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Current Activities in Small Earth Terminal Satellite Domestic Telecommunications

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CURRENT ACTIVITIES IN SMALL EARTH TERMINAL SATELLITE DOMESTIC TELECOMMUNICATIONS

Paul I. Wells*

This report discusses the recent, current, and planned activities in domestic satellite communications in the United States. The present satellites in the domestic satellite service are discussed and the general technical characteristics are presented. Several uses of earth stations operating in the domestic satellite service are discussed, with particular attention given to the effect the Federal Communications Commission has had on the growth in numbers of earth stations. In conjunction with small earth stations, the impact of the antenna size and preamplifier noise temperature on overall earth station cost was studied.

A summary of current activities on the Federal Communication Commission Docket No. 20271, the preparation for the 1979 General World Administrative Radio Conference is presented. Particular attention was given to FIXED-SATELLITE and BROADCASTING-SATELLITE service applications in the frequency bands between 2.5 GHz and 50 GHz.

Finally, tariff cost information for domestic satellite and terrestrial telecommunications services is presented. Telecommunication services tariffs on file with the Federal Communications Commission were used in this report.

Key words: domestic satellite communications; low-noise amplifiers; satellite communications; small earth stations; 1979 World Administrative Radio Conference

1. INTRODUCTION

The initiation and growth of communications satellite systems has been one of the primary beneficial spin-offs of the United States (U.S.) space program. Though the earliest communications

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satellites were low-orbit spacecraft, satellite communications as we know it today were initiated with the launch of the first geosynchronous spacecraft, the SYNCOM satellite, in 1963.

The early utilization of satellite communications was in international telecommunications. The first domestic use of satellite communications in the Western Hemisphere was by Canada, with the launch of the first ANIK satellite in 1972. Following this, the U.S. domestic satellite communications was initiated in 1973 with the lease of transponder space on the ANIK satellite by RCA Global Communications, Inc., and RCA Alaska Communications, Inc., for communications between Alaska and the U.S. west coast.

From this small beginning, there has been a steady growth of the U.S. domestic satellite communications industry. The early rate of growth was quite slow, but has shown a very significant acceleration in the past year.

The development of the U.S. domestic satellite communications systems is discussed in this report, including the presentation of the general technical characteristics of the satellite communications subsystem and of typical earth terminal systems; the presentation of a data base of earth stations licensed by the Federal Communications Commission (FCC) and discussion of earth station applications; and presentation of tariff information on satellite and terrestrial private line costs.

2. DOMESTIC SATELLITES - PRESENT AND PLANNED

The operational use of communications satellites in the United States for domestic telecommunications was initiated in 1973 by RCA Global Communications, Inc. on a link between the west coast and Alaska using a leased transponder on the Canadian ANIK satellite. This arrangement continued until the first U.S. domestic satellite was launched by Western Union in 1974. Following the launch of the Western Union WESTAR satellite, RCA was required by the Federal Communication Commission (FCC) to transfer its operational use to the WESTAR satellite. The RCA Corporation placed its first satellite, SATCOM, in orbit in 1975, which now provides the transponder space required for the west coast to Alaska telecommunications.

After a slow start, the domestic satellite communications capacity has grown rapidly. There are now six U.S. domestic communications satellites in orbit. These satellites are listed in Table 2.1, showing the satellite, the corporate owner, the launch date and the longitudinal position in the geostationary orbit.

Table 2.1. U.S. Domestic Satellites, 4/6 GHz

Owner	Satellite	Launch Date	Longitude
Western Union	WESTAR-1 WESTAR-2	April 1974 October 1974	99°W 123.5°W
RCA American Communications, Inc.	SATCOM-1 SATCOM-2	December 1975 March 1976	119°W 135°W
Comsat General Corp.*	COMSTAR-1 COMSTAR-2	May 1976 July 1976	128°W 95°W

Though the three communication satellite operators all provide U.S. domestic services, there are some differences in the authority granted by the FCC. The Western Union WESTAR satellites are authorized to provide service to the 48 contiguous states, plus Hawaii and Puerto Rico. The RCA SATCOM satellites are authorized to provide service to all 50 states, plus Puerto Rico. Both RCA and Western Union can provide private line common carrier service to all areas they serve. Also, both can lease transponder space to other common carriers, to private users, or to network users for television or audio program distribution. The RCA provides private line and dial service within Alaska and between Alaska and the rest of the United States. The Comsat COMSTAR satellites are authorized to provide service to the

*Comsat General Corporation is a common carrier's common carrier, providing the space segment for the telephone common carriers, AT&T and GTE, who provide their own earth stations.

contiguous 48 states only. Comsat is authorized to provide service only to domestic common carriers, American Telephone and Telegraph (AT&T) and General Telephone and Electric (GTE). For the initial period of operation through 1979, AT&T and GTE are limited to providing message service to the general public and the government, and private line service to the government only.

In addition to the commercial domestic satellites, there are two experimental satellites in current use. These are the Applications Technology Satellite number 6 (ATS-6) and the joint Canadian - U.S. Communications Technology Satellite (CTS). Although these two experimental satellites have an important role in the development and growth of communications satellites, they will not be treated in any detail in this report.

The orbital locations of the U.S. domestic satellites (including ATS-6 and CTS) are shown in Figure 2.1.

Second generation domestic satellite communications systems are now being planned by several companies. The Satellite Business Systems (SBS) recently awarded a contract for construction of three satellites. These satellites are designed for all-digital operation and will operate in the 12/14 GHz frequency band. The current SBS plan calls for launch of the first two satellites in the second half of 1980 and for initiation of operational service by January 1, 1981 (Electronic News, 1977b).

Western Union has been contracted by the National Aeronautics and Space Administration (NASA) to provide the spacecraft and system operation of the Tracking and Data Relay Satellite System (TDRSS). This system will have operational capability in the 12/14 GHz frequency band. Though the first two satellites will be dedicated to the NASA mission, Western Union has plans for a third satellite which would be available for domestic service in the 12/14 GHz band. These satellites are expected to be launched in the early 1980's.

RCA Americom is seeking permission from the FCC to make its next satellite, SATCOM-3, a hybrid system with operation in both the 4/6 GHz and 12/14 GHz frequency bands (Electronic News, 1977a).

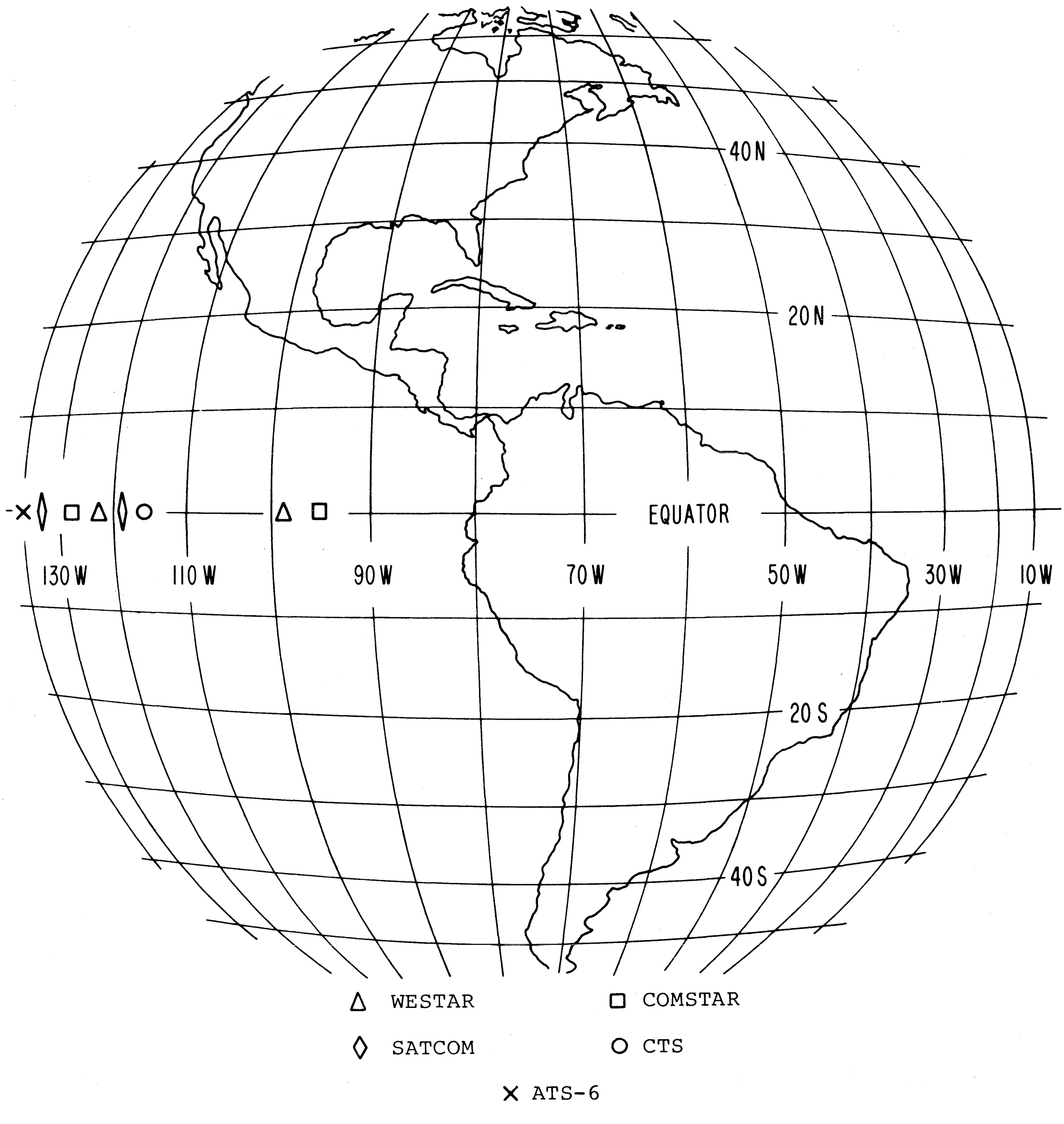

Figure 2.1. This map shows the orbital location of the U.S. domestic communications satellites.

However, RCA does not plan to launch its third satellite until present capacity is utilized, which is not expected before 1979.

