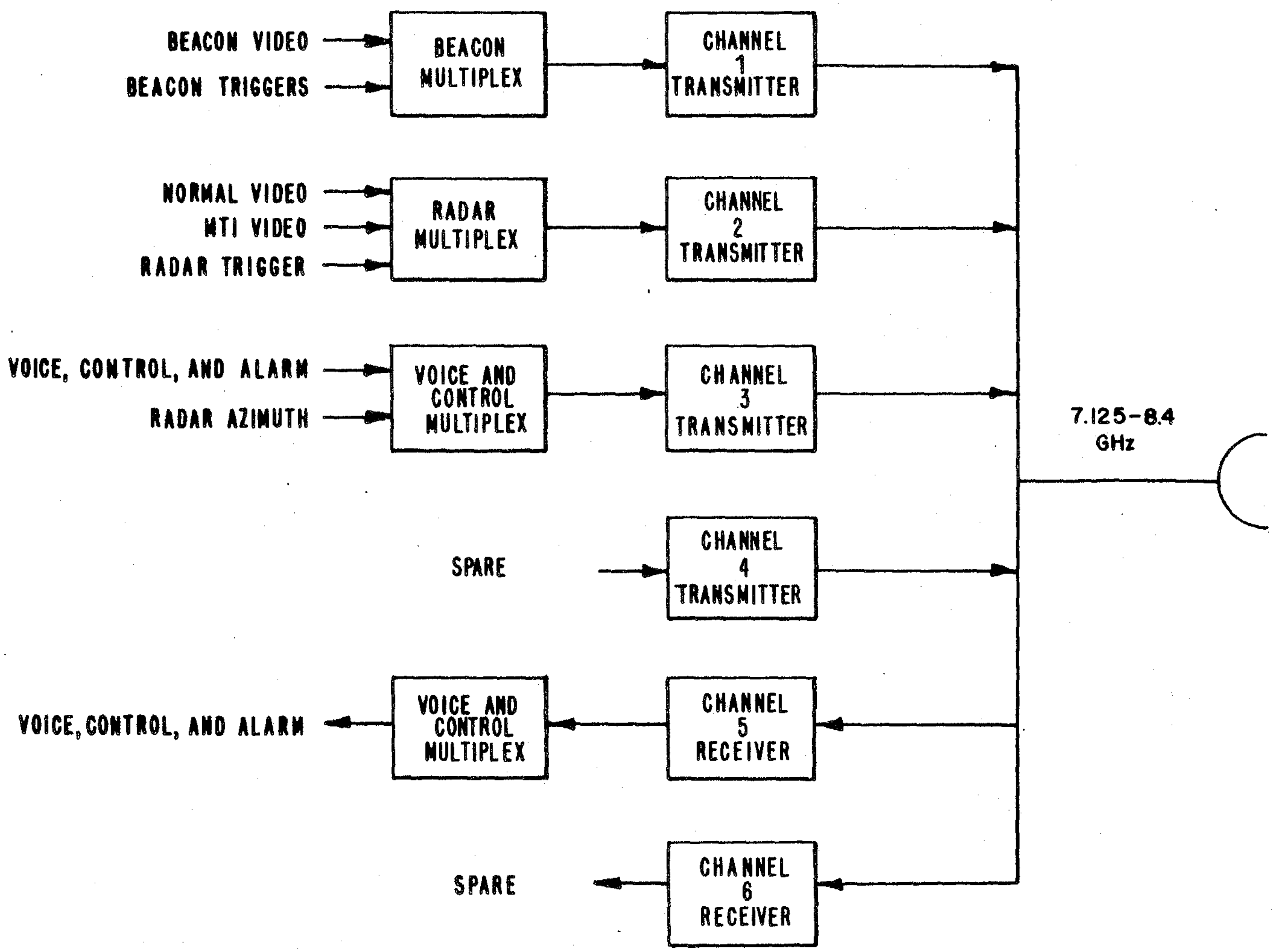


Figure 49. A General Block Diagram of the RML-4 at the Radar Terminal.

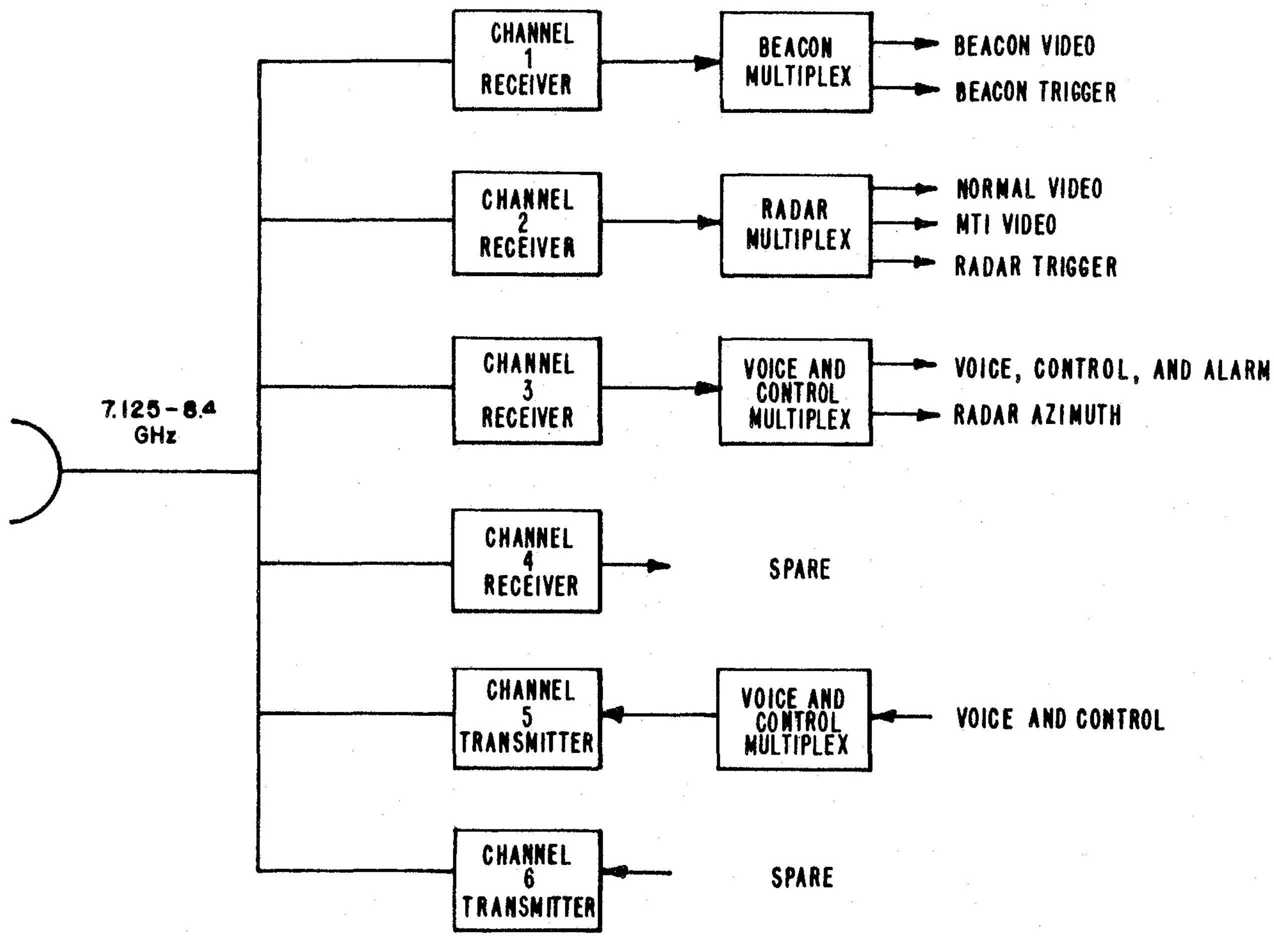


Figure 50. The Block Diagram of the RML-4 Indicator Terminal.

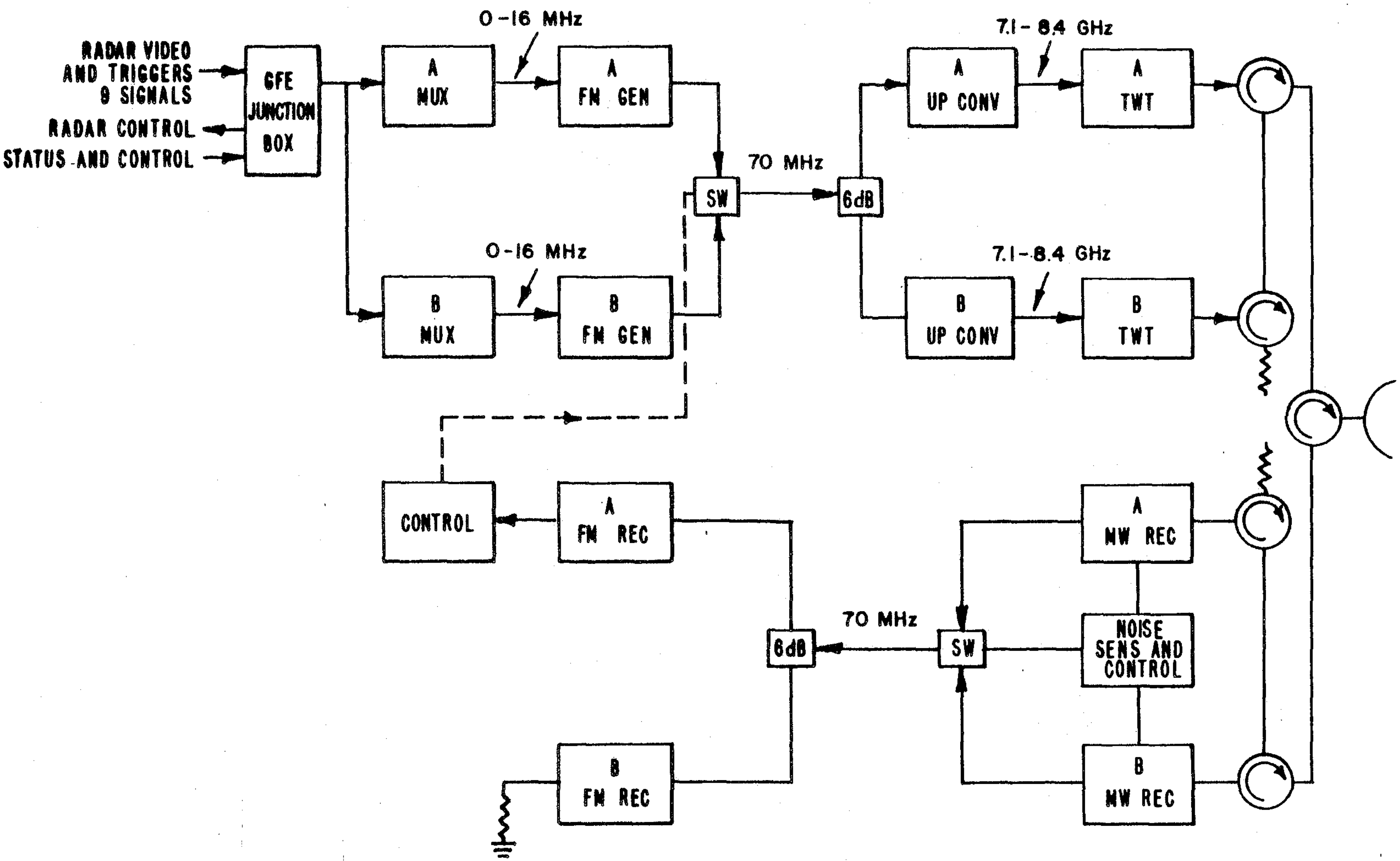


Figure 51. A General Block Diagram of the RML-6 at the Radar Sites.

The received signal at the indicator is applied to both microwave receivers. A noise-sensing circuit automatically monitors an 11.8 MHz pilot and the baseband noise, and then applies the best 70 MHz signal to both FM receivers. The demodulated baseband output is sent to the control equipment which controls the transmit switch. The control channel is a digital channel which carries frequency-shift data at a bit rate of 600 bps. A general outline of the RML-6 system parameters is given in Table 50.

TABLE 50

SYSTEM PARAMETERS FOR THE RML-6 MICROWAVE LINK

Power Output	38 dBm
RF Bandwidth	46 MHz
Frequency Range	7.125-8.4 GHz
Receiver Noise Figure	10 dB
Antenna	
Type	Parabolic Dish Direct Radiator
Diameter	6 feet 4 inches
Gain	40 dBi
Polarization	Horizontal or Vertical
Modulation	FM
Deviation Ratio	0.25
Peak Frequency Deviation	$\pm$ 4 MHz
Baseband Bandwidth	16 MHz

The indicator terminal is nearly identical to the radar terminal with the major difference being that the baseband signals are now demultiplexed so that they can be sent to the radar indicators. Even though the RML links are typical of the microwave links used in the 7125-8450 MHz bands, Table 51 gives a comparison of characteristics for various systems used by the agencies designated to show the variability between them [Mayher, 1976][Mayher, 1973]. As a particular example the Nevada Automatic Diagnostic System (NADS) operated by DOE has a bandwidth of 110 MHz compared to the RML-4 bandwidth of 15 MHz.

The main use of the 7125-8450 MHz bands other than the fixed microwave links is the satellite services: the Military Satellite Communication (MILSATCOM) Systems such as the Navy Fleet Satellite Communication (FLTSATCOM) Network, the NATO SATCOM III, the DSCS II and III, the DCA satellite communication links, and a few special purpose systems.

The greatest number of assignments to satellite communications are to the DSCS II and III systems. The DSCS was designed to provide communication services between the National Command Agency, Defense Communication Agency, and the various Army, Navy, and Air Force commands. It also provides communication between commands and war combat forces. Along with the NATO SATCOM III, the DSCS provides vital communication requirements of the Ground Mobile Forces: Navy ship to shore, the Diplomatic Telecommunication System, and the NATO Commands. The DSCS Phase I consisted of 26 operational satellites and became operational in 1967. The last of the Phase I satellites was launched in 1968 with a 3 to 4 year life.

TABLE 51

COMPARISON OF CHARACTERISTICS FOR TYPICAL POINT-TO-POINT MICROWAVE LINKS OPERATING IN THE 7125-8450 MHz BAND

EQUIPMENT CHARACTERISTICS

	NOAA	TVA	FAA	U.S. AIR FORCE/ARMY	U.S. NAVY	DOE: BONNEVILLE POWER	DOE: NADS	DOE: MTS - MOBILE CCTV
DIGITAL	$PE = 10^{-7}$, $(S/I)_o = 15$ dB		3 VOICE CHANNELS $P_E \sim 10^{-5}$, $(S/I)_{OUT} = 12$ dB	$(S/N)_{IN} = 22$ dB	HF, $(S/I)_{OUT} = 20$ dB AIR SURVEILLANCE, $(S/I)_{OUT} = 12$ dB		$PE = 10^{-6}$ $(S/N)_{IN} = 14$ dB MIN	
VOICE		600 CH; $(S/I)_o = 25$ dB UNWEIGHTED: WORST CASE		600 CH; $(S/I)_{OUT}$ $= 32.5$ dB	300 CH; $(S/I)_{OUT} = 27$ dB WORST CASE	600 - 1200 CH $(S/I)_{OUT} = 30$ dB		
BW_{IF}	44 MHz	25 MHz	15 MHz (RML-4) 45 MHz (RML-6)	15 MHz	15 MHz	20 MHz	40 MHz (SPECIFIED)	32 MHz (3 dB)
BW_{BB}	5 MHz	2.54 MHz; PILOT TONE AT 3.2 MHz	7 MHz (RML-4) 16 MHz (RML-6)	2.54 MHz	8.4 MHz	2.54 MHz	≈10 MHz	8.2 MHz
D_{PK}	± 1.25 MHz	3.9 MHz	3 MHz (RML-4) 6.3 MHz (RML-6)			4 MHz	4 MHz	4 MHz
$(S/N)_{OUT}$	58 dB	65 dB FLAT WEIGHTED FOR 1 HOP		72.5 dB	50 dB	65 dB		
NF	10 dB	12 dB	14 dB (RML-4) 10 dB (RML-6)	12 dB	14 dB	12 dB	13 dB	12 dB
FADE MARGIN	43 dB	40 dB	WORST CASE MOD. TYPE 18 dB (RML-4) 33 dB (RML-6)	40 dB	23 dB	35 dB	21 dB	≥ 45 dB 62 dE (EST)
PRE EMPHASIS	NO	NO	NO	INCLUDED IN 32.5 dB		NO - EXCEPT GE EQUIPMENT	NO	NO
PATH LENGTH	≈ 2 MILES	≈ 30 MILES	30 MILES RML-4,6	30 MILES	30 MILES	30 MILES	20 MILES	20 MILES
S_{IN}		- 40 dBm						
$(S/N)_{IN}$			38 dB (RML-4) 53 dB (RML-6)				35 dB	75 dB
D_{RMS}				140 kHz / CH	200 kHz / CH	200 kHz / CH		
TV								$(S/N)_{IN} = 13$ dB MIN
KEY FACTORS	NO DIVERSITY SINGLE HOP (2 MILES)	FREQUENCY DIVERSITY (OLD MAJORITY SYSTEMS SPACE DIVERSITY) (NEW SYSTEMS)	FREQUENCY DIVERSITY RML-4 RML-4 (MANUAL SWITCHING) MAJOR EQUIPMENT TYPES RML-4, 6 NEW RML INSTALLATIONS		FREQUENCY DIVERSITY	FREQUENCY DIVERSITY	NO DIVERSITY	NO DIVERSITY 13 MOBILE VANS (2 REPEATER VANS)

The DSCS Phase II satellites where the follow-on with the first one launched in November of 1971. There are now 8 operational with 15 launched. These satellites were designed to have a 5-year life. The basic system description is given in Table 52. The satellite transponder consists of a multichannel repeater, a receiver and transmit earth coverage antenna, a steerable narrow beam antenna, and a steerable area coverage antenna. There are four different channels of operation: spot to global, global to global, global to spot, and spot to spot.

TABLE 52

DSCS II SYSTEM DESCRIPTION

-- Services Provided-	U.S. Military Telephone, Digital Data, and Teletype			
-- Date of First Operation-	November 1971			
-- Number of Satellites-	8 operational			
-- Coverage Area-	Global			
-- Orbit Type-	Geostationary			
-- Design Life, yrs-	5			
-- Coverage-	18-deg. Global and 2, 2.5-deg. Spots			
-- Channels-	Spot to Global	Global to Global	Global to Spot	Spots to Spot
-- Channel Bandwidth, MHs-	50	125	50	185
-- Transponder Output Amp-	---- 20-W TWT ----		---- 20-W TWT----	
-- EIRP, dBW-	-------28 --------		40*	40*
-- G/T, dB/K-	20.2	8.5	8.5	20.2
-- Single Carrier Saturation Flux Density, dBW/sq.m-	-84	-78	-78**	-84**
-- Number of Transponders-	--------1 ---------		--------1 -------	
-- Frequency Band, Receive, GHz-	8.125-8.175	7.975-8.025	7.900-7.950	8.215-8.400
Transmit, GHz-	7.400-7.450	7.250-7.375	7.700-7.750	7.490-7.675
-- Polarization	Circular			
-- Number of Antenna Beams-	1 Global and 2 Spot Beams			

*40 dBW if both spot beams are used, 43.1 dBW if one spot is used.

**Typical, gain adjustable over a 24 dB range in 4-dB steps.

The DSCS Phase III satellites are the follow-on, next generation satellites and will have a 10-year life. The DSCS III has greater degree of antijam protection. The satellite has a six-channel transponder, each channel having its own travelling wave tube amplifier. Signals are received and transmitted through an interconnecting set of multibeam antennas that have the capability to spatially distribute receiver pattern gain and the transmission power. The basic system description is given in Table 53. As with the DSCS II, the Phase III satellites can be repositioned at least once during its operational lifetime. Other moves may be possible depending on fuel consumption.

The Navy acts as executive agent on behalf of DOD for the new LEASAT Communication Satellite System. This satellite system will be used by the Navy, Marine Corps, Army, and Air Force. The contractor (Hughes Communication Service) was not only responsible for the design and manufacture of the satellite system but is also tasked with the operational responsiblity under the guidance of the Navy. There will be five satellites in all. Telemetry, command, and fleet broadcast uplink and beacons operate in the 7250-7500 MHz and 7975-8025 MHz bands. Twelve UHF repeaters (240-400 MHz) provide the main communications activities. The main control center is at El Segundo, California, with stations in Guam; Hawaii; Norfolk, Virginia; and Stockton, California. Ground equipment used to communicate with the satellite is the Navy AN/FSC-79 SHF terminal.

There are a number of "small earth terminals" that are used with the MILSATCOM systems. Three will be described here [Adams, 1976]. They are the AN/MSC-59, AN/TSC-85, and the AN/TSC-86 satellite terminals. Each of these units is a transportable ground terminal that is used for duplex voice communications via a geostationary satellite. All of the terminals are similar in construction and differ primarily in the number of circuits they handle and maximum transmitter output power. One of the terminals, the AN/TSC-85, has two versions called the V1 and V2 which differ in that the V2 version can receive four carriers while the V1 is limited to one.

The terminals are digital; they transmit and receive pulse-code-modulated traffic via a biphase, differentially encoded, phase-shift keyed (PSK) signal. Provisions also have been made for eventual operation using 4-phase PSK. Each of the terminals transmits in the 7.9 to 8.4 GHz band and receives in the 7.25 to 7.75 GHz band. At the present time, the terminals communicate through one of Defense's Satellite Communication System, Phase II satellites (DSCS-II).

AN/MSC-59

The AN/MSC-59 is the smallest of the terminals and provides a nonredundant communication capability for 6 or 12 duplex, digitized voice channels. It is self contained in a portable equipment enclosure and is mounted on a 1/4 ton trailer. The antenna consists of a center section and four panels that assemble into an eight foot parabolic reflector. Protected voice traffic can be transmitted over the system using spread spectrum techniques. Conventional unprotected traffic also can be transmitted. The terminal has a capability of being switched into a coded mode of operation where the incoming data stream is coded with a 1/2 rate Viterbi convolutional code with a constraint length of seven. Transmitter output power is 100 W or less depending on operational requirements.

TABLE 53

DSCS III SYSTEM DESCRIPTION

-- Services Provided-	Telephone, Digital Data and Teletype for U.S. Military, NATO and Diplomatic Communications.						
-- Date of First Operation-	October 1982						
-- Number of Satellites-	Perhaps 4 in orbit, 12 planned for production						
-- Coverage Area-	Global						
-- Orbit Type-	Geostationary						
-- Design Life, yrs-	10						
-- Coverage-	Global and Spot						
-- No. of Transponders-	7: #1	#2	#3	#4	#5	#6	UHF*
-- Transponder Bandwidth, MHz-	60	60	85	60	60	50	
-- Transponder Output Amp.-***	40W TWTA	40W TWTA	10W TWTA	10W TWTA	10W TWTA	10W TWTA	Solid State
-- EIRP, dBW-	-------- 23 to 40** ------						N/A
-- G/T, dB/K-	-------- -16 to -1** ------						N/A
-- Single Carrier Saturation Flux Density, dBW/sq.m-	-------- N/A --------						---
-- Frequency Band, Receive, GHz-	----- 7.900-8.400 -----						UHF/SHF
Transmit, GHz-	----- 7.250-7.750 -----						UHF
-- Polarization-	Circular						
-- Number of Antenna Beams-	Transponders 1-6: 4 Receive, 6 Transmit UHF Transponder: 2 Receive, 1 Transmit						

*Special purpose "single channel" transponder.

**Various interconnections allowed between antennas and transponders.

***The fourth DSCS-III will fly with a GaAsFET amplifier replacing one of its 10-W TWTA's.

AN/TSC-85

The AN/TSC-85 model V1 is similar except that backup units are added to ensure full redundancy (excluding antenna). Power output has been increased to enable 500 W maximum output. Like the AN/MSC-59, the terminal is housed in a transportable shelter that is normally carried on a 1-1/2 ton truck.

The model V2 is similar to the V1 except that the unit is designed for multipoint operation in a tactical trunking system. Thus, the unit has the capability of receiving four separate high data rate carriers and transmitting one carrier. Therefore, the model V2 units will have four active modems and four down-converters as opposed to only one each in the V1 terminal. Both units are designed to handle up to 96 duplex, digitized voice channels; however, the V1 is normally limited to 24 channels due to the number of echo suppressors supplied. These units also can transmit protected spread-spectrum signals.

AN/TSC-86

The AN/TSC-86 is the largest of the terminals and is designed for use in a trunking system. The unit is mounted on a 2-1/2 ton truck with power generating equipment transported on a 3-1/2 ton trailer. Again, the antenna system and electronics are identical to that used on the other terminals. However, the unit is designed for multipoint operation and can transmit and receive on four separate carriers. Therefore, this terminal has four active up converters as well as four down converters. The maximum number of duplex channels that can be handled is again 96. Output power of this terminal is 1000 W or less depending on operational requirements.

Systems Parameters

Since all of the terminals use similar equipment, it will be helpful to list some of the common system characteristics. A typical block diagram of a small earth terminal is shown in Figure 52, where redundant backup units are denoted by dashed lines (for those terminals with redundant capability). Provisions for handling multiple carriers such as is encountered in the AN/TSC-86 are shown on the block diagram. A list of the data rates with which the terminals normally operate is given in Table 54 and a general summary of some of the system parameters is given in Table 55.

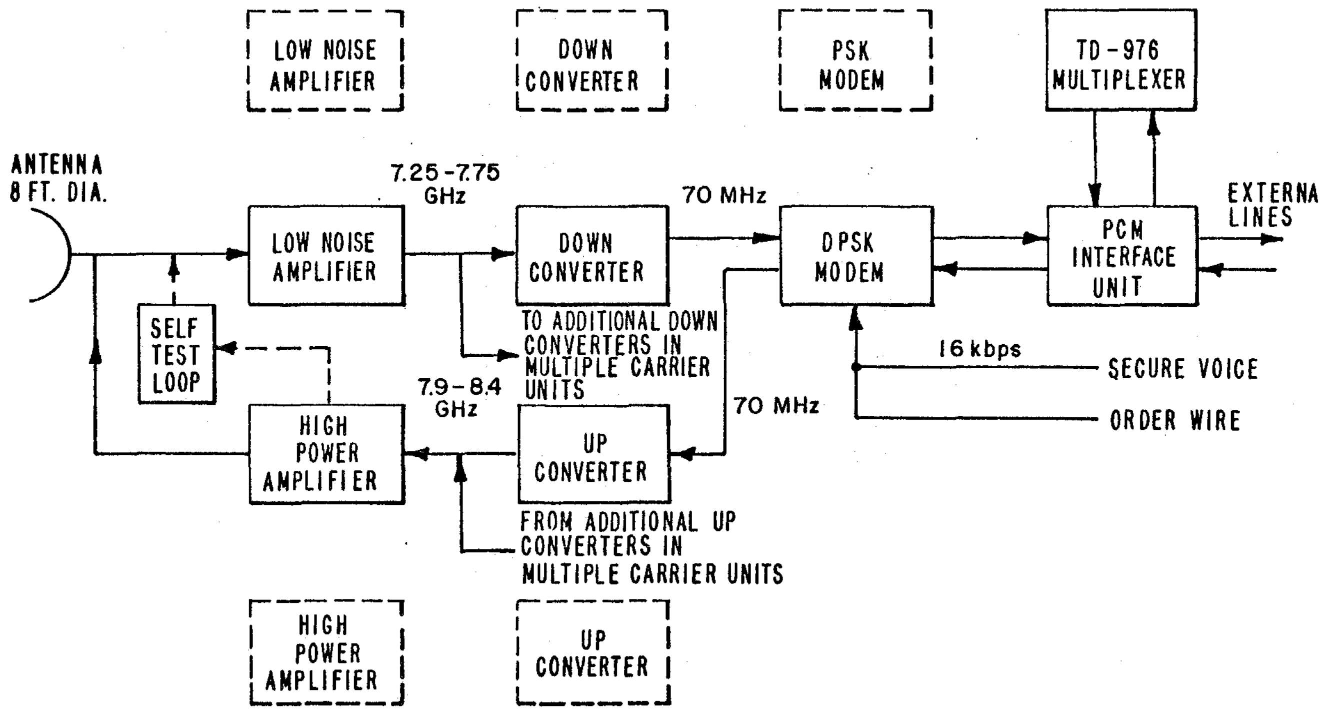


Figure 52. A Typical Block Diagram of a Small Earth Terminal.

TABLE 54

DATA RATES FOR SMALL EARTH TERMINALS

No. Voice Channels Per Carrier	Total Data Rate kb/sec
1	16.0
6	288.0
12	576.0
18	921.0
24	1152.0
24*	1228.8*
36	1843.2
48	2457.6
72	3686.4
96	4915.2

*Two groups of 12 channels per carrier.

The NASA Deep Space Network (DSN) is another system that uses frequencies in the 8400-8450 MHz band. This network has been used for programs such as Explorer, Pioneer, Mariner, Galileo, and Voyager. Figure 53 shows the communication links involved with the Galileo satellite mission which was sent to the planet Jupiter [Flynn, 1980]. The DSN receiving antenna is a 64 meter (210 ft) steerable and highly directive dish. The receiving system approaches the sensitivity of a radio astronomy receiver around -160 dBw. NASA operates only one deep-space earth station in CONUS at Goldstone, CA. Other NASA uses of the 7125-8405 MHz band is for fixed microwave links used in data transfer, command, control, remote surveillance, and communication.

All other Government agency systems are similar to what has been described here, mostly fixed microwave links for data, communication, remote surveillance and command/control.

TABLE 55

SYSTEM PARAMETERS FOR SMALL EARTH TERMINALS

Frequency	
Receive	7.25-7575 GHz
Transmit	7.90-8.40 GHz
Output Power	
AN/TSC-59	100 W
AN/TSC-85	500 W
AN/TSC-86	1000 W
Antenna	
Diameter	2.44m (8 ft)
Polarization	
Receive	Left hand circular
Transmit	Right hand circular
Modulation	Digital 2Φ-DPSK 4Φ-DPSK
Down Converter	
1st IF LO	700 MHz
2nd IF LO	70 MHz
BW	40 MHz
Noise Figure	10 dB max
Low Noise Amplifier	
Bandwidth	500 MHz
Gain	32-34.5 dB
Noise Temperature	165°K max
High Power Amplifier	
Instantaneous Bandwidth	40 MHz
Harmonic Output Level	-60 dB
Spurious Output	-80 dB
In Band Noise	-92 dBm/Hz
Out of Band Noise	-182 dBm/Hz
Up Converter	
Input Frequency	70 MHz
1st LO Frequency	630 MHz
2nd LO Frequency	7.2-7.7 GHz
Output Frequency	7.9-8.4 GHz
Modem	
Input	PCM
Output Frequency	70 MHz
Data Rates	
Minimum	288 kbps
Maximum	4915.2 kbps
Secure Voice	16 kbps

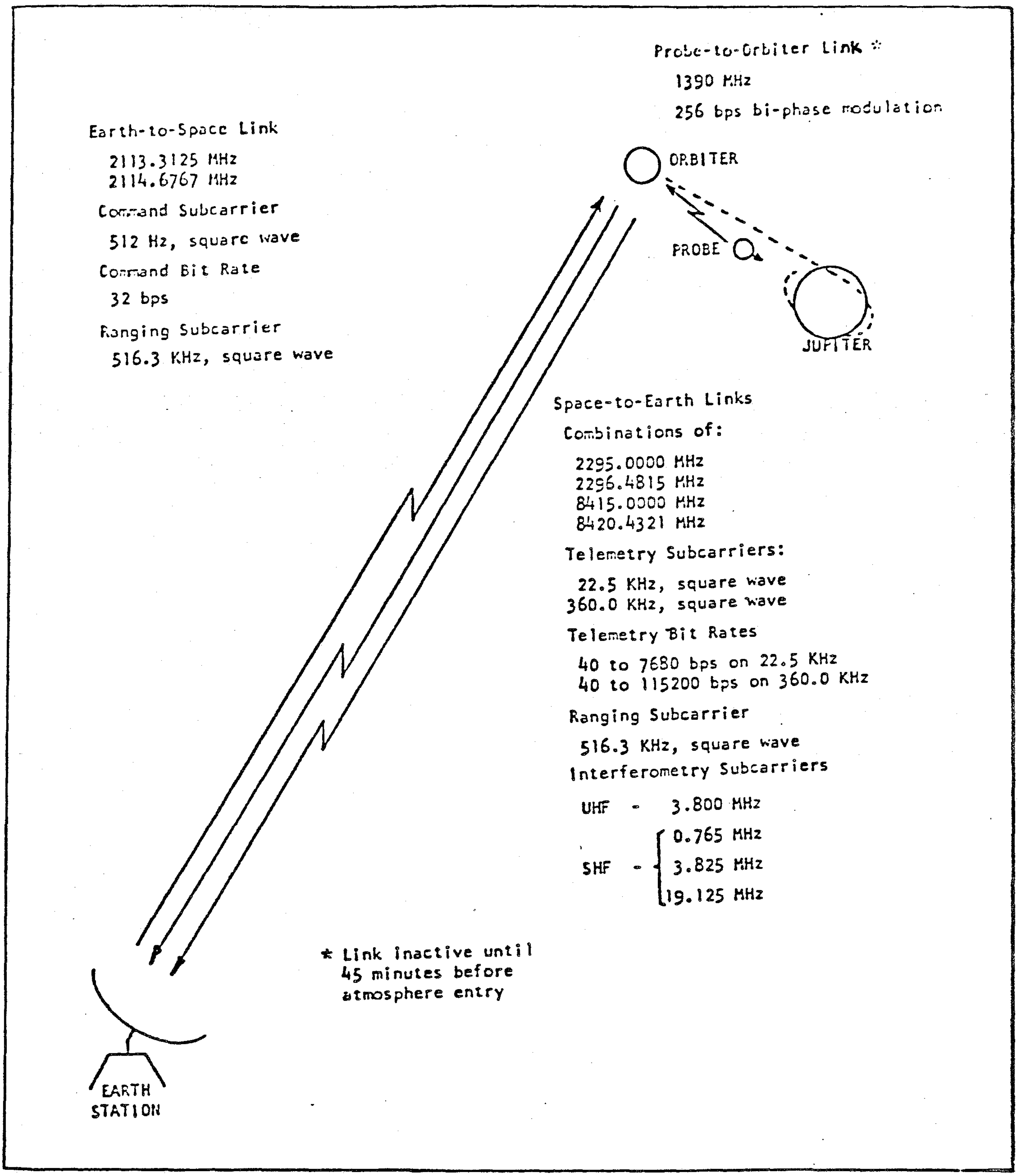


Figure 53. Galileo Satellite System Telecommunication Links.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

As shown in this report the 7125-8450 MHz portion of the radio frequency spectrum has a wide variety of systems and uses. There are over 7700 assignments to 22 different station classes and 20 Government departments and agencies. The fastest growing bands are those that include satellite communication assignments. As seen in Table 49 page 203, 26 of the 36 systems in the Systems Review File deal with space communications.

The uses of the 13 bands that make up the 7125-8450 MHz frequency spectrum are vital to the national defense (DCS, DSCS, NATO, the various fixed microwave tactical communication systems, etc.) providing a major portion of military communication capability not only within CONUS, Alaska, and Hawaii but with all of our major allies, protectorates and naval ships at sea. The nation's air traffic control systems, both civilian and military, are dependent on frequency assignments in these bands. The DOE and TVA have vital command, control, and communication links for electrical power transmission systems. The National Weather Service uses microwave links in these bands to bring radar information to central data collection and analysis facilities. The GOES meteorological satellite terrestrial data links are also in these bands and support domestic and worldwide weather forecasting services. The Coast Guard operates the Vessel Traffic System in these bands for communications and remote control of radars in support of harbor radar advisory ship control. The NASA Deep Space Network is in these bands along with data and communication links at the various NASA ranges. Other Government agency use is mainly for data, communication, and surveillance system microwave links.

Because of the importance of the systems operating in these bands and the obvious congestion in many areas of CONUS, there is very little possibility of general sharing with the private sector. However, there is an area as shown in Figure 43 from mid-Montana east through North and South Dakota, Minnesota, Wisconsin, Iowa, and northern Nebraska where sharing may be possible. The sharing would have to be with noncritical systems in the private sector since the ability for military tactical and emergency systems to be moved in and operated during time of national emergency or war would need to be preserved.

Although there appears to be growth potential from 8400-8450 MHz, this subband has purposely been avoided for fixed systems in certain areas because of potential interference problems from high power radars in the 8500-9000 MHz band. This band allows for some growth for Government users as the 7/8 GHz band becomes more crowded.

RECOMMENDATIONS

Because of the importance of the systems operating in the band and the congestion already present in many areas of CONUS, there appears to be little possibility of general sharing with the private sector at this time.

THE 14.5-15.35 GHz BAND

INTRODUCTION

The 14.5-15.35 GHz band is a Government exclusive band with most of the assignments to the Fixed Service. The band has shown considerable growth over the past ten years and many new systems are being planned for use in the future.

FREQUENCY ALLOCATIONS

There are three subbands in the 14.5-15.35 GHz band, as shown in Table 56. From 14.5-14.7145 GHz the allocation is to Government Fixed and Mobile Services on a primary coequal basis and to Space Research on a secondary noninterfering basis. From 14.7145-15.1365 GHz, the allocation is to the Government Mobile Service on a primary basis with Fixed and Space Research secondary. From 15.1365-15.35 GHz the allocation is to Government Fixed Service primary and to Mobile and Space Research secondary. International footnote 720 states that Space Research (passive) and Earth Exploration-Satellite (passive) Services are allowed from 15.2-15.35 GHz on a secondary basis. The United States footnote 211 states that systems, particularly airborne or space station assignments, are urged to take all practicable steps to protect radio astronomy observations in the 15.35-15.4 GHz band. Table 56 shows the band as it became official in 1983. Before the adoption of the new allocation tables, which were revised based mainly on WARC-79 agreements and IRAC and FCC consequent changes, the band from 14.5-15.35 GHz was allocated to the Government Fixed and Mobile Services on a primary coequal basis with Space Research (space-to-Earth) secondary. The band was divided into the three subbands to decrease potential interference problems between mobile and fixed systems operating or scheduled for operation in the band. Coordination of assignments for transmission or reception of earth stations in the 14.5-15.35 GHz band is given in the NTIA Manual, Chapter 8, Section 8.4.13. There is a channeling plane for Fixed Service assignments in this band and the following is an excerpt from the NTIA Manual covering this plan.

CHANNELING PLAN FOR ASSIGNMENTS IN THE FIXED SERVICE IN THE 14500.0 TO 14714.5 AND 15136.5 TO 15350.0 MHz

1. The following channeling plan became effective on January 1, 1982, for all assignments in the Fixed Service.

2. Existing assignments as of January 1, 1982, in the Fixed Service which are in the bands 14500.0 to 14714.5 MHz and 15136.5 to 15350.0 MHz that are not in compliance with the channeling plan may be retained until January 1, 1997. However, if existing equipment is replaced prior to January 1, 1997, assignments for the replaced equipment must be in accordance with the channeling plan.

TABLE 56

EXCERPTS FROM THE INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
14.5-14.8	FIXED FIXED-SATELLITE (Earth-to-space)863 MOBILE Space Research		14.5-14.7145		FIXED Mobile Space Research	
			14.7145- 15.1365		Fixed MOBILE Space Research	
14.8-15.35	FIXED MOBILE Space Research 720		15.1365-15.35	US211 720	FIXED Mobile Space Research	

720 - The bands 1370 - 1400 MHz, 2640 - 2655 MHz, 4950 - 4990 MHz and 15.20 - 15.35 GHz are also allocated to the space research (passive) and earth exploration-satellite (passive) services on a secondary basis.

US211 - In the bands 1670 - 1690 MHz, ...15.1365 - 15.35 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 interferences; however, US74 applies.

3. This channeling plan is only applicable to assignments in the Fixed Service in the bands 14500.0 to 14714.5 and 15136.5 to 15350.0 MHz. The assigned frequency shall be chosen such that the frequency ± 1/2 of its necessary bandwidth shall not extend beyond the upper or lower limits of bands indicated herein. A general breakdown of these bands is:

a. For emission bandwidths equal to or greater than 3.5 MHz:

14500.0 to 14710.0 MHz
15140.0 to 15350.0 MHz

b. For emission bandwidths less than 3.5 MHz:

14710.0 to 14714.5 MHz
15136.5 to 15140.0 MHz

4. Criteria for assignments in the Fixed Service with emission bandwidths equal to or greater than 3.5 MHz:

a. The assigned frequency must center on one of the frequencies given in Table 57.

b. Multiple contiguous channels are to be used for emission bandwidths of 3.5 MHz or greater.

c. In order to promote uniformity and to establish a natural guard band, it is strongly urged that frequencies be selected in pairs from the bands 14500.0 to 14710.0 and 15140.0 to 15350.0 on an equal basis.