2.1. Domestic Satellite Technical Characteristics

The present generation of domestic communications satellites all operate in the 4/6 GHz frequency bands. The specific frequencies are 5.925 GHz to 6.425 GHz for the earth-to-space link and 3.7 GHz to 4.2 GHz for the space-to-earth link. As discussed earlier, there are six domestic operational satellites in geosynchronous orbit. The technical parameters of these satellites are discussed in the following paragraphs.

2.1.1. Western Union WESTAR Satellite

The WESTAR is a spin-stabilized satellite with the solar power array on the cylindrical body. The antenna, which is mechanically despun, has a 1.52 m parabolic reflector with multiple feed horns to provide a shaped beam for continental U.S. (CONUS) coverage.

A summary of the general characteristics of the communications subsystem is presented in Table 2.2.

The solar array provides about 300 watts of DC power at the beginning of life of the spacecraft. The backup power is provided by nickel-cadmium batteries that provide adequate power for 10 transponder channels during the solar eclipse. The spacecraft has a design life of seven years. The transponder configuration consists of a wideband receiver and single conversion down-converter driving a channelized transmitter.

2.1.2. RCA Americom SATCOM Satellite

The SATCOM is a three-axis stabilized spacecraft with the solar-power array on deployable paddles, which are sun oriented. The spacecraft has 24 transponder channels, each with a usable bandwidth of 34 MHz. The 24 channels are in two groups of 12 channels each, with the two groups connected to cross-polarized antennas.

The general characteristics of the SATCOM spacecraft communications subsystem are presented in Table 2.3. The spacecraft

Table 2.2. Summary of the Characteristics of WESTAR Communications Subsystem

Antenna	1.52 m parabola with multiple feeds
Beamwidth	$6.8^{\circ} \times 3.5^{\circ}$ CONUS 2-8° Hawaii and Alaska
Polarization	Linear (single polarization)
Cross-polarization Isolation	Not Applicable
Receiver G/T	-7 dB/K CONUS -14 dB/K Alaska and Hawaii
Transmitter	12 channels
Power	5 watts each channel (approximate)
EIRP	33 dBw CONUS 26 dBw Alaska and Hawaii
Bandwidth	36 MHz

Table 2.3. Summary of the Characteristics of SATCOM Communications Subsystem

Antennas	4 polarization-gridded rectangular parabolic reflectors with overlap and offset multiple feeds
Beamwidth	$8.4^{\circ} \times 3.2^{\circ}$ CONUS and Alaska $2.6^{\circ} \times 1^{\circ}$ Hawaii
Polarization	Cross-polarized, horizontal and vertical
Cross-polarization Isolation	33 dB
Receiver G/T	-7 dB/K CONUS and Alaska -10 dB/K Hawaii
Transmitter	12 channels vertically polarized 12 channels horizontally polarized
Power	5 watts each channel (approximate)
EIRP	32 dBw CONUS and Alaska 26 dBw Alaska
Bandwidth	34 MHz

communications antenna assembly consists of four gridded rectangular parabolic reflectors, with some mechanical overlap, and offset multiple feeds to provide an elliptical pattern. The overlap is possible because the horizontally gridded reflector is transparent to the vertically polarized signal.

The spacecraft has two wideband receivers, each with a single conversion down-converter driving 12 channelized transmitters.

2.1.3. Comsat General COMSTAR Satellite

The COMSTAR spacecraft (Abutaleb, et al., 1977) is a spin-stabilized satellite which is similar to the Intelsat IV. The solar-power array, which is on the cylindrical body of the spacecraft, has a beginning-of-life power output of 760 watts and has a design life of seven years. The spacecraft has 24 transponder channels, each with a usable bandwidth of 34 MHz. The 24 channels are in two groups of 12 channels each, with the two groups connected to orthogonally polarized antennas. The general characteristics of the COMSTAR spacecraft communications subsystem are presented in Table 2.4. The spacecraft communications antenna assembly consists of two orthogonally polarized parabolic reflector antennas, with offset multiple feeds to produce shaped spot beams. Polarization screens made of horizontally and vertically strung parallel conductive strips for vertical and horizontal polarization, respectively, are mounted in front of the reflectors to improve the cross-polarization isolation.

The spacecraft has two wideband receivers, each with a single conversion down-converter driving 12 channelized transmitters. Each group of twelve transmitter channels is further subdivided, and switchable, for flexibility in affecting communications between earth stations in CONUS, Alaska, Hawaii, and Puerto Rico. The spacecraft transponders can be switched (from ground control) to the various antenna feed horns to provide the transponder distribution shown in Table 2.5.

Table 2.4. Summary of the Characteristics of COMSTAR Communications Subsystem

Antennas	2-1.27 x 2.78 m rectangular parabolic reflectors with orthogonal polarization and offset multiple feeds
Beamwidths	$7^{\circ} \times 3.2^{\circ}$ CONUS $4^{\circ} \times 2^{\circ}$ Alaska $3^{\circ} \times 3^{\circ}$ Hawaii and Puerto Rico
Polarization	Cross-polarized, horizontal and vertical
Cross-polarization Isolation	33 dB
Receiver G/T	-9 dB/K
Transmitter	12 channels vertically polarized 12 channels horizontally polarized
Power	5 watts each channel (approximate)
EIRP	33 dBw CONUS, Hawaii, Alaska and Puerto Rico 31 dBw Combined coverage of CONUS Alaska
Bandwidth	34 MHz

Table 2.5. COMSTAR Transponder Distribution

Satellite Receive	12 CONUS and Alaska 12 CONUS, Hawaii, and Puerto Rico
Satellite Transmit	6-24 CONUS ≤6 Alaska or CONUS/Alaska Combined ≤6 Hawaii ≤6 Puerto Rico

2.1.4. Satellite Business Systems Spacecraft

As indicated earlier, the Satellite Business Systems (SBS) recently contracted for three spacecraft, the first two to be delivered in 1980. The SBS system will operate in the 12/14 GHz frequency bands. The specific frequencies are: uplink 14.0 to 14.5 GHz and downlink 11.7 to 12.2 GHz. SBS will be the first domestic communications satellite system to operate in this band. The SBS system will utilize digital modulation and time division multiple access techniques with demand assignment.

The SBS spacecraft will be a spin-stabilized satellite with the solar-power array on the cylindrical body. The batteries for backup power are expected to be adequate for 50% communications capability during eclipse. The spacecraft will have eight transponder channels, each with a usable bandwidth of 54 MHz. The communications system is designed with 100% redundance for all elements except the output TWT amplifiers which have 50% redundancy. The spacecraft antenna assembly is a parabolic reflector with offset feeds to provide CONUS coverage. The antenna provides a nonuniform coverage of the continental U.S., with approximately 4 dB higher gain in the eastern coastal states, "region 1." The balance of the CONUS is designated as "region 2." The antenna polarization is linear with horizontal polarization for transmit and vertical polarization for receive.

The general characteristics of the SBS spacecraft communications subsystem are presented in Table 2.6.

2.2. Domestic Satellite Channel Capacity

The current generation of domestic satellites all utilize frequency division multiple access (FDMA) to provide communications service to multiple users. The total bandwidth allocated to domestic satellites is 500 MHz. This band is subdivided into 12 channels, providing the first step of frequency division. As described in Section 2.1, each channel has an RF bandwidth of either 34 MHz or 36 MHz. Each channel can carry one channel of TV, with video and voice, or multiple one-way voice circuits.

Table 2.6. Summary of the Characteristics of the SBS Communications Subsystem

	Region 1	Region 2
EIRP	42 dBw	38 dBw
Receiver G/T	-2 dB/K	-6 dB/K
Antenna	Parabolic reflector with offset feeds for CONUS coverage, 4 dB higher gain in east coast region.	
Transmitter	8 channels, horizontally polarized	
Power	20 watts per channel	
Bandwidth	54 MHz	

If all channels on the six domestic satellites were used for TV, 120 TV programs could be transmitted simultaneously. The use of satellites for television program distribution will be discussed further in Section 3.

The maximum one-way voice circuit capacity for a satellite transponder is 1200 voice circuits. This number is based on single carrier per transponder operation using FM/FDM, saturated TWT operation, and using large earth stations (antenna ≥15 meters and low-noise receiver front end). Thus, the launch of the first WESTAR provided a capacity of 14,400 one-way voice circuits. The growth of the voice circuit satellite capacity is shown in Figure 2.2. The current capacity is 144,000 one-way voice circuits. This number is greater than the total coast-to-coast one-way voice circuit capacity of the present terrestrial telephone network, including both the general common carriers and specialized common carriers.

Considering that this growth occurred in a period of two years, it is not surprising that the satellite transponder capacity is not yet fully utilized.

2.3. Multiple Access in Satellite Communications

With the increasing demand on the available frequency spectrum, there is increased emphasis on the use of multiple

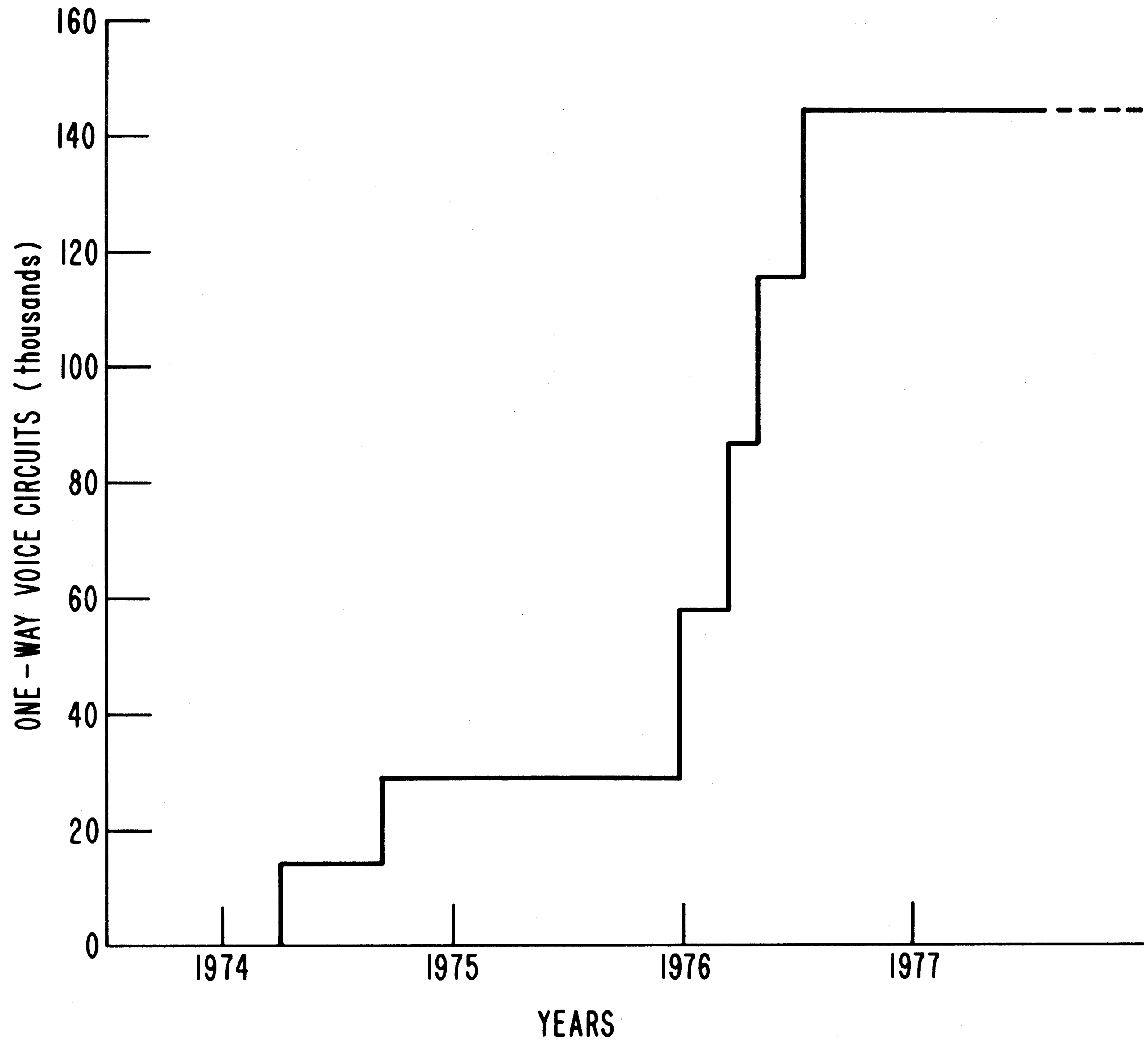

Figure 2.2. Growth of the domestic satellite capacity for one-way voice circuits.

access techniques to provide a greater degree of frequency reuse. We will consider here four general multiple access categories which are readily applicable to satellite communications. These are:

1. Space Division Multiple Access (SDMA);
2. Frequency Division Multiple Access (FDMA);
3. Time Division Multiple Access (TDMA); and
4. Code Division Multiple Access (CDMA).

Frequency division multiple access is a method of providing multiple access to a communications satellite in which the transmissions from a particular earth station occupy a particular assigned frequency band within the bandwidth of a transponder. In the satellite, the signals from several simultaneous earth stations are amplified in the same transponder.

Both SDMA and FDMA are used in the present domestic satellite systems. In the application of FDMA, there are several levels of frequency division. For example, the 500 MHz bandwidth is divided into 12 channels. Each channel can be used independently by a different user. Also, the 36 MHz bandwidth of a transponder can be subdivided to provide frequency division multiple access of the individual transponders. A disadvantage of using FDMA on a satellite transponder is that the capacity of the transponder is greatly reduced due to the required spacing (or guard-band) between channels. On a transponder which has a capacity of 1200 one-way voice circuits with a single carrier per transponder, the transponder capacity would reduce to less than half that with a single voice circuit per carrier. An FDMA system can operate either on a preassigned basis, where the channel access is assigned on a prearranged schedule, or on a demand-assigned basis, where the channel access is assigned in a dynamic sense in response to a request. The present systems use the preassigned FDMA.

The application of SDMA is in the geographical separation of earth terminals and the use of large, narrowbeam antennas, and in the orbit separation of the several satellites in the geostationary orbit.

Time division multiple access (TDMA) is a technique whereby earth stations communicate with each other on the basis of non-overlapping time sequenced bursts of transmission through a common satellite transponder. As with FDMA, there are several techniques for implementing TDMA in a satellite communication system. Time slot assignments can be as short as the time for one information bit, or longer as for a word or group of words. In a satellite communication system where the transmission time delay is quite significant, the assignment of time segments that allow transmission bursts of characters appears to be more practical. Though TDMA is not yet in general use in commercial satellite communications, there has been experimental use of TDMA. The SBS is currently leasing transponder space to test digital communication and TDMA techniques which are planned for their future system. The SBS satellite system which is planned for the early 1980's will use digital modulation with time division multiple access, exclusively.

Code division multiple access (CDMA) is a technique whereby earth stations communicate with each other using orthogonal code sets transmitted through a common satellite transponder. A CDMA system would utilize a spread-spectrum modulation technique. The CDMA technique has had some limited use in military systems, deep-space communications and data collection from remote sensors.

3. DOMESTIC EARTH STATIONS - PRESENT AND PLANNED

In a satellite communication system, the earth station is the equipment system (antenna, transmitter, receiver, etc.) which provides connection to the satellite and to the terrestrial interface with the end user. The interface with the end user can be direct (as in the case of an on-premise earth station), connection via a dedicated terrestrial link, or connection via a common-carrier terrestrial link. In this section, the various types of earth station systems and their general technical characteristics and costs will be discussed.

3.1. Domestic Earth Station Applications

The application or use of the domestic satellite communications system usually falls into two general categories: (1) point-to-point communications and (2) point-to-multipoint communications.

3.1.1. Point-to-point Communication Services

Within the general class of point-to-point communication services, the applications and services provided are quite varied. For example, the Comsat COMSTAR satellites are used by AT&T and GTE to expand and extend their message telephone service to the general public, and message telephone service and private line service to Government agencies. (The message telephone service is the standard long-distance telephone service and other measured use services.) The AT&T has general-use earth terminals at New York, NY; Atlanta, GA; Chicago, IL; and San Francisco, CA; while GTE has earth terminals at Tampa, FL; Los Angeles, CA; and Oahu, HI. The AT&T and GTE are presently restricted from offering commercial private line services to the general public. RCA Alaska Communications, Inc., provides a similar message telephone service in the State of Alaska using leased transponder space on RCA Americom satellites.

Private line point-to-point services are provided by several companies. These include the primary satellite owners, Western Union and RCA American Communications, and the other common carriers, such as American Satellite Corp. and Southern Pacific Communications Company. These other common carriers lease transponder space from other carriers and then lease communication channels to customers. The types of private-line point-to-point services provided to customers include voice, data, facsimile and video.

3.1.2. Point-to-Multipoint Communications Services

A point-to-multipoint satellite service is one where a message is transmitted from one earth station for reception and use by two or more end users. The number of end users can be few or a great many. In some instances, the uplink facility of a common carrier is used for the message origination; while in other instances, the message originator leases transponder space and provides his own uplink facility.

Some specific examples of point-to-multipoint satellite services are:

A. The Dow-Jones Corporation, which publishes the Wall Street Journal, has a plant facility in New England where the Wall Street Journal is compiled. It is then transmitted via satellite using high-resolution facsimile to printing plants in various parts of the U.S. The satellite communication service is provided by American Satellite Corporation.

B. The Home Box Office Company (an originator of home entertainment programming including movies and sporting events) distributes TV programming to over 130 earth stations owned by pay-TV operators. The uplink is via facilities of RCA Americom.

C. The Southern Satellite Service, which has its own uplink earth station, distributes TV programing from TV station WTCG in Atlanta, GA, to over 150 CATV-owned receive-only earth stations. Southern Satellite Service leases transponder space from RCA Americom.

D. During 1978, the Public Broadcasting Service of the Corporation for Public Broadcasting (CPB) will be transferring its TV network from the present terrestrial common-carrier network to a satellite network. The phaseover is scheduled to start in March 1978 and to be completed by the end of 1978. The CPB will own and operate the earth station facilities and will lease transponders from Western Union.

The above cited examples of point-to-multipoint satellite service are representative of a number of such services now in operation. Also, many additional systems are in the active planning stage.

3.2. Domestic Earth Station Facilities

The first earth stations constructed and placed into service in the domestic satellite service were the large, high capacity stations operated by the satellite common-carrier companies. These earth stations used large antennas which were typically 15 to 30 meters in diameter. The communications services provided by these early earth stations were the point-to-point class of telecommunications discussed earlier in this section. Earth stations of this type cost several hundred thousand dollars each. The high cost of earth stations of this type places a strong economic restraint on the number of such stations that can be built.

The first application of domestic satellites to the distribution of TV programing was by Home Box Office. Their first program was broadcast on September 3, 1975, with two earth stations receiving the program. Two years later in September 1977, there were 131 earth stations receiving Home Box Office TV programing. This is a good indication of the recent rapid growth in the number of earth terminals.

An initial guideline used by the FCC in considering applications for earth stations suggested the minimum diameter for an earth station antenna should be 9 meters. This was not a fixed rule, but rather, it was considered a minimum recommended size to insure flexibility of system design in the early development of domestic satellite systems. However, the 9-m size has always been considered by the FCC to be a comparability standard rather than an absolute size limitation.

In October 1975 the American Broadcasting Companies, Inc., (ABC) petitioned the FCC (RM-2614) to institute rule making proceeding to establish a basic overall design for the development of the domestic satellite service. As a part of the arguments supporting their petition, "ABC asked that the 4/6 GHz bands be reserved for domestic satellite services utilizing only large, high-gain antennas 9 meters or larger, with all other services assigned to the 12/14 GHz band" (FCC, 1976b).

In June 1976, the Community Antenna Television Association (CATA) filed with the FCC a petition for rule making or for declaratory ruling to permit the authorization of receive-only small earth station antenna (RM-2725). In the proceedings which followed, the CATA and others filed comments and technical data supporting the technical feasibility of using antennas as small as 4.5 meters with receive-only earth stations for receiving TV programing for the use of CATV systems.