5. Criteria for assignments in the Fixed Service with emission bandwidth of less than 3.5 MHz are restricted to the bands:

a. Assignments in the Fixed Service with emission bandwidths of less than 3.5 MHz are restricted to the bands:

14710.0 to 14714.5 MHz and
15136.5 to 15150.0 MHz

b. Narrowband assignments, those with less than 3.5 MHz of necessary bandwidth, shall not be made in the bands 14500.0 to 14710.0 and 15150.0 to 15350.0 MHz.

TABLE 57

CENTER FREQUENCIES (MHz) OF 2.5 MHz CHANNELS IN THE BANDS
14500.0-14714.5 MHz AND 15136.5-15350.0 MHz

14500.0-14714.5 MHz		15136.5-15350.0 MHz	
MHz	MHz	MHz	MHz
*14501.25	14601.25	*15141.25	15241.25
03.75	03.75	43.75	43.75
06.25	06.25	46.25	46.25
08.75	08.75	48.75	48.75
11.25	11.25	51.25	51.25
13.75	13.75	53.75	53.75
16.25	16.25	56.25	56.25
18.75	18.75	58.75	58.75
21.25	21.25	61.25	61.25
23.75	23.75	63.75	63.75
26.25	26.25	66.25	66.25
28.75	28.75	68.75	68.75
31.25	31.25	71.25	71.25
33.75	33.75	73.75	73.75
36.25	36.25	76.25	76.25
38.75	38.75	78.75	78.75
41.25	41.25	81.25	81.25
43.75	43.75	83.75	83.75
46.25	46.25	86.25	86.25
48.75	48.75	88.75	88.75
51.25	51.25	91.25	91.25
53.75	53.75	93.75	93.75
56.25	56.25	96.25	96.25
58.75	58.75	98.75	98.75
61.25	61.25	15201.25	15301.25
63.75	63.75	03.75	03.75
66.25	66.25	06.25	06.25
68.75	68.75	08.75	08.75
71.25	71.25	11.25	11.25
73.75	73.75	13.75	13.75
76.25	76.25	16.25	16.25
78.75	78.75	18.75	18.75
81.25	81.25	21.25	12.25
83.75	83.75	23.75	23.75
86.25	86.25	26.25	26.25
88.75	88.75	28.75	28.75
91.25	91.25	31.25	31.25
93.75	93.75	33.75	33.75
96.25	96.25	36.25	36.25
98.75	98.75	38.75	38.75
	14701.25		41.25
	03.75		43.75
	06.26		46.25
	*08.75		*48.75

*These channels cannot be used for bandwidths greater than 2.5 MHz. Total number of channels available: 168.

SPECTRUM USAGE AND MAJOR SYSTEMS

There are assignments to nine Government agencies in the band from 14.5-15.35 GHz as shown in Table 58. There are 248 assignments to fixed, point-to-point microwave systems and 172 assignments to the experimental services. More than half of the experimental assignments involve fixed microwave systems. There are 127 assignments in the 214.5 MHz from 14.5-14.7145 GHz, 263 assignments in the 442 MHz from 14.7145-15.1365 GHz and 66 assignments in the 213.5 MHz from 15.1365-15.35 GHz for a total of 456 assignments. The FAA has the most assignments with 140 used for remoting television systems for runway viewing, remoting air traffic control radars, remoting communication receivers, and for television microwave links dealing with the air traffic control network. The Air Force has 109 assignments for remoting radars for military air traffic control, various data and communication lines, microwave links to relay mission support data from launch sites to mobile vans during missile/satellite launch operations, microwave links for the transmission of timing and frequency data, antenna testing facilities, prelaunch checks of satellites, and to relay video data to central TV control facilities during missile/satellite launch operations.

The Army has 98 assignments in the 14.5-15.35 GHz band used for microwave data and communication links between remote sites and central facilities, radar microwave links, various electronic proving grounds and test site operations support, testing of various digital data links, and the AN/GRC-173 mobile RF data link for tests on improved HAWK missile system (this sytem will not lead to development of operational equipment in this band). The NASA has 50 assignments in the band used for microwave link path testing at the Kennedy Space Flight Center, for various TDRSS links both at White Sands Missile Range and Goddard Space Flight Center, for LANDSAT-D high rate data transmission via TDRSS, and for the microwave scatterometer, which is a prototype that infers ocean surface wind conditions from an aircraft by measuring radar scattering cross-section returns. The microwave scatterometer will eventually be used as a remote sensing device from an orbiting satellite.

The Navy has 29 assignments in the 14.5-15.35 GHz band used for dockside check of shipboard electronic systems, for a two-way wide band data communication system in Maryland, for various test range communications and data links, for the telemetry distribution system at China Lake, California, and for various target similator systems. The DOE has 25 assignments in the band used for CCTV, remote control of a crane, for security video links, various data links, for telemetry/data systems, and for timing/frequency commands and diagnostic data links in conjunction with the NTS in Nevada. The National Security Agency has four assignments mainly for secure video links between sites within the boundaries of their own facility. The Department of Agriculture has one frequency assignment for the transmission of TV images of infrared forest fire maps from aircraft to transportable ground receiving stations. This system is used normally between the hours of midnight and dawn and transmissions are normally limited to less than five minutes per flight. These systems are used on a limited base from aircraft that fly from ground level to 15,000 feet with a normal altitude of 8000 feet. The Department of Justice has one assignment for short distance, low power FM video links. There is some use of these bands by the military for EW/ECM training operations as given in IRAC Document 20779/1-2.10.

TABLE 58

FREQUENCY ASSIGNMENTS BY GOVERNMENT AGENCY AND STATION CLASS
FOR THE 14.5 - 15.35 GHz BAND

FREQ / AGENCY — STATION CLASS	EH	FB	FL	FLEC	FX	FXD	FXE	MA	ML	MO	MOE	MR	RL	THTD	THTR	XC	XD	XR	XT	TOTAL
14.5-14.7145 GHz																				
AIR FORCE					23								1			1		3	21	49
ARMY					11		3				2						3		11	30
DOE		1		1	5				5										1	10
FAA					12															12
NAVY					7														6	13
NASA						1				1								1	7	11
NS					1														1	2
14.7145-15.1365 GHz																				
A								1												1
AIR FORCE			1		23											4			22	51
ARMY					8		2				3	8					2	1	32	56
DOE				4	6				2											12
FAA					98															98
J																				0
NAVY					7														7	14
NASA					1										2			4	23	30
NS	1																			1
15.1365-15.35 GHz																				
AIR FORCE					2											1			5	8
ARMY					3														9	12
DOE				3																3
FAA					30															30
J					1															1
NAVY					1														1	2
NASA					1									3					5	9
NS					1															1
TOTAL	1	1	1	8	241	1	5	1	4	2	5	8	1	3	2	6	5	10	151	456

The growth trend for the 14.5-15.35 GHz band is shown in Figure 54. The 10-year growth from 1973 to 1983 shows approximately a 500% increase in assignments. The Systems Review File shows 18 active systems in the process of review. The systems, sponsoring agency and stage of review are given in Table 59. Three systems which are classified are not shown. The rate of growth is expected to be about the same for the next 5-year period. The number of assignments for given frequencies in the band is given in Figure 55 and shows that the upper subband from 15.1365-15.35 GHz can still accommodate considerable growth.

The geographic distribution of assignments is given by the three subbands in Figures 56, 57, and 58. The lines from sites on CONUS to the border represent satellite links. As can be seen, all three subbands use many of the same sites and there are a number of states on each map with no assignments, i.e. Figure 56 shows 23 states without assignments. As the Fixed and Mobile bands, such as the 7125-8450 MHz bands, become more congested there will be a real need to accommodate the shorter-hop, high data rate systems in these higher frequency bands. It may be difficult to project with accuracy a trend to the higher microwave and lower millimeter wave frequency bands in the near future, but it would appear that these bands would be the high growth bands of the 1990's.

MAJOR SYSTEMS

Most of the systems in the band are used for short-haul transmission of wideband, high-resolution video signals, high capacity voice channels, wideband radar video remoting, or digital data. The most used equipment in the 14.5-15.35 MHz band is the TCM-608B. Table 60 gives the basic characteristics of this system.

The TCM-608B is used by the various Government agencies for radar remote microwave links, television microwave links, data links, and communication links. Another system used in the band is the MW 908D. This system was designed for short-haul transmission of wideband, high-resolution video signals. However, it can be, and is used for data transmission and multichannel message signals in the 14.5-15.35 MHz band. Table 61 gives some of the basic system characteristics.

These would seem to be typical systems operating in the band. There are some threat simulators used by all of the military services for EW and ECM training. There is a modified version of the AN/GRC-173 used by the Army for testing at digital data links. The AN/GRC-173 is a mobile microwave wideband communications and high speed data link and can also be used for color video links. The IMC-1415 is another widely used microwave link for data and video transmissions in the band.

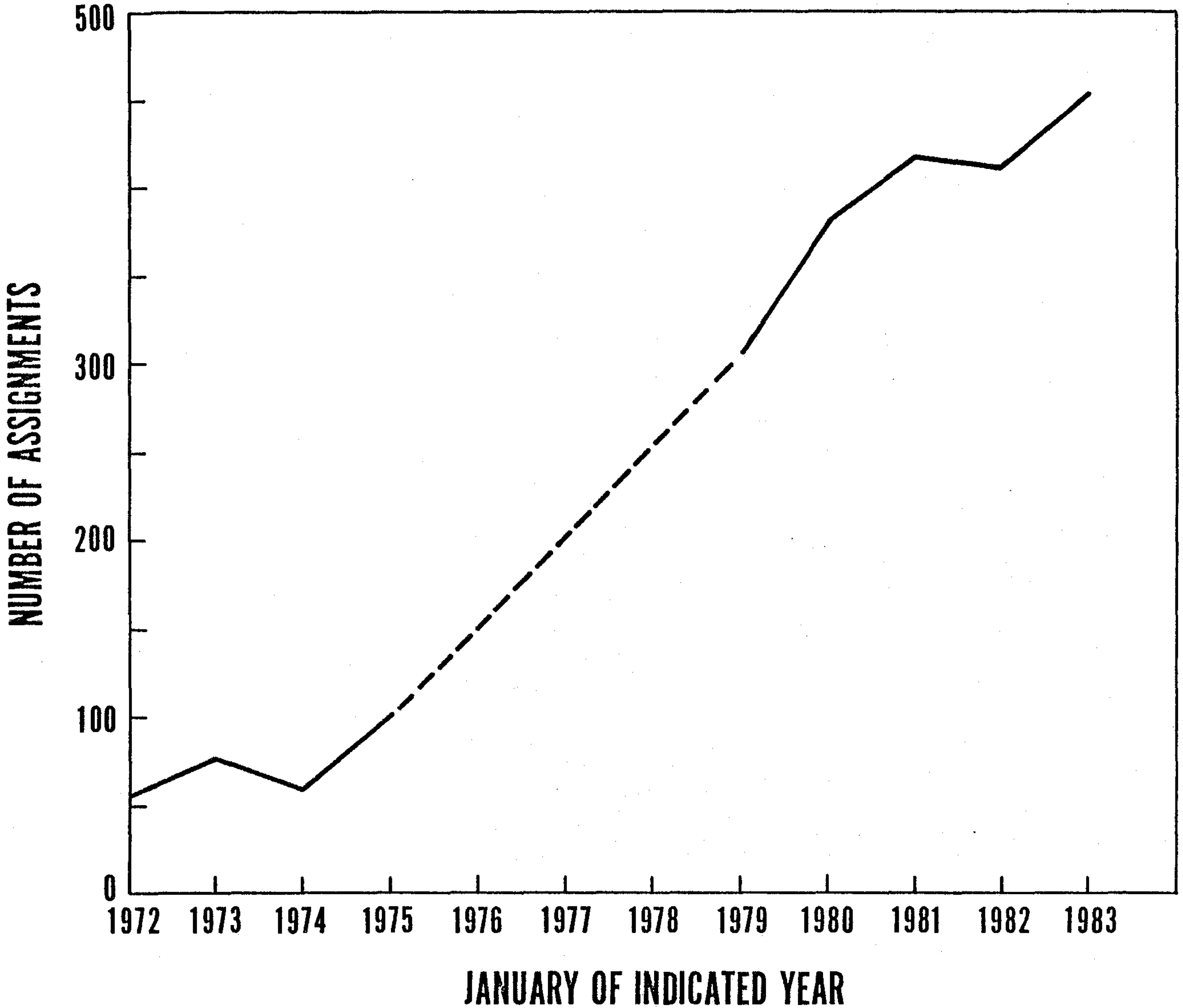


Figure 54. Growth Trend for the 14.5-15.35 GHz Band from January 1972 to January 1983.

TABLE 59

SYSTEMS IN THE SYSTEMS REVIEW FILE

FOR THE 14.5 - 15.35 GHz BAND

SYSTEM	SPONSORING AGENCY	STAGE OF REVIEW*
AN/GRC - 144(V)4	AR	4
TCM 604 and 608	AF	4
LANDSAT-D	NASA	3
IMC-15AM Microwave System	AR	4
TAWDS-Data Link 2	AF	2
Digital Microwave Radio	AR	1
AN/UPQ-3(B)	AF	3
TDRSS	NASA	3
TV Microwave Relay System	FAA	4
Anti-Jam Data Link	AF	3
Missile Video/Data Link	AR	4
Airport Packet Radio	FAA	1
Video Five Imagery Information System	A	4
VLBA Radio Telescope	NSF	0
Space Transportation System	NASA	4

*Stage of Review

0 - Stage of review was not indicated

1 - Stage 1, conceptual

2 - Stage 2, experimental

3 - Stage 3, developmental

4 - Stage 4, operational

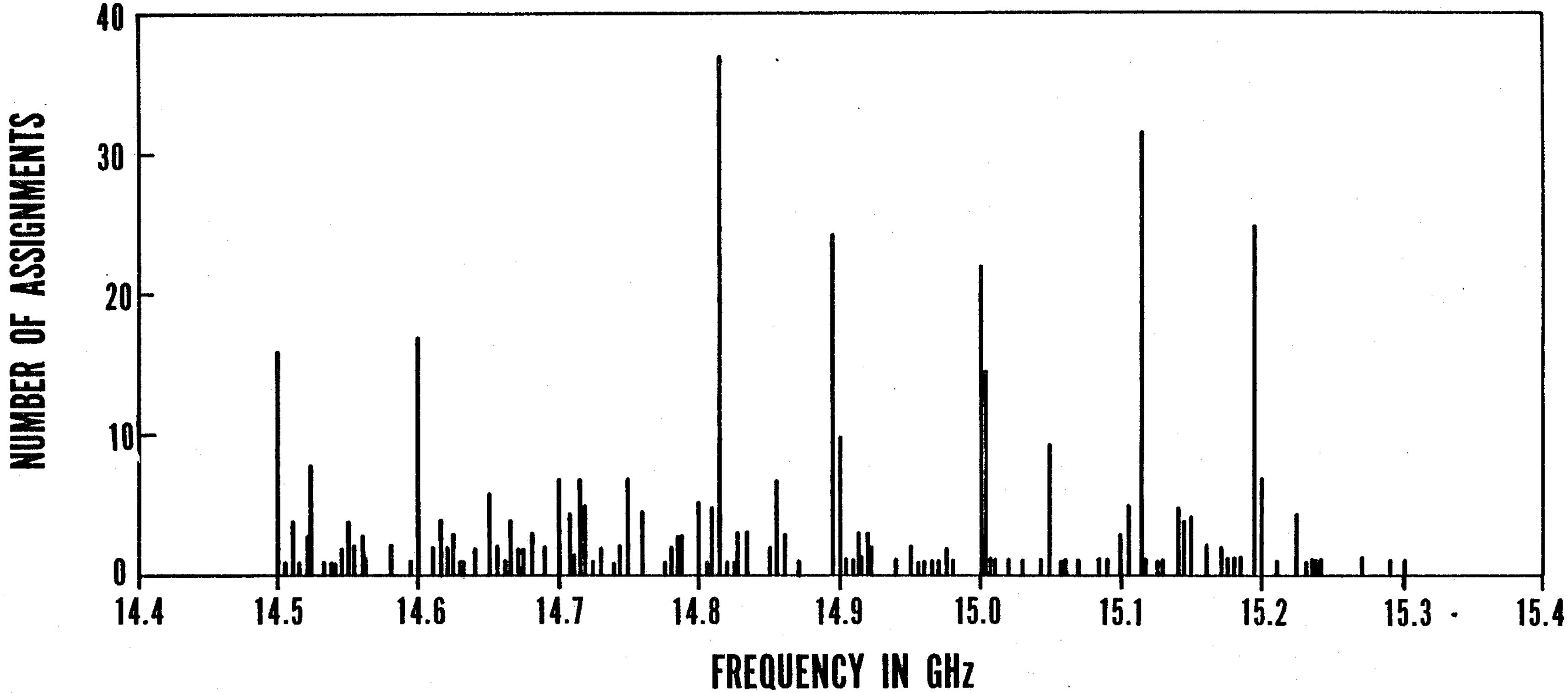


Figure 55. Frequency Assignment Distribution for the 14.5-15.35 GHz Band.

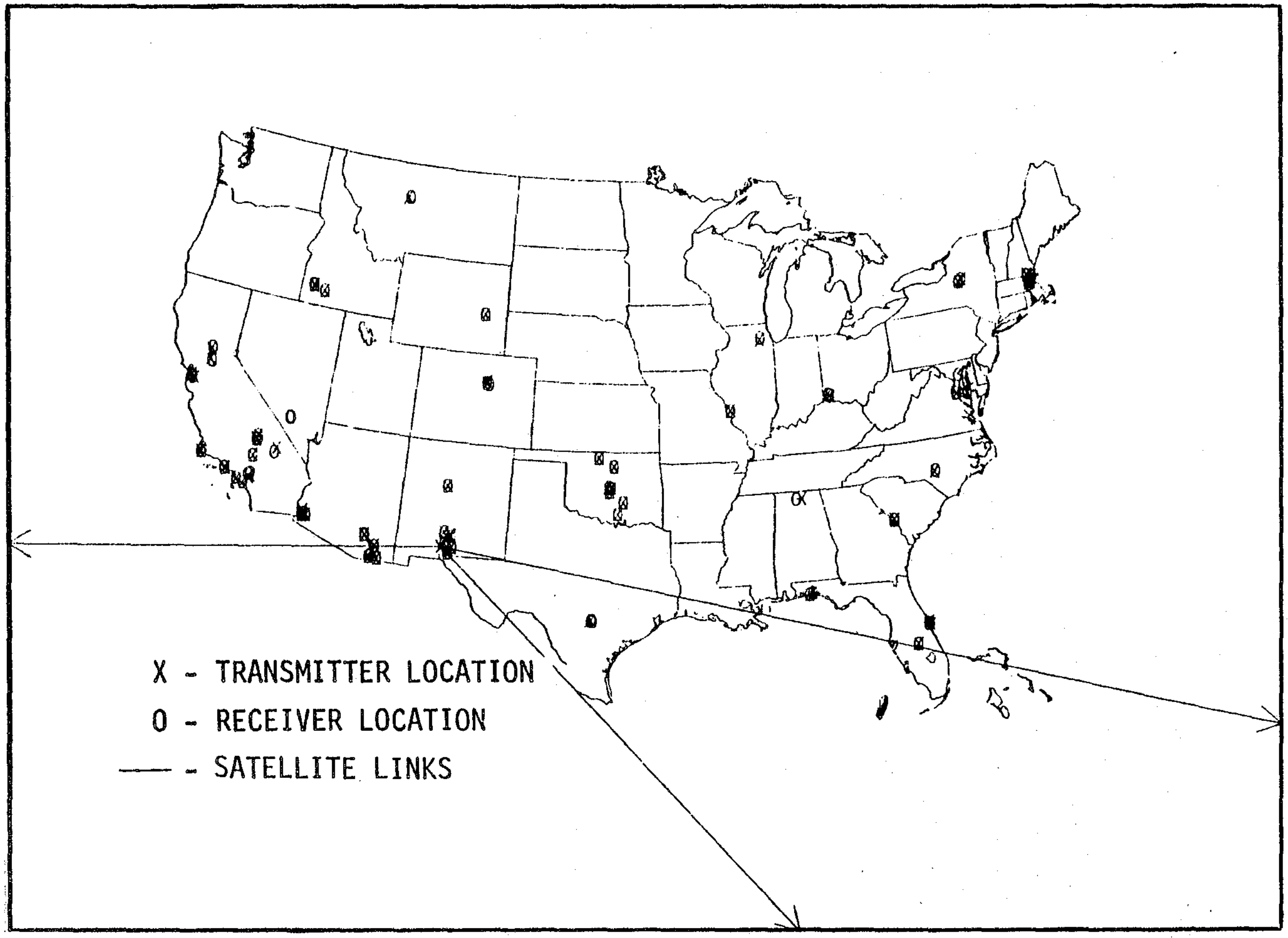


Figure 56. Geographic Distribution of Assignments in the 14.5-14.7145 GHz Subband.

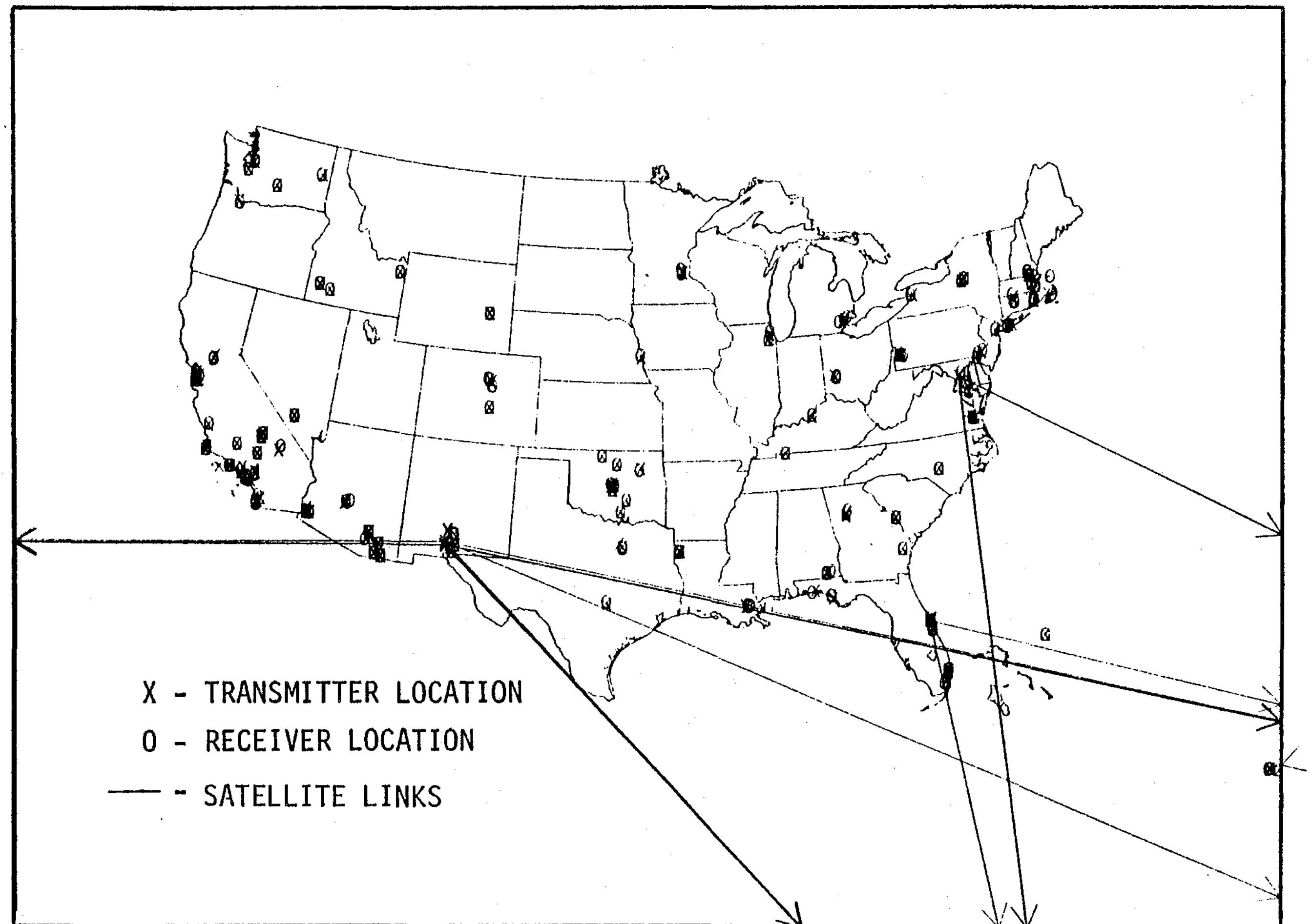


Figure 57. Geographic Distribution of Assignments in the 14.7145-15.1365 GHz Subband.

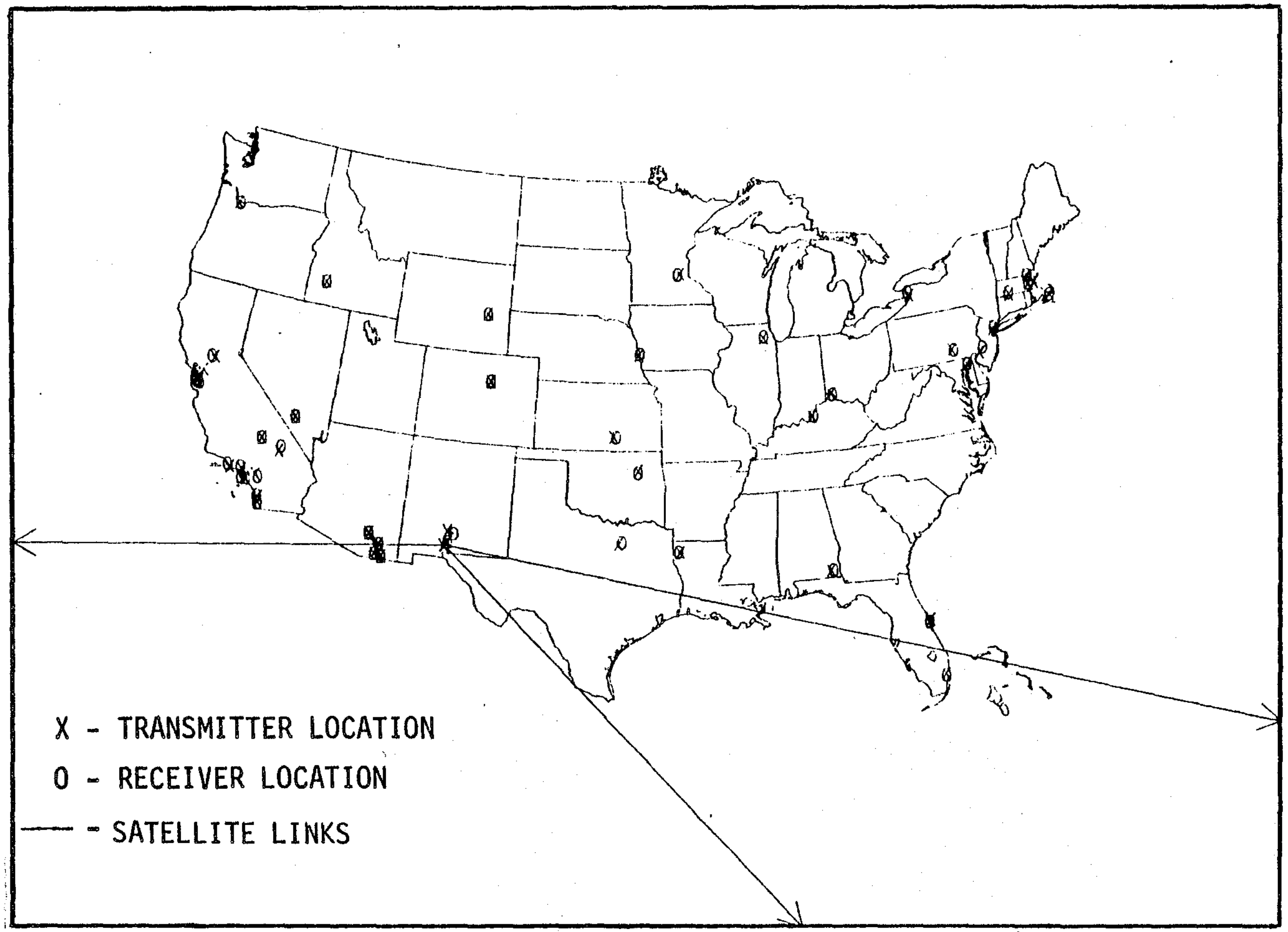


Figure 58. Geographic Distribution of Assignments in the 15.365-15.35 GHz Subband.

TABLE 60

SYSTEM CHARACTERISTICS OF THE TCM-608B

FREQUENCY RANGE	14.4-15.35 GHz
CAPACITY	Up to 1800 FDM voice channels, color video with up to 2.048 Mb/s digital subcarrier, up to 35 Mb/s digital data or wide-band radar
MODULATION	FM
TRANSMITTER POWER	.15 watt (higher output power available with optional power amplifiers)
FREQUENCY STABILITY	0.005% (crystal synthesizer) 0.003% to 0.001% (digital synthesizer)
RECEIVER	
NOISE FIGURE	12.0 dB
IF FREQUENCY	70 MHz
IF BANDWIDTH	30 MHz (5 to 40 MHz optional)
THRESHOLD	-78 dBm (30 MHz bandwidth)
RF INPUT LEVEL	-20 dBm maximum -30 dBm typical
TELEVISION SIGNAL-TO-NOISE (@ -30 dBm)	67 dB (weighted per CCIR)

TABLE 61

SYSTEM CHARACTERISTICS OF THE MW908D

FREQUENCY RANGE	14.4-15.25 GHz
CAPACITY (VIDEO)	One wide-band high-resolution video or one NTSC color TV signal plus up to 4 program channels
MODULATION	FM
TRANSMITTER POWER	1.5 watts
FREQUENCY STABILITY	.005% 40,000 F9
RECEIVER NOISE FIGURE	12.0 dB
IF FREQUENCY	70 MHz
IF BANDWIDTH	40 MHz
TELEVISION SIGNAL-TO-NOISE (P-P/RMS) (-35 dB Rec CXR LEVEL)	70 dB weighted per CCIR

CONCLUSIONS AND RECOMMENDATIONS

The 14.5-15.35 GHz band has shown a 500% growth in assignments in the past 10-years. This growth trend will continue into the near future. Greater growth may be expected in the 1990's because of congestion in the lower microwave bands. There is room for growth and there are many states at present that have only one or two assignments or no assignments. Before a recommendation for sharing can be made, more information is needed from Government agencies on future uses of the band. This will be accomplished in the Phase II report.

DETAILED SUMMARY OF GOVERNMENT AND NON-GOVERNMENT SHARED BANDS BY BAND

THE 1427-1535 MHz BAND

INTRODUCTION

The 1427 - 1535 MHz band is a Government/non-Government shared band with 853 assignments. Most of these assignments (736, 87%) are for telemetering. There are 122 non-Government assignments mostly used for aeronautical telemetering mobile stations.

ALLOCATIONS, RULES AND REGULATIONS

Table 62 shows the International and U.S. National Table of Frequency Allocations from the NTIA Manual for the 1427-1535 MHz band. The band is divided into four subbands--the first from 1427-1429 MHz. This subband is allocated to Government Fixed and Mobile Services on a primary basis. Space Operation (Earth-to-space) is both a Government and non-Government allocation on a coequal primary basis. There is a non-Government allocation to Land Mobile (telemetering and telecommand) and Fixed (telemetering) on a secondary basis. Government footnote G30 limits the Government Fixed and Mobile Services primarily to operations by the military services. The subband from 1429-1435 MHz is allocated to Government Fixed and Mobile Services on a coequal primary basis and G30 applies here also. The allocation to non-Government users is to Land Mobile (telemetering and telecommand) and Fixed (telemetering) Services on a secondary basis. International footnote 722 states that this band is used along with others listed for passive research by some countries for the search for intentional emissions of extraterrestrial origin.

The subband from 1435-1530 MHz is allocated to Government and non-Government Mobile Services (aeronautical telemetering) on a coequal primary basis. International footnote 722 also applies here, along with U.S. 78 which states that the frequencies between 1435-1485 MHz will be assigned primarily for the flight testing of manned aircraft, or major components thereof. The frequencies between 1485 and 1535 MHz will be assigned primarily for the flight testing of unmanned aircraft and missiles or major components thereof. Also, in the 1435-1535 MHz band a permissible usage is for aeronautical telemetering associated with launching and reentry into the Earth's atmosphere, as well as any incidental orbiting prior to reentry, of manned or unmanned objects undergoing flight tests. It also states that in the band 1530-1535 MHz the Maritime Mobile-Satellite Service will be the only primary service after 1 January 1990.

The Aerospace and Flight Test Radio Coordination Council (AFTRCC) a trade association of major private sector entities engaged in the design and manufacture of Government and non-Government aircraft, space vehicles, and their major components, filed a petition (RM-4077) to FCC requesting that Parts 2 and 87 of the Commission's rules be amended concerning aeronautical telemetry and associated telecommand operations in the bands 1435-1535 and 2310-2390 MHz. The FCC made a Notice of Proposed Rule Making in General Docket No. 84-RM-4077 with proposed changes as given in Appendix F. One of the changes deals with revision of Footnote US78 as follows:

> US78 The frequencies between 1435 and 1535 MHz will be assigned for the aeronautical telemetry and associated telecommand operations for flight testing of manned or unmanned aircraft and missiles, or major components thereof. Permissible usage includes telemetry associated with launching

TABLE 62
INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS
FOR THE 1427-1535 MHz BAND

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-government Allocation 4
1427-1429 SPACE OPERATION (earth-to-space) FIXED MOBILE except aeronautical mobile 722			1427-1429	722	FIXED MOBILE except aeronautical mobile SPACE OPERATION (earth-to-space) G30	SPACE OPERATION (earth-to-space) Land Mobile (Telemetering and telecommand) Fixed (Telemetering)
1429-1525 FIXED MOBILE except aeronautical mobile 722	1429-1525 FIXED MOBILE 723 722		1429-1435	722	FIXED MOBILE G30	Land Mobile (Telemetering and telecommand) Fixed (Telemetering)
			1435-1530	US78 722	MOBILE (Aeronautical telemetering)	MOBILE (Aeronautical telemetering)
1525-1530 SPACE OPERATION (space-to-earth) FIXED Earth Exploration-Satellite Mobile except aeronautical mobile 724 722	1525-1530 SPACE OPERATION (space-to-earth) Earth Exploration-Satellite Fixed Mobile 723 722	1525-1530 SPACE OPERATION to-earth) FIXED Earth Exploration-Satellite Mobile 723 724 722				
1530-1535 SPACE OPERATION (space-to-earth) MARITIME MOBILE-SATELLITE (space-to-earth) Earth Exploration-Satellite Fixed Mobile except aeronautical mobile 722 726	1530-1535 SPACE OPERATION (space-to-earth) MARITIME MOBILE-SATELLITE (space-to-earth) Earth Exploration-Satellite Fixed Mobile 723 722 726		1530-1535	US78 US272 722	MARITIME MOBILE-SATELLITE (space-to-earth) Mobile (Aeronautical telemetering)	MARITIME MOBILE-SATELLITE (space-to-earth) Mobile (Aeronautical telemetering)

US78-In the band 1435-1535 MHz, the frequencies between 1435 and 1485 MHz will be assigned primarily for the flight testing of manned aircraft, or major components thereof; the frequencies between 1485 and 1535 MHz will be assigned primarily for the flight testing of unmanned aircraft and missiles or major components thereof. Included as permissible usage for aeronautical telemetering station in the band 1435-1535 MHz, is telemetry associated with launching and re-entry into the earth's atmosphere, as well as any incidental orbiting prior to re-entry of manned or unmanned objects undergoing flight tests.. In the band 1530-1535 MHz, the maritime mobile satellite service will be the only primary service after 1 January 1990.

US272-The allocation to the Maritime Mobile-Satellite Service in the band 1530-1535 MHz shall be effective from 1 January 1990. Up to that date the allocation to the Mobile Service will be on a primary basis.

722-In the band 1 400 - 1 727 MHz, 101 - 120 GHz and 197 - 220 GHz, passive research is being conducted by some countries in a program for the search for intentional emissions of extra-terrestrial origin.

G30-In the bands 138-144,...,1427-1429 and 1429-1435 MHz, the fixed and mobile services are limited primarily to operations by the military services.

and reentry into the earth's atmosphere as well as any incidental orbiting prior to reentry of manned or unmanned objects undergoing flight tests. The following frequencies are shared with flight telemetering mobile stations: 1444.5, 1453.5, 1501.5, 1515.5, 1524.5 and 1525.5 MHz. In the band 1530-1535 MHz, the Maritime Mobile-Satellite Service will be the only primary service after January 1, 1990.

Other changes deal with definition of terms for aeronautical telemetering and telecommand stations and flight telemetering mobile stations, limits on transmitted power, frequency stability of transmitters, types of emission, frequencies available, frequency coordination, and telecommand operations.

SPECTRUM USAGE AND MAJOR SYSTEMS

Table 63 shows the Government and non-Government assignments by agency and station class for the 1427-1535 MHz band. There are a total of 853 assignments of which 736 (87%) are to various telemetering services. The Navy is the biggest user with 286 assignments and Air Force second with 274 assignments. The aeronautical telemetering mobile stations have the largest number of assignments with 564. Again, it must be emphasized that frequency assignments and equipment counts are not equal in number. There will most likely be higher equipment and system counts than frequency assignments. Equipment counts and future Government uses are intended to be part of a Phase II report as a follow-on to this Phase I report.

Figure 59 shows the growth trend in the 1427-1535 MHz band. There has been an increase in assignments of about 17% between 1979 and 1983. However, there has been about an 80% increase in assignments over the 10 years between 1973 and 1983. This is a major band for telemetering and is very important to Government research and development. Figure 60 gives the frequency assignment distribution and shows that the band is heavily used as far as assignments go. Usage depends on the number of tests going on at any given range. The White Sands Missile Range in New Mexico, ranges at Eglin, Tyndall, and Cape Canaveral, Florida, and the Point Mugu and China Lake ranges in California are some of the busiest ranges that use frequencies in this band for various range telemetry activities. The geographic distribution of assignments is shown in Figure 61. There are 30 states in CONUS that have assignments and as can be seen, most assignments are at the various military test ranges. There are 18 states that have no assignments in this band and an additional 9 that have only one to three assignments. California has 233 assignments--the most at Point Mugu and China lake; Florida has 110 assignments, followed by New Mexico with 102. Point Mugu, California, has 114 assignments in this band to support telemetry during various range activities.

There is a channeling plan for the 1427-1535 MHz band as follows:

In the band 1435-1485 MHz, fifty 1-MHz narrowband channels are designated, centered on 1435.5 MHz and each 1-MHz increment thereafter, through and including 1484.5 MHz. The use of emission bandwidths greater than 1 MHz is permitted, provided the assigned frequencies are centered on the center frequencies of narrowband channels. These channels are available for aeronautical telemetering a) primarily for the flight testing of manned aircraft or major components thereof and b) secondarily for the flight testing of unmanned aircraft and missiles or major components thereof.