The FCC combined these two petitions under one rule-making proceeding and adopted a Declaratory Ruling and Order on December 15, 1976, which states in part:

> "70. IT IS FURTHER ORDERED that applications filed by cable television operators proposing the use of 4.5 meter or larger antennas within the 48 contiguous states for reception of television programing material distributed by domestic satellites will be routinely processed in the future in accordance with the conditions set forth above." (FCC, 1976b)

An appendix to the ruling and order provides a "Technical analysis of small receive-only antennas for use by cable television systems within the 48 contiguous states."

This Declaratory Ruling and Order by the FCC has provided a strong impetus to the growth in the number of earth terminals being built. Prior to early 1977, all receive-only earth stations had approximately 10-meter antennas and typically cost between $100,000 and $150,000. A review of domestic earth station applications filed with the FCC in 1977 shows that most CATV operators are requesting small earth station antennas, 4.5 to 6 meters in diameter. Aside from any antenna size limits set by the FCC, the CATV and TV station operators must also meet the minimum picture quality guidelines of other parts of the FCC Rules and Regulations. In some instances, this requires an earth station antenna larger than the minimum size (Akima, 1978).

A review of recent domestic earth station applications filed with the FCC show that station construction costs generally range between $25,000 and $70,000. These figures include the cost of the communication equipment, cost of installation, cost of required building or equipment shelter and cost of any required terrestrial link to the TV transmitter or CATV head-end facility.

The growth in the numbers of domestic earth stations has been quite high during the past year. By the end of October 1977, the number of construction permits or licenses to operate had increased to 419 stations. A listing of these stations is presented in the appendix to this report. The recent high rate of growth in the number of domestic earth stations is apparent in the maps presented in Figures 3.1 through 3.4. Figures 3.1 and 3.2 show the domestic earth stations in Alaska in December 1976 and October 1977, respectively. While Figures 3.3 and 3.4 show the domestic earth stations in the contiguous 48 states as of those same dates.

3.3. Domestic Earth Station Equipment Costs

In this section, some of the cost factors affecting the total cost of an earth station will be discussed. A block diagram showing the major equipment components of a receive-only earth station is shown in Figure 3.5. Two items of equipment in the diagram account for most of the cost of the earth station; these are the antenna and the low-noise amplifier (LNA). These two items will account for 80% to 90% of the total equipment costs.

A survey was taken of several of the major manufacturers of antennas and LNA's for satellite earth stations. Cost data were collected for antennas ranging in size from 2 meters to

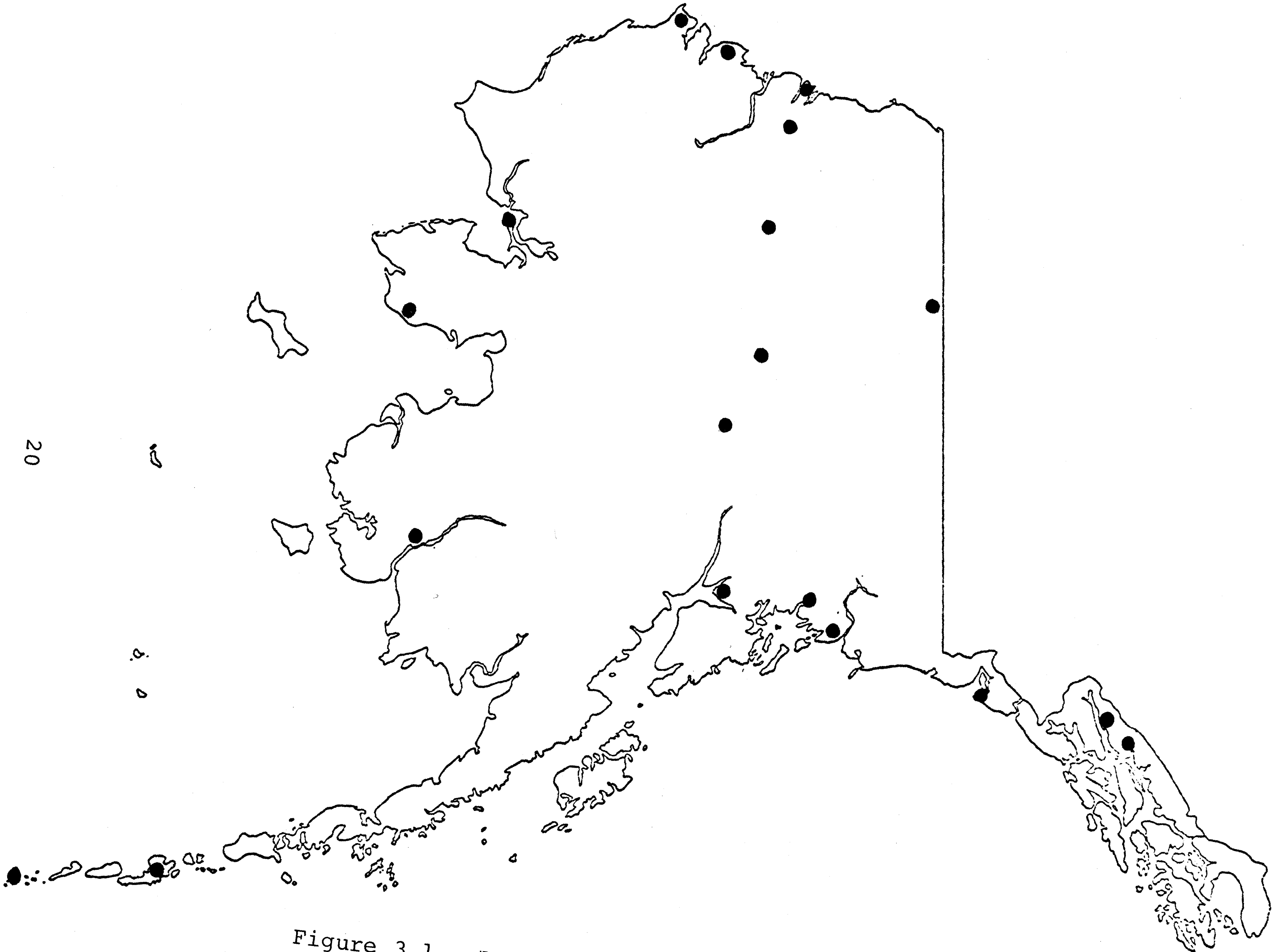

Figure 3.1. Domestic earth stations in Alaska, December 1976.

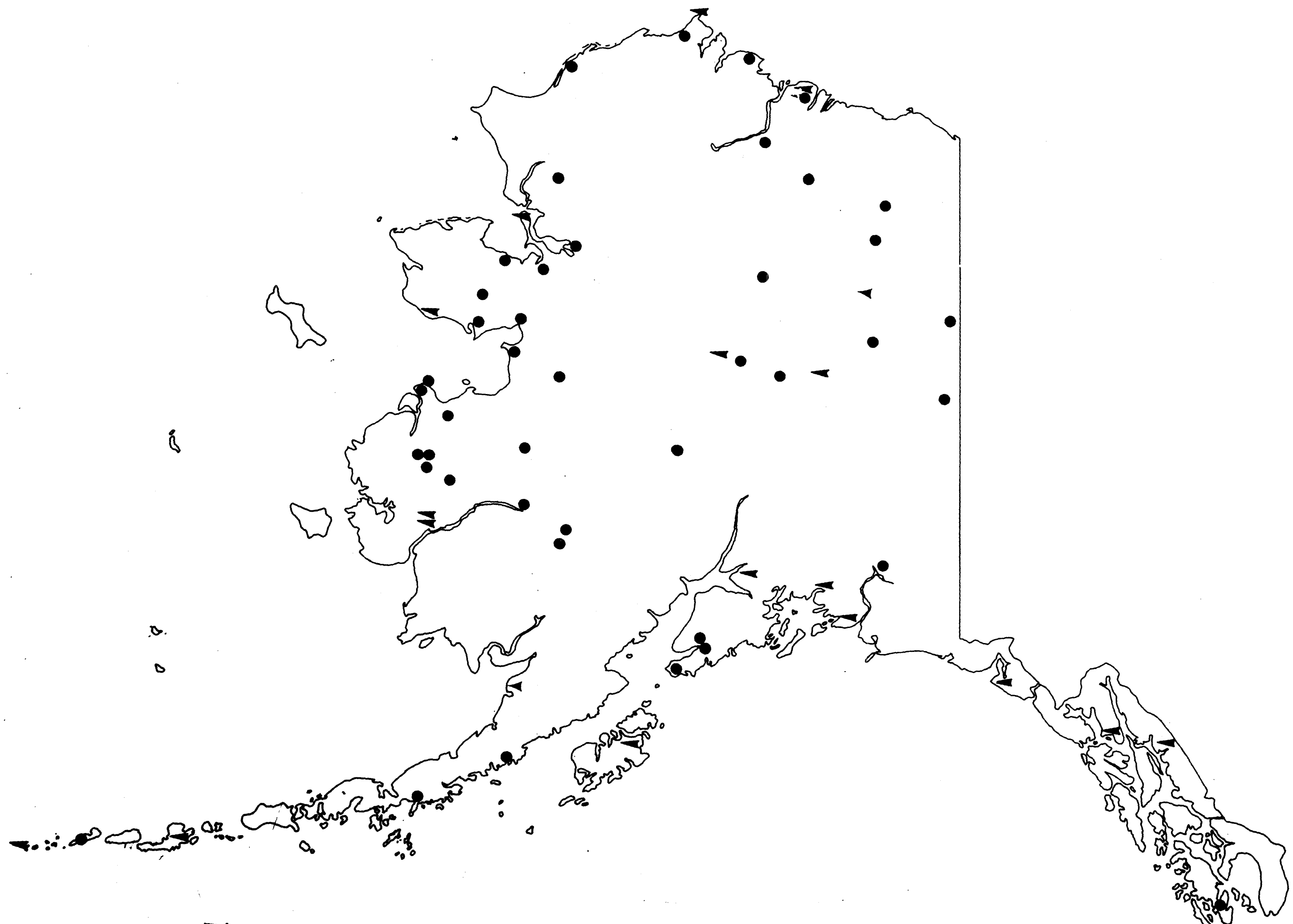

Figure 3.2. Domestic earth stations in Alaska, October 1977.

Figure 3.3. Domestic earth stations in the 48 contiguous states, December 1976.