In the band 1484-1535 MHz, fifty 1-MHz narrowband channels are designated, centered on 1485.5 MHz and each 1-MHz increment thereafter, through and including 1534.5 MHz. The use of emission bandwidths greater than 1 MHz is permitted, provided the assigned frequencies are centered on the center frequencies of

TABLE 63

GOVERNMENT AND NON-GOVERNMENT ASSIGNMENTS IN THE 1427 - 1535 MHz BAND

STATION CLASS / AGENCY	FAD	FLD	FLE	FLEA	FLEC	FX	FXE	MOB	MOE	MOEA	MOEB	MOEC	MA	XC	XD	XM	XT	TOTAL
AIR FORCE	2	6	1				1		2	210	26	8	1	5		2	10	274
ARMY				2		8		1	1	50	26	2					4	94
DOE									10	1	23	6						40
NAVY									1	190	23		22				50	286
NASA				4				1		11	14	1						31
NSF											6							6
NG					1					102		14		2	2		1	122
TOTAL	2	6	1	6	1	8	1	2	14	564	118	31	23	7	2	2	65	853

FAD Aeronautical Telecommand Station
FLD Telecommand Land Station
FLE Telemetering Land Station
FLEA Aeronautical Telemetering Land Station
FLEC Surface Telemetering Land Station
FX Fixed Station
FXE Telemetering Fixed Station
MOB Radio Beacon Mobile Station
MOE Telemetering Mobile Station
MOEA Aeronautical Telemetering Mobile Station
MOEC Surface Telemetering Mobile Station
MA Aircraft Station
XC Experimental Contract
XD Experimental Development
XM Experimental Composite Station
XT Experimental Testing Station

*NSF assignments transferred to NASA in 1983

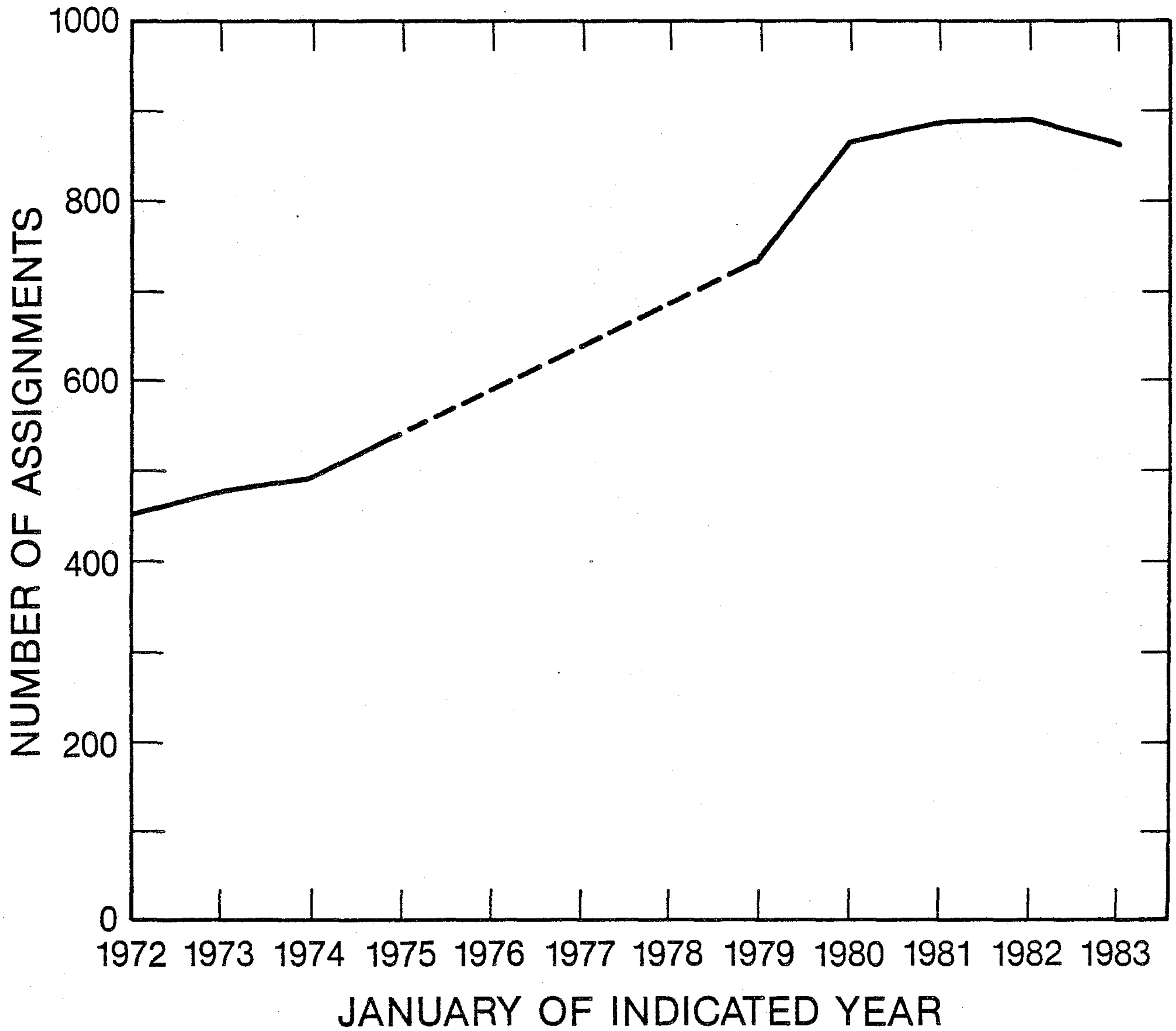


Figure 59. Growth Trend for the 1427-1535 MHz Band from January 1972 to January 1983.

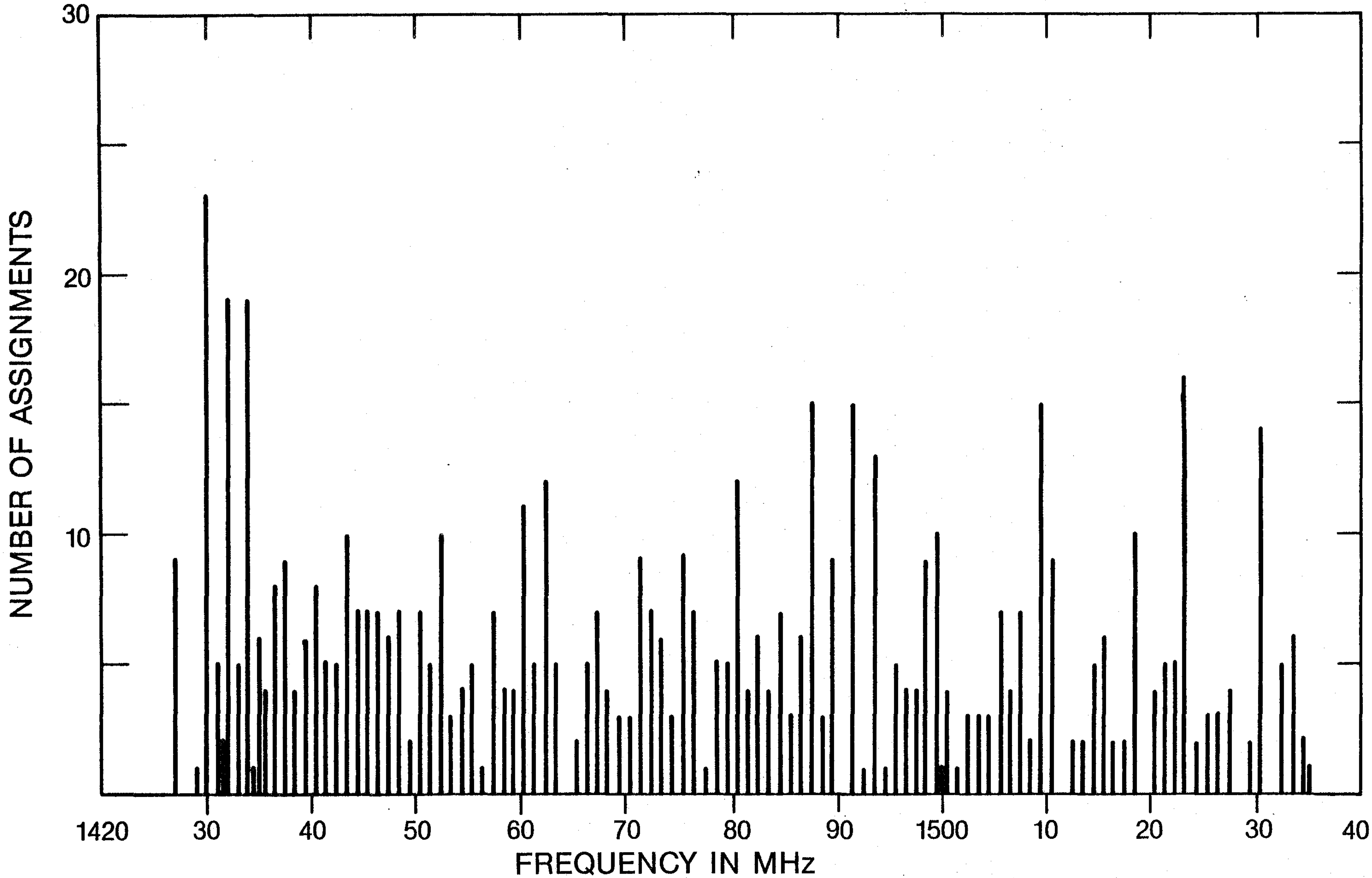


Figure 60. Frequency Assignment Distribution for the 1427-1535 MHz Band.

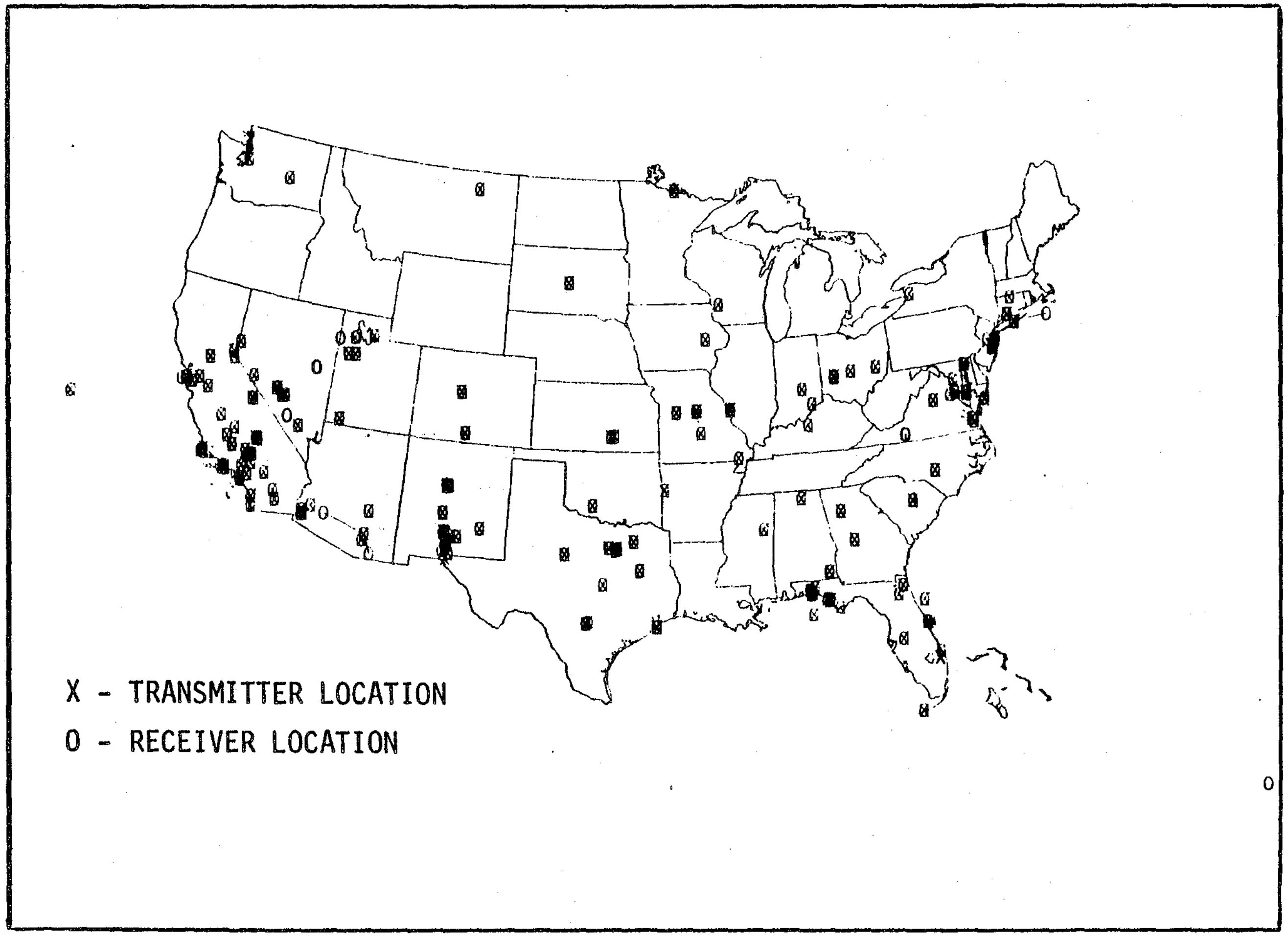


Figure 61. Geographic Distribution of Assignments in the 1427-1535 MHz Band.

narrowband channels. These channels are available for aeronautical telemetering a) primarily for the flight testing of unmanned aircraft and missiles or major components thereof and b) secondarily for the flight testing of manned aircraft or major components thereof.

Included as permissible usage for aeronautical telemetering stations in the band 1435-1535 MHz is telemetry associated with launching and reentry into the Earth's atmosphere, as well as any incidental orbiting prior to reentry, of manned or unmanned objects undergoing flight tests.

For the purpose of this plan, flight testing telemetry is defined as telemetry which is used in support of research, development, test, and evaluation, and which is not integral to the operational function of the system.

In the band 1525-1535 MHz, the channels designated for aeronautical telemetering are also available for space telemetering on a shared basis.

MAJOR SYSTEMS

The band from 1427-1429 MHz has only 13 assignments, 8 of which are to the Army for tactical and training purposes using radio relay equipment, mainly the AN/GRC-50 systems. The AN/GRC-50 is used mainly for radio communications and has a 1 MHz channel spacing. It is a point-to-point microwave radio that can tune from 1350 to 1849.5 MHz. It can transmit 30 watts maximum and the antenna normally used has a gain of 17 dBi. The receiver sensitivity is -100 dBm. The band from 1429-1435 has 92 assignments and is mainly used for telemetry in missile system testing. Most of the assignments (67) are to the Navy and are classified. There are assignments in this band under the experimental testing class for the AN/GRC-103. This is a portable tactical radio relay system that can be used for telephone, telegraph, data, teletype, and facsimile. This radio set can operate from 220 to 1850 MHz using five different bands. Band 4 operates from 1350-1850 MHz with an rf channel spacing of 0.5 MHz. The system will carry either 4, 12, or 24 channels FDM or 6, 12, or 24 channels PCM. The set can provide 4500 rf channels in the five bands:

Band 1	220-405 MHz	Band 3	695-1000 MHz
Band 2	395-705 MHz	Band 4	1350-1850 MHz
Band M	610-960 MHz		

The transmitter power in band 4 of interest here is 15 watts. The receiver voice figure is 8 dB nominal and the antenna gain (parabolic reflector in band 4) is 19 dBi. This system is a military forward area communications system.

There are 714 assignments in the band from 1435-1530 MHz. These are used mostly for a wide variety of telemetering activities. These include flight test telemetry of missiles, manned and unmanned aircraft, drones, high-speed test track telemetry, carrier launch catapults test and evaluation telemetry, aircraft ejection system test and evaluation telemetry, airborne LASER lab telemetry, telemetry from guided bombs, ground-to-ground telemetry at nuclear test facilities, parachute drop test telemetry, balloon experiment telemetry, and other similar uses.

There are an additional 33 assignments in the 1530-1535 MHz band. The uses are for telemetry with similar activities as listed under the 1435-1530 MHz band.

Telemetry transmitters used in the band are generally on aircraft or missiles or major components thereof. These transmitters provide command, video, and/or data links between the vehicle under test and a central control or data receiving recording and analysis facility. The transmitter units are generally of small size and weight (usually less than 12 cubic inches and less than 1 pound.) Transmitting power levels are available from a few milliwatts to 8 watts depending on the particular need. These transmitters have bandwidths of up to 10 MHz being typical.

A typical telemetry receiver operating in the band would be the Microdyne 1100-R. This unit has been used to support the Harpoon Missile, Cruise Missile, Polaris Missile, Trident Missile, F-14, F-15, AWACS, Space Shuttle, among other programs. This receiver with standard plug-in modules can tune from 65 MHz to 4.2 GHz. Appropriate modules provide AM, FM, and PM demodulation. Receiver design employs a double superheterodyne conversion for signal reception. Receiver noise figures vary from 5.5 to 16 dB depending on the rf tuner module used. Data bandwidths up to 6 MHz are typical to process video or high-speed digital data. The receivers also provide antenna tracking data and various ones are designed for airborne, shipboard, and ground installations.

Table 64 gives the systems presently in the Systems Review File. There are 11 systems, most of which deal with telemetry. There is nothing in this list that would lead to any significant increase in band usage but lead to normal upgrading of telemetry capability in the band.

TABLE 64
SYSTEMS PRESENTLY IN THE SYSTEMS REVIEW FILE FOR THE 1427-1535 MHz BAND

SYSTEM	SPONSORING AGENCY	STAGE OF REVIEW*
AN/GRC-103(V) Tactical Radio Relay	AR	4
Very Long Baseline Array (VLBA) Radio Telescope	NSF	0
Mini Remotely-piloted Vehicle (RPV)	AF	4
Seek Skyhook (Cudjoe Key)	AF	4
Seek Skyhook (Cape Canaveral)	AF	4
Cruise Missile (Tomahawk) System	N	2
National Scientific Balloon Facility	NASA	4
Bullet Hi Indicator	AF	3
Aydin Vector T-110LE Telemetry System	AF	4
Low Altitude Dispenser (LAD) Telemetry Instrumentation System	AF	4
AN/DSU-X Telemetry System	AF	3

*Review Stage

0 Not given
1 Conceptual
2 Experimental
3 Developmental
4 Operational

CONCLUSIONS AND RECOMMENDATIONS

There are 18 states with no assignments in the 1427-1535 MHz band with another 9 that have three or less (five have only one assignment). However, this band is heavily used by both Government and non-Government for telemetering purposes. The provisions have been made for the non-Government Fixed Service on a secondary basis. There does not seem to be a need to change allocations in the band at this time. The heavy use of telemetry services somewhat restricts use of the Fixed Service in the band due to potential interference problems.

THE 1700-1710 MHz BAND

INTRODUCTION

The 1700-1710 MHz band is a Government/non-Government shared band with few assignments by either Government or non-Government entities. The main use is for meteorological satellite data links. An NTIA SRA was written in 1981 (Flynn, 1981) covering the 1660-1710 MHz band. Some excerpts from that report will be used in the following summary of band usage.

RULES AND REGULATIONS

Prior to WARC-79, the allocations to the 1700-1710 MHz band were to Government and non-Government Fixed, Mobile, Meteorological-Satellite and Space Research Services on a primary coequal basis. The post-WARC allocation table for this band changed as shown in Table 65. The allocation to Mobile and Space Research Services was dropped and the Fixed Service for non-Government is now secondary. International footnote 671 states that the Earth Exploration-Satellite Service may also be used in this band. International footnote 722 states that the search for intentional emissions of extra-terrestrial origin are conducted in the band. Government footnote G118 states that Government fixed stations may be authorized in the band only if spectrum is not available in the band 1710-1850 MHz.

SPECTRUM USAGE AND SYSTEM DESCRIPTIONS

Table 66 shows the use of the 1700-1710 MHz band by station class and Government agency. There are only five Government assignments in the band, three support the TIROS-N meteorological-satellite, one supports the NIMBUS satellite, and one supports an experimental system being tested for the Air Force. Table 67 shows the seven systems that can tune into the 1700-1710 MHz band, presently in the Systems Review File. One classified system is not shown. It may be that not all systems listed here will use frequencies in the band 1700-1710 MHz. For example, most of the microwave systems listed can tune from 1700-1850 MHz and will most likely operate in the 1710-1850 MHz band.

There are six non-Governmental assignments for the 1700-1710 MHz band shown in the non-Government master file. There are five of these assignments that are in error. These five assignments are to Industrial Radiolocation and appear to be misplaced in the file by the frequency multiplier (e.g., 1709 vs M 1709). There is one assignment to the Industrial services in Alaska which leaves no non-Government assignments in CONUS.

TABLE 65

INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS FOR THE 1700-1710 MHz FREQUENCY BAND

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
1690-1700 METEOROLOGICAL AIDS METEOROLOGICAL SATELLITE (Space-to-Earth) Fixed Mobile except aeronautical mobile 671 722	1690-1700 METEOROLOGICAL AIDS METEOROLOGICAL-SATELLITE (Space-to-Earth) 671 722 740 742		1690-1700	671 722	METEOROLOGICAL AIDS (Radiosonde) METEOROLOGICAL-SATELLITE (Space-to-Earth)	METEOROLOGICAL AIDS (Radiosonde) METEOROLOGICAL-SATELLITE (space-to-Earth)
1700-1710 FIXED METEOROLOGICAL-SATELLITE(Space-to-Earth) Mobile except aeronautical mobile 671 722	1700-1710 FIXED METEOROLOGICAL-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile 671 722 743		1700-1710	671 722	FIXED METEOROLOGICAL-SATELLITE (Space-to-Earth) G118	Fixed METEOROLOGICAL-SATELLITE (Space-to-Earth)
1710-2290 FIXED Mobile 722 744 746 747 748 750	1710-2290 FIXED MOBILE 722 744 745 746 747 748 749 750		1710-1850	US256 722	FIXED MOBILE G42	

671 - Earth exploration-satellite service applications, other than the meteorological-satellite service, may also be used in the bands 460 - 470 MHz and 1 690 - 1 710 MHz for space-to-earth transmissions subject to not causing harmful interference to stations operating in accordance with the Table.

722 - In the bands 1 400 -- 1 727 MHz, 101 -- 120 GHz and 197 -- 220 GHz, passive research is being conducted by some countries in a programme search for intentional emissions of extra-terrestrial origin.

G118 - Government fixed stations may be authorized in the band 1700 - 1710 MHz only if spectrum is not available in the band 1710 - 1850 MHz.

TABLE 66

FREQUENCY ASSIGNMENTS BY AGENCY FOR THE 1700-1710 MHz BAND

STATION CLASS	REMARKS	AGENCY	NUMBER OF ASSIGNMENTS
EHER - Space Telemetering station in the Space Research Service	Supports the NIMBUS Satellite	NASA	1
EM - Meteorological-satellite space station	Supports the TIROS-N Satellite	COMMERCE	2
XC - Experimental contract development station	Specific use not given	AIR FORCE	1
XT - Experimental test station	Supports calibration and testing of TIROS-N Satellite, pre-launch	AIR FORCE	1

TABLE 67

UNCLASSIFIED SYSTEMS IN THE SYSTEMS REVIEW FILE FOR THE 1700-1710 MHz BAND

SYSTEM	SPONSORING AGENCY	STAGE OF REVIEW
o TIROS-N Meteorological-Satellite	C	4
o Fryingpan-Arkansas Project Microwave System	I	4
o Hanford Microwave System	DOE	4
o WAPA, Hettinger-New Underwood Microwave System	DOE	4
o Nevada Test Site Back-Bone Microwave System	DOE	4
o WAPA, Ft. Peck-Havre Microwave System	DOE	4
o WAPA/Bureau of Reclamation Joint Use Microwave System	DOE	4

Although nationally the Fixed Service is a primary allocation in the 1700-1710 MHz band, there are presently no assignments in the GMF.

The current use of the 1700-1710 MHz band is for polar-orbiting satellites, specifically the TIROS-N and NIMBUS 5, 6, and 7 series. For these orbits, the earth tracks are not repetitive in the short term. For TIROS-N the total orbital period is approximately 102 minutes. The Earth rotates beneath this orbit approximately 25.5 degrees during this period, allowing the satellites to observe a different portion of the Earth's surface with sufficient overlap from orbit-to-orbit. The orbit is sun-synchronous and rotates eastward about the Earth's polar axis one degree/day; this, in effect, being the Earth's annual revolution about the sun, which keeps the satellite in a constant position with reference to the sun for consistent illumination throughout the year. These orbital parameters are such that up to four orbits of data have to be stored for transmission over a CDAS site in a time period of 5 to 10 minutes duration. The short time the satellite will be in view of the CDAS, combined with the up to 420 minutes of stored data, dictate that the data be transmitted down through two 2.66 Mb/s stored data systems simultaneously with a 1.3 Mb/s real-time data system. These bit rates in turn dictate a need for a 15 MHz rf bandwidth receiver (1695-1710 MHz). The short time that the satellite is in view of any earth station and the fact that the earth tracks are not repetitive dictates a need for a tracking antenna. The above facts indicate a fairly sophisticated and costly system is required to obtain data directly from the satellite.

In frequency bands shared by terrestrial radio relay systems and earth stations, the potential for interference must be carefully examined to assure compatible operation. The potential coordination radius around an earth station may range as high as 600 to 800 kilometers, depending on terrain factors and relative orientations.

Part 8.4 of the NTIA Manual defines the coordination procedures to be followed for a new frequency assignment or a new radio station for which protection is required. Also, included are the special coordination procedures and standards to be applied between terrestrial stations and earth stations. The coordination process for these interactions is thus well documented.

MAJOR SYSTEMS

Meteorological-Satellite Systems in the 1700-1710 MHz Band

The United States has launched a number of polar orbiting and geostationary experimental and operational meteorological satellites since 1960. Projects involving geostationary meteorological-satellites are also in progress in Europe under the auspices of the European Space Agency (ESA), in Japan and in the USSR. In addition to their specific national purposes, these meteorological-satellites contribute to the World Meteorological Organizations' (WMO) weather watch program.

The chief use of meteorological-satellite data is in weather forecasting. They are used in other ways also; in the study of climate, in hydrology, and for many research purposes. Weather forecasts are predictions of the future state of the atmosphere and are based on a knowledge of its state shortly before a forecast is made. The errors in forecasts increase with the time interval between the known state and the forecast state and with the imperfections in knowledge of the initial state. Successful forecasts, therefore, require observations of the atmosphere that are both detailed and up to date. Polar orbiting satellites produce global data, while geostationary satellites monitor specific regions of the Earth.

Existing U.S. satellites in the Meteorological-Satellite Service utilize the 1700-1710 MHz band for telemetering data from the satellites to Earth as well as relaying of processed meteorological data. The active meteorological satellites program for this band are discussed in the following paragraphs. Data was obtained from TIROS-N SPS Stage 4 Review, Satellite System Handbook (Rocca, 1978) and the NTIA SRA Report (Flynn, 1981).

TIROS-N is an operational program which developed the third generation of polar-orbiting satellites. The prototype, TIROS-N was developed by NASA, the follow-on spacecraft NOAA-B, C, D, etc. are under the auspices of the NOAA, DOC. After successful launch the spacecraft number system is renamed (i.e., NOAA-B becomes NOAA-6, NOAA-C becomes NOAA-7, etc.). It should also be noted that NOAA-1 to NOAA-5 were used for the ITOS program.

TIROS-N, the NASA prototype was launched October 13, 1978. NOAA-6, the first operational satellite in this series was launched June 27, 1979. Additional spacecraft will be constructed and launched on a schedule planned to maintain continuous observations for at least 8 years. The operational spacecraft are expected to have a lifetime of 2 years in orbit.

The system comprises two operational spacecraft in nearly orthogonal orbits. There is no instrumental redundancy on either spacecraft; rather, the redundancy is provided by having two operational spacecraft in orbit.

The TIROS-N satellite carries several instrument systems that provide direct readout and remote recording of meteorological data. Each spacecraft will have two VHF and three UHF frequencies. In general, the spacecraft is capable of downlink transmission of the TIROS Information Processor (TIP), High Resolution Picture Transmission (HRPT), Automatic Picture Transmission (APT), Global Area, Limited Area, High speed dump of TIP data and a Data Collection System (DCS).

Downlinks:

(1) One VHF downlink transmits real-time TIP 8.32 KBPS split phase PCM data (136.77 or 137.77 MHz).

(2) The second VHF downlink transmits analog APT data. The data amplitude modulates a 2.4 kHz subcarrier which then frequency modulates the carrier (137.5 or 137.62 MHz).

(3) The three UHF frequencies provide for four data transmissions: HRPT, Global area, limited area, and stored TIP. There is a separate transmitter and antenna for each frequency (1698, 1702.5 and 1707 MHz). The center transmitter is left hand circularly polarized, the other two are right hand circularly polarized. One right hand circularly polarized link is used to continuously transmit the HRPT data unless a failure occurs. The modulation rates are as follows:

Stored TIP	:	0.3327 Mbps split phase
HRPT	:	0.6654 Mbps split phase
Limited Area	:	1.3308/2.6616 Mbps
Global Area	:	1.3308/2.6616 Mbps
Limited and Global area	:	1.3308 Mbps split phase 2.6616 Mbps NRZ

Uplinks:

(1) The VHF command uplink (148.56 MHz) contains 1000 bps FSK command information from Commerce CDA stations only.

(2) The UHF uplink is used to receive data from data collection platforms (401.6-401.7 MHz). The uplink is demodulated, processed, and the data is presented to the TIP for downlinking to the ground station and for recording on the spacecraft recorders.

Figure 62 diagrams the data-flow in the TIROS-N satellite system.

Within the United States, earth stations are located at Wallops Island, Virginia, and Gilmore Creek, Alaska, to receive and process meteorological, telemetry, and housekeeping data and provide command and control of satellite operations. A third Commerce receive-only station is located in Redwood City, California, to receive and process meteorological data. In addition, data collection platforms are deployed on buoys, balloons, and in selected land areas to accumulate atmospheric data for transmission to TIROS-N satellites. A number of other "user" terminals (particularly in DOD) also receive and use the TIROS-N output data transmissions.

NIMBUS Program. The NIMBUS series of spacecraft serves as a test bed in NASA's meteorological program for research and development of new sensors, subsystems, and system configurations. Improved systems and technology for weather prediction developed in NIMBUS flights go into operational meteorology spacecraft such as the TIROS-N series.

To provide daily global coverage, the NIMBUS satellites are launched into nominally circular, polar orbits at altitudes up to 1100 km (600 nmi). The inclination of the orbital plane is established during launch at a value (approximately 100 degrees) such that orbital precision keeps the local time of crossing the equator constant at a specified value.

The NIMBUS experiments include sensors for vertical temperature profiles, a microwave spectrometer, oceanographic and air pollution investigations. Additional experiments include those for a tropical wind, energy conversion, and reference level and an earth radiation budget experiment to monitor earth radiation levels.

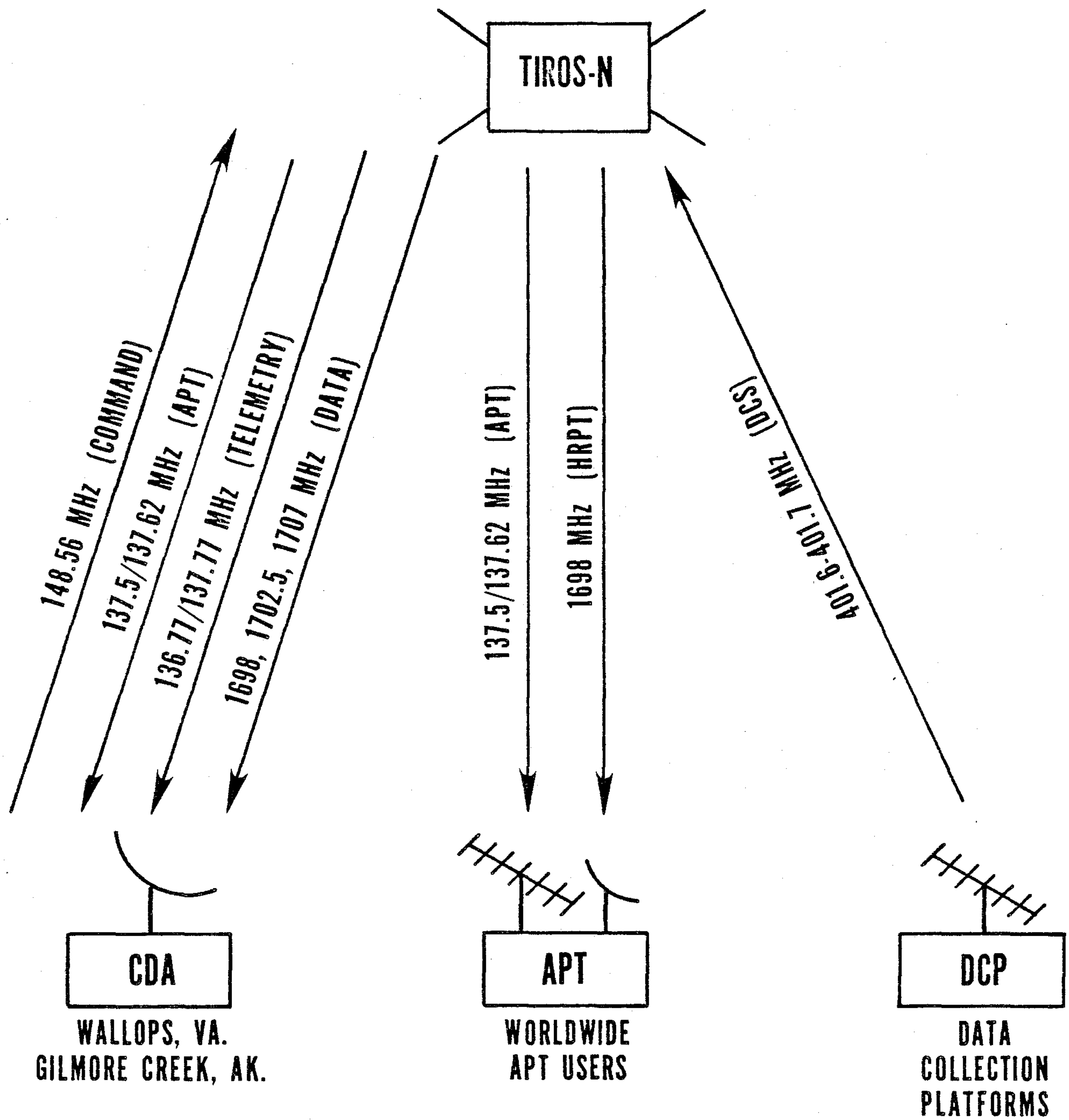


Figure 62. Data Flow From the TIROS-N Satellite.

NIMBUS 6, and 7, launched June 12, 1975, and October 24, 1978, respectively, are still operating. NIMBUS 7 appears to be the last of this series of satellites. Other programs such as LANDSAT (not in this band) and the GOES programs provide meteorological data developed under the NIMBUS program.

CONCLUSIONS

The Fixed Service in the post-WARC-79 allocations has been retained in the 1700-1710 MHz band. An issue that has surfaced revolves around whether a widespread use of the HRPT transmission of the TIROS-N to receive-only earth stations by non-Government users will evolve. The possibility of this use and the fact that receive-only earth stations need not be licensed by the FCC(i.e., therefore these locations are unknown) produces an untenable position to share with the Fixed Service. There is a question, however, if in reality this use will take place.

Contact with personnel of the DOC, National Environmental Satellite System (NESS), was made to identify the possible users of the direct satellite transmission to Government and non-Government earth stations in the United States. Currently, there are two earth stations in the 48 contiguous United States, one at Wallops Island, Virginia, the other at Redwood City, California. A third station is located at Gilmore Creek, Alaska. Information is widely dispersed to many users over a terrestrial network from these stations. Non-Government use has not been widespread being restricted by the considerable investment required to obtain data directly from the satellite. The cost/benefit of this direct transmission reception limits the use of this system in the United States. There apparently is little need for the direct reception since the information is disseminated by other means.

The growth in the band may depend greatly on the congestion of the Fixed Service in the upper adjacent band 1710-1850 MHz. The 1710-1850 MHz band is heavily used and is continuing to see rapid growth. There will soon be pressure to move fixed systems into this band. There is room in the 1700-1710 MHz band if well coordinated with the meteorological-satellite assignments. The present allocations are such that both Government and non-Government needs can be accommodated without changes.

THE 2290-2390 MHz BAND

INTRODUCTION

The 2290-2390 MHz band is a Government/non-Government shared band that is divided into three subbands: 2290-2300 MHz, 2300-2310 MHz, and 2310-2390 MHz, experimental stations have the greatest number of assignments. There have been two spectrum resource assessments which cover this band, one from 2200-2300 MHz (Flynn, 1980) and the other from 2300-2450 MHz (Watson, 1981). Excerpts from those two reports will be used in this summary.

RULES AND REGULATIONS

The 2290-2390 MHz band is divided into three subbands as shown in Table 68. The 2290-2300 MHz subband is allocated to Government/non-Government Space Research (space-to-Earth) (deep space only) and to Government Fixed and Mobile (except aeronautical mobile) on a coequal primary basis. The WARC-79 allocated the band 2290-2300 MHz to the Space Research Service for deep space only, to provide increased protection for this function. The primary allocation to the Mobile Service is limited to other than aeronautical mobile, to protect the very sensitive deep space systems from airborne transmissions.

From 2300-2310 MHz the allocation is to Government Radiolocation as the primary allocation with Government Fixed and Mobile and non-Government Amateur as secondary allocations. The U.S. footnote 253 states that in the band 2300-2310 MHz, the Fixed and Mobile Services shall not cause harmful interference to the Amateur Service. The subband from 2310-2390 MHz is allocated to Government Radiolocation and Mobile Services shared with non-Government Mobile Services, all on a primary coequal basis. There is also a secondary allocation to the Government Fixed Service. Government footnote G2 states that, along with other listed frequencies in the 2300-2450 MHz band, the Government Radiolocation is limited to the military services. The footnote U.S. 276 states that in the 2310-2390 MHz band, Mobile Service is limited to aeronautical telemetering and associated telecommand operations and that all other mobile telemetering is secondary.

In addition to these specific allocation rules and regulations, the NTIA Manual identifies frequency assignment and coordination procedures that are specifically applicable to this band. Section 8.2.33 provides a guideline for the selection of sites and frequencies for earth and terrestrial stations in the bands above 1 GHz shared with equal rights by terrestrial and space radio communication services. Section 8.2.36 of the NTIA Manual limits the power flux density at the Earth's surface from space stations in the Space Research Service operating in the 2200-2300 MHz frequency band. These are derived on the basis of protecting stations in the Fixed Service which employ line-of-sight communications. Sections 8.4.12, 8.4.13, 8.4.14, of the NTIA Manual establishes the coordination criteria for earth station frequency assignments. The purpose of the coordination criteria is to assure that terrestrial stations will not interfere with the earth station and vice versa. The coordination area for an earth station is calculated in accordance with Appendix 28 of the ITU Radio Regulations. The existing earth stations listed in the NTIA Manual within the 2200-2300 MHz band are:

TABLE 68

INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS FOR THE 2290 - 2390 MHz BAND

INTERNATIONAL			UNITED STATES				
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4	Remarks 5
2290-2300 FIXED SPACE RESEARCH (Deep Space) (Space-to-Earth) Mobile except aeronautical mobile	2290-2300 FIXED MOBILE except mobile SPACE RESEARCH (Deep Space) (Space-to-Earth)		2290-2300		SPACE RESEARCH (Space-to-Earth) (Deep Space Only) FIXED MOBILE except aeronautical mobile	SPACE RESEARCH (Space-to-Earth) (Deep Space Only)	
2300-2450 FIXED Amateur Mobile Radiolocation	2300-2450 FIXED MOBILE RADIOLOCATION Amateur		2300-2310	US253	RADIOLOCATION Fixed Mobile G2	Amateur	
			2310-2390	US276	RADIOLOCATION MOBILE Fixed G2	MOBILE	
664 752	664 751 752		2390-2450	664 752	RADIOLOCATION G2	Amateur	(ISM 2450 ± 50 MHz)

Footnotes:

US253 - In the band 2300-2310 MHz, the fixed and mobile services shall not cause harmful interference to the amateur service.

US276 - Use of the band 2310-2390 MHz by the mobile service is limited to aeronautical telemetering and associated telecommand operations. Exceptionally all other mobile telemetering uses shall be secondary.

G2 - In the bands..., 2300-2450 MHz, ..., the government radiolocation is limited to the military services.

Frequency MHz	Location	Coordinates Latitude	Longitude	Agency
2290-2300	Goldstone, CA	35 25 29N	116 53 24W	NASA
2200-2300	Andersen AFB, Guam	13 36 48N	144 51 12E	USAF
	Buckley Field, CO	39 43 XXN	104 46 XXW	USAF
	Cape Kennedy, FL	28-24 XXN	080 30 XXW	USAF
	Fairchild AFB, WA	47 30 XXN	118 10 XXW	USAF
2200-2300	Kaena Pt., HI	21-34 18N	158 16 34W	USAF
	Loring AFB, ME	47 00 XXN	068 01 XXW	USAF
	New Boston, NH	42 56 54N	071 38 24W	USAF
	Shemya, AK	52 43 XXN	174 07 XXE	USAF
	Vandenberg AFB, CA	34 29 24N	120 31 54W	USAF

The Aerospace and Flight Test Radio Coordination Council (AFTRCC), a trade association of major entities engaged in the design and manufacture of Government and non-Government aircraft, space vehicles, and their major components, filed a petition (RM-4077) to FCC requesting that Parts 2 and 87 of the Commission's rules be amended to permit the operation of aeronautical flight test telemetering airborne stations in the 2310-2390 MHz band. The AFTRCC also recommends that the Commission's rules be amended to authorize the use of the 1435-1535 MHz and 2310-2390 MHz bands for ground-to-air telecommand operations. These would be authorized to operate on six 1 MHz channels in both of the above stated bands and use directional antennas meeting specified standards to minimize collocation interference.

The proposed amendments to FCC Parts 2 and 87 also include new definition of terms, Power output, Frequency stability, Type of emissions, Frequency coordination, etc., for the above named bands as given in Appendix F.

SPECTRUM USAGE AND MAJOR SYSTEMS

Table 69 shows the assignments in the 2290-2390 MHz band by agency and subband. There are 25 assignments in the 10 MHz between 2290-2300 MHz, 11 of which are to NASA for space telemetering stations. There are 14 assignments in the 10 MHz between 2300 and 2310 MHz, 10 of which are to Air Force for radiolocation mobile stations and experimental stations. There are 57 assignments in the 80 MHz between 2310 and 2390 MHz with DOE as the major user with 24 assignments of which 20 are experimental stations. There are a total of 96 assignments to 14 different station classes. Air Force is the largest user with 28 assignments; DOE with 24, Army with 15, Navy with 14, NASA with 12, NSF with 1 and there are 2 non-Government assignments to companies engaged in Government research and development. It should be stressed again that assignments are not equivalent to actual system or equipment usage in the band. Equipment counts will be part of the Phase II report on the 947 MHz-17.7 GHz bands.

Figure 63 shows the growth trend for the 2290-2390 MHz band. There has been a fluctuation in usage over the past 10 years but the band shows approximately a 50% growth in assignments over the past 5 years. The band use is expected to grow at about the same rate for the next five years. Table 70 shows the unclassified systems in the Systems Review File for the 2290-2390 MHz band.

TABLE 69

FREQUENCY ASSIGNMENTS BY AGENCY FOR THE 2290-2390 MHz BAND

FREQUENCY BAND / AGENCY	EHER	FX	FXE	FLE	LR	ML	MOE	MOEA	MOEB	MOEC	MR	XC	XR	XT	TOTAL
2290-2300 MHz															
AF								1				4		1	6
AR		2						1		3					6
DOE															0
N									1						1
NASA	9												2		11
NSF															0
NG												1			1
															25
2300-2310 MHz															
AF											4	2		4	10
AR													1		1
N														2	2
NG												1			1
															14
2310-2390 MHz															
AF					5	1			1					5	12
AR											5			3	8
DOE		4												20	24
N		1	2	6			2								11
NASA									1						1
NSF													1		1
															57
TOTAL	9	7	2	6	5	1	2	2	3	3	9	8	4	35	96

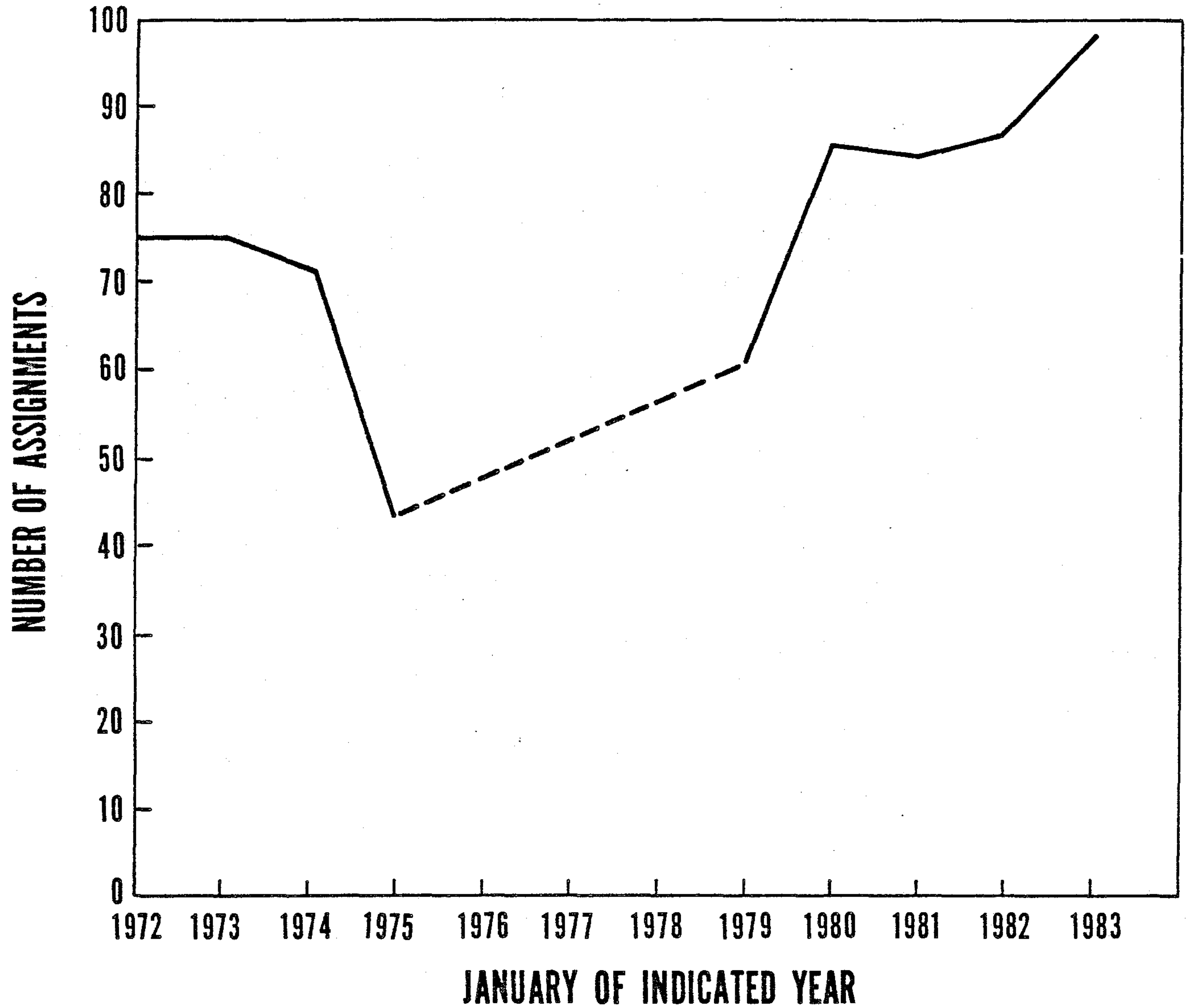


Figure 63. Growth Trend for the 2290-2390 MHz Band.

TABLE 70

SYSTEMS IN THE SYSTEMS REVIEW FILE FOR THE 2290 - 2390 MHz BAND

SYSTEM	SPONSORING AGENCY	STAGE OF REVIEW
NTS Backbone Microwave System	DOE	4
Very Low Cost Expendable Harrassment Vehicle	AF	2
BOOST Measurement and Analysis Program	AR	2
SEEK SKYHOOK	AF	4
Spinning Solid Upper Stage	NASA	4
Space Shuttle	NASA	4
Solar Mesosphere Explorer	NASA	2
TDRSS	NASA	4
TRI-Stitic Planetary Radar System	NASA	2
VOYAGER Telecommunication System	NASA	3
Deep Space Network	NASA	3
SOLAR POLAR Mission	NASA	0
AN/DSQ-X Telemetry System	AF	3
Transportable/Mobile Ground Station	AF	2
Bullet Hit Indicator	AF	4

SPECTRUM USAGE AND MAJOR SYSTEMS (Continued)

Figure 64 shows the distribution of Government frequency assignments in the band. As can be seen, there is room for growth particularly from 2300-2390 MHz. However, the 2290-2310 MHz subband is where the highest potential growth may occur because of the Space Research allocation.

Figure 65, shows the geographic distribution of assignments in the 2290-2390 MHz band. As can be seen in Table 71, there are 27 states that have no assignments, and 9 states that have only one assignment. There is one assignment in Puerto Rico not listed.

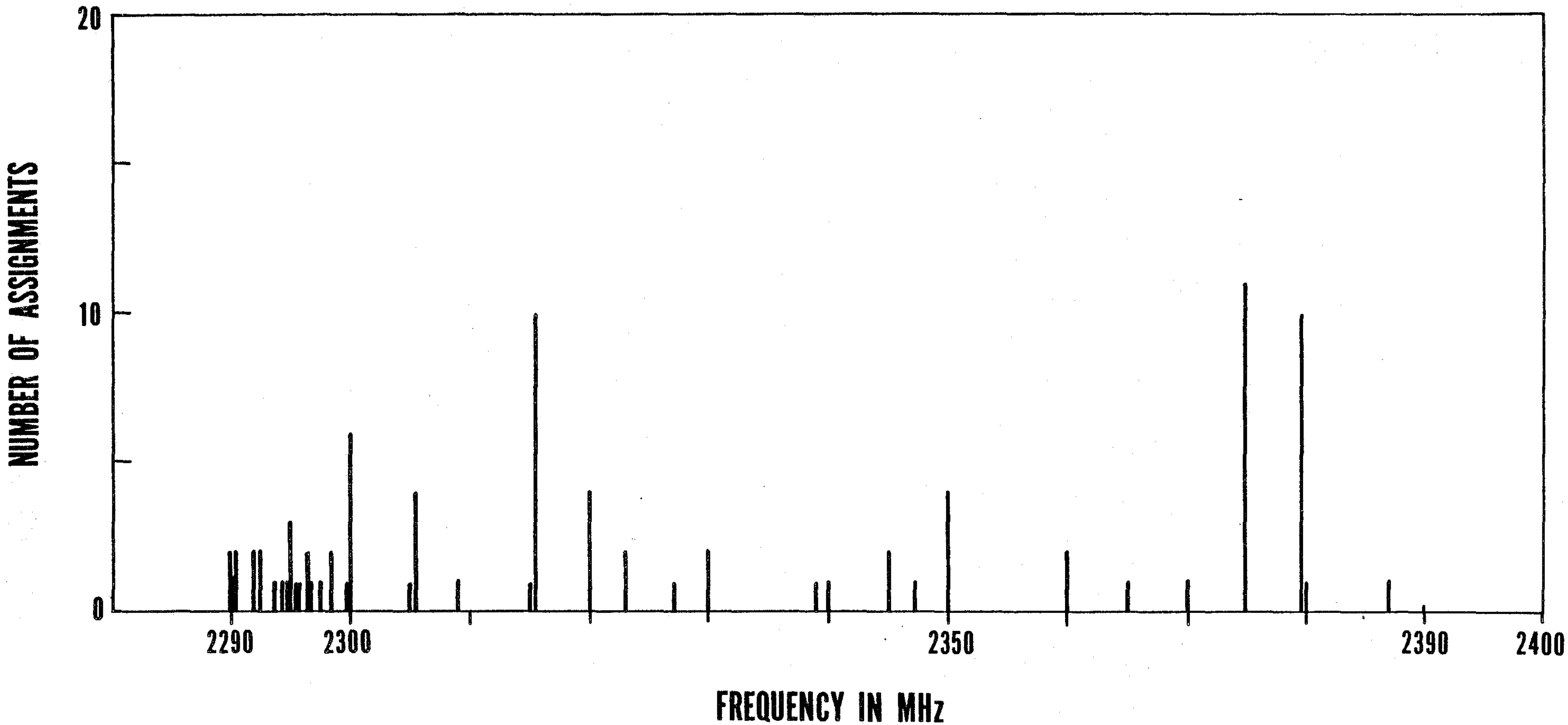


Figure 64. Frequency Assignment Distribution for the 2290-2390 MHz Band.

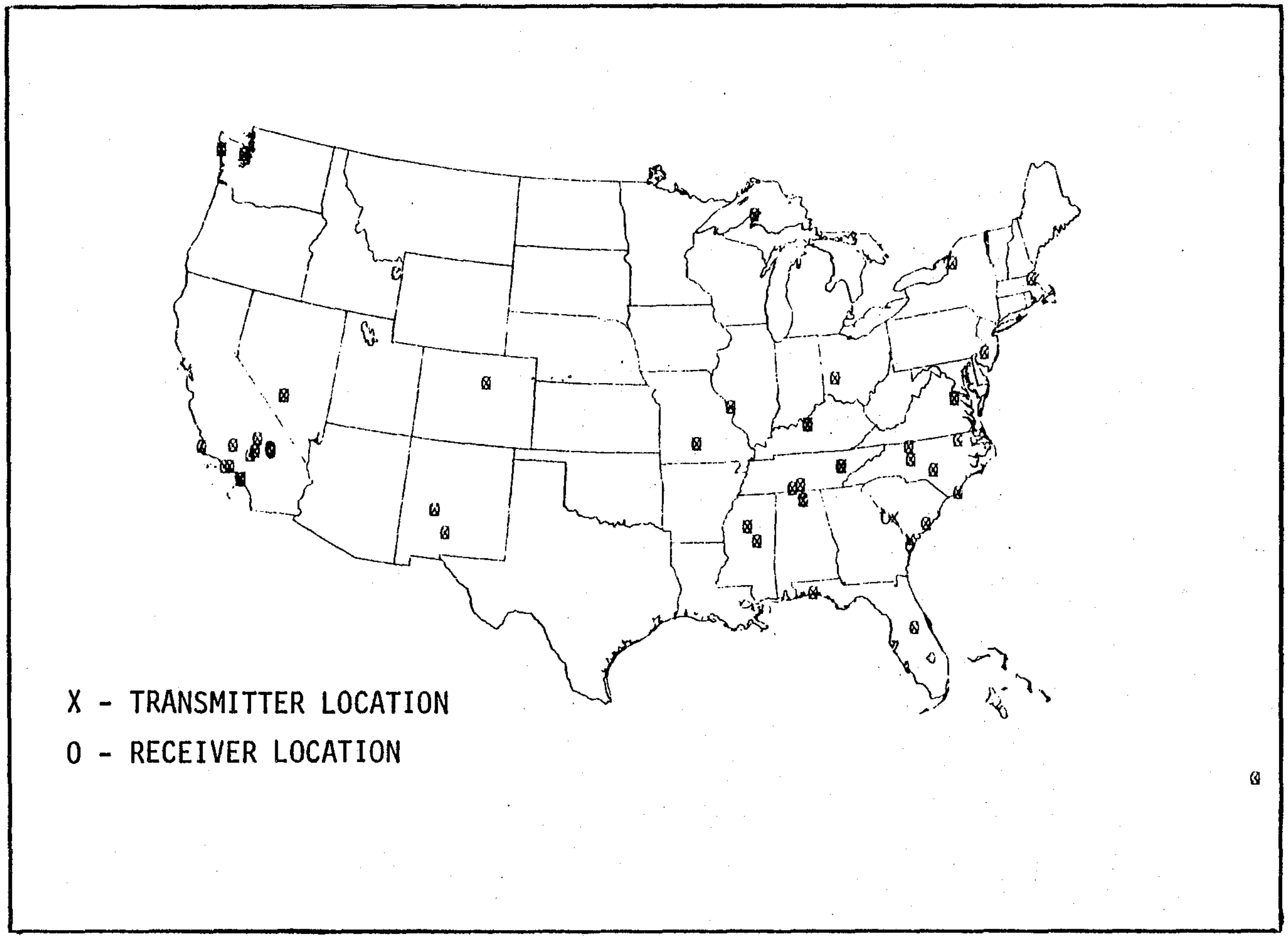


Figure 65. Geographic Distribution of Assignments for the 2290-2390 MHz Band.

MAJOR SYSTEMS

Radiolocation

AN/FPS-27. The only major land-based radar system identified in the band is the AN/FPS-27 radar equipments that are part of the Semi-Automatic Ground Environment System referred to as the SAGE Air Defense System. The SAGE system, initially installed during the 1950's, makes use of a centralization of collecting and processing of surveillance and warning data to inform, guide and control of aircraft for the purpose of defending the air space. SAGE makes use of a number of radar sensors feeding into a group of Regional Control Centers (RCCs) which, in turn, interact with the North American Air Defense (NORAD) Combat Operation Center (COC). There were only three assignments for AN/FPS-27 type radars in a 1983 GMF list in this band. This is a considerable reduction from the initial deployment during the 1950's. The U.S. SAGE system is being phased out and replaced with the Joint Surveillance System (JSS). The JSS is intended for operation in another frequency band. The nominal characteristics of the AN/FPS-027 radar are itemized in Table 72. Functionally, it is a ground-based, stacked-beam, frequency-diversity, search radar capable of operating in a severe jamming environment. Range and altitude information can be provided on air targets out to 400 km (220 nautical miles) and up to 45 km (150,000 ft.) in altitude. The signal processing capabilities of the AN/FPS-27 system includes a video integrator, an indicator, an interrogator and coder-decoder, along with coordinate data transmitting equipment (DOD, 1973).

Goldstone/Arecibo. The NASA Deep Space Network has assigned frequencies at 2320 MHz and 2390 MHz for use in planetary radar imaging experiments. These assignments are associated with the Jet Propulsion Laboratory (JPL)/Goldstone facility. Equipment of a developmental nature is being used for experimental research as a tri-static planetary radar to resolve North/South ambiguities and to obtain terrain altitude data. The various pulse intervals and pulse durations being used are measured in hours and minutes, respectively. The assignment at 2320 MHz is on an experimental basis, thus having only limited EMC rights within this band.

The National Science Foundation's Arecibo Observatory in Puerto Rico has an assignment at 2380 MHz. This is also used on an experimental research basis to obtain radar echoes from planets. The broadest emission is continuous waves with pseudo-random phase reversals, which permits effective pulsewidths down to 1 microsecond. The frequency is chosen in cooperation with the Radio Astronomy Service which uses the same equipment for passive observation of nearby molecular resonance frequencies. The equipment is operated by Cornell University under contract to the National Science Foundation.

MTTS. The Mobile Target Tracking System (MTTS) is an Army system used to support surface-to-air missile practice firing. These systems are deployed throughout the United States. Procurement of these systems began in 1967. The MTTS equipment operates on a primary basis in the band. This equipment is used as an airborne missile beacon to transmit range and altitude data to a ground controller and tracker. The equipment is capable of being tuned throughout the 2300-2450 MHz band, while the control function operate in another band. The beacon portion of the MITS is triggered from the ground.

TABLE 71

ASSIGNMENTS IN THE 2290 - 2390 MHz BAND BY STATE

STATE	NUMBER OF ASSIGNMENTS
Alabama	2
California (5 at Seal Beach, 11 at Gold Stone)	31
Colorado	1
Florida	6
Georgia	1
Hawaii	1
Idaho	1
Kentucky (one site)	4
Massachusetts	2
Michigan	1
Mississippi	4
Missouri	3
Nevada	2
New Jersey	1
New Mexico	4
New York	1
North Carolina	5
Ohio	1
South Carolina	2
Tennessee (2 sites)	8
Texas	1
Virginia	3
Washington (2 sites)	10
27 States	0

TABLE 72

AN/FPS-27 RADAR SYSTEM CHARACTERISTICS
(DOD, 1973)

Transmitter Characteristics	
Peak Power	15 Megawatts
Average Power	30 Kilowatts
Frequency Range	2322 to 2670 MHz
Pulse Rate	328-333 pps
Pulse Width	6 μsec
Emission Designator	330PO (338KPON)
Receiver Characteristics	
IF Bandwidth	4.5 MHz
Video Bandwidth	200 kHz
Noise Figure	6 dB
Sensitivity	-114 dBm
Antenna Characteristics	
Antenna Gain	19-40.5 dBi*
Horizontal Beam Width	0.9 degrees
Scan Rate	5 rpm

*Antenna gain varies as beam steps through the various beam positions.

Data on the MTTS is tabulated in Table 73. One of the items identified is a frequency stability of ± 0.1 percent which is slightly worse than the required ± 0.08 percent.

The GMF indicates several current uses for this equipment. The first use is for position tracking of an airborne missile and the terminal guidance equipment therein. Other assignments refer to the terminal guidance system and specifies the system as used with the Pershing II missile.

CIRIS. The Air Force's Completely Integrated Range Instrumentation System (CIRIS) appears in the GMF under radiolocation land and radiolocation mobile station classes. The purpose of the system is to provide precise position data for test programs concerned with evaluating the performance of aircraft navigation systems (SPS, 1977).

CIRIS consists of an inertial platform with doppler radar inputs, air speed data, an on-board range-rate radio link, and a general purpose computer to obtain accurate aircraft navigation data. The portion of the system associated with this band covers the range-rate subsystem which consists of an airborne interrogator and precisely located portable ground transponders.

The ground transponders within range of the aircraft are randomly sampled at approximately two-second intervals to update and calibrate the CIRIS. This is accomplished by phase comparison of tone modulated signals for range measurement and a coherent carrier signal for range rate measurement. The comparison is made during a one-second interrogation by the aircraft of a ground station transponder.

Transponders can be deployed in a triangular pattern, 200 to 240 km per leg, along a flight path. One typical flight path suggested was from Holloman AFB, NM, to San Diego, CA. The CIRIS equipment utilizing this band is the AN/URQ-22 airborne interrogator transmitting at 2412.4 MHz and receiving at 2347.2 MHz. The AN/URQ-22 ground transponder then receives at 2412.4 MHz and transmits at 2347.2 MHz.

Telemetering Mobile Systems

This functional class of systems is used for supporting mobile telemetering operations of assorted varieties. These systems provide real-time data links for communicating telemetering information over both short and relatively long-range distances, the latter in some cases going into established long-range networks which initially make use of a short-range telemetering link. In other cases, the short-range link goes into the established network.

The overall usage of each of these systems at any location can be quite dynamic as systems may be moved in and out of one primary central headquarters, of which there may be many. Spectrum usage has been enhanced by the coordination of activity in those environments where there is a high probability of interference. The fact that tests can be scheduled and persist for a relatively short time allows coordination procedures to be a useful tool in the management of this band.

TABLE 73

GENERAL MTTS SYSTEM CHARACTERISTICS
(DOD, 1968)

Airborne Transmitter Characteristics	
Emission Designator	80P9 (80K0P9B)
Peak Power	500-3000 W
Average Power	7-42 W (estimated)
Antenna Gain	0 dBi
Frequency	2375 & 2393 MHz (current (assignments)
Stability	0.1 %
Ground Receiver Characteristics	
RF Bandwidth	20 MHz
IF Bandwidth	1 MHz
Sensitivity	-94 dBm for 10 dB S/N
Frequency Range	2300-2450 MHz
Spurious Response	-60 dB
Antenna Gain	22 dBi

Space Shuttle

The Space Shuttle is a joint NASA and DOD program under development to reduce the cost of manned space operations and to support a wide range of scientific, defense, commercial and international interests. At present, a fleet of five reusable orbital vehicles is planned. The communication links for the space shuttle of primary interest in the 2290-2390 MHz band are the telemetry downlink from the shuttle, TDRSS, and NASA payload telemetry links.

Tracking and Data Relay Satellite System (TDRSS)

The TDRSS is a NASA program under development to reduce the cost and improve the efficiency of returning spacecraft gathered scientific data to Earth. In addition, real-time coverage of the low-orbit satellite can be provided on a more complete basis, as compared to the current network of U.S. earth stations that can support a given space research mission for about 15 percent of the time due to visibility constraints. TDRSS will consist of a ground station at White Sands, NM, and two operational Tracking and Data Relay Satellites separated by approximately 130° (41° and 171° West Longitude). The primary path of interest in the 2290-2390 MHz band is space-to-Earth transmission from 2200-2300 MHz.

Deep Space Network System (2290 - 2300 MHz)

In deep space research, the spacecraft is so distant, except during its launch from Earth, that there is little probability of its signals interfering with terrestrial space stations or near-Earth space station receivers.

The situation is very different at the Deep Space Network earth stations, which have very sensitive receivers. NASA operates the only Deep Space Network earth station in the United States at Goldstone, CA. The coordination contour for this receiver is in the NTIA Manual and extends across a large portion of the United States. However, the highly directive characteristics of the earth station antenna and its location reduce the probability of harmful interaction with terrestrial services. Space-to-Earth links in the band are at 2295 MHz and 2296.4815 MHz. Telemetry bit rates are 40 to 7680 bps on a 22.5 kHz subcarrier and 40 to 115,200 bps on a 360 kHz subcarrier. The NASA satellites that use the band are the PIONEER, VIKING, VOYAGER, and GALILEO series.

FIXED SYSTEMS

There are only seven fixed assignments in the band. These are to Army for the Savannah River Backbone Microwave System, one assignment to Navy for the AN/FRC-37 microwave link in Virginia, and four assignments to DOE for closed circuit TV links between various building guard posts and the main communications center for security purposes at Oakridge, Tennessee.

Amateur

The amateur allocation pertinent to this study is shared with the non-Government band of 2300-2310 MHz. This is a secondary allocation to the Radiolocation Service. The amateur activity is not large in these bands, numbering perhaps less than 100 operations around the country. In these bands, amateur activities are mostly experimental, and limited somewhat by the available equipment. The activity is sporadic, being primarily in the Los Angeles, San Francisco, and Boston regions, with even less in a few other metropolitan regions.

Internationally, the Amateur-Satellite Service has an allocation by footnote 664 allowing operation on a non-interference basis. This allocation has not been implemented in the United States.

Summary of Key Parameters

A summary of key parameters for equipment operating in the 2290-2390 MHz band is given in Table 74.

CONCLUSIONS AND RECOMMENDATIONS

There are 27 states (including Alaska) which do not have assignments in the 2290-2390 MHz band with another 9 that have only one assignment. It would seem, in light of the sparse use of radiolocation from 2310-2390 MHz, that this portion of the band could be opened for more use of the Fixed Service and could support some private sector use. Since the Mobile Service, both Government and non-Government, is new as a primary service, it may be too soon to establish the impact on band usage and sharing. However, since the Mobile Service is restricted to aeronautical telemetry the assignments will tend to be geographic, centering around test facilities.

It is recommended that this band be considered for greater sharing between Government agencies and that it be considered for greater sharing with the private sector.

TABLE 74

SUMMARY OF KEY SYSTEM PARAMETERS (2290-2390 MHz)

SYSTEM	AGENCY	FREQUENCY (MHz)	ENVIRONMENT	POWER (WATTS)	GAIN (dBi) Xmtr	GAIN (dBi) Recvr	EMISSION	COMMENTS
Radiolocation								Air Defense Radar to be phased out
AM/FPS-27	AF	2320-2500	MI, MN, NJ, NY, OR, SC	15 MW	32	32	333 PO	
Planetary Research	NASA	2320, 2390	CA (Goldstone)	0.4-0.5 MW	52-62	52-62	M1PO, M10A9, M10F9	
	NSF	2380	Puerto Rico (Arecibo)	10-450 RW	76	75	M2F9	
AN/URQ-22	AF	2412.4, 2347.2	USP	24	3	3	M11F9	Air/Ground Ranging System
	DOE	2315.5, 2379.8	CA, MS, MO, NV, NM	18	3	3	M11F9	Air/Ground Ranging System
MTTS	ARMY	2375, 2393	AL, FL, NC, NY	0.5-3 KW	0	22	80P9	Ranging System
Aeronautical Mobile								
A/6 Video Link	AF	2340	USA	5	0	28	M8F9	Tunable 1.7-2.5 MHz
A/6 Telemetry	AF	2350	PAC	2	0	0	66A0	
Fixed								
AN/FRC-37	N	2315, 2365	VA		40	40	M6P9	
Video Link	DOE	2327, 2375, 2387	TN	0.002	30	30	M6F9	

THE 4500-4800 MHz BAND

INTRODUCTION

The 4500-4800 MHz band is a Government/non-Government shared band. The primary allocation for the Government is for Fixed and Mobile Services. The allocation for the non-Government use is Fixed-Satellite (space-to-Earth). There are currently a total of 482 assignments in this band. The majority of the assignments (70%) are for fixed stations. The non-Government Fixed-Satellite Service operating in this band in the United States has been limited to international satellite systems by U.S. footnote 245. Consideration must also be given to the 69 assignments that range tune through the entire 4400-4900 MHz band [NG, 1981]. An NTIA Spectrum Resource Assessment covering the 4500-4800 MHz band was published in September 1981. This report will serve as resource material and will be updated with newer information inputs that are currently available.

ALLOCATION

Excerpts from the International and U.S. National Table of Frequency Allocations are given in Table 75 and show the allocations for the 4500-4800 MHz band, and upper adjacent bands along with applicable footnotes.

The one footnote, U.S. 245 applicable to the 4500-4800 MHz band, limits the Fixed-Satellite Service to international intercontinental systems such as INTELSAT. Since this band is predominately used by the military for mobile and fixed operations, special consideration will have to be given to electromagnetic compatibility requirements for military and non-Government satellite reception requirements.

SPECTRUM USAGE AND MAJOR SYSTEMS

GOVERNMENT USE

Within the United States the military agencies are the major users of the 4500-4800 MHz band. The systems authorized to operate in this band typically have a tuning capability over the 4400-4990 MHz band. There are currently 69 assignments that have this capacity. Figure 66 illustrates the assignments trend from 1972 to 1983. The statistics have been kept over the entire 4400-4990 MHz band and the 4500-4800 MHz portion cannot be separated out. The number of overall assignments have decreased primarily due to the reduction of assignments to the Navy. However, the figure shows a gradual increase in assignments from the other Government users over the past 5 years. (No statistics on number of assignments are available for the time shown by the dashed line).

The Government users of the shared band are shown in Table 76. The number, assignments and types of service allocated are detailed in this Table along with a percentage distribution of assignment. The vast majority of the users (70%) are for Fixed Service application. This band does provide for a

TABLE 75

EXCERPTS FROM THE INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS, MAY 1983

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
4400-4500	FIXED MOBILE		4400-4500		FIXED MOBILE	
4500-4800	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE 792		4500-4800	US245	FIXED MOBILE	FIXED-SATELLITE (Space-to-Earth)
4800-4990	FIXED MOBILE 793 Radio Astronomy 720 778 794		4800-4990	US203 US257 720 778	FIXED MOBILE	

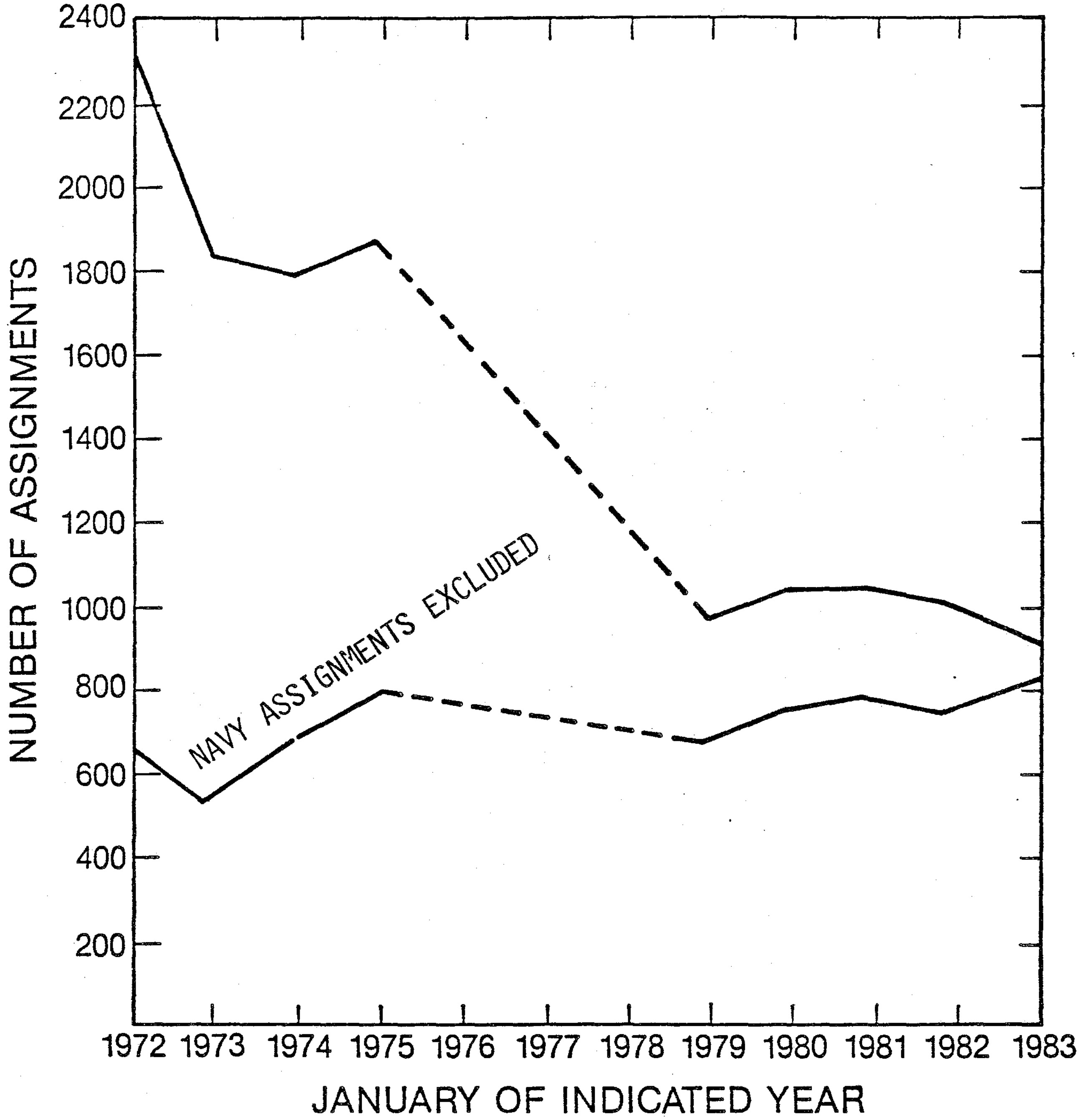


Figure 66. Growth Trends for the 4400-4990 MHz Band from January 1972 to January 1983.

TABLE 76

SUMMARY OF GOVERNMENT ASSIGNMENTS IN THE 4500 - 4800 MHz BAND

AGENCY/ SERVICE	STATION CLASS																NUMBER OF ASSIGNMENTS	% OF ASSIGNMENTS
	FL	FLD	FX	FXE	LR	MA	ML	MO	MOD	MOE	MOEA	MOEB	MOEC	XC	XD	XT		
AIR FORCE	2		195					3			2			1		24	227	47%
ARMY		5	71			3	4					3	1	2		2	91	19%
DOE			15	12													27	5.6%
NAVY	1	5	55		4				26	9	2				20	8	130	27%
NASA			3	2											2		7	1.4%
NUMBER OF ASSIGNMENTS	3	10	339	14	4	3	4	3	26	9	4	3	1	3	24	32	482	
PERCENTAGE OF ASSIGNMENTS	.6%	2%	70%	3%	.8%	.6%	.8%	.6%	5.5%	1.9%	.8%	.6%	.2%	.6%	5%	7%		

number of relatively high power troposcatter links. Troposcatter units are essential for military wartime and training operations and will need access to this band. The non-Government Fixed-Satellite Service (space-to-Earth) could be significantly impacted by high-level transmitters. Space separation, antenna pointing, frequency of operation, and time-sharing constraints will have to be effectively managed to insure compatible operation for this shared band.

The CONUS geographical distribution of assignments in the 4500-4800 MHz band is shown in Figure 67. It should be noted that there are geographical areas where no assignments have been made. However, since many of these systems are portable, in time of an actual national emergency they could be used anywhere in CONUS as the need arises.

Figure 68 shows the frequency assignment distribution for the 4500-4800 MHz band. There would seem to be the possibility of expansion of the fixed and mobile assignments in this band. However, the military tactical communications in the band must be protected and have priority in time of disaster or war. No non-Government users are shown in the figure because of the very limited number currently in use.

NON-GOVERNMENT USE

The use of the non-Government frequency assignments in this shared band appears to be very limited. The non-Government Master File shows 108 assignments in the band. Most of these seem to be erroneous, being misplaced in the file by the frequency multiplier and are to the Industrial Service for FB and MO with an emission designator of 3K00A3J.

Previous studies and personal contacts (private communication) indicated that these assignments do not belong in this band. Some of these assignments have passed planned expiration date of either August, 1975, or July, 1979. Some telephone companies are using assignments in this band. There are currently four assignments on two frequencies. In view of these items a review of current non-Government users would be appropriate at this time.

FIXED SERVICE

Line-of-Sight (LOS) Radio Relay

Fixed and transportable point-to-point LOS radio-relay equipments operating in this band are characterized by moderate transmitter power, high gain directional antenna, low capacity and moderate receiver sensitivity. The radius of operation of the transportable equipments identified in the GMF varies from 8 km to 480 km.

The technical characteristics of representative equipment are summarized in Table 77. A few of the common LOS systems are highlighted in the following paragraphs.

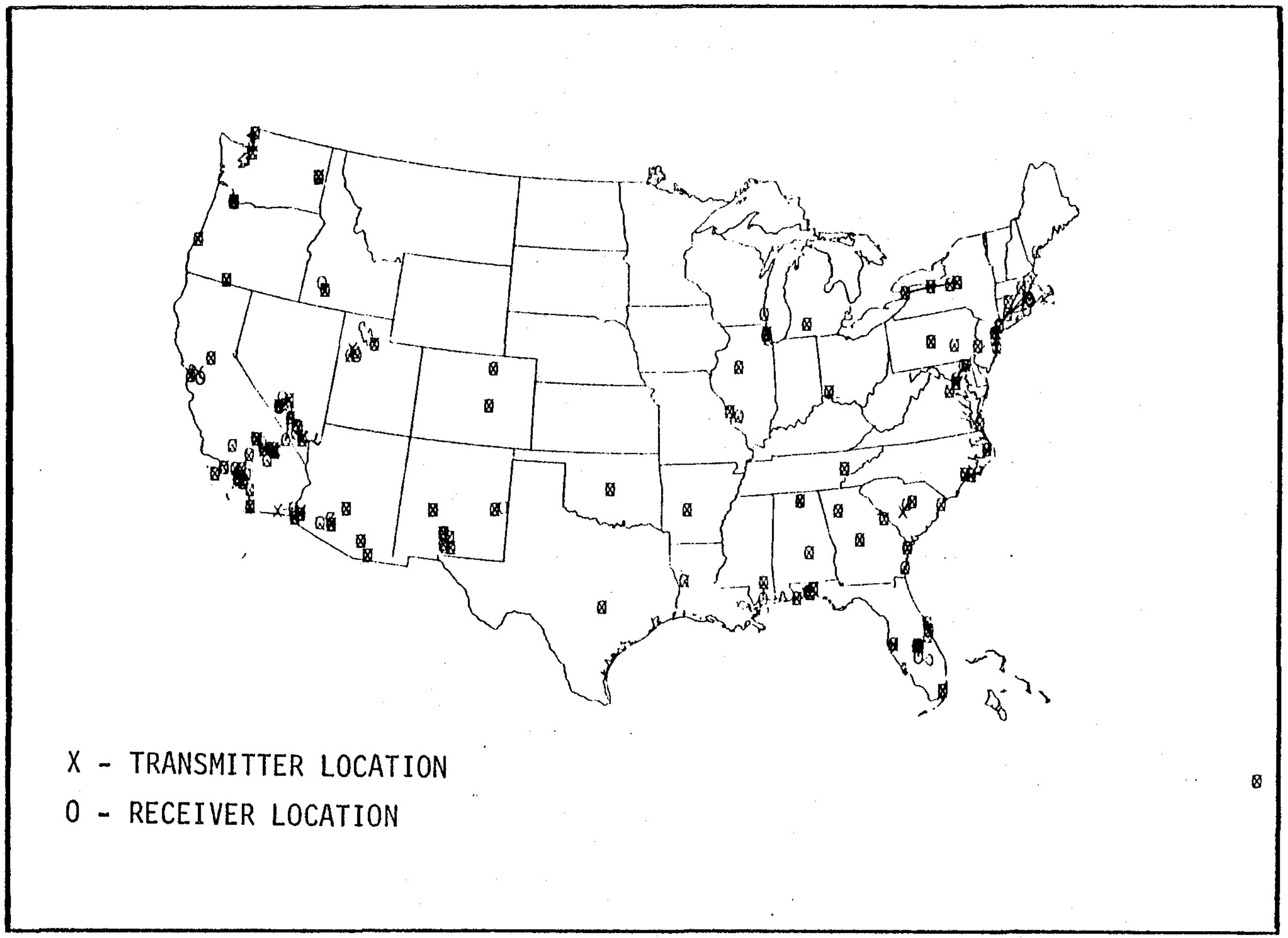


Figure 67. Geographic Distribution of Assignments for the 4500-4800 MHz Band.