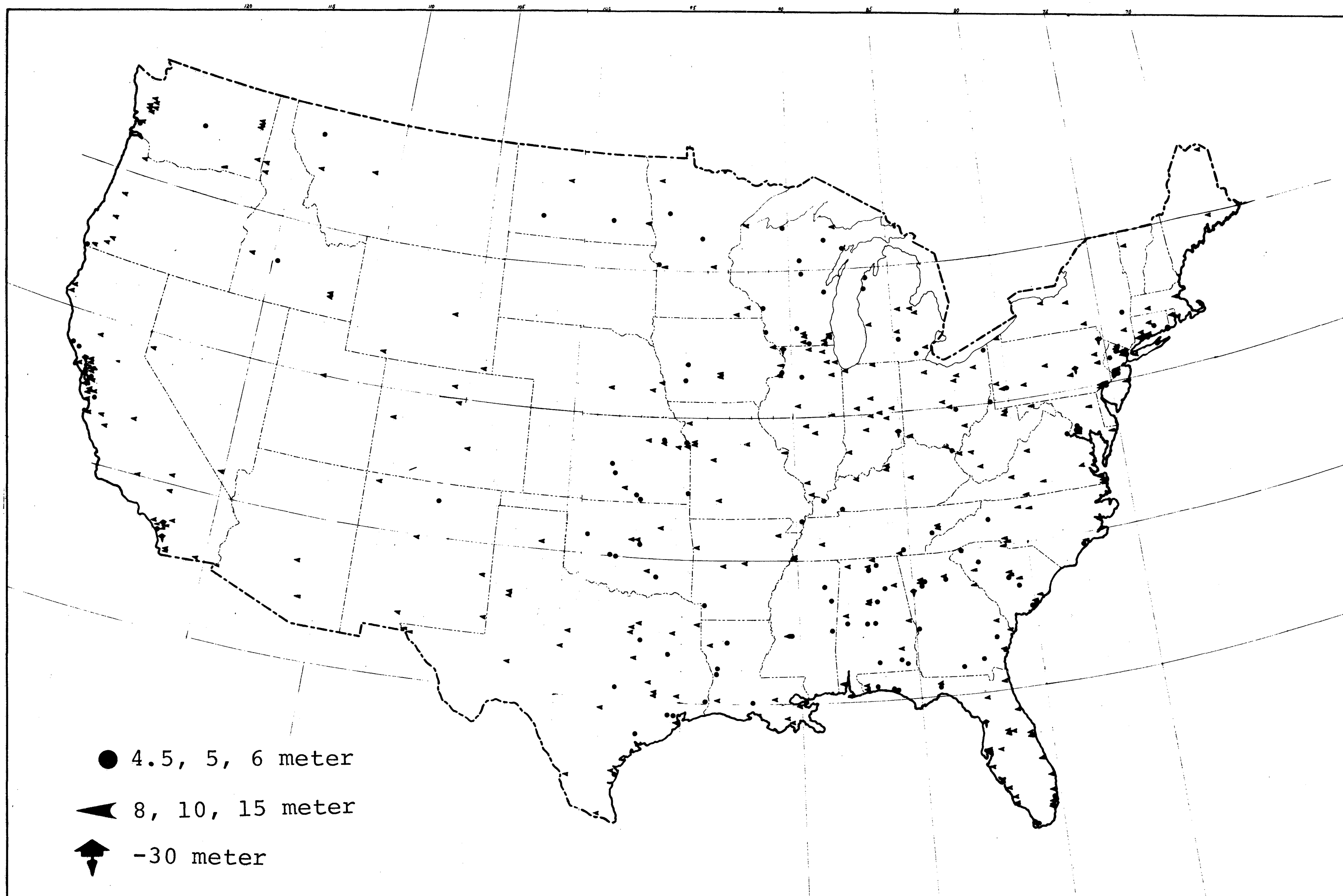

Figure 3.4. Domestic earth stations in the 48 contiguous states, October 1977.

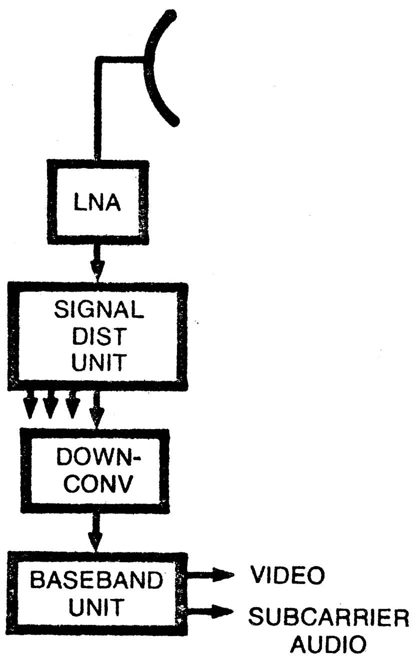

Figure 3.5. Block diagram of receive-only equipment for TV reception.

10 meters in diameter. An antenna larger than 15 meters has such a narrow beamwidth that a steerable antenna mount with automatic tracking capability is required to track the small daily movements of the satellite. The addition of the automatic tracking capability causes a major increase in the antenna cost. The antenna cost data that were collected during the survey are plotted with a smooth eyeball-fit curve in Figure 3.6. These data show clearly the importance of the FCC Declaratory Rulemaking and Order allowing earth-station antennas as small as 4.5 meters. The possible savings in the cost of the antenna is fivefold, from about $50,000 for a 10-meter antenna to about $10,000 for a 4.5-meter antenna. In addition, other advantages accrue. For example, the foundation and site preparation costs are reduced; and, with the lower overall height of the smaller antenna, more effective use can be made of terrain features to shield the antenna from radio interference from terrestrial microwave relay systems which share the same frequency band. It should be noted in Figure 3.6 that the datum points marked by a circle are for antennas for the combined transmit/receive application. The increase in cost is due to the more complex antenna feed system required for the combined function.

The data collected during the cost survey on 4-GHz low-noise amplifiers are presented in Figure 3.7. In the figure, the dollar cost of the LNA is plotted versus the amplifier input noise temperature. The noise temperature of the LNA is the most important parameter; however, the survey showed that LNA's with the same noise temperature may have a different gain. The data collected indicate that the LNA gain ranges from about 25 dB to more than 40 dB, and LNA's with higher gain are also higher in cost. The data plotted in Figure 3.7 include only LNA's which have a gain in the range between 25 and 32 dB. This was done to remove from the data presented the effect of the cost-differential of LNA's with higher gain.

It is noted in Figure 3.7 that there is a sharp break in the cost/noise-temperature function at a noise temperature of

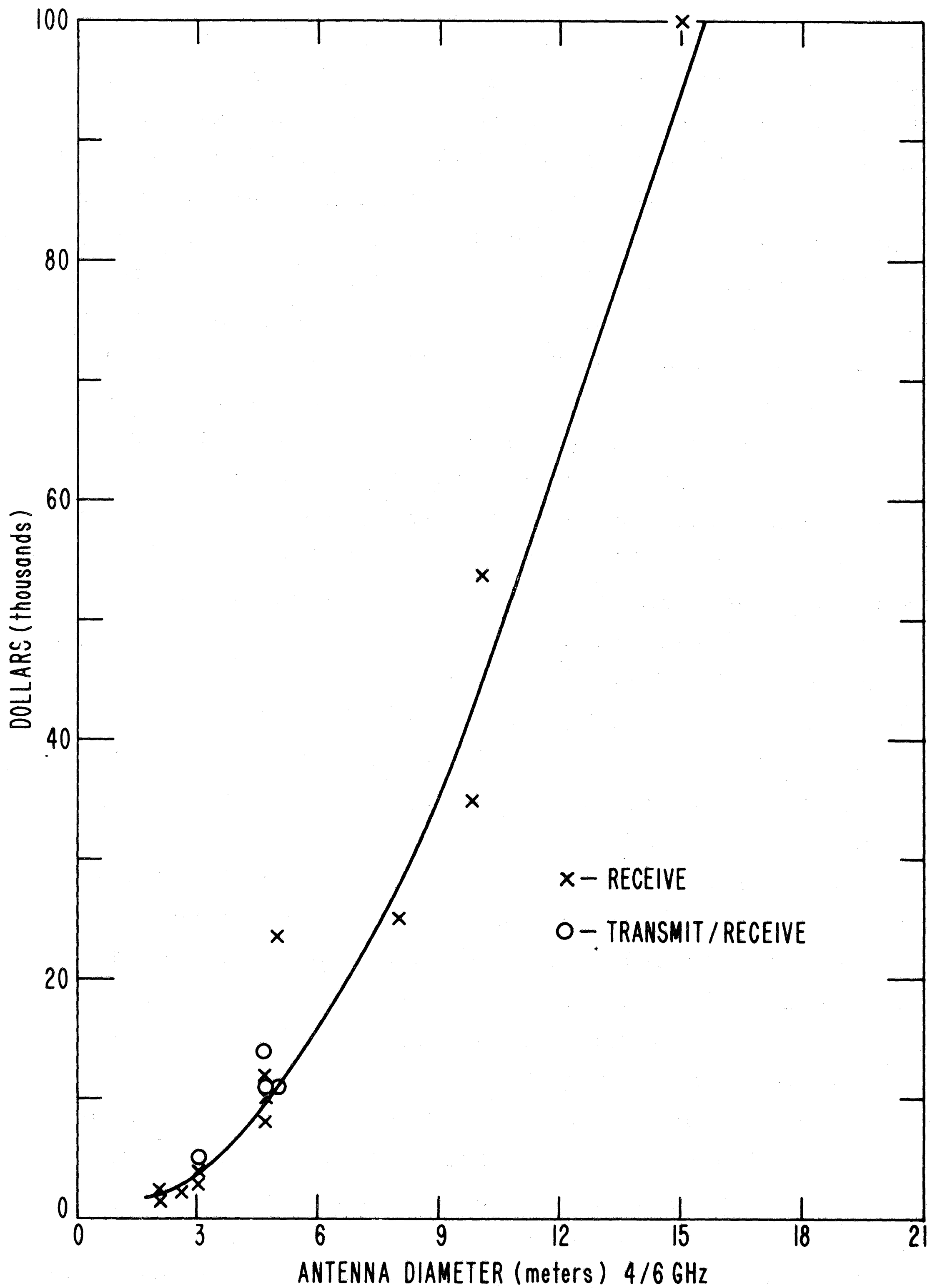

Figure 3.6. Cost of earth station antennas as a function of antenna diameter for operation in the 4 GHz band.