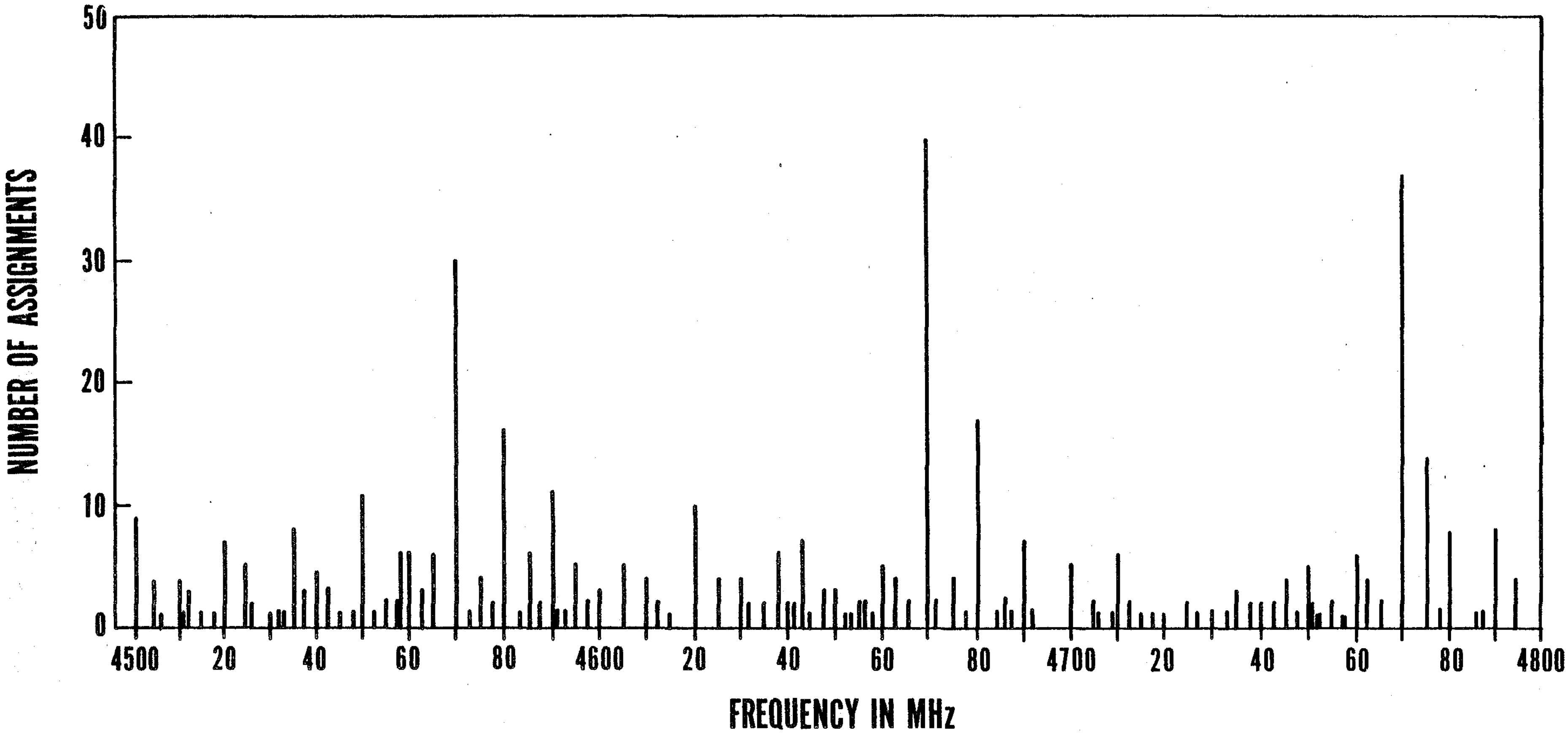


Figure 68. Frequency Assignment Distribution for the 4500-4800 MHz Band.

TABLE 77

TYPICAL LINE-OF-SIGHT RADIO RELAY EQUIPMENT IN THE BAND 4500-4800 MHz

TRANSMITTER				RECEIVER	
EQUIPMENT NOMENCLATURE	POWER (Watts)	ANTENNA GAIN (dBi)	EMISSION BANDWIDTH (MHz)	NOISE FIGURE (dB)	ANTENNA GAIN (dBI)
AN/TRC-97	15.0	38.0	1.0F9	5.0	38.0
AN/GRC-144	2.0	33.0	4.1F9	11.0	33.0
AN/TRC-027	3.0	30.0	10.0P9	13.0	30.0
AN/GSQ-120	0.5	37.0	1.0F9	---	37.0
TERTCM 602	1.0	33.0	36.0F9	8.5	33.0
AN/TRC-144	0.1	33.0	3.0F9	---	33.0

The AN/GSQ-120 is a radar data transfer system and provides data transfer links for the 407 L system. Radar data is time division multiplexed on an FM carrier for remoting the data to a central site.

The AN/TRC-27 is a tactical LOS set designed primarily for operating in a forward area. It may be used in a radio relay net configuration with the stations spaced 15 km or more apart. The system is a 24-voice channel equipment with 30 rf channels in 20 MHz increments.

<u>Tropospheric Scatter (TROPO) Radio Relay</u>

Fixed and transportable TROPO communications systems are being used extensively in this band to provide reliable multichannel circuits when the use of LOS systems is not feasible or desirable. A typical TROPO link spans a distance between 80 and 480 kilometers. The transmitter power is normally between 1 kW and 10 kW and the receiver has a noise figure as low as 3 dB. The antenna varies from transportable parabolic to fixed-billboard type antenna with typical gains ranging from 38 to 50 dBi. The system reliability is attained through the use of space, angle and/or frequency diversity techniques. Typical equipments are listed in Table 78 and three typical systems are discussed in the following paragraphs.

The AN/TRC-97 (·) is a transportable or fixed-tactical TROPO set which has similar characteristics to the LOS version, except, the transmitter has a 1 kW power amplifier. This family of systems was developed by the Air Force and has been operating since 1963.

The AN/TRC-132 (A) is a heavy-route TROPO system. It has two complete transmitters and four receivers. Hence, it has the capability of operating in either dual space diversity mode or quad diversity (space and frequency) mode. This family of systems is designed for use over long distance, typically 320 to 480 km.

TABLE 78

TYPICAL TROPOSPHERIC SCATTER EQUIPMENT IN THE 4500-4800 MHz BAND

TRANSMITTER				RECEIVER	
EQUIPMENT NOMENCLATURE	POWER (kW)	ANTENNA GAIN (dBi)	EMISSION BANDWIDTH (MHz)	NOISE FIGURE (dB)	ANTENNA GAIN (dBI)
AN/TRC-97 (·)	1.0	38.0	1.0F9	5.0	38.0
AN/TRC-132A	10.0	49.0	5.0F9	9.0	49.0
AN/GRC-143	1.0	40.0	2.3F9	4.0	40.0
AN/TRC-170(V1)	6.6	45.0	3.5P9	3.0	45.0
-170(V2)	1.85	41.0	3.5P9	3.0	41.0
-170(V3)	2.0/0.65	41.0	3.5P9	3.0	41.0

The AN/TRC-170 family of tactical TROPO terminals is presently under full-scale development by the Tri-service Tactical Communication Program (TRI-TAC) under the guidance of USAF/ESD. This equipment employs digital transmission techniques and is intended as a replacement for the present AN/TRC-97. The nominal range capability and the diversity mode for the AN/TRC-170 family is given as follows:

Equipment	Diversity Mode	Nominal Range (km)
AN/TRC-170 V1	Quad (frequency and space)	321 (200 miles)
AN/TRC-170 V2	Quad (frequency and space)	241 (150 miles)
AN/TRC-170 V3	Dual (frequency or space)	161 (100 miles)

These nominal range capabilities are under typical deployment, but substantially greater ranges could be achieved depending on the combination of terrain features and the channel capacity. The digital transmission capabilities are from 128 kbps to 2048 kbps. The low-noise amplifier is a thermoelectric cooled FET device which provides 27 dB gain with a noise figure of 1.8 dB.

The AN/TRC-170 has undergone a System Review under the provisions of Part 8.3 of the NTIA Manual. The review indicated that this system meets the applicable specification of Chapter 5 of the NTIA Manual for frequency tolerance and spurious emission levels. The review also indicated that all three versions of the AN/TRC-170 are capable of producing field intensity levels in excess of the mW/cm^2 specified in 29 CFR 1910.97 as the safe exposure limit for personnel. The maximum power density expected for each configuration of the AN/TRC-170 and the distance out from the antenna where the 10 mW/cm^2 will be exceeded within the mainbeam are as follows:

AN/TRC-170	Maximum Power Density (mW/cm^2)	Safe Distance (meters)
V1	160	384
V2	121	133
V3	121	133
V3 (LO-PWR)	37	73

MOBILE SERVICE

Radio Command and Drone Control

This band has been designated by the Military Communications Electronics Board (MCEB) for radio drone control operations. The Integrated Target Control System (ITCS) is a radio drone control system now being used in this band. The ITCS integrates the functions of command, control, tracking, and telemetry into a single system. Basically, the ground control station transmits ranging and command data and the transponder on the target simultaneously transmits telemetry data for tracking and performance monitoring by the control station. The technical characteristics of the equipment components of the ITCS system are summarized in Table 79. The radius of operation for this system is typically between 130 and 400 km.

TABLE 79

TYPICAL CHARACTERISTICS OF THE ITCS COMPONENTS

TRANSMITTER					RECEIVER	
Component Nomenclature	Function	Power (Watts)	Antenna Gain (dBi)	Emission Bandwidth (MHz)	Sensitivity (dBW)	Antenna Gain (dBi)
AN/TFW-9 & AN/TSW-10	Transportable Control Station	250 800	35.5 33.0	1.0F9 1.0F9	-132 -132	35.5 33.0
AN/PSW-1	Portable Control Station	250	25.0	1.0F9	-138	25.0
AN/DKW-1	Target Drone	2.5	-3.0	1.0F9	-123	03.0

A similar system designed to provide command, via relay pods carried aboard an aircraft, to a remotely piloted vehicle (RPV) is also operating in the 4500-4800 MHz band. The telemetry and video information links from the RPV also operate in this band.

At the present time, a stage 4 (operational) system review has been granted to the Army for its MQM-33C Command Control System (SPS-5029). This system is intended to be used for control of pilotless drone aircraft. The transmitter is located on the ground while the receiver is located in the drone. The System Review indicated that the MQM-33C conforms to all applicable standards given in Section 5.2.3 of the NTIA Manual and the transmitters are not expected to produce power density in excess of $10 mV/cm^2$.

Television Ordnance Scoring System (TOSS)

The TOSS is an ordnance scoring system that locates the impact point of ordnance dropped from aircraft in a training or operational test environment.

Experimental

The number of assignments for experimental stations for each agency was given in Table 76. Three of these assignments are for "XC" stations used for evaluation or testing under Government contract of electronic equipments or systems in a design or development stage. A second class of experimental assignments (designated XD or XT) is indicative of stations used in basic research or for evaluation or testing of electronic equipment or systems that have been developed for operational use. This latter category includes such activities as site selection, transmission path surveys, predelivery factory checkout and antenna calibration and includes three assignments to non-Government companies to support Government research and development.

Following is a list of the unclassified systems in the Systems Review File for the 4500-4800 MHz band. (There is one classified system which if described here would not particularly add to the conclusions made in this report so are not included).

SYSTEM	SPONSORING AGENCY	REVIEW STAGE *
Integrated Target Control System (ITCS)	NA	0
Television Ordnance Scoring System (TOSS)	AF	4
Space Transportation System (Space Shuttle)	NASA	4
Remotely Piloted Vehicle System (RPV)	AR	2
Video Microwave Link	DOE	4
Airborne RPV Radar Telecommand and Data Relay	AF	2
Integrated Communications and Navigation System (ICNS)	AR	2
Nuclear Emergency Search Team	DOE	4
Digital Radio and Multiplex Acquisition Systems	AR	4
AN/TRC-170	AF	4
MQM-33C Command Control System	AR	4
Vega 6156/6157 Target Control System	N	3
Nevada Test Site Backbone Microwave System	DOE	4
Digital Microwave Radio	AR	1

The basic requirements, spectrum use and powers for these systems are not much different than existing systems in the 4400-4990 MHz band.

*Review Stage Status

0 - stage of review was not indicated

1 - conceptual

2 - experimental

3 - developmental

4 - operational

CONCLUSIONS

The 4500-4800 MHz band is not highly saturated with assignments. There are a few areas with many Government assignments, such as southern California and the northeastern seaboard, where tight management by Government area frequency control personnel is necessary. Because the systems in the band include military tactical radio communication links (many portable), any increased use of the band would have to be well coordinated with the various military agencies involved and would of necessity be secondary to their needs. As seen from the Systems Review File there are many new systems coming into the band. This trend appears to be continuing for the foreseeable future.

The non-Government users in this shared band are very few in number. The national use of this band is for international satellite service (space-to-Earth) for which there are no present assignments shown. There are non-Government assignments in the band that appear to be misplaced in the file. Neither the station class nor the emission designator seem to fit this band. More accurate information on non-Government use needs to be solicited from FCC.

The new Fixed-Satellite allocation to non-Government may pose some interference potential to existing terrestrial systems, particularly troposcatter systems.

Since so many of the other Government exclusive bands that are primarily allocated to Fixed and Mobile Services (1710-1800 MHz, 2200-2290 MHz, 7125-8450 MHz) are becoming very crowded, the 4400-4990 MHz band will most likely see much greater growth in the next 10 to 20 years than it has in the past 10 years. Careful planning must be accomplished in the growth of this band which is important to national security.

THE 8450-8500 MHz BAND

INTRODUCTION

The 8450-8500 MHz band shows 19 Government assignments, mainly to the Fixed Service, in the GMF and seven non-Government assignments in the non-Government Master File (NGMF). The seven assignments in the NGMF may be in error since they are mainly to industrial business for land mobile use which is not on allocation to this band. This has only recently become a Government/non-Government shared band, and it is questionable whether any non-Government assignments exist as yet. The band at present is not heavily used.

FREQUENCY ALLOCATIONS, RULES AND REGULATIONS

Table 80 shows the International and U.S. National Table of Frequency Allocations for the 8450-8500 MHz band, along with the adjacent bands, as given in the May 1983 NTIA Manual. Prior to WARC-79 the band from 8400-8500 MHz was a government exclusive band for Fixed, Mobile and Space Research on a primary coequal basis. After the WARC, the U.S. National Table of Allocations was revised to its present form, splitting the old band into two segments, 8400-8450 and 8450-8500 MHz. Mobile assignments, which were almost non-existent, were dropped from the band and non-Government Space Research (space-to-Earth) was added.

Limits at the Earth's surface from space stations sharing with the Fixed and Mobile Services are given in Chapter 8 of the NTIA Manual, specifically 8.2.36. Coordination of assignments for terrestrial stations located within the coordinates area of a receiving earth station are also given in Chapter 8. Technical standards for the band are given in Chapter 5 of the NTIA Manual and are summarized in Appendix E of this report.

SPECTRUM USAGE AND MAJOR SYSTEMS

There are 19 systems listed in the GMF for this band as follows:

Air Force

- 1 radar microwave link (FX)
- 1 microwave data link (FX)
- 1 multi-purpose system used in EW training (XT)

Army

- 1 microwave video radar link

Coast Guard

- 3 assignments to the VTS for frequency diversity (FX)

DOE

- 2 assignments used for command, control and protection at electrical power distribution systems (FX)

Justice

- 8 assignments for microwave video links operated by the FBI and Border Patrol (FX)

Navy

- 1 microwave link for data and communications (FX)
- 1 system used in EW training (XT)

TABLE 80

INTERNATIONAL AND U.S. NATIONAL TABLES OF FREQUENCY ALLOCATIONS FOR THE 8450-8500 MHz BAND

INTERNATIONAL			UNITED STATES				
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4	Remarks 5
8400-8500	FIXED MOBILE except aeronautical mobile SPACE RESEARCH (Space-to-Earth) 816 817		8400-8450		FIXED SPACE RESEARCH (Space-to-Earth) (Deep Space Only)		
	818		8450-8500		FIXED SPACE RESEARCH (Space-to-Earth)	SPACE RESEARCH (Space-to-Earth)	
8500-8750	RADIOLOCATION 713 819 820		8500-9000	US53 US110 713	RADIOLOCATION G59	Radiolocation	See Part 7.18 of the NTIA Manual
8750-8850	RADIOLOCATION AERONAUTICAL RADIONAVIGATION 821 822						
8850-9000	RADIOLOCATION MARITIME RADIONAVIGATION 823 824						

Figure 69. Geographic Distribution of Assignments in the 8450-8500 MHz Band.

There are a total of 17 fixed point-to-point microwave systems and 2 systems in the Experimental Service. There are also two NASA systems listed in the 8400-8450 MHz band that can range tune through the 8450-8500 MHz band. These two assignments deal with the NASA Deep Space Network used in the VOYAGER and GALILEO space missions. There is also one Navy assignment in the 8400-8450 MHz band which range tunes into the 8450-8500 MHz band. This is a system used in EW training.

Growth trend statistics are not available for this band but a check over the past 3 years shows a growth from 13 assignments to the present 19. Geographical distribution of assignments are shown in Figure 69. Here it can be seen that there is much room for expansion of use in this band. Figure 70 shows the frequency distribution of assignments in the 8450-8500 MHz band. The 19 assignments only use 6 frequencies in the band.

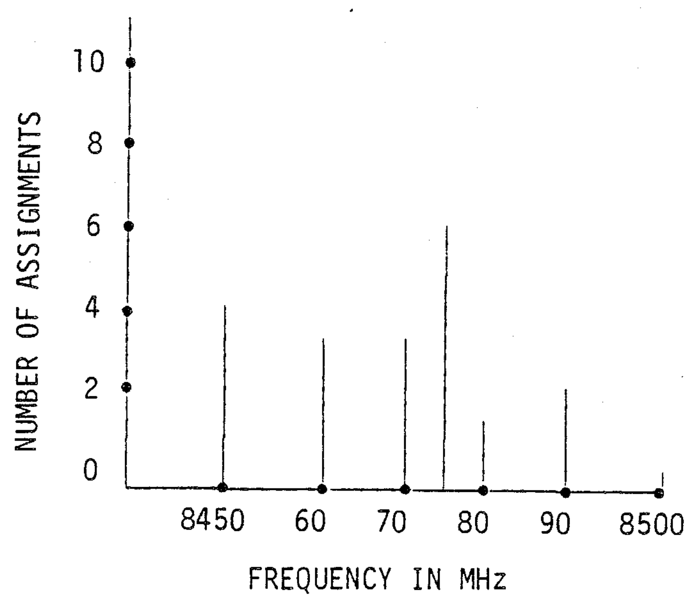


Figure 70. Frequency Assignment Distribution for the 8450-8500 MHz Band.

MAJOR SYSTEMS

The systems used in the band are as follows:

AN/DPT-1	Radar for EW training
AN/SLQ-32	Shipboard ECM training
AN/MST-1A	EW/ECM training

Collins	MDR 8-5N	Point-to-point microwave system	
Collins	MDR 8	Point-to-point microwave system	
Collins	MW 518/WB	Point-to-point microwave system	
International Microwave Corp.	7080	Point-to-point microwave system	
Ferinon Electric	FV8F	Radar video microwave link	
Household Data Services	GD 1205	Short distance video link	
	GD 1305	Short distance video link	
	GD 1145	Short distance video link	

Some of the basic microwave system characteristics are given in Table 82.

Most systems in the band are short-hop microwave links for remoting radars, remoting CCTV systems, and for communications and data transmission. There are nine states with assignments, however, the Justice Department has four assignments to the United States and possessions that allow them to set up links where needed in CONUS taking into account certain coordination requirements in California, Texas, and Washington.

CONCLUSIONS AND RECOMMENDATIONS

As pointed out in previous sections, this is not a heavily used band with only 19 assignments to six frequencies. It is recommended that the 8450-8500 MHz band be opened up for a limited and well coordinated Fixed Service shared with non-Government users. There are potential interference problems between fixed systems in this band and high power radars in the 8500-9000 MHz band. Distance separation will have to be practiced by fixed system users to minimize interference.

TABLE 81

BASIC SYSTEM CHARACTERISTICS FOR MICROWAVE LINKS IN THE 8450 - 8500 MHz BAND

TYPE NUMBER	FREQUENCY DESIGNATOR	CHANNEL CAPACITY	DATA RATE	TRANSMITTER POWER	RECEIVER NOISE FIGURE	RECEIVER THRESHOLD (BER @ 1 x 10^{-6})
MW 518	25,000 F9	960		1 W	10 dB	-67 dBm
MDR-8	40,000 F9Y	1344	90 mb/s	10 W	8 dB	-67 dBm
MDR-8-5N	20,000 F9Y	672	45.5 mb/s	4 W	8.5 dB	-70 dBm
FV 8F	40,000 F9W	1200		1 W	5.5 dB	-83 dBm

THE 10.6-10.68 GHz BAND

INTRODUCTION

The 10.6-10.68 GHz band is a Government/non-Government shared band. At present there are no Government assignments for this band in the GMF. There are 28 non-Government assignments in the August 1983 printout from the NGMF for the band. Of the 28 assignments, 19 are to the Mobile Service which are not allocated to this band.

Allocations, Rules and Regulations

Table 82 is an excerpt from the May 1983 NTIA Manual giving the frequency allocations for the 10.6-10.68 MHz band. The allocations are to both the Government and non-Government Earth Exploration-Satellite Service (passive) and Space Research Service (passive) and to the non-Government Fixed Service on a coequal primary basis. The U.S. footnote 265 limits the maximum equivalent isotropically radiated power for fixed systems to 40 dBW. United States footnote 277 allocates the Radio Astronomy Service to this band on a primary basis. The Very Large Array radio telescope in New Mexico operated by NSF can tune into this band.

SPECTRUM USAGE

Table 83 shows the non-Government assignments by service and station class. Mobile assignments have the greatest number with 19. All fixed assignments (FX) and 6 of the 13 mobile assignments are to Tymnet, Inc. in California. There are no Government assignments in this band; however, there are two Air Force XT assignments in the lower adjacent band that can range tune into this band.

TABLE 83

PRIVATE SECTOR USE BY SERVICE AND STATION CLASS FOR THE 10.6-10.68 GHz BAND

SERVICE	STATION CLASS			TOTAL NUMBER OF ASSIGNMENTS
	FX	FB	MO	
IB		1	5	6
IX			3	3
PH			1	1
PL			2	2
PP		1	1	2
PS			1	1
XD	7		6	13
	7	2	19	28

XB - Industrial Business
IX - Manufacturers
PH - Highway Maintenance
PL - Local Government
PP - Police
PS - Special Emergency
XD - Experimental Development
FX - Fixed Station
FB - Base Station
MO - Mobile Station

TABLE 82

INTERNATIONAL AND U.S. NATIONAL TABLE OF ALLOCATIONS FOR THE 10.6-10.68 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
10.55-10.6	FIXED MOBILE except aeronautical mobile Radiolocation		10.55-10.6			FIXED
10.6-10.68	EARTH EXPLORATION-SATELLITE (Passive) FIXED MOBILE except aeronautical mobile RADIO ASTRONOMY SPACE RESEARCH (Passive) Radiolocation 831 832		10.6-10.68	US265 US277	EARTH EXPLORATION-SATELLITE (Passive) SPACE RESEARCH (Passive)	FIXED EARTH EXPLORATION-SATELLITE SPACE RESEARCH (Passive)
10.68-10.7	EARTH EXPLORATION-SATELLITE RADIO ASTRONOMY SPACE RESEARCH (Passive) 831 832		10.68-10.7	US74 US246	RADIO ASTRONOMY EARTH EXPLORATION-SATELLITE (Passive)	RADIO ASTRONOMY EARTH EXPLORATION-SATELLITE (Passive)

US265-In the band 10.6-10.68 GHz, the fixed service shall be limited to a maximum equivalent isotropically radiated power of 40 dBW and the power delivered to the antenna shall not exceed -3 dBW, per 250 kHz.

US277-The band 10.6-10.68 GHz is also allocated on a primary basis to the radio astronomy service. However, the radio astronomy service shall not receive protection from stations in the Fixed Service which are licensed to operate in the one hundred most populous urbanized areas as defined by the U. S. Census Bureau. The following radio astronomy sites have been coordinated for observations in this band: National Radio Astronomy Observatory, Green Bank, West Virginia; National Radio Astronomy Observatory, Socorro, New Mexico; Harvard Radio Astronomy Station, Fort Davis, Texas; Hat Creek Observatory, Big Pine, California; Naval Research Laboratory, Maryland Point, Maryland.

Table 84 shows the assignments by state. There are only 12 states with assignments and only 3 with more than one assignment.

TABLE 84

ASSIGNMENTS IN THE 10.0-10.68 GHz BAND BY STATE

STATE	NO.	STATE	NO.	STATE	NO.
California	14	Kentucky	1	Texas	2
Colorado	1	Michigan	1	Utah	1
Florida	3	New Jersey	1	West Virginia	1
Indiana	1	Ohio	1	Wisconsin	1

A new user service recently introduced into this band is the Digital Termination System (DTS) or sometimes referred to as the Digital Electronic Message Service. These systems in general will be point-to-multipoint systems used for digital data transmission, digital voice, digital video teleconferencing, etc., on a subscriber basis. Proposed systems will offer 4.8 kb/s per channel all the way to 1.544 Mb/s per channel depending on the company and offered services. Some systems will serve the local access and transport areas while some will serve long distance user needs. The DTS is expected to be a rapid growth area and the 10.6-10.68 GHz band may experience congestion in large metropolitan areas in the near future as subscribers to these services grow.

CONCLUSIONS AND RECOMMENDATIONS

This band at present has room to expand because only 12 states have any assignments and there are no Government assignments. It is recommended that the Fixed Service already allocated to non-Government be used for some of the displaced fixed assignments from the 12.2-12.7 GHz band. However, if the new DTS Services grow as rapidly as expected this band may only accommodate 12 GHz users in geographic areas away from large metropolitan areas.

THE 14.4-14.5 GHz BAND

INTRODUCTION

The 14.4-14.5 GHz band is a Government/non-Government shared band. The Government presently has 22 assignments and there is 1 non-Government assignment. Most assignments are in the Fixed Service. There are 112 systems from the lower adjacent band that use the band from 14.0-14.5 GHz. All but one are for space communication systems and related test facilities. One hundred and four of the assignments are to Satellite Business Systems, Inc.

Allocations, Rules, and Regulations

Table 85 shows the international and national frequency allocations for the 14.4-14.5 GHz band. This table is an excerpt from the NTIA Manual, May 1983. The primary allocation is to the non-Government Fixed-Satellite Services (Earth-to-space). The secondary allocation is to Government Fixed and Mobile Services. The U.S. footnote 203 states that radio astronomy observations of the formaldehyde line are made at 14.47-14.5 GHz at listed sites and that all precautions should be made not to interfere with those measurements. The U.S. 254 footnote states that all Government fixed and mobile stations are secondary except for the four listed sites which may continue to operate on a coequal basis with the non-Government Fixed-Satellite Service until December 31, 1986. The U.S. footnote 287 states that the 14.4-14.5 GHz band is also allocated to the non-Government Land Mobile-Satellite Service (Earth-to-space) on a secondary basis. The international footnote 862 urges all administrations to protect spectral line observations of the Radio Astronomy Service from harmful interference.

The rules and regulations for the non-Government satellite service are found in Part 25 of the FCC Rules and Regulations. Technical standards for the 14.4-14.5 GHz band are given in Chapter 5 of the NTIA Manual, part of which are given in Appendix E.

SPECTRUM USAGE AND MAJOR SYSTEMS

There are 22 assignments to eight Government agencies in the band from 14.4-14.5 GHz. Table 86 shows the assignments by agency and station class. The Fixed Service has the most assignments (15).

There are 112 assignments in the lower adjacent band which operate from 14.0-14.5 GHz. Of the 112, 106 have a station class designator of TC, fixed-satellite earth stations. The other six are assigned to the Experimental Services, 2 to experimental testing stations (XT) and four to experimental development stations (XD).

TABLE 85

INTERNATIONAL AND U.S. NATIONAL TABLE OF FREQUENCY ALLOCATIONS FOR THE 14.4-14.5 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
14.3-14.4 FIXED FIXED-SATELLITE (earth-to-space) 858 MOBILE except aeronautical mobile Radionavigation-Satellite 859	14.3-14.4 FIXED-SATELLITE (earth-to-space) 858 Radionavigation-Satellite 859	14.3-14.4 FIXED FIXED-SATELLITE (earth-to-space) 858 MOBILE except aeronautical mobile Radionavigation-Satellite 859	14.3-14.4	US287		FIXED-SATELLITE (earth-to-space)
14.4-14.47	FIXED FIXED-SATELLITE (earth-to-space) 858 MOBILE except aeronautical mobile Space Research (space-to-earth) 859		14.4-14.5	US203 US234 US287 862	Mobile Fixed	FIXED-SATELLITE (earth-to-space)
14.47-14.5	FIXED FIXED-SATELLITE (earth-to-space) 858 MOBILE except aeronautical mobile Radio Astronomy 859 862					

US203-Radio stronomy observations of the formaldehyde line frequencies 4825-4835 MHz and 14.470-14.500 GHz may be made at certain radio astronomy observatories as indicated below:

Bands to be observed

4 GHz	14 GHz	Observatory
X		National Astronomy and Ionosphere Center, Arecibo, Puerto Rico
X	X	National Radio Astronomy Observatory, Green Bank, W. Virginia
X	X	National Radio Astronomy Observatory, Socorro, New Mexico
X	X	Hat Creek Observatory (U. of Calif.) Hat Creek, California
X	X	Haystack Radio Observatory (MIT-Lincoln Lab) Tyngsboro, Massachusetts
X	X	Owens Valley Radio Observatory (Cal. Tech) Big Pine, California
	X	Five College Radio Astronomy Observatory, Quabbin Reservoir (near Amherst) Massachusetts

Every practicable effort will be made to avoid the assignment of frequencies to stations in the fixed or mobile services in these bands. Should such assignments result in harmful interference to these observations, the situation will be remedied to the extent practicable.

US234-In the band 14.4-14.5 GHz, all government fixed and mobile stations, effective December 31, 1981, shall be on a secondary basis to stations in the non-government fixed-satellite service. Exceptionally, the government operations listed below, which were in existence on December 31, 1981, may continue to operate on a co-equal primary basis with stations in the non-government fixed-satellite service untile December 31, 1986.

Operation	Points of Communication
Point Mugu, CA	From 34° 07' N 119° 07' W to 34° 00' N 119° 38' W
Fort Bragg, NC	From 35° 08' N 79° 05' W to 35° 10' N 79° 01' W
Vandenberg, CA	Transportable terminals within 25 km radius of 34° 44' N 120° 35' W
Bolling AFB, DC	Transportable Terminals within 25 km radius of 38° 50' N 77° 01' W

US287-The band 14-14.5 GHz is also allocated to the non-government land mobile-satellite service (earth-to-space) on a secondary basis.

862-In making assignments to stations of other services to which the band 14.47 - 14.5 GHz is allocated, administrations are urged to take all practicable steps to protect spectral line observations of 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 and Article 36).

TABLE 86

FREQUENCY ASSIGNMENTS BY GOVERNMENT AGENCY AND
NON-GOVERNMENT SERVICE AND STATION CLASS
FOR THE 14.4 - 14.5 GHz BAND

AGENCY	STATION CLASS			
	FX	XT	TCTD	
AIR FORCE	4	3		7
ARMY	5	4		9
DOE	2			2
FAA	1			1
JUSTICE	1			1
NAVY	1			1
NASA	1			1
NG/CS			1	1
TOTAL	15	7	1	23

FX - Fixed Station
XT - Experimental Station
CS - Domestic Fixed-Satellite Service
TCTD - Space telecommand earth station in the Fixed-Satellite Service

A growth trend over the past 5 years in this band has been nonexistent. The band has varied no more than two or three assignments over this period averaging 23 assignments as seen in Figure 71. However, assignments in the lower adjacent band must be considered since there are systems which require bandwidths (≈500 MHz) that extend into this frequency range (operate from 14.0-14.5 GHz).

The frequency assignment distribution is shown in Figure 72. As can be seen, there is room for growth in the band.

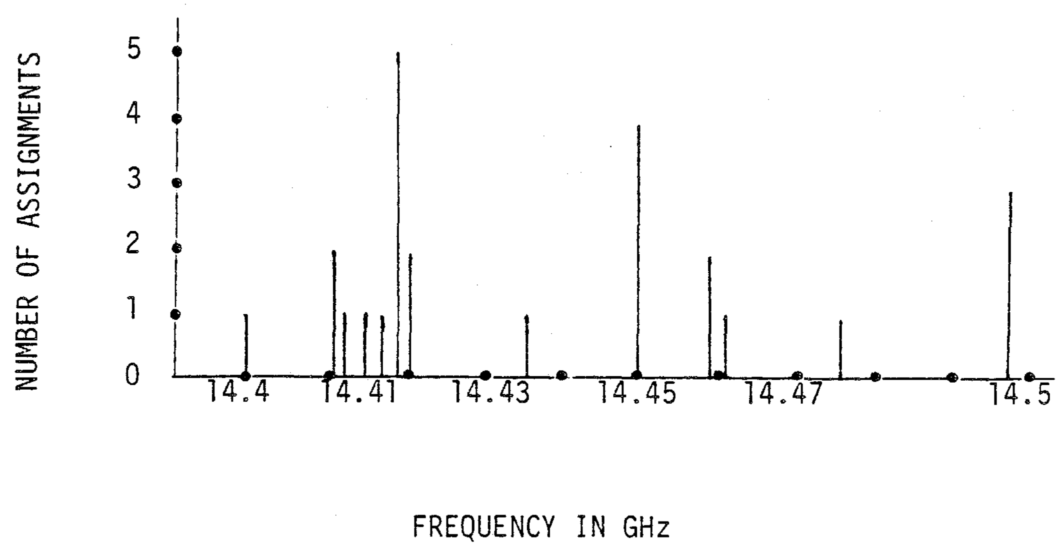


Figure 72. Frequency Assignment Distribution for the 14.4-14.5 GHz Band

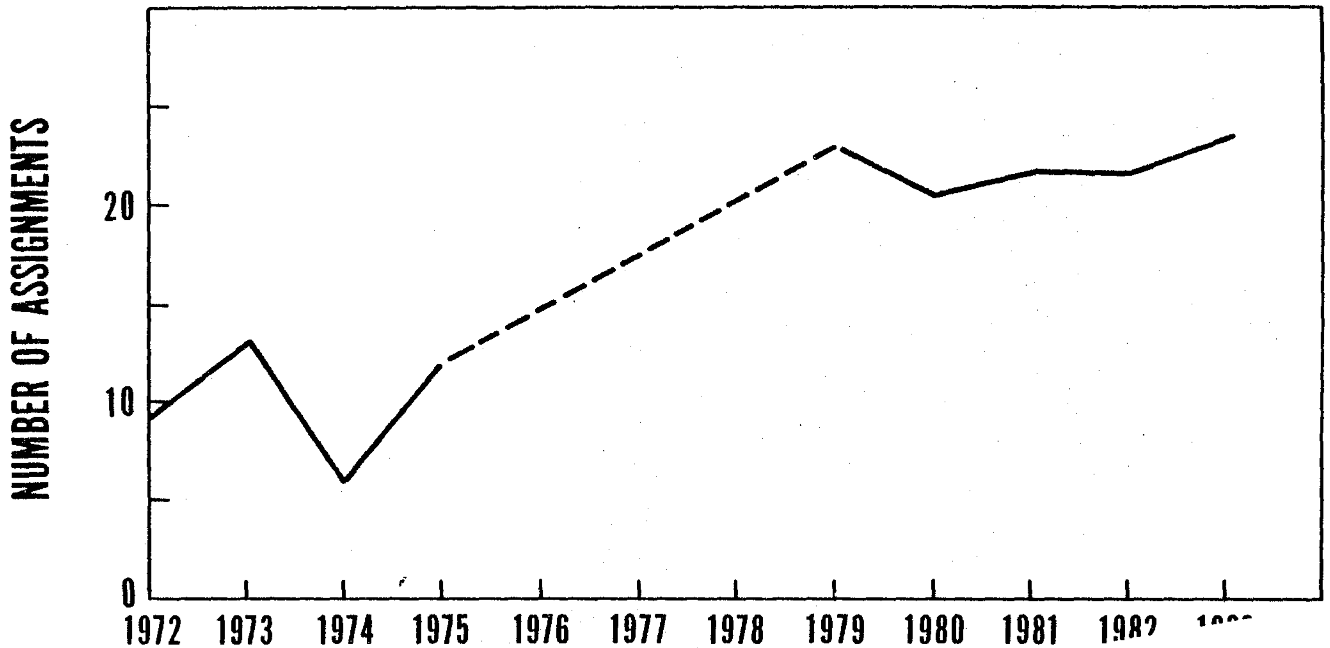


Figure 71. Growth Trend for the 14.4-14.5 GHz Band for January 1972 to January 1983.

Figure 73 shows the geographic distribution of assignments. There are only 11 states with assignments and only California and Arizona have more than one site with assignments. The Systems Review File shows 11 active systems in the process of review that have the capability of operation in this band. The systems, sponsoring agency, stage of review, and security classification are shown in Table 87. Three systems that are classified are not shown.

MAJOR SYSTEMS

Most of the Government systems in the band are used for short-haul transmission of wide-band, high-resolution, video signals; high capacity voice channels; wide-band radar video remoting; or digital data. The most used equipment in the 14.5-15.35 GHz band is the TCM-608B. Table 88 gives the basic characteristics of this system.

The TCM-608B is used by the various Government agencies for radar remote microwave links, television microwave links, data links, and communication links. Another system used in the band is the Collins MW 908. This system was designed for short-haul transmission of wide-band, high-resolution video signals. However, it can be, and is, used for data transmission and multi-channel message signals in the 14.5-15.35 GHz band. Table 89 gives some basic system characteristics of the MW 908.

The major non-Government (NG) user of this band is the Satellite Business Systems Company with 104 listed systems that can tune into this band. There is only one NG system assignment from 14.4-14.5 GHz. The others are listed as band assignments from 14.0-14.5 GHz.

The systems mentioned are typical Government systems operating in the band. There are some threat simulators used by all of the military services for EW and ECM training. There is a modified version of the AN/GRC-173 used by the Army for testing of digital data links. The AN/GRC-173 is a mobile microwave wide-band communications and high speed data link and can also be used for color video links. The IMC-1415 is another widely used microwave link for the data and video transmissions in the band.

The use of the band by the private sector is mainly by Satellite Business Systems (SBS). Table 90 shows the basic information on this system. As given in this table the satellite receivers have 10 transponders each with a 43 MHz bandwidth per transponder. There is actually a 49 MHz channel spacing so that each receiver needs 490 MHz of band, thus the needed operation range from 14.0-14.5 GHz. The 104 earth stations have communication uplinks to the SBS satellites in the 14.0-14.5 GHz band. The SBS earth stations are at present the fastest growth use in the 14.4-14.5 GHz band.