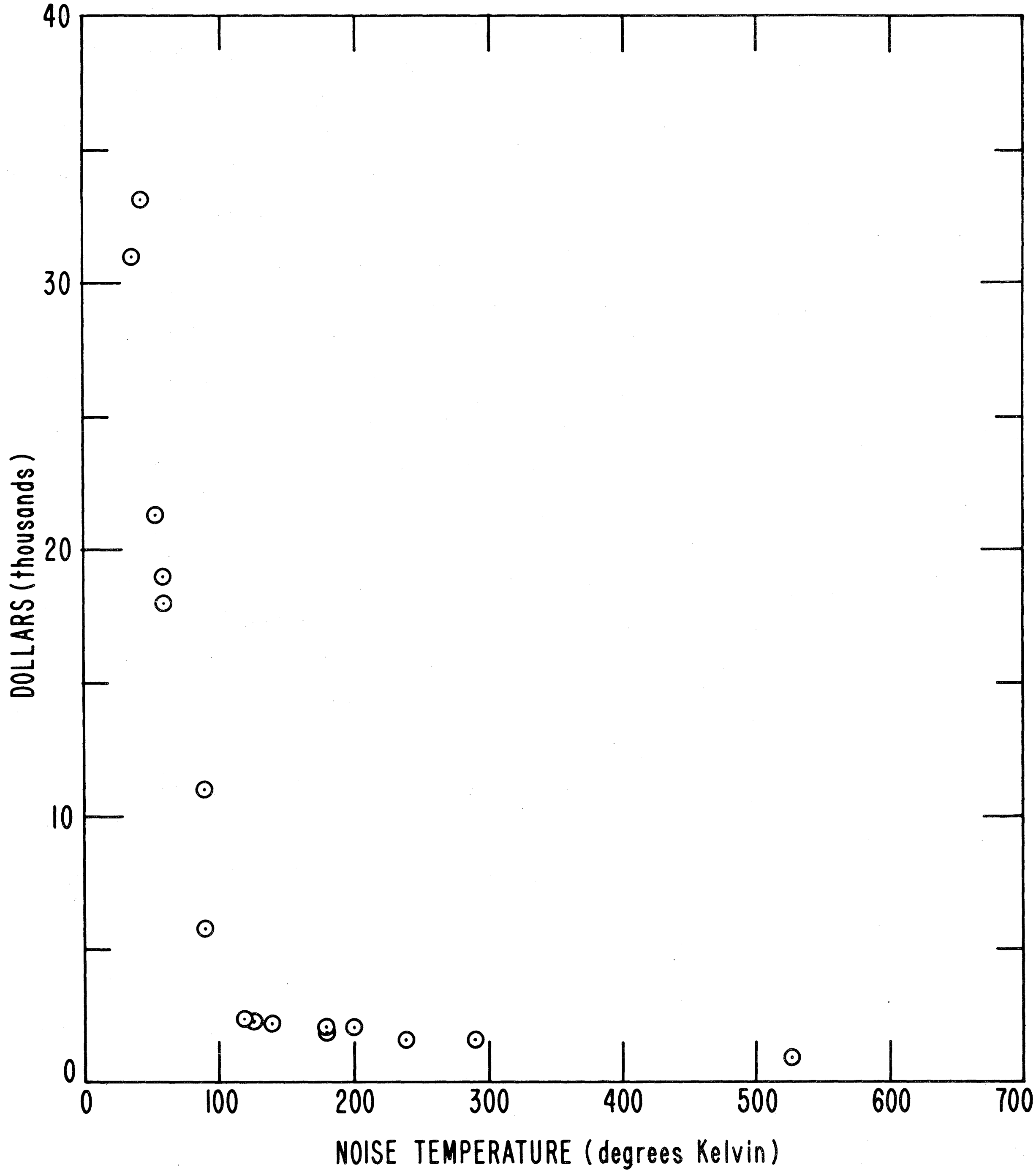

Figure 3.7. The cost of low noise amplifiers as a function of input noise temperature for systems operating at 4 GHz.

about 100 K. The curve should not be considered continuous through this point. The LNA's with noise temperatures above about 100 K use a GaAs FET (field effect transistor) as the first stage of the amplifier. A noise temperature of 100 K is about the state-of-the-art limit for the FET amplifier. Below 100 K, parametric amplifiers are used, and the cost of parametric LNA's increases sharply for lower noise temperatures. The cryogenically cooled parametric amplifier was not included with these data since its use with a small earth station is not appropriate.

During the survey, cost data were also collected for antennas and LNA's designed for operation in the 11.7 to 12.2 GHz frequency band. However, there was not very much data available. As yet, the only satellite applications in this frequency band are experimental. Hence, very few manufacturers have tooled up to produce equipment for use at 12 GHz. The data collected on antenna cost are presented with a smooth eyeball-fit curve in Figure 3.8. The antenna sizes for which data were available range from 1.5 meters to 4.5 meters. The cost of a specific size antenna is about the same whether it is for 12 GHz or 4 GHz. However, it was noted previously that at 4 GHz antennas larger than about 15 meters require satellite tracking capability. Similarly, at 12 GHz, a satellite tracking capability will be required on antennas larger than about 5 meters. This depends, of course, on the station-keeping accuracy of the satellite, which is usually held within $\pm 0.1^{\circ}$ in both the north-south and east-west directions.

Again, in Figure 3.8, the datum points marked by circles represent the cost of an antenna with a two-frequency feed system for simultaneous transmit and receive for a 12/14 GHz system.

The data collected during the cost survey on 12 GHz low-noise amplifiers are presented in Figure 3.9. The dollar cost of the LNA is plotted versus the amplifier input noise temperature. As yet, there are not many manufacturers producing LNA's for the 12 GHz frequency range. Only three LNA models were located. The two lower temperature datum points are for parametric amplifiers

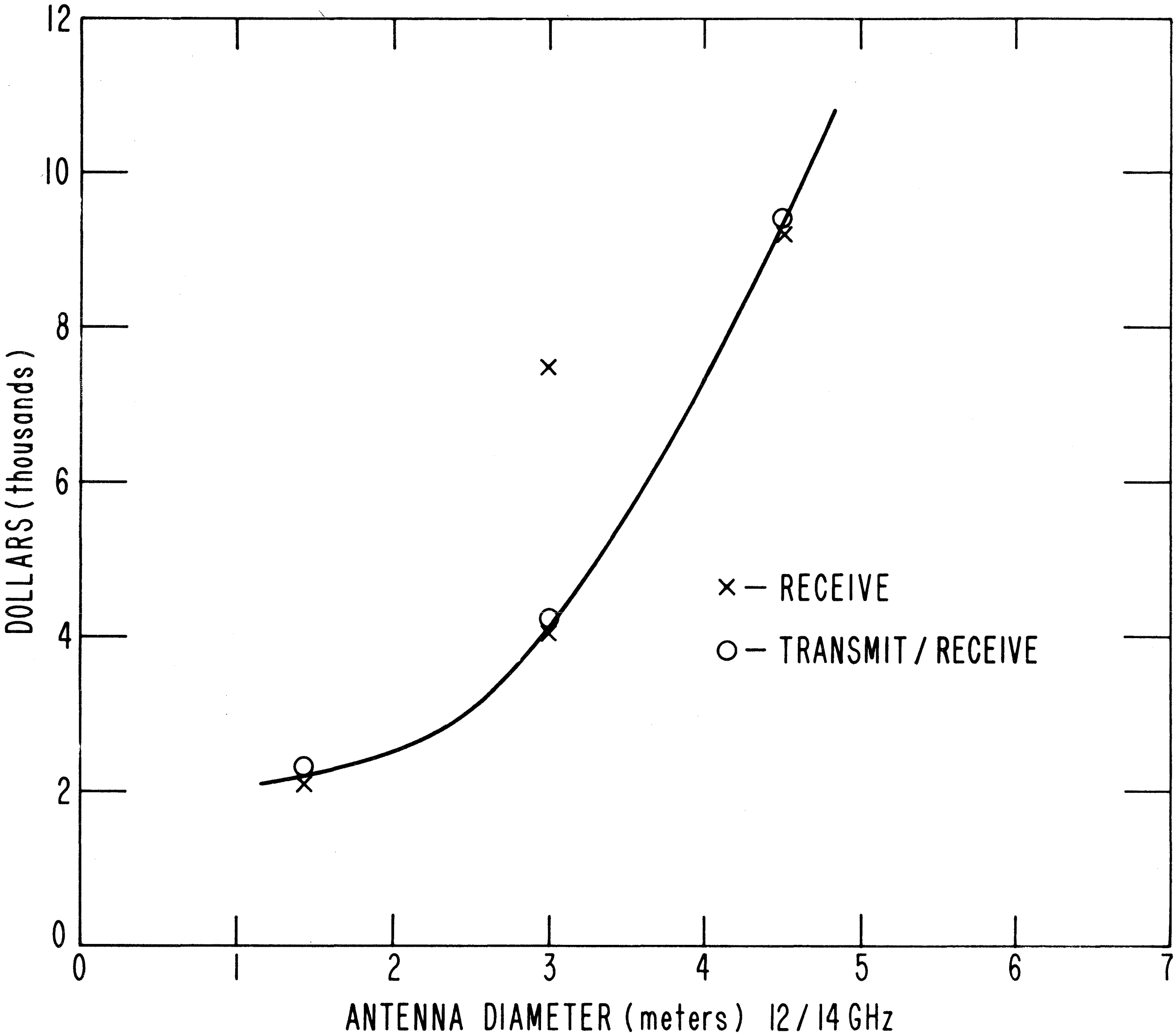

Figure 3.8. Cost of earth station antennas as a function of antenna diameter for operation in the 12 GHz band.