TABLE 87

SYSTEMS IN THE SYSTEMS REVIEW FILE

FOR THE 14.4-14.5 GHz BAND

	AGENCY SPONSORING	STAGE OF REVIEW*
AN/GRC - 144(V)4	AR	4
TCM 604 and 608	AF	4
LANDSAT-D	NASA	3
IMC-15AM Microwave System	AR	4
TAWDS-Data Link 2	AF	2
Digital Microwave Radio	AR	1
AN/UPQ-3(B)	AF	3
Space Transportation System	NASA	4

*Stage of Review

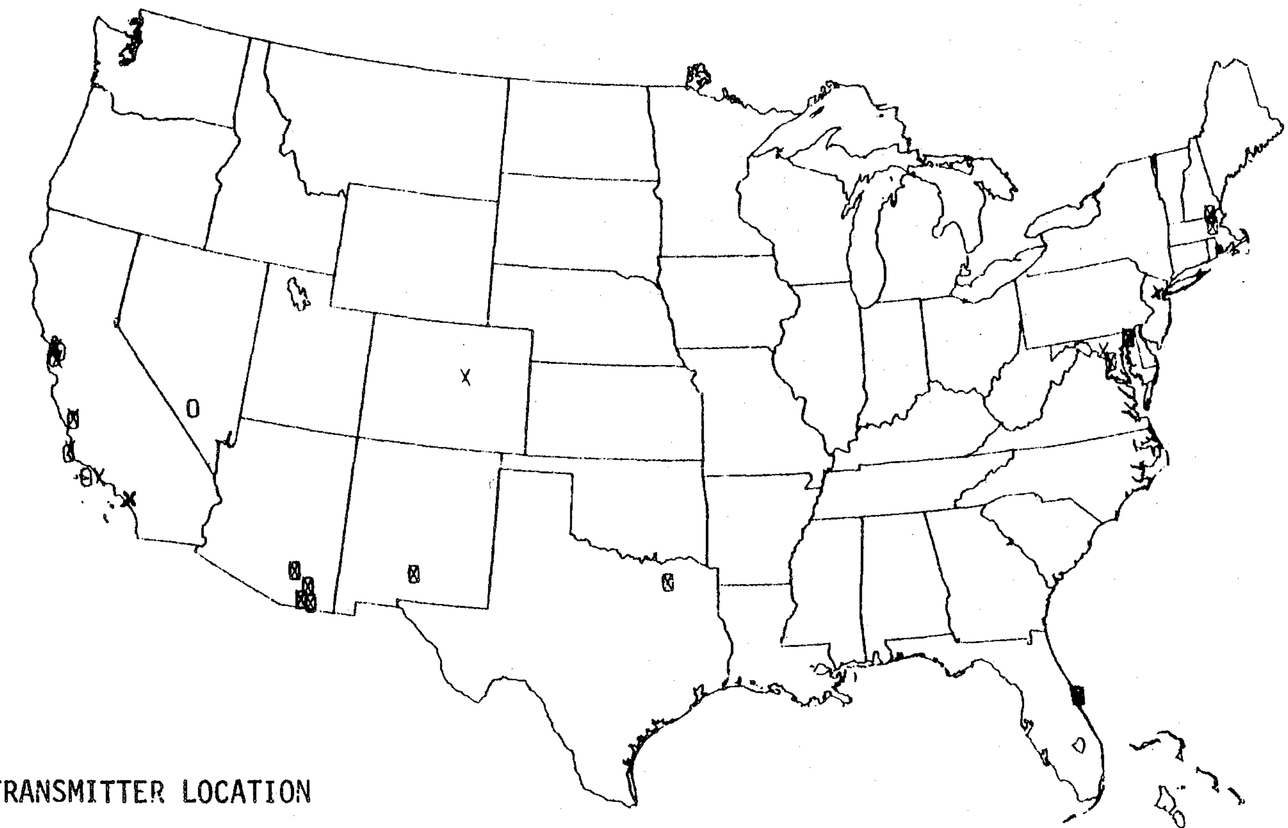
0 - State of review was not indicated

1 - Stage 1, conceptual

2 - Stage 2, experimental

3 - Stage 3, developmental

4 - Stage 4, operational



X - TRANSMITTER LOCATION
O - RECEIVER LOCATION

Figure 7[illegible]. Geographic Distribution of Assignments in the 14.4-14.5 GHz Band.

TABLE 88

SYSTEM CHARACTERISTICS TCM-608B

FREQUENCY RANGE	14.4-15.35 GHz
CAPACITY	Up to 1800 FDM voice channels, color video with up to 2.048 Mb/s digital subcarrier, up to 35 Mb/s digital data or wide-band radar
MODULATION	FM
TRANSMITTER POWER	.15 watt (higher output power available with optional power amplifiers)
FREQUENCY STABILITY	0.005% (crystal synthesizer) 0.003% to 0.001% (digital synthesizer)
RECEIVER	
NOISE FIGURE	12.0 dB
IF FREQUENCY	70 MHz
IF BANDWIDTH	30 MHz (5 to 40 MHz optional)
THRESHOLD	-78 dBm (30 MHz bandwidth)
RF INPUT LEVEL	-20 dBm maximum -30 dBm typical
TELEVISION SIGNAL-TO-NOISE (@ -30 dBm)	67 dB (weighted per CCIR)

TABLE 89

SYSTEM CHARACTERISTICS OF THE MW908D

FREQUENCY RANGE	14.4-15.25 GHz
CAPACITY (VIDEO)	One wide-band high-resolution video or one NTSC color TV signal plus up to 4 program channels
MODULATION	FM
TRANSMITTER POWER	1.5 watts
FREQUENCY STABILITY	.005%
	40,000 F9
RECEIVER NOISE FIGURE	12.0 dB
IF FREQUENCY	70 MHz
IF BANDWIDTH	40 MHz
TELEVISION SIGNAL-TO-NOISE (P-P/RMS) (-35 dB Rec CXR LEVEL)	70 dB weighted per CCIR

TABLE 90

BASIC DATA ON SATELLITE BUSINESS SYSTEMS SATELLITE OPERATIONS

SYSTEM DESCRIPTION

-- Ownership-	Satellite Business Systems, a partnership of IBM, Aetna Life, and Comsat General Corp.
-- ITU Service-	Fixed Satellite.
-- Services Provided-	Domestic Digital Data Service, Television
-- Date of First Operation-	1981.
-- Number of Satellites-	3 in orbit, 3 more planned.
-- Coverage Area-	CONUS.
-- Note-	Satellites contracted to Hughes Aircraft Co.

SPACECRAFT LAUNCH AND ORBIT DATA

-- Spacecraft Designation-	SBS.					
-- Orbit Type -	Geostationary.					
-- Spacecraft No-	1	2	3	4	5	6
-- Longitude-	100 W	97 W	94 W	89 W	124 W	Spare
-- Launch Date-	Nov 80	Sept 81	Nov 82	Jul 84 Planned	1986 ------	
-- Design Life, yrs-	7					

SPACECRAFT COMMUNICATIONS SUBSYSTEM DATA

Coverage	CONUS (weighted)
-- EIRP, dBW-	40.0 to 43.7
-- G/T, dB/K-	+2 to -2
Saturation Flux Density, dBW/sq.m-	-82 for G/T= -2*
-- Number of Transponders-	10
-- Transponder B.W., MHz-	43 (49 MHz channel spacing)
-- Frequency Band,	
Receive, GHz-	14.000-14.500
Transmit, GHz-	11.700-12.200
-- Transponder Output Amp-	20-W TWTA's (10 active & 6 standby)
-- Polarization-	Dual Linear
-- Number of Antenna Beams-	1 transmit and 1 receive

EARTH STATION DATA

-- Station Designation-	Manned	Remote 1	Remote 2
-- Frequency Band, GHz-	12/14	12/14	12/14
-- Antenna Diameter, m-	10	5	7
-- Antenna Gain,			
Transmit, dBi		55.3	58.2
Receive, dBi-	--	53.8	56.7
-- Maximum Transmitter Power, dBW-	--	27.0	27.0
-- EIRP, dBW-	--	79.8	82.7
-- G/T, dB/K-	36.6	30.4	33.3
Modulation Type	35-55 Mb/s QPSK	35-55 Mb/s QPSK	35-55 Mb/s QPSK
-- Transponder Access-	TDMA	TDMA	TDMA

*Ground commandable 6 dB gain adjustment.

CONCLUSIONS AND RECOMMENDATIONS

The 14.4-14.5 GHz band has growth potential. Even though the use of satellite systems is growing nationally, significant changes in the number of assignments in this band has yet to occur.

However, this tends to be misleading since there are 112 satellite communication related systems that require 500 MHz of bandwidth listed in the lower adjacent band. These systems use the spectrum from 14.0 to 14.5 GHz. These assignments show about a 10% growth per year over the past 3 years.

Since this is primarily a non-Government band, expansion of allocations in the band is mainly under FCC jurisdiction.

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APPENDIX A

NTIA Response to FCC Docket 82-334.

The United States Department of Commerce hereby submits the following comments on the Notice of Proposed Rule Making (NPRM) released January 23, 1983, in the above captioned matter. These comments have been coordinated through the Interdepartment Radio Advisory Committee (IRAC) and therefore represent the federal agencies' collective assessment of the rule changes proposed for the following frequency bands:

i) 1990.-2110. MHz
ii) 6.525-7.125 GHz
iii) 12.7-13.25 GHz
iv) 17.7-19.7 GHz
v) 31.0-31.2 GHz

We support the Commission's effort in attempting to achieve more efficient spectrum use by the non-Government radio services; and we believe that the approach proposed in the NPRM is consistent with our objectives for managing the Government radio services. However, we cannot determine the impact that the specific rule changes contained in the NPRM would have on existing or proposed Government radio services because i) we find no provisions in the proposed rules for coordinating future non-Government radio services with the existing and planned Government operations in the 1990.-2110. MHz and 12.75-13.25 GHz bands that are critical elements of the United States Space Program; ii) we find certain discrepancies in the minimum path length calculations presented in the NPRM; iii) we find certain ambiguities in the proposed technical standards regarding transmitter powers and channelization authorized in the 18.6-18.8 GHz band reserved for passive satellite sensor operations 4/ ; iv) we find no provisions in the NPRM for coordinating those Government and non-Government radio services that will share the 12.75-13.25 GHz, 18.6-18.8 GHz and 31.-31.2 GHz bands under the allocations proposed in FCC General Docket

4/ Final Acts, WARC 1979, Geneva.

80-739 5/ ; and v) we find no provisions in the proposed coordination procedures for avoiding conflicts between future non-Government radio services and those existing and planned Government operations on military test ranges that are essential elements of our nation's defense and emergency preparedness activities.

Although our analysis of the NPRM indicates that areas of potential conflict between Government and non-Government radio services exist in the bands addressed, our analysis also indicates that these conflicts can be reduced, or avoided, i) by establishing a coordinating mechanism for improving the exchange of planning information between Government and non-Government planners; ii) by revising certain FCC and IRAC procedures to include coordination between Government and non-Government radio service operations; and iii) by continuing to review the technical and economic compatibility of those radio services that may be authorized use of the same spectrum.

We believe that the coordination between Government and non-Government users of the spectrum which has in the past been accomplished through the Federal Communication Commission's participation in the Frequency Assignment Subcommittee (FAS) of the IRAC, has been effective. Therefore, we propose that the existing FAS procedures 6/ , be used in coordinating those Government and non-Government radio services that may in the future be sharing the 12.75-13.25 GHz, 18.6-18.8 GHz 31 -31.2 GHz bands 7/ .

Government radio services operating or scheduled to operate in the remaining bands addressed by the NPRM are likely to cause conflicts with only those future non-Government radio services operating in the vicinity of space ground stations and military test ranges. Therefore, we propose that procedures be adopted by both the FAS and the FCC to assure coordination between license applicants and appropriate Government personnel whenever possible to avoid conflict between Government and non-Government radio service operations.

5/ Notice of Proposed Rule Making in FCC General Docket 80-739 released December 30, 1982, Implementation of the Final Acts of the World Administrative Radio Conference, Geneva, 1979. (WARC-79 Implementation).

6/ NTIA Manual, Chapter 10, see footnote 3/.

7/ WARC-79 Implementation, see footnote 5.

The discussion below identifies those essential Government uses of the spectrum which need to be considered by the Commission before the rules proposed in the NPRM are implemented. The discussion below also identifies the geographic areas where coordination of Government and non-Government uses of the spectrum is proposed to achieve the objective of improving the efficient use of the spectrum.

GOVERNMENT RADIO SERVICE OPERATIONS

United States Space Program (1990-2110 MHz, 12.75-13.25 GHz, 18.6-18.8 GHz, 17.7-20.2 GHz Bands).

Radio communications operations that support essential elements of our nation's space program can be partitioned into two types of operations: i) mission operations and ii) communications network operations. Both types of operations include the transmission of valuable scientific data and the monitoring of vital life support systems; however, these two types of operations differ in their requirement for access to the spectrum. Mission operations are defined as those activities that are unique to a given space mission, such as a shuttle mission, earth exploration mission, and space telescope mission. A list of major missions tentatively planned by the National Aeronautics and Space Administration (NASA) is presented in Appendix C; mission operations are by their very nature limited to a defined duration (lifetime of spacecraft) and therefore some flexibility may exist in coordinating these types of activities with non-Government radio service users. Communications network operations on the other hand are defined as those activities that are common to multiple space missions, such as the Tracking and Data Relay Satellite System (TDRSS) communications activities; these operations serve as the "fabric" that integrates many disparate elements of the United State's role in the global space program. Communications network operations therefore are subject to extensive international agreements that severely constrain the Government's flexibility in attempting to coordinate these operations with future non-Government radio services. Geographic locations of ground stations included in NASA's current worldwide communications network are presented in Appendix A.

Radio communications operations using the TDRSS facilities will be performed in the band 2025-2120 MHz. These facilities will consist of three synchronous relay satellites and an earth station at White Sands, New Mexico. The TDRSS will be capable of simultaneously relaying data between the White Sands ground terminal and up to 25 individual spacecraft. Spacecraft from both the United States and foreign space programs will be supported through the TDRSS facilities. From our analysis of the proposed technical standards defined in the NPRM, we understand that there will be no change in the characteristics of the non-Government transmitters currently authorized in the 1990-2110 MHz band. Our review of future potential users of this band indicate, however, that the introduction of either wideband services, long haul multihop services or multipoint distribution services could seriously impact future space communications network operations in this band. We therefore propose that all relevant service rule changes which would result in introducing the above defined services into this band be coordinated through the IRAC to avoid potential conflicts.

International Fixed-Satellite Service, under the Commission's proposed rules 5/ , is allocated spectrum in the 12.75-13.25 GHz band for the Earth-to-space direction. The Department of Communications in Canada and NASA have proposed to use the 13.20-13.25 GHz segment of this band for the feeder link in a planned mobile satellite experiment. This choice was made only after exhaustive search to satisfy the feeder link requirements 10/ . The decision to pursue this band for a non-Government frequency allocation will be debated in the forthcoming Notice of Inquiry on Mobile Satellite Systems. Therefore, the Commission should be aware of the potential for satellite feeder link operations in the 12.75-13.25 GHz band when considering the impact of additional terrestrial systems.

Procedures need to be established, we believe, for coordinating future non-Government radio service license applications with those Government radio service operations that support essential elements of the United States Space Program. We also believe that to assure expeditious coordination of each license application the Commission's rules should contain the following coordination requirements: i) when frequencies in shared bands are requested by a license applicant, then coordination is to be accomplished using existing IRAC/FAS procedures 3/ ; and ii) when other frequency bands addressed in the NPRM are requested by a license applicant for use in the vicinity of space communications ground stations, as listed in Appendix A for the U.S. Possessions and Territories, the coordination is to be accomplished directly between the license applicant and the Frequency Manager at NASA Headquarters, Washington, D.C.

10/ "An Evaluation of Candiate Feeder Link Frequency Bands for M-SAT" Prepared by ORI, Inc., under Contract NAS3-22885 October 1982.

SUMMARY

In summary we propose that the Commission consider the actions below:

i) Revise the proposed coordination procedures in Part 200.2 to assure that future license applications will be coordinated with Government radio service operations in the following manner--

1) License applications for radio services to operate in the shared 18.6-18.8 and 31-31.2 GHz bands will be coordinated through existing FCC/IRAC procedures.

2) License applications for radio services to operate in the 1990-2110 MHz band in the vicinity of the National Aeronautics and Space Administration's (NASA) ground stations, for the United States territories and possessions, listed in Appendix A will be directly coordinated with the Frequency Manager at NASA Headquarters, Washington, D.C.

3) License applications for radio services to operate in the vicinity of the military test ranges listed in Appendix B will be directly coordinated with the respective Government Area Frequency Coordinators.

ii) Adopt rules for the bands addressed that are consistent with the rules proposed in the Notice of Proposed Rule Making released December 30, 1982, in General Docket 80-739 and will reflect the following:

1) The frequency bands 18.6-18.8 GHz and 31.-31.2 GHz will be shared by both Government and non-Government radio services.

2) The frequency band 18.6-18.8 GHz is allocated for passive satellite sensor operations.

3) In the frequency 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 (U.S. footnote 254).

4) The frequency band 12.75-13.25 GHz, in addition to being allocated for FIXED and MOBILE radio services, is also allocated for space research reception at Goldstone, California (U.S. footnote 251) and international fixed satellite service (NG footnote 104).

iii) Issue a revised set of technical standards that reflects the transmitter powers, path lengths, and channelization intended to be included in the proposed rules.

Appendix

NASA Earth Stations

U.S. Territories	non U.S. Territories
Goldstone, Ca.	Orroral Valley, Australia
Greenbelt, Md.	Madrid, Spain
Merrit Island, Fla.	Bermuda Is.
Fairbanks, Alaska*	Santiago, Chile*
Guam, Mariana Islands*	Ascension Is.*
Kauai, Hawaii*	Dakar, Sennegal*
White Sands, N.M.	
Edwards, A.F.B.*	

*Ground stations to remain operational at least until 1985 when TDRS is tentatively planned to replace certain operations of the ground network.

Appendix

Military Test Ranges

Activity	Geographical Area of Cognizance	Service Responsibility
Continental Operations Range Nellis AFB, Nevada	Entire State of Nevada plus Utah west of 111° W and Idaho south of 44° N.	Air Force
Air Force Eastern Test Range, Patrick AFB, Florida	Area bound by 22° N, 31° 30' N, 77° W, and 83° W.	Air Force
Armament Development and Test Center, Eglin AFB, Florida	Area bounded by 27° N, 33° 31' N, 83° W, and 90° W.	Air Force
Pacific Missile Test Center, Pt. Mugu, California	Area enclosed within a 200-mile radius of the Headquarters Building, PMR, and the area of California that lies South of 27° 31' N.	Navy
Army Electronic Proving Ground, Ft. Huachuca, Arizona	Entire State of Arizona	Army
Military Ranges within State of Hawaii	Area enclosed by 200 mile radius of Honolulu, Hawaii	CINCPAC
Atlantic Fleet Weapons Training Facility, Roosevelt (AFWTF)P.R.	Area within 200 nautical miles of Headquarters Building ATWTF	Navy

Activity	Geographical Area of Cognizance	Service Responsibility
White Sands Missile Range, Las Cruces, New Mexico	Entire State of New Mexico and other U.S. territory enclosed within a 150-mile radius of the Headquarters Building, WSMR, plus the area of the States of Utah and Colorado that lies south of 41° N and between 108° and 111° W.	Army

APPENDIX B

EXISTING STUDIES ON SHARING BETWEEN BROADCASTING SATELLITE SERVICE (BSS) AND FIXED SERVICE (FS)

Some studies already exist on the sharing problems between the BSS and the FS in the 12 GHz band (CCIR, 1978 a,b,c; Comsat, 1978; SBS, 1978; Western Union, 1978; Lee et al., 1979). This appendix presents summaries of those studies with some comments whenever deemed appropriate.

CCIR SPM REPORT (CCIR, 1978a)

This report states that "interference caused by broadcasting satellites to typical terrestrial systems sharing the same frequencies and locations is generally acceptable provided that the elevation angles to the satellite from these locations are not too small." Regarding the interference of the other direction, this report states that "co-channel interference caused by transmitting stations of the terrestrial Fixed Service to broadcasting-satellite receiving stations is generally a very serious problem." These statements seem to be in general agreement with the results of other studies.

This report summarizes two input documents (CCIR, 1978 b,c) regarding this subject. The report states that "the geographical separation required is largest for high-capacity digital radio-relay systems, and smallest for certain short-haul radio-relay systems whose transmission parameters are carefully constrained and whose frequency plans are carefully aligned with those of the interfering system(s) in the Broadcasting-Satellite Service." Since the two input documents will be discussed in more detail, comments on this statement are not given here.

CCIR SPM Document by Canada (CCIR, 1978b)

This document studies the sharing problem between the BSS and an FS system now envisioned in Canada. The FS system is premised on the use of the combined 11 and 13 GHz band (10.7-11.7 GHz and 12.2-13.25 GHz) to form a long-haul high-capacity digital trunking system. The nominal value of the transmitter power is 6 dBW, and its maximum value is 13 dBW. The antenna diameter is 2 m. The nominal hop length is 8 km. The RF (radio frequency) bandwidth is 240 MHz. The RF spectral power is assumed to be uniformly distributed over the total RF bandwidth and, therefore, the transmitter power is equal to -7.8 dBW (nominal) and -0.8 dBW (maximum) per 20 MHz of bandwidth.

Concerning the interference from the BSS to the FS, this document derives the condition for necessary discrimination by the BSS transmitting antenna and the FS receiving antenna. It concludes that the pointing constraints of the FS antenna to avoid the azimuths of specific BSS transmitters in the geosynchronous orbit will be minimal. This conclusion seems to be consistent with those of other studies.

Concerning the interference from the FS to the BSS, this document calculates the minimum separation distance required between an FS station (transmitter) and a BSS Earth station (receiver) which is referred to as the coordination distance. The calculated result indicates that separation distances required to meet the co-channel interference protection allowance for the BSS of individual reception will range from a minimum of 100 km up to approximately 300 km. Based on these relatively large coordination distances coupled with unpredictability of all possible locations of BSS receivers within a given service area, the report concludes that sharing between these two services would only be feasible on a geographical basis, i.e., the two services cannot use the same frequency in the same geographical area.

The analysis presented in this document seems to be well-founded insofar as the calculation of the coordination distance in the direction of the FS transmitting antenna main beam is concerned. Since the FS system is a long-haul relay system, however, the coordination distance in the direction normal (perpendicular) to the main-beam direction is also very important to determining the size of the interference area. Although the coordination distance in the normal direction can be read from the figures given in the document, explicit discussions of this subject are not presented in the document.

The document concludes that sharing between the BSS and the FS will only be feasible on a geographical basis. This conclusion may imply that, where the FS system is constructed, the BSS reception must be given up. This is, however, not necessarily the case. Since the total band considered for the FS system is 2000 MHz and the bandwidth of each FS signal is 240 MHz, there are eight frequencies to be assigned to the FS system. If one frequency out of eight can be spared in a geographical area, the BSS can be accommodated in that area. Discussions of this subject are also not included in the document.

CCIR SPM Document by France (CCIR, 1978c)

This document studies the sharing problem between the BSS and the FS system used in France in the band 11.7-12.5 GHz. This FS system operates on one hop or on a small number of hops (not more than five hops) for the transmission of national television programs. The nominal value of the FS transmitter EIRP (equivalent isotropically radiated power) is 1.5 dBW, and its maximum value is 7.5 dBW. The antenna diameter is 1.5 m. The length of a hop is 15 to 20 km.

Concerning the interference caused by the BSS transmitter to the FS radio relay system receiver, the document shows calculated values of the signal-to-interference ratio for the minimum power flux density and for the nominal power flux density of the FS signal. The calculated values range between 33 dB and 46 dB. The document concludes that this interference is negligible in all channels other than that of the satellite itself. This conclusion seems to be consistent with those of other studies.

Concerning the interference caused by the FS system transmitter to the BSS receiver, the document shows the calculated areas of interference caused to a BSS receiver by an FS transmitter operating in the same channel and in the adjacent channel. The size of the area in the direction of the FS transmitting antenna main beam ranges from about 10 km in the case of adjacent-channel interference and a maximum EIRP of 7.5 dBW. The document concludes that sharing between the BSS and the FS is possible subject to certain constraints.

The document assumes an antenna envelope sidelobe pattern that continues to decrease until the off-axis angel reaches 180°. The antenna envelope sidelobe pattern, however, ususally does not decrease beyond a certain value called the residual response. In many cases, the residual response is assumed to be 0 dBi (ITU, 1977). The areas of interference shown in the document must be modified by taking into account the residual response. This revision will increase the area in the direction of distant angles.

The document gives no reasoning that leads from the calculated size of the area on interference to the possibility of sharing. The calculated area of interference is not necessarily small, particularly in case of cochannel interference, yet the document concludes that sharing is possible. The document lacks the discussion as to how dense (or sparse) the planned FS system is, whether the same channel, an adjacent channel, or a further distant channel is planned for the FS system, etc.

The Comsat Study (Comsat, 1978)

In Para. 49 of its comments on the Eighth Notice of Inquiry, FCC Docket No. 20271, Comsat states that "The BSS would, in general, use only a small part of the band in any one service area, ... In the 1977 Geneva Plan for Region 1, for example, only 12.5% of the band (5 channels out of 40) was assigned to any particular service area. Even allowing for spillover from adjacent service area, terrestrial service could use most of any band it shared with the BSS." These statements are in good agreement with those by SBS (1978) to be discussed later.

These statements, however, overlook two factors. First, since the BSS band is 500 MHz (instead of 800 MHz) in Region 2, only 24 (instead of 40) BSS channels are available in Region 2 if the 1977 WARC-BS plan for Regions 1 and 3 (ITU, 1977) is followed. Second, BSS channels adjacent to a channel which is actually assigned to the BSS cannot be used by the FS systems and, therefore, adjacent channels on both sides must also be included in the BSS channel occupancy. If five BSS channels are assigned to a BSS service area, we must consider that about 10 to 15 channels are occupied by the BSS and that only about one-half of the 500-MHz band can be utilized by the FS at best.

The SBS Analysis (SBS, 1978)

SBS (Satellite Business Systems) analyzed the sharing problem between the BSS and the FS systems currently used in the United States in the band 12.2-12.7 GHz. The conclusions of the analysis are reproduced as follows:

> 55. If a BSS system were based on community reception, then the FS could utilize the full 500 MHz band virtually across the country, subject only to standard coordination of earth station location. In this case there would be little or no restriction on the operation and growth of either BSS of FS systems.
>
> 56. Only if BSS systems were based on a direct-to-home configuration would any sharing complications arise, and even in this case, if the Region Master Plan (1977 WARC) formula were used, the FS could utilize nearly 7/8 of the bandwidth in any service area. That formula is based on a multi-beam configuration designed to increase significantly the total number of channels available through frequency reuse, a goal apparently shared by United States BSS planners.

57. An analysis undertaken by SBS, summarized below in the Attachment, indicates that in the United States, BSS community reception systems and FS systems could readily share a 500 MHz band through the end of this century, including foreseeable growth of each service. If a domestic direct-to-home BSS system were established, a sharing plan based on a multi-beam formula comparable to the Region 1 Master Plan would impose no restrictions on the number of present FS systems in the United States. Furthermore, even anticipating a 10% compound annual growth rate for the FS, only the Los Angeles metropolitan area would appear to fall outside such a plan by the year 2000.

58. Even assuming a worst case situation, namely one in which a BSS direct-to-home system were limited to four beams (time zone division) for the United States, our studies indicate that the BSS and the FS could reasonably share the 12.2-12.7 GHz band. In brief, even in this situation, present FS links need not utilize more than 250 MHz except in two, or possible three, major metropolitan areas. Even projecting an annual compound growth rate of 10%, the number of restricted metropolitan areas would appear to be between three and six by the year 2000 (see Attachment).

* * * * * * * *

61. Given that the delivery of BSS video services in congested metropolitan areas would be better served by community rather than direct-to-home antennas, the entire 500 MHz band as presently allocated for terrestrial services could be retained in those areas. Our studies indicate that the less interference-sensitive community reception service could be provided anywhere in the United States. In crowded metropolitan areas, the only restriction imposed would be on the precise location of the BSS community receiver. For example, even in the most congested area, namely the Los Angeles basin, BSS community receivers could be located in approximately 90% of the metropolitan area without harmful interference from existing terrestrial sites.

The SBS analysis concludes that, if the BSS system were based on community reception, then the FS could utilize the full 500 MHz band, subject only to standard coordination on earth station locations. This conclusion, however, is given without any indication of the required minimum separation distance between an FS transmitting antenna and a BSS receiving antenna. Use of a larger antenna in community reception than in individual reception can reduce the required distance, but not drastically. Also, since a BSS receiving station is not to be licensed, standard coordination procedure of earth station locations is not applicable to a BSS receiving station even if the station is intended for community reception.

The analysis assumes that, if the 1977 WARC-BS formula for Region 1 (ITU, 1977) were used, the BSS would utilize only one-eighth of the band and the FS could utilize nearly seven-eights of the band in any service area. The fraction one-eighth assumed for the BSS seems to be based on the observation that only five channels at most out of 40 are assigned to any service area (Comsat, 1978). As discussed earlier, however, we must consider that, if five BSS channels are assigned to a BSS service area, about 10 to 15 channels are occupied by the BSS and that at best only about one-half of the 500 MHz band can be utilized by the FS.

In its appendix, the analysis considers the following four cases:

(1) BSS uses community reception - Region 1 type plan;

(2) BSS uses community reception - FS uses entire 12.2-12.7 GHz band;

(3) BSS uses direct-to-home reception - Region 1 type plan; and

(4) BSS uses direct-to-home reception - limited frequency reuse.

The analysis assumes that the FS uses seven-eighths of the band 12.2-12.7 GHz in Cases (1) and (3), the entire band in Case (2), and one-half of the band in Case (4). Based on the above observations, we consider that only the result for Case (4) is useful.

The result of the SBS study for Case (4) is summarized in Para. 14 of the appendix. It reads:

> 14. The results of our studies indicate that, as the band restriction imposed on the FS is increased from one-eighth to one-half of the allocated band, the first area in the United States that would be seriously constrained is in the Los Angeles basin. Assuming a 10% compound annual growth rate to the year 2000, several additional major metropolitan areas might be constrained, including New York and Boston. According to the current FS data base, Cleveland is the next most congested area following Los Angeles, Boston and New York. The frequency assignment program was run for the Cleveland area assuming a 10% annual compound growth rate to the year 2000.

This result is reflected in Para. 58 of the text quoted above. Although this case is treated as a worst case in the SBS analysis, it must be considered to be a typical case in the United States because of the above reasons.

The Western Union Study (Western Union, 1978)

In Para. 13 of its comments on the Eighth Notice of Inquiry, FCC Docket No. 20271, Western Union summarizes the results of its study as follows: Sharing of the 12.2-12.75 GHz band by the BSS with terrestrial services is feasible, but not on a co-frequency basis. (Papers presented to various CCIR study groups and service working groups have demonstrated this.) However, since the BSS will not use the full band in all areas in any case, a frequency division arrangement alternating by time zones across the country (or region) would be a viable alternative. We have investigated the present usage of this band by terrestrial services in the United States, and have found that only small areas on the east and west coasts (essentially the New York and Los Angeles metropolitan areas) show significantly heavy usage, with lesser concentrations in the Chicago, Cleveland and Dallas areas. Since these heavily populated areas are and will continue to be well served by land-based broadcast transmitters, there appears to be no conflict with a sharing arrangement with the BSS countrywide. The areas likely to require BSS service reception (the more lightly populated areas) will experience minimal interference from terrestrial transmitters.

No quantitative discussions are presented in the comments.

The EDUTEL Report (Lee et al., 1979)

Pointing out that sharing between BSS and FS is limited by the interference from FS transmitter into BSS receiver, the report discusses nine different sharing techniques that would reduce the interference. It calculates improvements in discriminating the interfering FS signal at the BSS receiver. The nine techniques discussed in the report are labelled Schemes A to I. They are:

- A: Frequency interleaving;
- B: Split bands and time zone advantage;
- C: Power control for terrestrial systems;
- D: Increasing terrestrial transmitter antenna size;
- E: Avoiding the terrestrial main beam;
- F: Larger azimuthal offset angle;
- G: Higher elevation angle;
- H: Terrain protection;
- I: Increasing the broadcasting receiver antenna size.

The report classified Schemes A and B as techniques imposing restrictions on both BSS and FS; Schemes C and D, on FS only; and all the remaining schemes, on BSS only. The report summarizes the results of the study as follows:

> Some techniques are more attractive, significant improvement can be bought at reasonable prices (like Schemes B, C, E, and H) and some are relatively less attractive (like Schemes A, D, F, G, and I).

After presenting some examples of combined use of the nine techniques, the report concludes as follows:

> Nine different sharing techniques, called Schemes A through I, are proposed, and their improvements and prices are investigated. Examples indicate that sharing will be possible and even become easy if appropriate combinations of sharing techniques are chosen although tradeoffs must be made by broadcasting or terrestrial services or both. This provides a guideline for the consideration of allocation of broadcasting service to this band.

The report lists Scheme B (split band) as one of more attractive techniques. However, it does not discuss the number of BSS channels and the number of FS systems to be accommodated in a particular geographical area.

The report considers only one FS transmitter at a time. In the United States, however, there are a number of FS systems in this band concentrated in or around a large city. Although the report discusses Scheme E (avoiding the terrestrial main beam) as one of the more attractive techniques, it does not treat these FS systems collectively in its discussion.

The report lists Scheme H (terrain protection) also as one of the more attractive techniques. However, it does not give any figure about the extra costs of achieving terrain protection.

B.1. References

CCIR (International Radio Consultative Committee) (1978a), Technical bases for the World Administrative Radio Conference 1979, SPM (Special Preparatory Meeting) of the CCIR, Geneva, Switzerland.

CCIR (1978b), Frequency sharing between the Broadcasting-Satellite Service and digital fixed services, CCIR SPM Doc. P/146 (a contribution from Canada).

CCIR (1978c), Sharing between the Broadcasting-Satellite Service and the Fixed Service in the band 11.7-12.5 GHz in the case of television transmission, CCIR SPM Doc. P/271 (a contribution from France).

Comsat (Communications Satellite Corporation) (1978), Comments on the Eighth Notice of Inquiry, FCC Docket No. 20271, July 17, 1978.

ITU (International Telecommunication Union) (1977), Final Acts of the World Administrative Radio Conference for the Planning of the Broadcasting-Satellite Service in Frequency Bands 11.7-12.2 GHz (in Regions 2 and 3) and 11.7-12.5 GHz (in Region 1), ITU, Geneva, Switzerland.

Lee, Lin-shan, S. P. Russell, and J. M. Janky (1979), Impact of various sharing strategies in the 12.2-12.7 GHz band for broadcasting and terrestrial services, EDUTEL Communications and Development, Inc., Palo Alto, CA 94304.

SBS (Satellite Business Systems) (1978), Comments on the Eighth Notice of Inquiry, FCC Docket No. 20271, July 14, 1978.

Western Union (Western Union Telegraph Company) (1978), Comments on the Eighth Notice of Inquiry, FCC Docket No. 20271, July 14, 1978.

APPENDIX C

UNITED STATES PROPOSAL TO THE RARC (Regional Administrative Radio Council) 1983 FOR DIVISION OF THE 12.1-12.3 GHz BAND TO PROVIDE ADDITIONAL BROADCASTING-SATELLITE SERVICE (BSS)

United States of America
Proposals

Division of the band 12.1-12.3 GHz
(agenda item 1.1)

Introduction

Under Section 1.1 of its agenda, and No. 841 of the Radio Regulations, the Conference is directed to divide the band 12.1-12.3 GHz into two sub-bands. The lower sub-band is to be allocated to the fixed-satellite service, and the upper sub-band to the broadcasting-satellite, broadcasting, mobile except aeronautical mobile, and fixed services. All services are to be on a primary basis.

The United States believes that the 11.7-12.7 GHz portion of the spectrum holds great promise for national telecommunications systems providing both fixed and broadcasting satellite services. Fixed-satellite networks operating in the 11.7-12.2 GHz band are already in service. A wide variety of voice, data, teleconferencing and video services can be provided between small, low cost earth stations over fixed-satellite systems operating in this band. Additional fixed-satellite networks operating in this band are being planned by the United States and other Region 2 Administrations.

The broadcating-satellite service also holds great promise for high quality, economical mass media services in the upper portion of this band. Although not as far developed as the fixed-satellite service, the broadcasting satellite service can be expected to develop rapidly after the final acts of this conference are placed into effect by Region 2 Administrations.

Adequate amounts of spectrum should be allocated to both space radiocommunications services to insure that the plans adopted at this conference for the broadcasting-satellite service do not inhibit the ability of any Region 2 Administration from implementing its planned space radiocommunications systems in this portion of the spectrum. For this reason, the United States concludes that an allocation of 500 MHz should be made to each of the fixed-satellite and broadcasting-satellite services.

Proposal

With respect to Item 1.1 of the agenda for the 1983 Regional Conference for Planning the Broadcasting-Satellite Service in Region 2, the United States proposes that:

(1) The frequency band 12.1-12.3 GHz in Region 2 be divided in accordance with No. 841 of the Radio Regulations at 12.2 GHz;

(2) The present allocation at 11.7-12.1 GHz be expanded to include the sub-band 12.1-12.2 GHz;

(3) The present allocation at 12.3-12.7 GHz be expanded to include the sub-band 12.2-12.3 GHz;

(4) Nos. 836, 843, 844 and 846 be modified to reflect this change in allocated frequencies; and

(5) No. 841 be suppressed.

Reason:

Fixed-satellite networks currently under construction or in the planning stages can make effective use of 500 MHz of spectrum. A typical Delta class spacecraft can achieve full re-use of a 500 MHz frequency allocation within its weight limitations. This includes full eclipse protection and sufficient on-board redundancy and stationkeeping fuel to achieve a nominal 10 year lifetime.

Typical satellite designs being planned in the United States incorporate 20 transponders with 43 MHz bandwidths or 16 transponders with 54 MHz bandwidths. E.I.R.P. values between 41 and 51 dB(W) are achieved with the 10 to 20 watt travelling wave tube amplifiers used in these designs depending on the coverage area selected. Transponders with these capabilities can usually be expected to support several hundred SCPC channels between 3 to 5 meter earth stations, 40 to 60 Mbps of data between 5 to 7 meter terminals, or one video channel to a 2 to 3 meter antenna. Although initial traffic requirements within a country might appear to be satisfied by only a portion of such capacity, experience has shown that demand grows rapidly beyond minimum expectations once a satellite network has been placed into service.

A frequency allocation of less than 500 MHz to the fixed-satellite service is technically, operationally and economically disadvantageous because it does not allow efficient utilization of the capacity inherent in typical spacecraft designs. It would also be inefficient spectrum use since full advantage could not be taken of the 500 MHz of uplink available for such networks at 14.0-14.5 GHz. Finally, an allocation of 500 MHz to the fixed-satellite service allows maximum flexibility for hybrid satellites designed to operate at both 4/6 and 12/14 GHz since full cross-strapping is possible when the allocations have the same bandwidth. Cross-strapping is particularly desirable to avoid problems of terrestrial interference in particular locations in the 4/6 GHz band and to overcome precipitation induced transmission difficulties at 12/14 GHz in high rainfall areas of a country.

However, the fixed-satellite service obtains no particular advantage from a downlink allocation of more than 500 MHz of spectrum as long as only 500 MHz of spectrum is available for the uplink in the associated 14.0-14.5 GHz uplink band.

While there are significant penalties to the efficient and economical design of fixed-satellites if less than 500 MHz of spectrum is available, the converse situtation does not hold for the broadcasting-satellite service. Typical broadcasting satellites will be physically capable of carrying at most a dozen television channels and more likely only three to six channels. Thus, a single spacecraft will not be capable of using the entire allocation, whether it is as little as 400 MHz or as large as 600 MHz. The cost of the broadcasting-satellite will therefore depend only on the channel parameters chosen and not on the size of the frequency allocation.

Moreover, there is no reason to believe that an allocation of more than 500 MHz is needed to insure that successful plans for the broadcasting-satellite service will be developed for Region 2. An allocation of 500 MHz was sufficient for Region 3 at the 1977 World Administrative Radio Conference and both Region 2 and Region 3 have comparable numbers of Administrations.

An allocation of 500 MHz of spectrum should be made for both the fixed-satellite and the broadcasting-satellite services. Any less than this would result in inefficient and uneconomical fixed-satellite networks. A larger allocation provides no economic or operational advantages for broadcasting-satellite networks and is not necessary to successfully develop plans for this service in Region 2.

Approach to Developing the Plan and Regulatory Procedures

1. The U.S. approach to the development of the Plan is designed to promote the orderly development of Broadcasting Satellite Services in Region 2. The Plan should contain a compilation of the necessary technical characteristics of assignments and the analytical data needed to ensure that the agreed interference protection will be afforded. The assignments in the Plan will be made to the extent possible in conformity with the protection criteria. In certain instances these protection criteria may be waived by administrations in order to advance the work of the Conference.

2. In recognition of the complexity of creating a plan involving numerous variables, mathematical models have been developed with the aid of computers for use prior to and at the conference. The Panel of Experts (POE) Final Report includes the documentation of these techniques and models. In developing the Plan, the Conference must consider requirements for channels, service areas, and orbital locations submitted by the opening day of the Conference. A validated data base of these requirements then would be established. In order to create a plan, technical characteristics which describe an assumed system must be agreed upon. Technical data including interference protection limits also must be adopted. The U.S. proposes that the CPM Report be utilized to establish these parameters. However, the U.S. proposes improvements in certain values which will allow more efficient use of the available spectrum/orbit resource. These proposals result from recent analyses which were validated by testing and measurements.

3. The system of computer programs developed by the POE will be used to evaluate whether a plan containing all the stated requirements achieves the specified protection criteria. Creating the Plan will be an iterative process of refining a series of working plans by modifying requirements, technical criteria and protection limits.

4. The U.S. believes that appropriate procedures for implementing and modifying the Plan are crucial to the attainment of an acceptable Region 2 plan for use of the Broadcasting Satellite allocations. These procedures must allow for maximum flexibility in system implementation. These procedures must reflect the fact that this new service will develop at different rates and under different conditions throughout the Region. These goals can be accomplished by providing the opportunity for all administrations to:

(1) employ revised system characteristics without unnecessary procedural complication and delay, and

(2) add new assignments as necessary to meet growing needs for service.

In all instances the agreed protection will be afforded to all systems in accordance with the Plan, whether their implementation is rapid or delayed. It is recognized that a willingness to accommodate proposed changes is essential to make the Plan truly flexible. This is even more important in view of the fact that systems will be implemented over a period of years. A streamlined modification process would also permit exploitation of technological advances.

TECHNICAL PROPOSALS

The technical proposals of the United States are presented as modifications to the current Annex 8 to Appendix 30 of the Radio Regulations. Proposals relating to the technical characteristics of the BSS feeder links are presented as an Annex to a proposed new Appendix 30A that will deal exclusively with the BSS feeder links.

The United States expects to launch a number of BSS systems in the very near future. In this regard, the United States has spent considerable effort investigating the technical parameters that will be used in actual system design and implementation. The United States believes that it is in the best interest of all administrations that the Region 2 Plan be flexible enough to permit the implementation of BSS systems of different technical design. At the same time, the United States believes that efficient use of the spectrum and orbit resources should also be of prime concern in the Plan in order that the needs of all administrations for BSS can be adequately met. The technical proposals of the United States reflect these two concerns.

The United States believes that the output report of the CCIR Conference Preparatory Meeting (CPM) can serve as a strong foundation for the technical parameters and data to be used in the development of the Region 2 Plan and the application of the various provisions that are applied to the Plan. In some areas the CPM failed to come to conclusive recommendations on certain technical parameters. In most of these areas the United States has specific proposals. In other areas, additional research and study has shown that further technical improvements are possible that will increase the efficiency of use of the spectrum and orbit resources. The costs involved in these technical improvements was also investigated. The United States believes that the adoption of these technical improvements will have little or no impact on the cost of providing BSS service for any administration but will greatly facilitate the task of meeting the BSS requirements of all Region 2 countries.

The principal proposals of the United States in the technical area are summarized below:

14 dB Total C/N for 99% of the worst month

-25 dB Protection Ratio for co-channel signals

[ ]dB Protection Ratio for adjacent channel signals

13 MHz spacing between adjacent channels

8 dB/°K figure of merit of receiving installation

1.9° (.9 m.) minimum planning diameter of receiving antenna

Improved offset feed receive antenna reference pattern

24 MHz necessary bandwidths with provision for multi-channel assignments employing significantly larger bandwidths

0.8° minimum beamwidth of satellite transmitting antenna

APPENDIX D

GENERAL SUMMARY OF THE FEDERAL GOVERNMENT'S USE OF THE RADIO FREQUENCY SPECTRUM

A number of studies (Spectrum Resource Assessments), investigations, publications and actions over the past decade have dealt with the problems of Radio Frequency Spectrum Management.

While considerable data on equipment and frequency usage are being collected from the Federal Government agencies under a continuing program, these data include classified information and are in some detail. It is the objective of this summary to present in brief unclassified form, the nature and scope of the Federal Government's use of the radio frequency spectrum including the dominant factors which dictate such use, and the impact of national policies on Government use of the spectrum.

At the onset if should be recognized that "use of the radio frequency spectrum" covers a gamut of radiocommunication and electronic facilities far in excess of the "radio" of by-gone years which meant, for the public at least, primarily broadcasting and wireless communications to ships at sea. The spectrum involved is that intangible resource that allows electromagnetic radiation to be propagated through free space with frequencies from about 30 Hz (1 Hertz is a cycle per second) to those in the order of 3,000,000 MHz or 3000 GHz (1 Megahertz is a million cycles per second and 1 GHz Hertz is 1000 MHz). This spectrum represents a range in frequencies of 100 billion to 1, within which one finds many bands of frequencies, each with its own peculiarities and usefulness. As a point of reference, the UHF television broadcast band in the U.S. is 470 to 806 MHz, and this SRA includes the range from 947 MHz to 17.7 GHz. The facilities involved include not only radio stations of many categories but a myriad of electronic devices all characterized by radiation, both desired and undesired, within the radio frequency spectrum.

In understanding the Federal Government's use of the spectrum, one must appreciate the interplay with non-Federal Government use of the same spectrum. In addition to the shared use of spectrum, there is a substantial interface between Government and non-Government radio operations. Non-Government ships and aircraft are served by Government radio facilities: Federal Law enforcement agencies have intercommunication with their state and local government counterparts; Federal electrical power systems interconnect with non-Federal, both domestic and international; Civil Air Patrol stations communicate with the Military--and so forth.

Further, it should be recognized that the Government depends heavily (1) on the use of commerical telecommunication facilities in lieu of Government-owned and operated and (2) on the use of landline facilities in lieu of radio where such use is feasible.

U.S. Government radio facilities, supported by a significant research and development complex, fall in the following categories:

1. Conventional radiocommunication facilities - such as high-frequency overseas telegraph and telephone circuits; satellite communications; radiocommunication services to ships and aircraft; land-mobile and microwave communication facilities.

2. Radars (Radiolocation) - such as for the location of aircraft or ships, missile detection, and storm cloud observation.

3. Radionavigation facilities - serving ships and aircraft.

4. Telemetry - radio transmission of measured or sensed quantities or conditions of given physical properties such as hydro/meteorological or stress/strain data including the receipt of such information from spacecraft. Radio astronomy observations may be considered as a form of telemetry in the broad sense where the transmitted signals are of natural origin.

5. Various radio frequency spectrum dependent systems - serving the production, control, and protection of natural energy resources such as electrical solar power, strategic petroleum reserves, and oil tar sands.

The requirements for conventional radiocommunication facilities are generally understood; those for the multitude of radio stations and electronic devices involved in categories (2) through (5) above are, however, generally less known. Nonetheless, the latter represents a major portion of the Government's investment in, and use of, the spectrum. Details as to Federal agency responsibilities and commitments having a corresponding impact on the spectrum are given in Section 1.2.1 and 1.2.2 (a summary of use by no means exhaustive).

In addition to the radio facilities listed above, the following category of non-radiating facility is also utilized by the U.S. Government:

> Carrier current facilities - power line carrier radio frequency systems used for transmission of analog and digital information in the control and protection of electrical power supply systems to insure reliable, adequate, and timely generation and transmission of electrical energy.

Two dominant themes are present in the Government's use of radio:

1. The requirement for telecommunication is placed upon the Federal Agencies by virtue of the missions and programs approved by the President consistent with congressional legislative and funding support, and

2. The use of radio rather than other forms of communications is dictated by the inescapable elements of time and space.

DEPARTMENT OF DEFENSE

General. Use of the Radio Frequency Spectrum by the Military Services.

The paramount requirement of military communications-electronics (C-E) is to provide telecommunications, navigation and special purpose electronics systems that are responsive to the requirements of the National Command Authorities, the Joint Chiefs of Staff, the Commanders of Unified or Specified Commands, the Services, and defense agencies in the accomplishment of designated missions and functions in peacetime, contingency situations, and at all levels of conflict, including general nuclear warfare. Military C-E systems are developed and produced to perform functions that accommodate crisis management, support nuclear strategy, and meet other wartime requirements. These systems are designed to facilitate a rapid transition from peace to war as well as to satisfy peacetime needs. The nature of the systems and the functions to be performed make military tactical and strategic operations highly dependent on the usable radio frequency spectrum. The foregoing demands that sound engineering and administrative practices be applied by the military services toward ensuring efficiency in the management and use of the radio frequency spectrum to support operations.

Some idea of the military services dependence on radio frequencies is presented below.

DEFENSE COMMUNICATIONS AGENCY: The Defense Communications Agency (DCA) engineers, manages and operationally directs the Defense Communications Systems (DCS) which provides the necessary long-haul worldwide communications for the National Command Authorities, the Joint Chiefs of Staff, the Unified and Specified Commanders, the defense agencies, the military departments, and designated subordinate military command elements. In addition to landlines (including cable and fiber optics) and submarine cables, the DCS includes a vast network of troposcatter, microwave, and high frequency (HF) systems, as well as the satellites and earth terminals of the Defense Satellite Communications Systems (DSCS). The individual components of the DCS are provided by the Military Departments who are responsible for the operation and maintenance of the facilities. The frequency spectrum with which the DCA is concerned ranges from the lower portion of the high-frequency band up through the EHF radio frequencies, and into laser frequencies used in the fiber optic cables.

DEPARTMENT OF THE ARMY (DA)

1. Army Regulation 5-12 assigns duties and responsibilities of the Army General Staff and Army Commands for spectrum management. Each major command has been given the specific tasking in accordance with its mission. For example, the Materiel Development and Readiness Command is responsible for research and development, while the Army Communications Command handles the day-to-day frequency coordinations and assignments. These comply with the primary Army spectrum management policy of conservative, efficient use of authorized spectrum resources, critical consideration is given to electromagnetic compatibility in the development and use of equipment. As the spectrum becomes congested with more and more users, the ability of equipment to operate without causing or experiencing unacceptable interference becomes even more critical. The Army has now guidance to all activities that research, plan, design, develop, lease, procure, produce, select sites for, install, operate, modify and/or maintain spectrum dependent equipment.

2. Use of the Electromagnetic Spectrum. Throughout this year, the Army's use of the electromagnetic spectrum has grown significantly, particularly by noncommunications emitters. Significant new noncommunications users include a laser individual training system, ground and airborne radars, sensors and navigation devices. This equipment is used in many diverse fields, from training to air traffic control, intelligence gathering, surveillance, early warning, target acquisition, guidance of munition, and meteorological predictions. Mobile satellite terminals will be placed worldwide to provide additional means of command and control and passing critical communications to support Army missions.

3. Army Aviation. Army aviation activities utilize the electromagnetic spectrum for communications, data links, air navigation, and related radar systems. The aviation-related C-E equipment is operated from ground stations and from fixed- and rotary-wing aircraft as appropriate.

4. Corps of Engineers (Civil Works Directorate). The U. S. Army Corps of Engineers (Civil Works Directorate) uses radio frequencies from 2 MHz to 9400 MHz for voice communications, data collection, relay systems, Raydist surveying, radar, TV monitoring, and telemetry. Radio is the only communications link to many remote areas and during catastrophes where land lines are destroyed. It is also used for communications between the widely separated division and district offices and flood control dams. Radar and TV are used as an aid in scheduling and controlling canal traffic. Telemetry is used in the collection of hydrological and meteorological data. Raydist is used in surveying and dredge positioning. Relay systems are used to extend line-of-sight communications in remote areas. Certain frequencies are retained exclusively throughout the United States for the Corps, so that in emergencies equipment may be shifted and be operated immediately on arrival.

DEPARTMENT OF THE NAVY. The Department of the Navy includes the Executive Office of the Secretary of the Navy, the Office of the Chief of Naval Operations, the Headquarters U.S. Marine Corps, and other commands and activities located at the seat of the Government; the entire operating forces of the Navy and Marine Corps, including reserve components; all shore and field activities under the control of the Secretary of the Navy; and, in time of war or when the President so directs, the U. S. Coast Guard.

1. Navy Fleets. The Navy fleets are a vital part of our defense establishment in peace as well as in wartime. Their mission is to perform specific functions in connection with area defense, rapid response strike forces, control and protection of shipping, search and rescue, harbor defense, continental air defense, logistic support, and domestic emergencies.

2. Naval Aviation. Navy and Marine Corps Air Stations support shore based aircraft and fleet-deployed aircraft squadrons. Aircraft are equipped with communications transmitters and receivers, and equipment such as search radars, IFF, NAVAIDS, ASW, ECM, and weapon control systems.

3. Naval Telecommunications System. The Naval Telecommunications System (NTS) provides command, control, and communications support to the Navy and Marine Corps operating forces and other military activities. The NTS must be responsive to the requirement for the command, control, and support of unilateral naval operations, as well as joint operations undertaken by a Unified Command. The NTS is a worldwide system configured to support naval and joint forces in those ocean areas where the presence of U.S. military and naval power has been determined

essential by the Joint Chiefs of Staff or other higher authority. World circumstances and U.S. national interests have required the continued commitment of U.S. forces to the Pacific, North Atlantic, Mediterranean, and Indian Ocean areas. The Naval Telecommunications System is oriented to the support of forces in these areas. The basic shore elements of the System are the Naval Communications Area Master Stations and their supporting naval communication stations. They serve the operating forces and provide a DCS interface.

4. Marine Amphibious Forces. Operation of communications-electronics equipment, systems, and subsystems is a necessity to support, coordinate, and control Marine Air/Ground Task Forces and other independently operating Fleet Marine Force (FMF) units. The equipment and systems that require frequency spectrum, are tactical radios, sensors, battlefield surveillance radars, air defense radars, tactical data link terminals, and satellite communication links.

DEPARTMENT OF THE AIR FORCE

1. Tactical Air Command (TAC). TAC organizes, equips, trains, administers, and operates forces assigned or attached to participate in prompt and sustained tactical air operations including tactical fighter, tactical air reconnaissance, special operations, tactical air control, and support units. TAC also functions as a component command (USAFRED) under the U.S. Readiness Command (USREDCOM) and as component command (AFLANT) within the Atlantic Command (LANTCOM). TAC's use of the frequency spectrum runs the gamut from low frequencies (LF: 30-300 kilohertz) to super-high frequencies (SHF: 3-30 gigahertz). Satellites, airborne, ground, and intrabase radios, radars, transponders, beacons, electronic warfare, and electronic countermeasures equipment, enemy threat simulators, homing devices, and navigational aids are radiating devices used by TAC which make use of the frequency spectrum.

2. USAF Aeronautical Operations. About 10,000 aircraft are maintained by the USAF. These aircraft and the worldwide supporting ground stations require numerous UHF communications sets in the band 225-400 MHz, airborne navigation and fire control radars in bands above 1000 MHz, and numerous HF communications sets.

3. Strategic Air Command (SAC). SAC maintains a continuous strategic alert requiring extensive command and control communications support. The SAC Airborne Command Post, Post Attack Command Control System (PACCS), National Emergency Airborne Command Post (NEACP), Air Force Satellite Communications (AFSATCOM) and SAC support of DOD air refueling tracks scattered throughout the U.S. require considerable use of the 225-400 MHz frequency band. Air refueling requires interference-free operation to preclude any hazard to safety of flight. These same frequencies are also used for bomber/tanker cell inflight coordination. UHF communications are also used at Strategic Training Ranges (STR) for combat crew proficiency training. STR operations located throughout the United States are conducted in the bands 2700-2900 MHz and 8500-9600 MHz. HF frequencies are assigned to long-range radio communications for strategic contingency operations. Low Frequencies (LF) are used by SAC for long-haul command control communications as a survivable medium in a nuclear environment. Very High Frequency (VHF) communications are utilized extensively at all SAC bases for intra-base radio systems. SAC makes limited use of Medium Frequency (MF) radio communications.

4. Air Force Communications Service. The mission of the Air Force Communications Service (AFSC) is to engineer, program for (or provide), install, operate, maintain, and manage C-E, meteorological, air traffic control facilities (NAVAIDS), and air traffic control and flight inspection services for the Air Force and for other agencies as directed by the Chief of Staff, USAF. This mission must be performed during both the static conditions of peacetime and the highly mobile conditions brought about by contingencies and national disasters at indeterminate locations. Communications services provided run the gamut from the commonplace land-line through sophisticated communications satellites. In addition to those frequencies required to directly support its own command mission, AFSC manages radio frequencies for the USAF.

5. Air Force Systems Command. The Air Force Systems Command (AFSC) mission is to advance aerospace science and technology and acquire qualitatively superior aerospace systems and equipment. Recognition of the RF spectrum as a finite and vital resource requiring prudent use/management is intrinsic to the AFSC mission. The enhancement of national defense would be diminished if new electromagnetic equipment for USAF were not compatible with its intended environment or were in a frequency band either already overcrowded or allocated for a different radio service. Research, development, and test activities conducted at AFSC laboratories, base operating sites, and test ranges, plus those at numerous and diverse facilities of associated contractors, rely heavily on the use of the radio frequency spectrum. Approximately one-third of the IRAC RF assignments for Air Force operations are of AFSC origin.

6. Air Defense. The USAF Aerospace Defense Command (ADCOM) operates an extensive system providing identification, surveillance, and interception of air breathing vehicles, and the detection and tracking of missiles and space vehicles or objects destined to impact on or pass over the United States. C-E systems and their frequency spectrum utilization in support of this mission includes ground radar facilities, Semiautomatic Ground Environment (SAGE) ground-air facilities, drone control and target scoring facilities, tactical UHF air-ground facilities, nontactical radio facilities, and HF single sideband facilities. In addition, ADCOM utilizes a considerable portion of the transcontinental telephone systems, leasing both point-to-point and switched circuitry. However, current planning calls for the transfer of certain functions, and many of the operations given here will continue, under the control of other Air Force Commands.

National Test Ranges. National test ranges, such as the White Sands Missile Range, are major users of the electromagnetic spectrum. Typical equipments/systems are fixed, land mobile, and airborne communication and data links, ground and airborne radars, drone control, beacons, instrument control, and various experimental systems. In addition, extensive ECM testing is done at some of the ranges.

Reserve Components. In addition to the regular Armed Forces, there are reserve units of the Army, Navy, Air Force, and Marine Corps, including the Army National Guard, Air National Guard and the Coast Guard in the United States. The mission of the reserve is to provide trained and qualified individuals to augment the active forces and to provide a combat ready team in time of war or national emergency. The reserve routinely conducts amphibious assault exercises with extensive use of communications-electronics equipment and relies heavily on all parts of the radio frequency spectrum for its communications, command control capability.

Conclusion. In conclusion, the Military Departments, both on unilateral and joint basis, are critically dependent upon the usable radio frequency spectrum in the fulfillment of requirements incident to the defense and security of the nation. In making use of this resource, the military is acutely aware of the need for diligent care in the management thereof. Many measures toward improvement are underway and the military establishment will continue to devote maximum effort to this endeavor. The frequency engineering and management function is carried out in DOD at a level thoroughly familiar with and immediately responsive to the requirements of the operating forces. This function is an integral part accomplished sufficiently close to major policy making levels (intraservice, joint, and DOD) to facilitate referral of issues warranting high level consideration.

U. S. Government Civil Agencies

The use of radio by the Government Civil Agencies is characterized by a wide variety of missions distributed among several Departments and Agencies. A brief description for each such Agency follows:

The Department of Agriculture's use of radio is primarily dedicated to the protection and management of the national forests, which comprise about 200 million acres.

The 36,000 radios of the U.S. Forest Service are used in the programs of timber production, forest firefighting, operation of recreation sites, control of watersheds and water supply areas, control of water and air pollution, wildlife and grassland conservation, and forest research.

The Department of Commerce, in its mission to promote full development of the economic resources of the United States, requires radio to provide essential services to the public and to other agencies of Government. Within the Department, the largest user of the radio spectrum is the National Oceanic and Atmospheric Administration (NOAA) which has the mission of managing, conserving and monitoring marine resources and to predict atmospheric and marine conditions for the protection of life and property. These services are rendered primarily by the following units of NOAA:

1. The National Weather Service (NWS), with personnel located at more than 320 offices throughout the United States and Possessions, is the most pervasive of the environmental science services. Direct use of the service by the public is second only to the U.S. Postal Service. The NWS is charged with observing and reporting the weather, issuing forecasts and warning of weather and flood conditions affecting national safety, welfare and economy. These functions depend on radiocommunication facilities and touch virtually every citizen's life through the public weather service and specialized weather/hydrologic services to aviation, maritime activities, agriculture, space operations, and the like.

   The National Weather Service operates more than 100 weather radars, 134 weather balloon stations (radiosonde) and electronically instrumented weather reconnaissance aircraft.

The NOAA Data Buoy Center develops and operates environmental data buoys for weather monitoring, prediction, and various other scientific programs. Data is sent from the buoys and relayed to land via UHF signals through the GOES and TIROS satellites.

2. The National Environmental Satellite, Data, and Information Service (NESDIS), operates meteorological satellites which make day and night observations of weather (clouds, temperature, and winds) over the entire Earth. These data and other environmental meteorological data are transmitted to Earth by radio.

   The meteorological satellite system provides for the collection and radio relay of data from fixed and mobile environmental observing platforms (ships, aircraft, ocean buoys, and remote surface sites). There are some 4,100 data collection platforms currently using the data collection radio and relay service of the meteorological satellites. These observation platforms are operated by NOAA, other Government agencies, and private industry to obtain data on stream flow and water quality, snow depth, and rainfall in remote mountain areas, oceanic measurements from buoys and remote islands, and wind and temperature information from commercial aircraft, for example. All these depend on radio communications to provide data to central data analysis facilities.

3. The National Marine Fisheries Service (NMFS), conducts exploratory fishing and equipment research programs using ships of the NOAA Fleet. HF and VHF radios provide communications between major fishery centers and the ships as the latter conduct research and enforce marine and wildlife conservation laws, international agreements and treaties. The NMFS marine enforcement elements coordinate conservation activities with the U.S. Coast Guard and state marine enforcement agencies. VHF radio communications is an essential factor during these operations.

4. The National Ocean Service (NOS) radiocommunication facilities are used to support some 22 ships and 18 mobile field parties engaged in oceanographic, marine and geodetic survey, and also National Marine Fisheries Service (NMFS) fisheries activities. The programs include marine surveys for nautical charts; measurement of tides, currents, winds, and ocean states; and research on resources of the sea. The vessels operate in coastal waters, on the Great Lakes, and in international waters. These programs, activities, and related radiocommunications are conducted by the NOAA Corps, scientists, and technicians to measure the Earth's surface, its coastlines and its undersea features. Communications are principally for safety, control of navigation, operations, medical emergencies, and administrative messages between ships conducting joint operations and between ships and shore stations using NOS, NMFS, Navy, and United States Coast Guard communication circuits. The National Geodetic Survey, an office within NOS, also utilizes radio frequencies in the visible and infrared spectrums for very precise distance measurements. Radio communications between field personnel are handled by voice communications in the VHF frequency band. In addition, the Ocean Services Division (OSD) of the National Ocean Service responds to oil and hazardous chemical spills. Radio communications are used to coordinate clean-up teams and tract movement of contamination. Radio communications are employed also in the Outer Continental Shelf Environmental Assessment (OCSEA) Programs in Alaska.

5. The Environmental Research Labs (ERL) uses radio techniques (from LF through Laser frequencies) to research the physical environment. Operating from laboratories and field sites at about fifty locations across the United States, ERL currently is researching hurricanes, weather modification, weather prediction, wind profiles, atmospheric movement, air pollution, acid rain, and coastal currents and wave heights. ERL also studies solar behavior and provides warning of unusual occurrences for satellite operations, space shuttle flights, and HF propagation conditions.

In addition to NOAA, the Department's National Bureau of Standards is located 20 miles Northwest of Washington, D. C. in suburban Maryland. Radiocommunications are vital to the following operations:

a) Dispatch and control of mail and passenger service vehicles between this installation, DOC and other Federal agencies in Washington, D. C.

b) Support of emergency services including the NBS Fire Department, ambulance service, and the Physical Security Unit.

c) Building and plant maintenance staff make use of both two-way radio and radio paging service to efficiently transfer staff and equipment when and where needed.

d) Radio communications are also used in support of a number of technical operations at NBS including two-way, radio paging, and radio telemetry.

NBS also has facilities in Boulder, Colorado which are responsible for primary time and frequency standards, and dissemination of these data through radio stations WWV and WWVB in Colorado and WWVH in Hawaii to over one hundred thousand listeners throughout the world. Data is also disseminated through GOES and GPS satellites. NBS also conducts extensive experimentation using the radio spectrum in such areas as earthquake prediction, EMC/EMI, and antenna calibration measurements. Specific areas of radio usage include communication, data telemetry, and satellite transfer of information.

The Institute for Telecommunication Sciences (ITS), within the National Telecommunications and Information Administration, conducts research and engineering support in communications devices, radio propagation, and advanced technology. Particular emphasis is on the use of millimeter waves as a means of extending usable spectrum. Techniques include computer simulation, and propagation modeling.

The Federal Emergency Management Agency (FEMA) was created to provide a single point of accountability for all Federal emergency preparedness, mitigation and response activities.

To ensure the overall integration of the programs administered by FEMA, a systems approach strategy has been developed known as the Integrated Emergency Management System or IEMS. IEMS builds on a foundation of preparedness and response elements (such as direction, control, and warning systems) which are common to the full range of emergencies--from small, isolated events to the ultimate emergency of a war.

NEMA consists of the total telecommunications and data processing resources necessary for FEMA to accomplish its assigned peacetime and wartime functional responsibilities and meet all established operational requirements under the IEMS umbrella. Current capabilities of NEMS include the National Warning System, the FEMA National Teletype System, the FEMA National Voice System, the FEMA National Radio System, and the capability to activate the Emergency Broadcast System at the direction of the President. NEMS, and all supporting ADP and communications systems are managed by the Office of Information Resources Management.

Department of Energy - The Department of Energy (DOE) utilizes approximately 6000 radio frequency assignments from the low frequency (76.5 kHz) range through the laser frequency (585 THz) range to support the Department's functions of electrical power transmission and marketing, nuclear and national security programs, and petroleum reserves. In addition, the DOE is responsible for the operation of more than 1300 power line carrier circuits.

1. Electrical Energy

The DOE, through its Power Marketing Administrations, markets electrical energy generated at 123 Federal hydroelectrical projects from Alaska to the east coast. To protect, control, and maintain these extensive networks, DOE uses more than 1300 power line carrier circuits from 8 through 496 kHz and 2190 assignments in the HF, VHF, UHF, and SHF bands for fixed, Land Mobile, Aeronautical Mobile, Mobile, and Meteorological-Satellite Services.

The transportation of electrical energy from the generating plants to the load centers and the interconnection of bulk electrical power supply systems for reliability and adequacy have resulted in the development of extremely complex national networks aimed at the optimum economic configuration. The systems have, as integral and critical parts, extensive telecommunications for voice and data. These telecommunications networks are the nerve systems between control centers and many hundreds of generating stations, switching stations, and substations, which are required to operate harmoniously as an interrelated and interconnected whole. These telecommunication facilities must be of the highest level of reliability, economically and technically feasible, and must be instantly available for the successful operation of the nation's electrical power systems.

2. Nuclear and National Security

The DOE utilizes over 3700 assignments for voice, data, and video in the MF, HF, VHF, UHF, and SHF bands to support nuclear and national security efforts.

Five national laboratories, eight production plants, and the Nevada Test Site play significant roles in design, development, engineering, production, surveillance and testing of nuclear weapons. Supporting these facilities are radio systems in the Radionavigation, Fixed, Mobile, Land Mobile, Aeronautical Mobile, Maritime Mobile, Radiolocation, and Experimental Services.

3. Petroleum Reserves

The strategic petroleum reserves program provides storage and retrieval facilities for imported crude oil. It is controlled from New Orleans and has terminal and storage facilities located at six sites along the Gulf Coast at Louisiana and Texas. The complex has five VHF/FM radio networks that cover the local area around each of the sites. Each site also has a radio paging system, and there is a microwave link for pipeline control. The program uses 53 assignments in the VHF and UHF bands in the Fixed, Land Mobile, and Maritime Mobile Services.

Department of Health and Human Services. The principal user of radio spectrum in the Department of Health and Human Services (DHHS) is the Public Health Service (PHS). The Indian Health Service (IHS), a component of the Health Resources and Services Administration, a PHS operating agency, is responsible for about 80% of the approximately 1400 frequency assignments utilized by DHHS. The IHS supports the delivery of health care to Native Americans by using radio to communicate with emergency medical vehicles, remote health stations and mobile health units. Radio is also used extensively for paging systems to communicate with key medical personnel. In Alaska, the IHS uses both HF radio and common carrier satellite communications to provide "Doctors Call" assistance to village health aides at isolated locations. IHS radio base stations at 50 hospitals also communicate with 60 tribal government ambulance services for dispatch and control to respond to serious medical emergencies at remote Indian locations. The IHS participates in State emergency radio networks to coordinate the rendition or delivery of medical care using medical radio communications frequencies. The Bureau of Devices and Radiological Health, Food and Drug Administrations and the Lister Hill National Center for Biomedical Communications use frequencies for experimental purposes. The PHS also uses radio frequencies for bio-medical telemetry to conduct medical research and for monitoring the treatment of patients. Radio frequencies are used by the Office of the Secretary and DHHS operating divisions for communications to control various security and administrative operations.

The Department of Interior is custodian of 0.75 billion acres of land and is charged with the conservation and development of the nation's natural resources. It has a wide variety of radio operations throughout the spectrum distributed among nine operating bureaus with diverse missions serving the public and protecting the country's natural resources. The major activities using radio are:

1. Point-to-point fixed base station and mobile radios for land management and protection and development of natural resources as required by the Bureau of Land Management.

2. Water Management, control and distribution by the Bureau of Reclamation is a major factor in the growth and economy of the west. Telemetry, land mobile and point-to-point radios are essential to the operation of the Bureaus 320 water storage dams and reservoirs, 344 diversion dams, 51,000 miles of carriage and distribution channels and canals, and 145 very large pumping stations.

3. The Government of American Samoa and the Government of the Trust Territory of the Pacific Islands which provide, in their respective areas, public correspondence (including overseas telephone and telegraph); radiocommunication services to ships and aircraft; local broadcast, AM, FM and TV; amateur radio; and numerous utility services incident to the responsibilities of civil government.

The Department of Justice is the largest law firm in the nation, and serves as counsel for citizens of the United States. It represents them in enforcing the law in the public interest.

1. Organized units of the Department of Justice which use or coordinate use of the radio frequency spectrum are:

    a) The Justice Management Division (JMD) provides program leadership in establishing basic Department policy for telecommunications, security, and for all matters pertaining to organization, management, and administration. Responsibility for Department-wide radio frequency management and IRAC support resides in the JMD.

    b) The Federal Bureau of Investigation (FBI) is charged with investigating all violations of Federal laws with the exception of those which have been otherwise assigned by legislative enactment to some other Federal agency. The FBI utilizes most of the frequency assignments listed for the Department of Justice and, for this reason, has been designated to represent the Department on the Frequency Assignment Subcommittee.

    c) The Immigration and Naturalization Service (I&NS) is responsible for administering the immigration and naturalization laws relating to the admission, exclusion, deportation, and naturalization of aliens. Through numerous enforcement activities, such as the Border Patrol, the I&NS protects the security of the United States' boundaries and participates in stemming the inflow of illegal narcotics. Radio communications play a vital role in these responsibilities.

    d) The Bureau of Prisons (BOP) has general supervision over the operation of Federal correctional institutions and community treatment facilities. Correctional institutions have self contained, dedicated communications and electronics systems to provide necessary safety and security measures.

    e) The United States Marshals Service (USMS) responsibilities reflect all aspects of the complex society they serve; personal security of Federal witnesses and their families, courtroom security, protection of Federal property, and special assignments at the direction of the Attorney General.

2. Radio systems are used by the Department of Justice to serve the national security; to safeguard life and property; and to support crime prevention and law enforcement. The radio systems used by the Department of Justice to effect these responsibilities consist primarily of land mobile radio facilities. Tactical communications among investigative, protective and enforcement personnel in the field as well as liaison communication with cooperating law enforcement organizations are essential operational tools. Mission success as well as safety of life and property is frequently dependent upon the availability of radio communications systems.

The National Aeronautics and Space Administration (NASA) is charged with the conduct of research and development in the areas of space science, astronautics and aeronautics.

NASA is responsible for near and deep space exploration -- using both manned and unmanned spaceflight vehicles. Also, NASA has an on-going terrestrial and space applications program. The Search and Rescue (SARSAT), the Mobile Satellite (MSAT) and the Advanced Communications Technology Satellite (ACTS) programs are illustrative.

In short, all of NASA's R&D and application programs are more or less dependent on access to the radio spectrum resource -- nationally and internationally considered a limited and valued natural source.

From an operational point of view, NASA is currently providing launch and tracking support for approximately 45 spaceflight vehicles. (This includes NASA, other Federal agency(s), commercial and foreign government spacecraft or satellites.)

The National Science Foundation (NSF) has the responsibility of promoting scientific knowledge, and to this end it initiates and supports fundamental and applied research in all scientific disciplines. The NSF sponsors major national and international science programs both of a special and a continuing nature, it sponsors small, as well as, large research projects throughout the nation's academic and scientific communities, and it funds large research facilities at national centers which would be beyond the financial scope of individual institutions. The prime objective of radio spectrum management at the NSF is to ensure the scientific community of adequate radio frequency spectrum for research purposes. There are numerous areas in which the radio spectrum is used for scientific research. The spectrum plays a vital support role for experiments, with telemetry from remote sensing platforms such as balloons, meteorological sensors, ocean buoys, or transmitters attached to animals. Telecommunications links must be provided to coordinate experiments and to maintain contact with remote sites. While the magnitude of these activities is not comparable to active spectrum usage at other Federal agencies, the failure to adequately plan for allocations or obtain frequency assignments can adversely affect scientific objectives. Furthermore, the NSF has a tremendous responsibility for protecting frequency bands for passive spectrum users -- particularly radio astronomy; a responsibility which most other agencies do not have.

The Department of Transportation was established for the purpose of developing national transportation programs conducive to the provision of safe, fast, efficient, and convenient transportation on land, sea and in the air. The achievement of these objectives, particularly in the air and marine environments, is totally dependent upon the continuing availability of rapid and reliable communications. Since radio is the only practical means of communicating with mobile units, achievement is equally dependent upon spectrum space. Radio spectrum utilization by the several operating administrations of the Department serves numerous and diverse operational and technical functions. Nevertheless, these operations have a common purpose--the enhancement of the safety factor, or one or more of the other important aspects of transportation for the general public.

Within the Department:

1. The mission of the Federal Aviation Administration is to provide for the safe and expedient movement of aircraft, both civil and military. In so doing, it uses radio frequencies for communications, radionavigation and radar. Radio frequencies are assigned for use at approximately 3,808 air/ground communication sites, 817 instrument landing system facilities, 940 en route and terminal very-high-frequency omnidirectional ranges and 321 radar stations.

2. U.S. Coast Guard missions include (1) Maritime and recreational boating safety, (2) Search and rescue services, (3) Maritime law enforcement, (4) Marine environmental protection, (5) Port safety and security, (6) Aids to Navigation, (7) Marine science activities, (8) Enforcement of offshore fishery laws, (9) Suppression of smuggling, and illicit drug trafficking, (10) Ice operations, both domestic and in the polar regions, (11) Maintaining a state of Military Readiness, and (12) Operating vessel traffic systems.

   Radio frequencies are assigned for a variety of U.S. Coast Guard operations including (1) a network of about 563 ship/shore radio stations for safety and distress communications with the general maritime community and for command and control of its own fleet of about 255 vessels and 2,100 smaller, radio-equipped rescue craft, (2) a network of 26 aeronautical radio stations for operational control of its fleet of about 200 aircraft, (3) a national network of about 200 radiobeacon stations used primarily by small recreational and commercial vessels operating in coastal waters, and (4) an international network of 40 LORAN radionavigation stations and 2 Omega radionavigation stations used primarily by larger vessels at sea and by air and surface units of the armed forces.

3. Other important uses of radio include (1) a communication network of the St. Lawrence Seaway Development Corporation used to expedite and control the safe passage of U.S. and foreign vessels through the St. Lawrence Seaway, (2) telemetering speed measurements, remote control and other technical operations carried out by the Federal Highway Administration in their efforts to improve the safety aspects of highway travel, and by the Federal Railroad Administration in connection with the development of high speed rail equipment, and (3) vehicle location techniques in programs sponsored by the Urban Mass Transportation Administration.

The Department of Treasury is responsible for enforcement of Federal laws pertaining to protection of the President and other designees, as well as those dealing with counterfeiters, forgers, smugglers, moonshiners, gun law violators, tax evaders, etc.

Radio frequency devices such as portables, mobiles, base stations, lasers, infrared beams, microwave sensors, ground intrusion sensors, and radars play a vital role in detection and apprehension of criminals, and the safety and welfare of law enforcement officers. Radio communications are vital for the administration and management of the U.S. Secret Service, U.S. Customs Service, Internal Revenue Service, and the Bureau of Alcohol, Tobacco and Firearms, as well as the non-law enforcement bureaus such as the Bureau of Engraving and Printing, the Bureau of the Mint, the Comptroller of the Currency, and the Federal Law Enforcement Training Center. Frequency support is also provided to the Federal Reserve System.

The Tennessee Valley Authority is a multipurpose regional development agency involved in activities such as flood control, agriculture and environmental research, forestry, recreation, diversified industry and the largest electrical utility in the United States. The Tennessee Valley Authority uses extensive powerline carrier, microwave, land mobile and point-to-point radio systems to aid in carrying out its responsibilities for the management and operation of a 2 billion dollar per year multipurpose activity which is essential to the socioeconomic well being of the south.

The United States Information Agency (USIA) has the mission to promote understanding abroad for the United States, its policies, its people and its culture. As the official voice of the U.S. Government, USIA plays a significant role in the achievement of long-range foreign policy objectives as it informs and explains--encouraging the maximum flow of ideas and information between the people of the United States and the people of other countries. The Agency provides a consistently reliable, objective, and authoritative source of news to give a balanced view of American society and a background against which a listener can better understand what is happening in this country and the world.

Radio is the only means of communicating directly with peoples of other nations. USIA's global radio network, the Voice of America (VOA), consists of 107 shortwave and medium wave transmitters located in the United States and ten foreign countries with a total transmitting power of over 22 million watts. A total of 960 hours of direct broadcast programming in 42 languages are transmitted overseas each week reaching an audience estimated to exceed 100 million listeners. All broadcasts originate from studios in Washington, D.C. and are transmitted simultaneously by microwave or leased satellite circuits to domestic relay stations operating a total of 31 transmitters. Overseas relay stations operate a total of 75 transmitters and receive all broadcasts by leased satellite circuits or by shortwave from domestic relay stations. These broadcasts are then simultaneously rebroadcast on shortwave and medium wave frequencies to designated target areas. In addition to the direct broadcasts, VOA operates a radio teletype network five days a week sending five regional transmissions of policy statements and interpretive material to over 100 USIA posts abroad.

The U. S. Postal Service (USPS) became a member of the IRAC on September 11, 1979. The USPS has 969 frequency assignments. These assignments are used for Vehicle Control, Plant Maintenance and Mail Processing. The Postal Service also makes extensive use of radio frequencies for law enforcement purposes.

The Veterans Administration provides health care, education, insurance, and mortgage benefits for our military veterans, widows, and orphans. To provide expeditious health care, the VA has over 1933 radio frequency assignments for operation of radio paging, two-way radio, wireless microphones, cardiac telemetry, Emergency Medical Service radio nets. CB radio, vehicular radar, microwave video transmission systems, and High Frequency (HF) emergency contingency radio nets.

VA research is continuing on the biological effects of microwave radiation, RF devices for the blind and the deaf, and new applications of RF technology to improve health care for the military veterans and their dependents.

Other Government agencies, with equally important but diverse responsibilities to serve the public, use radio. However, these are at levels having less impact on the radio-frequency spectrum. Among these are the Environmental Protection Agency, the Federal Communications Commission, Department of State, and the General Services Administration. Use of radio in such agencies, as throughout Government, is increasing significantly because of the country's growth as reflected by new legislation; increasing awareness of environmental problems; and the acute need to protect both the public and its property from internal disorders and disturbances unheard of a decade ago.

APPENDIX E

SUMMARY OF TECHNICAL STANDARDS

In this section the Technical Standards for the Fixed and Mobile bands between 947 MHz and 17.7 GHz are presented. The primary data sources were the NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management and the FCC Rules and Regulations as contained in the code of Federal Regulations. In addition, the results of all available NTIA Spectrum Resource Assessments in these bands were reviewed and incorporated in this survey.

The Spurious Emissions and Frequency Tolerances for these bands are listed in Table 4-1. The detailed technical standards for each assignment band will be dealt with separately in Section 5.

TECHNICAL STANDARDS 947-960 MHz BAND

The technical standards and limitations on systems operating in the 947-960 MHz band are briefly summarized in Table 1. For further discussion of limitation on systems operating in this band see FCC Parts 22, 23, 74 and 94.

TECHNICAL STANDARDS 1350-1400 MHz BAND

The frequency band 1350-1400 MHz is primarily a radar band used for search, surveillance, and navigation. The Radio Spectrum Engineering Criteria (RSEC) apply to Government radars. RSEC specifications are contained in Part 5.3 of the NTIA Manual. While specific technical criteria and parameters are omitted here, the following list identifies the topics of the radar characteristics considered in the Manual:

1. Emission bandwidth
2. Emission level
3. Antenna gain pattern
4. Transmitter frequency tolerances
5. Transmitter tunability
6. Spurious emissions

It should be pointed out that some of the radars in the 1350-1400 MHz band were developed before RSEC was adopted and were not required to meet the criteria specified in RSEC.