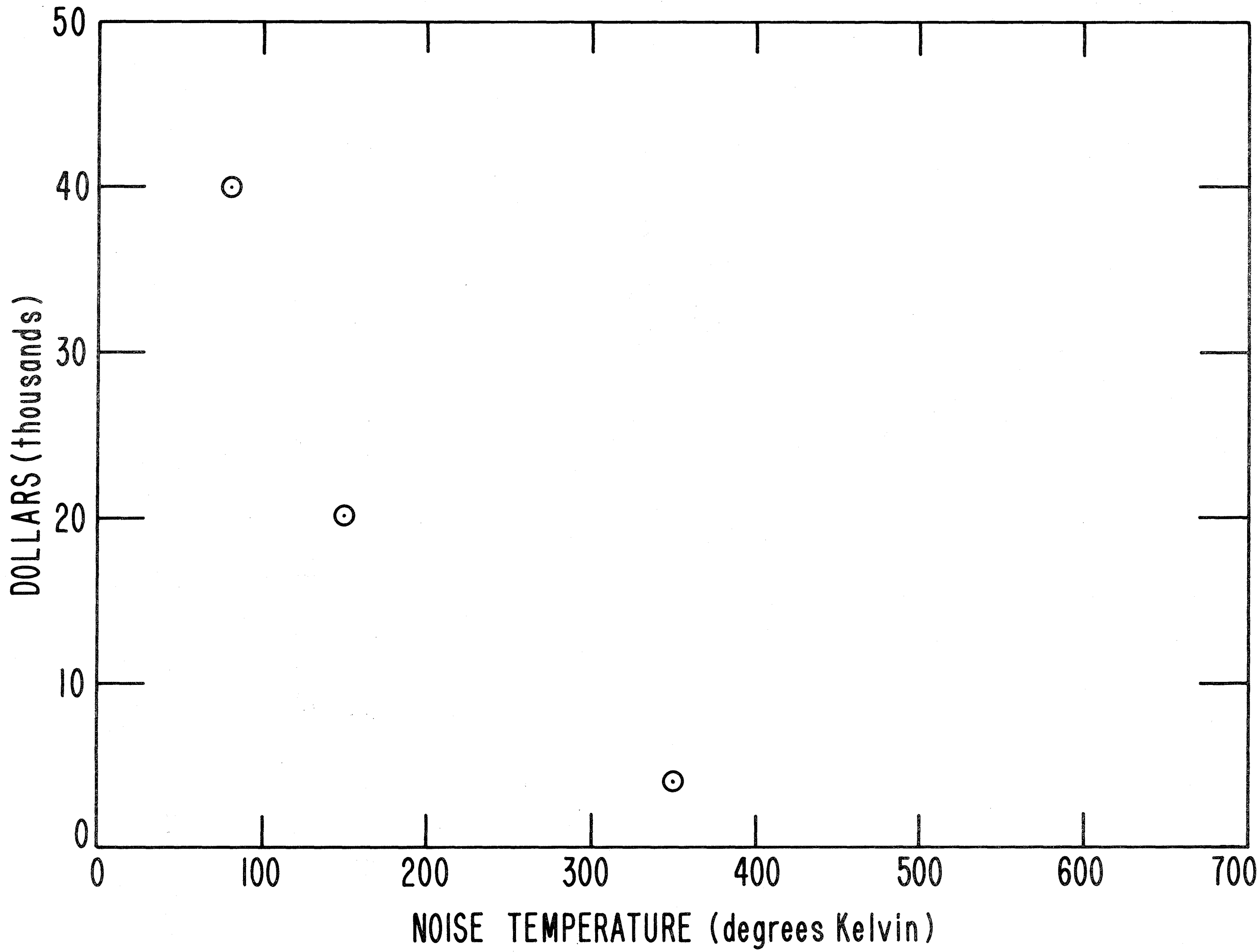

Figure 3.9. The cost of low noise amplifiers as a function of input noise temperature for systems operating at 12 GHz.

and the one datum point at 350 K is for an FET amplifier. About 300 K to 350 K appears to be the current state-of-the-art noise temperature limit using FET's.

4. PREPARATION FOR THE GENERAL WARC IN 1979

The purpose of the General World Administrative Radio Conference (WARC), to be held in 1979, is to review, and where necessary, revise the provisions of the Radio Regulations. The matters to be considered at the 1979 WARC are very broad; they include all aspects of the international radio regulations. However, the analysis and discussion presented here will not be all-inclusive. Only those aspects relating to satellite communications will be discussed.

Preparations in the United States for the WARC has been in active progress since early 1975. The development of U.S. positions for the WARC is being coordinated by the Federal Communications Commission through FCC Docket 20271. Proposals and comments regarding a realignment of the international table of frequencies were solicited by the Second Notice of Inquiry (NOI) (FCC, 1975), which was released in September, 1975. The Second NOI also requested comments and supporting technical material with respect to the use of small earth terminals in the space radiocommunications services in the near-term (1975-1985) and long-term (1985-2000) time frames.

From the input received in response to the Second NOI, the FCC presented a proposed new International Frequency Allocations Table in the Third NOI. The Third NOI (FCC, 1976) on Docket 20271 was released by the FCC in December, 1976.

The International Frequency Allocations Table contained in Article 5 of the Radio Regulations of International Telecommunications Union (ITU) (ITU, 1976) covers frequencies from 10 kHz through 275 GHz. The proportion of the table which includes frequencies allocated to satellite systems is shown in Figure 4.1. In the pie-diagram in Figure 4.1, the allocated spectrum is

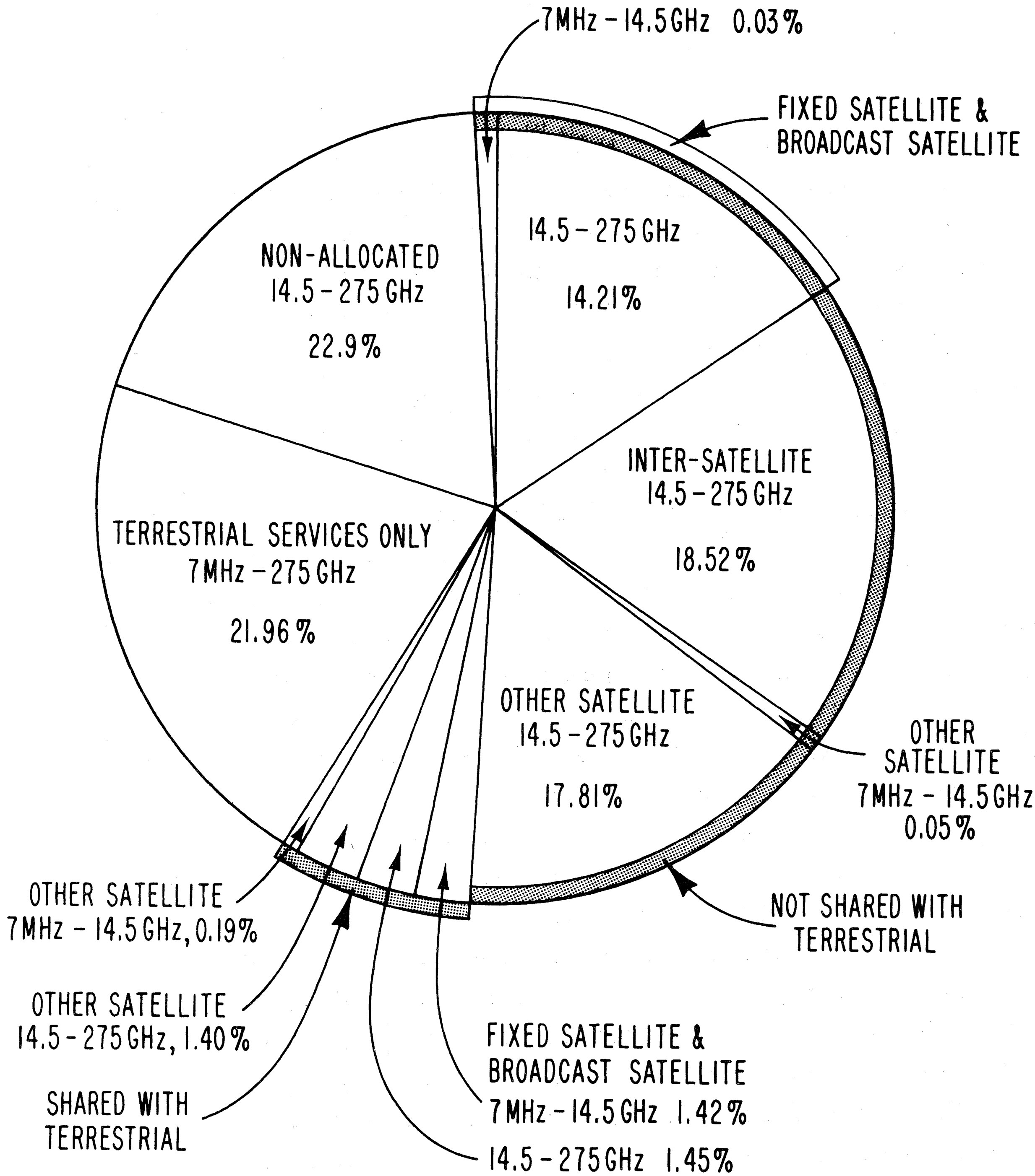

Figure 4.1. Subdivision of allocated frequencies in Region 2 in the present International Frequency Allocation Table.

divided into two parts, 7 MHz to 14.5 GHz and 14.5 GHz to 275 GHz. (The spectrum below 7 MHz is not included since none of these frequencies is allocated to satellite systems.) The use of frequencies above 14.5 GHz is considered to be limited by technology, and the current activity in satellite communications is occurring at frequencies below 14.5 GHz. Thus, the allocated frequencies are divided into two blocks in this report, with the dividing line at 14.5 GHz.

In Figure 4.1, the frequency allocations are subdivided into four parts, those frequencies which are (1) allocated to terrestrial services only, (2) allocated to satellite services only, (3) shared by terrestrial and satellite services, and (4) not allocated. In the current allocation table, 22.9% of the spectrum above 14.5 GHz was not allocated. The satellite services are further divided into three subparts, fixed- and broadcast-satellite services, inter-satellite service and other satellite services (these include meteorological, radiolocation, space research, etc.).

As was mentioned above, proposed modifications to the International Frequency Allocation Table were released in the Third NOI in December, 1976. These proposed allocations are subdivided in Figure 4.2 in the manner discussed above. The Third NOI was followed by the Fifth NOI in May, 1977 proposing additional modifications, based on responses to the Third NOI. (The Fourth NOI deals with a different topic.) The modified table proposed in the Fifth NOI is subdivided in Figure 4.3.