Table 1

Frequency Bands and Station Types	Tolerances: Spurious	Tolerances: Frequency
BAND: 470 to 960 MHz		
1. Fixed Stations	D	5
2. Land Stations	D	5
3. Mobile Stations		
3.1 3 W or less	D	20 (z)
3.2 above 3 W	D	5
4. Radiolocation Stations		
4.1 radar	F	400
4.2 other than above	D	400
5. Broadcasting Stations		
5.1 TV Broadcasting Stations	D	500 Hz (o)(p)(z)
5.2 TV Broadcasting Translator Stations.	D	200
6. Earth Stations	G,H	20
7. Space Stations	G,H	20
BAND: 960 to 1215 MHz		
1. Aeronautical Radionavigation Stations		
1.1 Land and Ship Stations	I	10
1.2 Aircraft Stations	I	50
2. IFF/ATCRBS or Similar Type Stations		
2.1 Interrogators 1030 MHz	I	200 kHz
2.2 Transponders 1090 MHz	I	3 MHz
BAND: 1215 to 2450 MHz		
1. Fixed Stations		
1.1 100 W or less	I	30
1.2 above 100 W	I	10
2. Land Stations	I,J	20 (k)
3. Mobile Stations	I,J	20 (k)
4. Radionavigation Stations		
4.1 radar	F	500 (y)
4.2 other than above	I	500 (y)
5. Radiolocation Stations		
5.1 radar	F	500 (y)
5.2 other than above	I	500 (y)
6. Earth Stations	K	20
7. Space Stations	K	20

Frequency Bands and Station Types	Tolerances: Spurious	Tolerances: Frequency
BAND: 2450 to 4000 MHz		
1. Fixed Stations		
1.1 100 W or less	I	30
1.2 above 100 W	I	10
2. Land Stations	I	30
3. Mobile Stations	I	30
4. Radionavigation Stations		
4.1 radar	F	800
4.2 other than above	I	800
5. Radiolocation Stations		
5.1 radar	F	800
5.2 other than above	I	800
6. Earth Stations	K	20
7. Space Stations	K	20
BAND: 4000 MHz to 10.5 GHz		
1. Fixed Stations		
1.1 100 W or less	I	50
1.2 above 100 W	I	10
2. Land Stations	I	50
3. Mobile Stations	I	50
4. Radionavigation Stations		
4.1 radar	F	1250 (z)
4.2 other than above	I	1250
5. Radiolocation Stations		
5.1 radar	F	1250 (z)
5.2 other than above	I	1250
6. Earth Stations	K	20
7. Space Stations	K	20
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

General Notes

The letters A through K in the columns headed *Spurious* refer to the spurious levels specified in the latter part of this section.

Units for frequency tolerance are (±) parts per million (ppm) unless otherwise stated.

Table 1 (Notes)

Notes For Frequency Tolerance

[a] If the emergency transmitter is used as the reserve transmitter for the main transmitter, the tolerance for ship station transmitters applies.

[b] In the area covered by the North American Regional Broadcasting Agreement (NARBA), the tolerance of 20 Hz may continue to be applied.

[c] 20 Hz is applicable to other than Aeronautical Mobile (R) frequencies.

[d] Travelers Information Stations (TIS) have a tolerance of 100 Hz.

[e] The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 50 Hz applies to other equipment.

[f] For AIA emissions the tolerance is 50 ppm.

[g] The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 50 ppm applies to other equipment.

[h] The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 200 ppm applies to other equipment.

[i] The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 300 ppm applies to other equipment.

[j] The tolerance for aeronautical stations in the Aeronautical Mobile (R) service is 10 Hz.

[k] The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 30 ppm applies to other equipment.

[l] For AIA emissions the tolerance is 10 ppm.

[m] For ship station transmitters in the band 26.175–27.5 MHz, on board small craft, with a carrier power not exceeding 5W operating in or near coastal waters and utilizing A3E or F3E and G3E emissions, the frequency tolerance is 40 ppm.

[n] 50 ppm applies to wildlife telemetry with mean power output less than 0.5W.

[o] The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 1000 Hz applies to other equipment.

[p] In the case of television stations of:

—50W (vision peak envelope power) or less in the band 29.7–100 MHz;

—100W (vision peak envelope power) or less in the bank 100–965 MHz;

and which receive their input from other television stations or which serve small isolated communities, it may not, for operational reasons, be possible to maintain this tolerance. For such stations, this tolerance is 1000 Hz.

[q] This standard does not apply to FXX emissions, see section 5.4.6.

[r] This tolerance is applicable to all transmitters, including survival craft stations, after Jan 1, 1983.

[s] Except for the RR Appendix 18 Maritime Mobile frequencies, where the tolerance is 20 ppm except for transmitters put in service after January 1, 1973, a tolerance of 10 ppm shall apply, and this tolerance shall be applicable to all transmitters after January 1, 1983.

[t] Outside band 156–174 MHz, for transmitters used by on-board communications stations, a tolerance of 5 ppm shall apply.

[u] For transmitters used by on-board communications stations, a tolerance of 5 ppm applies.

[v] The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 20 ppm applies to other equipment.

[w] The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 400 ppm applies to other equipment.

[x] For transmitters for system M(NTSC) the tolerance is 1000 Hz. However, for low power transmitters using this system note (p) applies.

[y] The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 800 ppm applies to other equipment.

[z] For 10–10.5 GHz, the indicated tolerance applies to new equipment after 1/1/87. A tolerance of 2500 ppm applies to other equipment.

Table 1 (Notes)

Notes on Spurious Emissions Tolerance

LEVELS OF SPURIOUS EMISSIONS

For purposes of this Manual, the term "authorized bandwidth" is defined as the necessary bandwidth (bandwidth required for the transmission and reception of intelligence) and does not include allowance for transmitter drift or doppler shift. See, in addition, Section 6.1.1 for the definitions of special terms including authorized bandwidth and mean power.

In the case of specific services where technical provisions have been adopted, the values of spurious emission may be other than that specified in this table as shown below:

	PART
Radar Spectrum Engineering Criteria (RSEC)	5.3
FM Operations	5.4
Mobile SSB (2-30 MHz)	5.6
Aeronautical Mobile (R) Service	5.6; APP 27 ITU RR. 1968
Fixed SSB and ISB (2-30 MHz)	5.7
Non-Space Telemetering (1435-1535 MHz and 2200-2290 MHz)	5.9
Fixed Services (1710 MHz-15.35 GHz)	5.10

A. The mean power of any spurious emission supplied to the antenna transmission line, as compared with the mean power of the fundamental, shall be in accordance with the following:

1. On any frequency removed from the assigned frequency by more than 100 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 by 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), except that

a. For transmitters of mean power of 50 kilowatts or greater and which operate over a frequency range approaching an octave or more, a minimum attenuation of 60 decibels shall be provided and every effort should be made to attain at least 80 decibels attenuation.

b. For hand-portable equipment of mean power less that 5 watts, the attenuation shall be at least 30 decibels, but every effort should be made to attain 43 plus 10 $\log_{10}$ (mean power of the fundamental in watts) decibels attenuation (i.e., 50 microwatts absolute level).

c. For mobile transmitters, any spurious emission shall be at least 40 decibels below the fundamental without exceeding the value of 200 milliwatts, but every effort should be made to attain 43 plus 10 $\log_{10}$ (mean power of the fundamental in watts) decibels attenuation (i.e., 50 microwatts absolute level).

d. When A1A, F1B, or similar types of narrowband emissions are generated in an SSB transmitter, the suppressed carrier may fall more than 300 percent of the authorized bandwidth from the assigned frequency. Under these conditions, the suppressed carrier shall be reduced as much as practicable and shall be at least 50 decibels below the power of the fundamental emission.

B. Spurious tolerances for fixed SSB/ISB stations in the band 2-30 MHz are contained in Section 5.7.1.

C. Spurious tolerances for mobile SSB stations in the band 2-30 MHz are contained in Section 5.6.1.

D. 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:

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 by more than 150 percent, up to and including 300 percent, of the authorized bandwidth, at least 35 decibels attenuation; and

Table 1 (Notes)

Notes on Spurious Emissions Tolerance (Continued)

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), except those for frequency modulated maritime mobile radiotelephone equipment, the mean power of the spurious emission falling in any other international maritime mobile channel, due to products of modulation, shall not exceed a limit of 10 microwatts, and the mean power of any other spurious emission on any discrete frequency within the international maritime mobile band shall not exceed a limit of 2.5 microwatts; where, exceptionally, transmitters of mean power above 20 watts are employed, these limits may be increased in proportion to the mean power of the transmitter.

E. Spurious tolerances for FM stations are contained in the following sections:

Frequency (MHz)	*Section of Manual*
29.89–50.00	5.4.2
150.8–162.0125	5.4.4
162.0125–174	5.4.5
406.1–420	5.4.6

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

G. For systems with mean power above 25 watts, the spurious component attenuation shall be at least 60 dB and the absolute mean power level shall not exceed 20 milliwatts.

H. For systems with mean power 25 watts or less, the spurious component attenuation shall be at least 40 dB and the absolute mean power level shall not exceed 25 microwatts.

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 by 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).

J. Spurious tolerances for telemetering stations, excluding those for space radiocommunication, in the bands 1435–1535 and 2200–2290 MHz are contained in Section 5.9.

K. Development of spurious tolerances is pending.

The tolerances for spurious emissions and transmitter frequencies, applicable to the Government equipment in the 1215-1400 MHz frequency band, are given in Chapter 5 of the NTIA Manual and are reproduced in Table 1 for easy reference.

The MIL-STD-469 was adopted prior to the RSEC (Part 5.3 of the NTIA Manual). Therefore, the RSEC requirements were not considered in the design of some of the systems which came into existence earlier in the band. The Department of Defense also requires compliance of its radars with MIL-STD-469. This standard entitled "Radar Engineering Design Requirements, Electromagnetic Compatibility" sets forth engineering design requirements to control spectral characteristics of all new radars operating between 100 MHz and 40 GHz. The MIL-STD-469 also outlines the measurement procedures that are required. In general, the criteria outlined in the MIL-STD-469 are more stringent than those given in RSEC. One of the distinguishing features of MIL-STD-469 is that it requires measurements for compliance. A technical subcommittee of IRAC is presently investigating the utility of incorporating similar measurement requirements into the RSEC. It should be mentioned that the requirement of "measurement for compliance" discussed in the MIL-STD-469 is generally for the purpose of DoD procurement. However, the purpose of incorporating the measurement requirements into the RSEC is to develop recommended measurement procedures for each of the thirteen equipment parameters defined in the RSEC.

The International Telecommunication Union (ITU) has a table on transmitter frequency tolerances (Final Acts, 1979) for 470-2450 MHz. The table specifies transmitter tolerances for each category of station in the band. In addition, the ITU has specified maximum permitted levels of spurious emission, in terms of the mean power level of any spurious component supplied by a transmitter to the antenna transmission line (Final Acts, Appendix 8). Emergency position-indicating radio beacon stations and emergency locator transmitters need not comply with the requirement of Appendix 8. The Appendix states that, "for radiodetermination stations, until acceptable methods of measurement exist, the lowest practicable power of spurious emission should be achieved."

TECHNICAL STANDARDS (1427-1535 MHz BAND)

The technical standards and limitations on systems operating in the 1427-1535 MHz bands are summarized in Table 1 and discussed in detail in the individual summary for this band.

TECHNICAL STANDARDS (1700-1710 MHz BAND)

The general technical standards of Chapter 5 of the NTIA Manual contain minimum performance requirements and design objectives applicable to transmitters, receivers, and antennas used in Government radio stations. As of January 1979, stations transmitting in the 1700-1710 MHz band are required by Section 5.2.3 to have frequency and spurious tolerances specified in Table 1.

TECHNICAL STANDARDS (1710-1850 MHz BAND)

Technical standards have been adopted for certain fixed stations operating in designated bands above 1710 MHz including 1710-1850 MHz. These standards address technical parameters including emission spectrum, frequency tolerance, receiver selectivity, etc. For other station classes used in the band, only standards for frequency tolerance and spurious emissions are specified. In this portion of the section, these various requirements will be evaluated with a view towards possible improvements in the spectrum management of the band. The areas to be discussed are in order; frequency tolerance, antennas, frequency selection, bandwidth, receiver standards, and frequency diversity.

Frequency Tolerance

The frequency tolerance of a transmitter is its maximum departure of its carrier, or center frequency, from the assigned frequency. The frequency tolerance can have an effect on the efficient use of the spectrum in several ways. For very unstable transmitters, the resulting frequency drifting can cause interference to assignments on adjacent frequencies. This is, in general, not a problem in the 1710-1850 MHz band since the current standards call for a tolerance of no more than .003 percent for new fixed and mobile stations. This relates to a maximum frequency drift of approximately 60 kHz. Considering the bandwidths used in this band of typically 1 to 10 MHz, a drift of at most 60 kHz would be adequate to protect adjacent frequency operations.

Another effect of the frequency tolerance is more subtle and generally is a factor only among frequency division multiplex (FDM/FM) links which are nominally cochannel tuned. For cochannel tuned FDM/FM links, the protection criteria to insure interference-free operation is usually considered to be a combination of two factors; sideband beat and carrier beat interference. The former results from the interfering emission modulation sideband energy which falls within the baseband of the victim receiver. The degree of this interference is dependent primarily upon modulation parameters and is relatively independent of minor frequency drifts of the carrier. Carrier beat interference, as the name implies, results when the interfering and desired transmitter carriers are slightly separated in frequency such that beat frequencies are generated which fall within the desired signal baseband. The latter effect is highly dependent upon the frequency tolerance, and as such, the tolerance establishes which factor dominates. The EIA [1976] has studied these protection criteria in detail and has derived C/I protection ratios required to preclude interference for various classes of systems.

Antennas

The use of quality antennas is a recognized technique in promoting efficient use of the spectrum. With radiated power minimized in all but the desired direction, transmitter power and coordination distances can be reduced. In the NTIA Manual, the only current limitations on antennas used in this band apply to the Fixed Service.

The question arises as to whether more restrictive antenna specifications, or specifications in a different form, would prove beneficial in the management of the Fixed systems in the band. The Federal Communications Commission (FCC) has had in force, for a number of years, specifications for antenna patterns similar to the newly adopted Federal standards. In these rules [FCC, 1975] Grade A and Grade B criteria are specified for portions of the adjacent 1850-2200 MHz band which correspond to the characteristics for a 2.4 meter and 1.8 meter diameter antenna, respectively. The more restrictive Grade A antenna must be used except in areas not subject to frequency congestion where the Grade B antenna may be used.

For the Federal Government, it is unlikely that justification could be made, based on current band congestion, for adoption of a 2.4 meter antenna standard in the 1710-1850 MHz band. However, the concept of a Grade A and B criteria does have merit. For example, a subsequent section of this report shows that certain regions of the country are more congested than others. Within these areas, specifications for 1.8 meter antennas rather than the currently required 1.2 meter antenna would lead to somewhat improved sharing in the band. Compare a microwave link which employs 1.8 meter antennas at each end versus a link with 1.2 meter antennas. The resulting increased antenna gain would be approximately 3.5 dB at each end. Thus the system with 1.8 meter antenna could, theoretically, employ 7 dB less transmitter power to achieve the same carrier-to-noise ratio at the receiver, for example, a reduction from a five-watt to a one-watt transmitter. The lower power and resultant lower sidelobes will obviously reduce the required distance separation for frequency re-use. For the less congested areas of the country, the present 1.2 meter standard would be adequate. Specific areas where a proposed Grade A and B criteria might apply are discussed in a subsequent section of the report. A proposed modification to the existing standards is given below to effect this result (underlined portions added). In order to use terminology compatible with the FCC, the terms Grade B (1.8 meter diameter) and Grade C (1.2 meter diameter) will be used here, i.e., the Grade B criteria would be identical for both FCC and proposed NTIA standards.

Requiring minimum antenna performance specifications for aeronautical mobile stations, is less practical than for fixed stations. The airborne components typically require either omnidirectional or hemispheric patterns. The ground-based components will normally require either an omnidirectional or a directional tracking antenna. Adopting an antenna pattern requirement for these land stations may significantly impact tracking capabilities. Specifying antenna patterns for such systems would require additional analysis and is not considered further herein.

Frequency Selection

The selection of frequencies for equipment used in this band is accomplished in several ways. The vast majority of equipments are capable of operating over the entire 1710-1850 MHz band, and are tuned to a specific frequency by crystal controlled oscillators. For a given station, the frequency that best suits its intended environment is, typically, designated at the time of purchase. The frequency often will remain the same during the life of the equipment, although the capability exists to change frequency by crystal replacement should circumstances dictate.

A more limited number of equipment types used in this band have the capability of operator selectable frequencies. These are predominantly intended for military tactical applications and used within the U.S. for testing, training and/or evaluation. Some, like the AN/GRC-50, have fully synthesized tuning in 1 MHz steps across the band (as well as additional bands). Other systems provide operator selection capability among three to five predetermined crystal controlled channels. Those channels may or may not be fixed at the factory. Such tuning capability can, if well controlled, be managed satisfactorily. For example, one or two of the channels may be authorized for use during peacetime. The specific channel(s) used may be varied geographically to best fit with existing spectrum usage.

Bandwidth

The bandwidth of a system is one of the key factors in evaluating the potential compatibility with other systems. The need for accurate reporting of bandwidth information in both the spectrum planning and frequency assignment processes is well recognized. The following paragraphs discuss a proposed standard approach to specifying bandwidth parameters. Three key terms that are important in considering the bandwidth associated with a particular system or station are the authorized, necessary, and occupied bandwidths which are defined in the NTIA Manual as follows:

> Authorized Bandwidth: Authorized bandwidth is, for purposes of this Manual, the necessary bandwidth (bandwidth required for transmission and reception of intelligence) and does not include allowance for transmitter drift or doppler shift.
>
> Necessary Bandwidth: For a given class of emission, the minimum value of the occupied bandwidth sufficient to ensure the transmission of information at the rate and with the quality required for the system employed, under specified conditions. Emissions useful for the good functioning of the receiving equipment as, for example, the emission corresponding to the carrier or reduced carrier systems, shall be included in the necessary bandwidth.
>
> Occupied Bandwidth: The frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission. In some cases, for example multichannel frequency-division systems, the use of 0.5 percent may lead to certain difficulties in the practical application of the definitions of occupied and necessary bandwidth. In such cases a different percentage may prove useful.

The above definitions for necessary and occupied bandwidth are identical to current definitions given in the International Radio Regulations [ITU 1979]. Authorized bandwidth is not defined internationally. The Final Acts of the 1979 WARC adopted new definitions as follows:

Necessary Bandwith: For a given class of emissions the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and quality required under specified conditions.

Occupied Bandwidth: The frequency bandwidth such that below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage B/2 of the total mean power emitted by a given emission. The percentage B/2 will be specified for each class of emission.

For multichannel telephony stations in this Fixed Service, Chapter 5 of the NTIA Manual provides clear and specific methods for calculating necessary bandwidth. However, methods for calculating necessary bandwidths for several other common signals, including frequency modulated video, telemetry, telecommand, and data, are not explicitly defined. Because of this, there exist numerous conflicting values for necessary bandwidths for these systems. For example, the necessary bandwidth for FM modulated television is often calculated using the "Carson Rule" (Keenze, 1979) according to the following formula:

$$B = 2M + 2DK$$

where

B = Necessary bandwidth
M = Maximum modulation frequency
D = Peak frequency deviation
K = Multiplying constant, usually 1

Using this equation for a typical FM video link having a 4.2 MHz maximum modulating frequency and a 4 MHz peak deviation results in calculated necessary bandwidth of 16.4 MHz. In the GMF, the stated necessary bandwidths for two identical video systems can be from 8 to 20 MHz depending on the particular method used by the submitting agency.

Receiver Standards

The standards for fixed stations cited in Part 5.10 of the NTIA Manual require certain minimum values for receiver selectivity. In particular, the -3 dB receiver bandwidth should be commensurate with the authorized emission bandwidth plus twice the frequency tolerance of the associated transmitter. Additionally, the -60 dB receiver bandwidth shall not exceed five times the -3 dB receiver bandwidth.

Frequency Diversity

Although not used extensively, frequency diversity is a technique employed to improve the reliability of a fixed microwave link under the conditions of selective fading. This diversity technique, however, consumes twice the spectrum of a non-diversity link while other forms of diversity such as space or polarization do not. Section 8.2.25 of the NTIA Manual recognizes the necessity of some form of diversity in selected cases where its use can be justified from a requirements standpoint. Additionally, a statement must be provided that an engineering evaluation has been made demonstrates that the required reliability necessitates frequency diversity.

TECHNICAL STANDARDS (1850-2200 MHz BAND)

The technical standards for transmitting and receiving equipment operating in the 1850-2200 MHz Bands are given in Section 5.10 (Spectrum Related Standards for Federal Government Fixed Service Operating within the U.S.A. Between 1710 MHz and 15.35 GHz) of Chapter 5 (Technical Standards) of the NTIA Manual, and the FCC Rules and Regulations, Part 94.

TECHNICAL STANDARDS (2200-2300 MHz BAND)

The general technical standards (which are more stringent than those specified in the ITU Radio Regulations) of Chapter 5 of the NTIA Manual contain minimum performance requirements and design objectives applicable to transmitters, receivers, and antennas used in Government radio stations. As of January 1979, stations transmitting in the 2200 to 2300 MHz band are required by Section 5.2.3 to have frequency and spurious tolerances as specified in Table 1.

New standards were adopted applicable to Government fixed systems operating between 1710 MHz and 15.35 GHz (NTIA Manual 5.10). Along with these technical standards, the Telemetry Working Group of the Range Commanders Council (RCC) has proposed a document of standards to foster the compatibility of telemetering transmitting, receiving and signal processing equipment at all the Test and Evaluation ranges under the cognizance of the RCC (Telemetry Standards, Document 106-77). This Inter-Range Instrumentation Group (IRIG) standard is used as guide by managers and users of telemetry in the 2200-2300 MHz band, at National, Service, or other DoD test ranges/facilities. These telemetry standards are intended to further the compatibility and interoperability of airborne transmitting equipment at these test ranges. To this end, the IRIG Steering Committee recommended that telemetering equipment at Government test ranges conform to these standards. The quality of terminal equipment, in general, will be raised by concentrating development on a minimum of system types. An equipment that deviates from these standards must be shown to be both technically necessary and economically feasible. To ensure that the standards remain current, the Telemetry Working Group reviews and revises them periodically.

Telemetering Frequency Plan (Section 4.3.4 NTIA Manual)

In the band 2200-2290 MHz, 90 one-megahertz narrowband channels are designated, centered on 2200.5 MHz and each one-megahertz increment thereafter, through and including 2289.5 MHz. The use of emission bandwidths greater than 1 MHz is permitted, provided the assigned frequencies are centered on the center frequencies of narrowband channels. These channels are available for: a) telemetering from space research space stations irrespective of their trajectories; and, b) aeronautical telemetering, including telemetry associated with launch vehicles, missiles, and upper atmosphere research rockets. Such use is on a coequal shared basis with fixed and mobile line-of-sight operations in the band conducted in accordance with the Government provisions of the U.S. National Table of Frequency Allocations. No provision is made in this band for the flight testing of manned aircraft. In the band 2290-2300 MHz, no specific channels have been established.

TECHNICAL STANDARDS (2300-2450 MHz BAND)

This discussion identifies technical standards and limitations on systems operating in the 2300-2450 MHz band. The primary data sources were the Manual of Regulations and Procedures for Federal Radio Frequency Management (NTIA Manual, 1982) and the FCC Rules and Regulations as contained in the Code of Federal Regulations.

The general technical standards of Chapter 5 of the NTIA Manual (1982) contain minimum performance requirements and design objectives applicable to transmitters, receivers, and antennas used in Government radio stations. As of May 1983, stations transmitting in the 2300-2450 MHz band are required by Section 5.2.3 to have frequency and spurious tolerances as specified in the NTIA Manual (Table 1).

Standards applicable to Government fixed stations operating between 1710 MHz and 15.35 GHz are contained in Part 5.10 of the NTIA Manual.

Radar Standards

The Radar Spectrum Engineering Criteria (RSEC) applies to Government radar systems. RSEC specifications are contained in Part 5.3 of the NTIA Manual (NTIA, 1980). While specific technical requirements of RSEC are omitted herein, the following list identifies the types of radar criteria that are considered:

(1) Emission bandwidth
(2) Emission levels
(3) Antenna pattern
(4) Frequency tolerance
(5) Tunability
(6) Image and spurious response rejection
(7) Local-oscillator radiation

Industrial, Scientific, and Medical (ISM) Equipment Standards

Technical standards for ISM equipment are contained in Part 7.10 of the NTIA Manual, 1980 and Part 19 of the Code of Federal Regulations (CFR, 1980). ISM is a general term referring to equipments that generate and uses RF energy for purposes other than radiocommunications. The frequency 2450 MHz with a tolerance of ± 50 MHz is designated for ISM use. There are six other frequency bands designated for ISM. Any authorized radio station operating on an ISM frequency (including tolerance) must accept any harmful interference from in-band ISM equipment. If harmful interference is caused by ISM operation to any authorized radio service outside the ISM frequency limits, then the operator of the ISM equipment must take the necessary steps to eliminate the interference. ISM standards and measurement techniques are being reviewed both in the United States and via the ITU. The FCC has a Rule Making procedure underway in Docket 20718, with two notices published and a third in the preparation stage. The following discussion identifies the requirements for the various types of ISM equipment, including miscellaneous ISM equipment, which applies to microwave ovens.

Industrial Heating Equipment. This type of equipment may be operated on any designated ISM frequency (e.g., 2450 MHz), but shall be adjusted to operate as close to that ISM frequency as practicable. Within an ISM frequency band, there is no limit on the radiated electric field although an attempt is made to keep 90 percent of the power within 70 percent of the bandwidth of ± 50 MHz. Outside of the ISM band, the average electric-field at a distance of 1.6 km (one mile) from the ISM equipment must be less than 10 μV/m at a distance of 50 ft. from the power line.

Medical Diathermy Equipment. This type of equipment may be operated on any of the designated ISM frequencies with no limit on the radiated electric field. Any harmonic or other spurious radiation outside of the ISM frequency limits shall not exceed an average electric-field of 25 μV/m at a distance of 1000 feet (305 meters).

Miscellaneous ISM Equipment. All other types of ISM equipment may be operated on the designated ISM frequencies with no limit on the in-band radiated electric field provided any harmonic or other spurious radiation outside the frequency limits is suppressed so as to not exceed:

> 25 μV/m at a distance of 1000 feet (305 meters) for less than 500 W; or, for equipment generating more than 500 watts of RF power on the fundamental frequency, 25 μV/m times the square root of P/500 at 1000 feet (305 meters) (where P is the actual RF power generated in watts), but not to exceed 10 μV/m at one mile (1.6 kilometers), provided this increase is not permitted for equipment located in a predominantly residential area and operating on a frequency below 1000 MHz.

Restricted Radiation Device Standards

Technical standards for restricted radiation devices are included in Part 7.9 of the NTIA Manual (1980) and Part 15 of the FCC Rules and Regulations (CFR, 1980). This class of devices includes field-disturbance sensors and low-power communication equipment. Non-Government users operating such devices in accordance with the standards are exempt from license requirements and Government users do not require a frequency assignment. In any case, all operations of restricted radiation devices are on a non-interference basis to authorized services.

Field Disturbance Sensors. These devices operate at 2450 MHz with a frequency tolerance of ± 15 MHz. The carrier frequency is recommended to be kept within the central 80 percent portion of the band. At 100 feet (30.5 meters), the average field strength for 2450 MHz is not to exceed 50,000 μV/m.

ITU Spurious and Frequency Tolerance Specifications

The technical standards discussed previously are national standards. These are tied to a large extent to the International or ITU standards for the spurious emission levels and frequency tolerances, as can be seen by comparing them with the current ITU Radio Regulations. The 1979 WARC, however, did make changes, and supplied extensive new tables for both frequency tolerances and spurious emissions. In addition to these tables, WARC-79 adopted the following recommendations related to this band:

Recommendation No. 66 - Relating to Studies of the Maximum Permitted Levels of Spurious Emissions - an urgent matter

Recommendation No. 69 - Relating to the Frequency Tolerances of Transmitters

Recommendation No. 3 - Relating to the Transmission of Electric Power by Radio Frequencies from a Spacecraft

Resolution No. 63 - Protection of Radiocommunication Services Against Interference Caused by Radiation from Industrial, Scientific and Medical (ISM) Equipment

ITU Interim Working Party IWP 1/4

Included among the follow-up actions of the 1979 WARC were the following two items: RR182, Section III of Chapter V entitled "Interference from Industrial, Scientific and Medical Equipment," and Resolution 63 entitled "Relating to the Protection of Radiocommunication Services against Interference Caused by Radiation from Industrial, Scientific and Medical (ISM) Equipment." As a result of these items the Interim CCIR meetings in mid 1980 established IWP 1/4, an Interim Working Party coordinating both CCIR and CCITT interests as they may relate to other international efforts such as the ICAO, IMCO, CISPR and IEC in the area of ISM. The IWP will make recommendations on limits of radiation from ISM equipment.

WARC Follow-Up Efforts

WARC and CCIR follow-up work related to this band includes the 1979 WARC specified efforts in the Solar Power System, ISM, Frequency Tolerance, Geostationary Orbit Use, Aeronautical Mobile, Spurious Emissions and Amateur Band Use during National Disasters.

TECHNICAL STANDARDS (2450-2655 MHz AND 3700-4200 MHz BAND)

The technical standards and limitations on systems operating in the non-Government 2450-2655 and 3700-4200 MHz bands are detailed in the FCC Rules and Regulations, Parts 74, 90, 94, 21, and 25. Also, the existing Government technical standards for the terrestrial services contained in the NTIA Manual are sufficient to serve as a guide for system implementation and development in these bands.

TECHNICAL STANDARDS (4400-4990 MHz BAND)

The technical standards for transmitting and receiving equipment operating in the 4400-4990 MHz Bands are given in Section 5.10 of the NTIA Manual. The present ITU Radio Regulations and the Final Acts of the WARC-79 contained no limitation on transmitter power, equivalent isotropically radiated power, and antenna orientation on the fixed and mobile stations in the 4500-4800 MHz Band. The major problem area for the United States involves the proposal to have the Fixed-Satellite Service (space-to-Earth) share the 4500-4800 MHz band with the Fixed and Mobile Services. Because of the mobility of aeronautical and transportable systems and tropospheric scatter operations, sharing with Fixed-Satellite Service may be difficult, and in some situations impractical. Hence, widespread introduction of the Space Service in this band in the United States may have significant impacts on existing and future military operations. However, at the same time, the United States has agreed to accommodate, in as far as practical, a limited implementation of the international Fixed-Satellite Service in this band in the United States. Therefore, consistent with the U.S. policy and to the extent that stations in the international Fixed-Satellite Service can coordinate sites, on a case-by-case electromagnetic compatibility analysis basis with other authorized users, the Fixed-Satellite Service can be afforded the protection of a primary service in the United States.

TECHNICAL STANDARDS (5925-7125 MHz BAND)

The technical standards and limitations on systems operating in the non-Government Bands between 5927 and 7125 MHz are given in the FCC Rules and Regulations, Parts 21, 25, 74, and 94.

The ITU Regulations specify that the standard frequency and time signal-satellite service operating Earth-to-space transmissions on 6427 MHz confine these transmissions to a bandwidth of ± 2 MHz.

TECHNICAL STANDARDS (7125-8500 MHz BAND)

The technical standards for the Government Fixed Service employing line-of-sight, point-to-point and transportable type equipments in the 7125-8500 MHz bands are given in Section 5.10 of the NTIA Manual.

TECHNICAL STANDARDS (10.55 - 13.25 GHz BAND)

The technical standards and limitations on systems operating in the non-Government bands between 10.55 and 13.25 GHz are detailed in the FCC Rules and Regulations, Parts 21, 25, 74, 78, and 94.

A recent study by Akima (1980) of Sharing of the 12.2-12.7 GHz band between the Broadcasting-Satellite and Fixed Services, indicates that interference from the Fixed Service and the Broadcasting-Satellite Service is not a negligible problem.

TECHNICAL STANDARDS (14.4 - 14.5 GHz BAND)

The technical standards and limitations on fixed and mobile systems operating in this band are given in the FCC Rules and Regulations (Part 25) for the non-Government assignments and the existing Government technical standards for terrestrial services contained in the NTIA Manual (5.10) are sufficient to serve as a guide for system implementation in the Government assignments.

TECHNICAL STANDARDS (14.5 - 15.35 GHz BAND)

The technical standards for transmitting and receiving equipment operating in the Government exclusive 14.5 to 15.35 GHz band are given in Section 5.10 of the NTIA Manual.

APPENDIX F

EXCERPT FROM FCC GENERAL DOCKET NO. 84-RM-4077
NOTICE OF PROPOSED RULE MAKING

Parts 2 and 87 of Chapter I of Title 47 of the Code of Federal Regulations are amended as follows:

A. Part 2 - Frequency Allocation and Radio Treaty Matters; General Rules and Regulations

1. In Section 2.106 Footnote US78 is revised to read as follows:

US78 The frequencies between 1435 and 1535 MHz will be assigned for the aeronautical telemetry and associated telecommand operations for flight testing of manner or unmanned aircraft and missiles, or major components thereof. Permissible usage includes telemetry associated with launching and reentry into the earth's atmosphere as well as any incidental orbiting prior to reentry of manned or unmanned objects undergoing flight tests. The following frequencies are shared with flight telemetering mobile stations: 1444.5, 1453.5, 1501.5, 1515.5, 1524.5 and 1525.5 MHz. In the band 1530-1535 MHz, the Maritime Mobile-Satellite Service will be the only primary service after January 1, 1990.

Part 87-Aviation Services

1. Section 87.5 is amended by adding after "Aeronautical telemetering mobile station" a new definition for "Aeronautical telemetering telecommand station" and after "Fixed station" a new definition for "Flight telemetering mobile station" to read as follows:

§87.5 Definition of terms.

*   *   *   *   *   *   *   *

<u>Aeronautical telemetering telecommand station</u>. A station used for the telecommand of aeronautical telemetering mobile stations.

*   *   *   *   *   *   *   *

<u>Flight telemetering mobile station</u>. A telemetering mobile station used for telemetering from a balloon; from a booster or rocket, excluding a booster or rocket in orbit about the earth or in deep space; or from an aircraft.

2. Section 87.63 is amended by adding a new paragraph (e) to read as follows:

§87.63 Power.

*   *   *   *   *   *   *   *

(e) The unmodulated carrier power at the output terminals of transmitters operating in the frequency bands 1435-1535 MHz and 2310-2390 MHz must not exceed 25 watts, peak envelope carrier power.

3. In Section 87.65 paragraph (f) is revised to read as follows:

§87.65 Frequency stability.

* * * * * * * *

(f) The carrier frequency of transmitters operating in the 1435-1535 MHz band installed before January 2, 1985, must remain within 0.003 percent of the assigned frequency. The carrier frequency of transmitters operating in the 1435-1535 MHz band installed after January 1, 1985 must remain within 0.002 percent of the assigned frequency. After January 1, 1990, the carrier frequency of transmitters operating in the 1435-1535 MHz band must remain within 0.002 percent of the assigned frequency regardless of the date of their installation. The carrier frequency of transmitters operating in the 2310-2390 MHz band must remain within 0.002 percent of the assigned frequency.

* * * * * * * *

4. In Section 87.67 footnote 8 in paragraph (b) is revised and a new paragraph (f) is added to read as follows:

§87.67 Types of emission.

* * * * * * * *

(b) * * *

The authorized bandwidth is equal to the necessary bandwidth for frequency or digital modulated transmitters used in flight test telemetering and associated flight test telecommand stations operating in the 1435-1535 MHz and 2310-2390 MHz bands. The necessary bandwidth must be computed in accordance with Part 2 of this chapter.

* * * * * * * *

(f) Emissions for assignments in the 1435-1535 MHz and 2310-2390 MHz bands will be designated according to their class and necessary bandwidth.

5. In Section 87.71 paragraphs (a), (e) and (f) are revised to read as follows:

§87.71 Emission limitations.

(a) When using transmissions other than single sideband (A3A, A3H, or 3A3J), or frequency modulation (F9) or digital modulation (F9Y) in the frequency bands 1435-1535 MHz and 2310-2390 MHz, the mean power of the emission must be attenuated below the mean output power of the transmitter as follows:

* * * * * * * *

(e)(1) When using frequency modulated transmissions (F9) or digital modulated transmissions (F9Y) for telemetry at flight test stations in the 1435-1535 MHz and 2310-2390 MHz frequency bands with an authorized bandwidth equal to or less than 1 MHz:

* * * * * * * *

(f)(1) When using frequency modulated transmissions (F9) or digital modulated transmissions (F9Y) for telemetry at flight test stations in the 1435-1535 MHz and 2310-2390 MHz frequency bands with an authorized bandwidth greater than 1 MHz:

* * * * * * * *

6. In Section 87.331 paragraphs (e) and (g) are revised, paragraph (f) is redesignated (h), and a new paragraph (f) is added to read as follows:

§87.331 Frequencies available.

* * * * * * * *

(e) The frequencies between 1435-1535 MHz and 2310-2390 MHz will be assigned primarily for telemetry associated with the flight test of manned or unmanned aircraft and missiles or major components thereof. Permissible uses include telemetry associated with the launching and reenetry into the earth's atmosphere as well as any incidental orbiting prior to reentry of manned or unmanned objects undergoing flight tests and related telecommand transmissions. The Maritime Mobile Satellite Service will be the only primary service in the 1530-1535 MHz band after January 1, 1990.

(f) Aeronautical telemetry mobile stations operating in the bands 1435-1535 MHz and 2310-2390 MHz will normally be authorized channel bandwidths of 1, 3, or 5 MHz. Applications for channels with greater bandwidths will be considered in accordance with the provisions of §87.67(e). Each channel assignment will be centered on frequencies at standard intervals of 1 MHz, beginning at 1435.5 MHz in the 1435-1535 MHz band and 2310.5 MHz in the 2310-2390 MHz band.

(g) The frequencies 1444.5, 1453.5, 1501.5, 1515.5, 1524.5 and 1525.5 MHz are shared with flight telemetering mobile stations. Stations operating on these frequencies are limited to an authorized bandwidth of 1 MHz.

* * * * * * * *

7. In Section 87.334 paragraphs (a)(1), (a)(2) and (c)(1) are revised to read as follows:

§87.334 Frequency coordination.

(a) * * *

(1) A report based on a field study, indicating the degree of probable interference to existing stations operating in the same area. The applicant must consider all stations operating on frequency or frequencies requested or assigned within 200 miles of the proposed area of operation.

(2) A written statement must be included with the report verifying that a notice of intention to file such application has been provided to all existing licensees within the frequency and mileage limits contained in paragraph (a)(1) of this section. The notice of intention to file must contain the following information: the frequency and emission description; power and area of operation of transmitter; gain and description of antenna system; and altitude of proposed operation. Copies of the written statement and notice of intention to file must also be provided to the frequency advisory committee as defined in paragraph (c)(2) of this section.

* * * * * * * *

(c)(1) In lieu of the report and written statement required by paragraphs (a)(1) and (2) of this section, a statement from a frequency advisory committee may be submitted. Taking into account the frequency or frequencies requested or the proposed changes in the authorized station the committee shall forecast the probable interference of the proposal to existing stations. The committee shall consider all stations operating on the frequency or frequencies requested or assigned within 200 miles of the proposed area of operation. The committee shall coordinate in writing all requests for frequencies or proposed operating changes in the 1435-1535 MHz and 2310-2390 MHz bands with the responsible Department of Defense Area Frequency Coordinator. The committee shall recommend a frequency or frequencies which will result in the least amount of interference to proposed and existing stations. The committee may comment on the technical factors and recommend conditions or restrictions to prevent interference.

* * * * * * * *

8. New Section 87.338 is added to read as follows:

§87.338 Telecommand operations.

(a) Telecommand of flight test vehicles will be authorized in the 1435-1535 MHz and 2310-2390 MHz bands but only for transmissions that are directly associated with the support of the telemetering functions of the specific flight vehicle being tested.

(b) Telecommand systems are limited to an authorized bandwidth of 1 MHz and must use antennas having a half power beamwidth of no more than 8° and a front-to-back ratio of at least 20 dB.

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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 of the bands containing Fixed and Mobile Services in the 947 MHz to 17.7 GHz portion of the radio frequency spectrum. Included is information of rules and regulations, allocations, technical standards, frequency assignments, and major system characteristics. The possibility of increased sharing between Government agencies and between Government and non-Government entities is considered for the various bands. Conclusions are drawn and recommendations made on sharing potential based on current usage data. This is a Phase I Report; A Phase II Report will include actual system and equipment counts and projected future use by the various Government agencies who presently have, or plan, future services in these bands.

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

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