With the ever increasing demand for spectrum space by various service groups, there has been a strong trend toward frequency reuse through the sharing of frequency bands by two or more services. This trend is evident from a comparison of the pie-diagrams of Figures 4.1 and 4.3. The portion of the allocated spectrum shared by terrestrial and satellite services is now 4.46%, and in the fifth notice of inquiry it is recommended that it should be 81.73%. At the same time, it is recommended that the spectrum allocated exclusively to terrestrial services

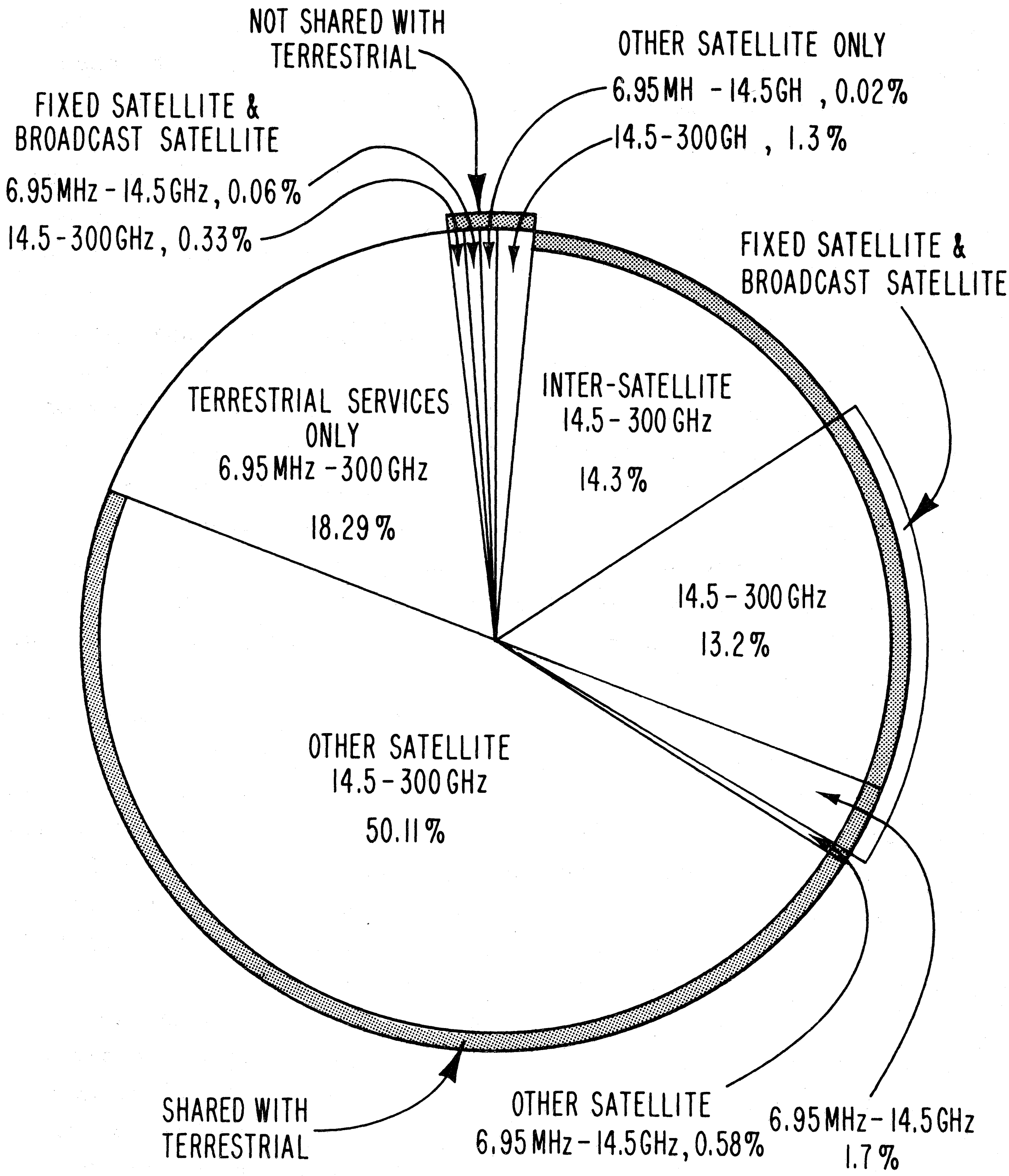

Figure 4.2. Subdivision of allocated frequencies proposed for Region 2 in the Third Notice of Inquiry of FCC Docket 20271.

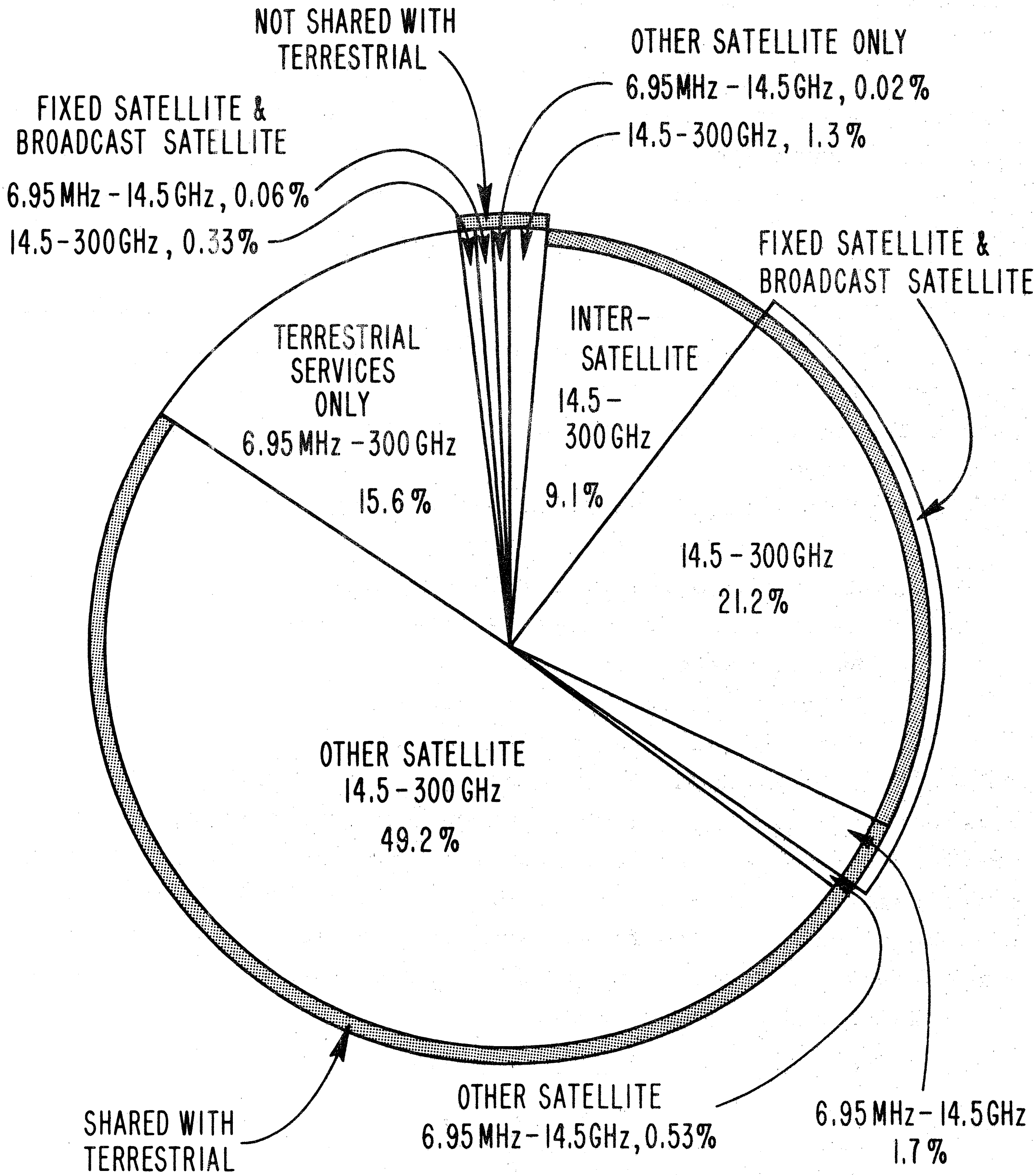

Figure 4.3. Subdivision of allocated frequencies proposed for Region 2 in the Fifth Notice of Inquiry of FCC Docket 20271.

be reduced from 21.96% to 15.6%, and that portion allocated exclusively to satellite services be reduced from 50.62% to 1.71%.

In the current frequency allocation table, 14.3% of the allocated spectrum was reserved for the exclusive use of the inter-satellite service, none of which has yet been used. In the fifth notice, the recommended allocation to inter-satellite service is reduced to 9.1%, and is to be shared with terrestrial services.

4.1. Allocations for Fixed- and Broadcasting-Satellite Service

In the International Frequency Allocation Table, there are a number of different communication services which utilize satellites that are allocated spectrum space. These include:

Fixed-satellite service,
Broadcasting-satellite service,
Land mobile-satellite service,
Maritime mobile-satellite service,
Aeronautical mobile-satellite service,
Amateur-satellite service,
Inter-satellite service, and
Meteorological-satellite service.

This list is not intended to be all-inclusive; rather, it is intended to show that a number of communications services are provided for in the frequency tables. In this report, only the fixed-satellite service and the broadcasting-satellite service will be discussed. The fixed-satellite service is defined in the Radio Regulations (ITU, 1976) paragraph 84AG, as follows:

84AG Fixed-Satellite Service

A radiocommunication service:

-between earth stations at specified fixed points when one or more satellites are used; in some cases this service includes satellite-to-satellite links, which may also be effected in the inter-satellite service;

-for connection between one or more earth stations at specified fixed points and satellites used for a service other than the fixed-satellite service (for example, the mobile-satellite service, broadcasting-satellite service, etc.).

Similarly, the broadcasting-satellite service is defined in paragraphs 84AP, 84APA, 84APB, and 84AP.1 as follows:

84AP Broadcasting-Satellite Service

A radiocommunication service in which signals transmitted or retransmitted by space stations are intended for direct reception by the general public.

84APA Individual reception (in the broadcasting-satellite service)

The reception of emissions from a space station in the broadcasting-satellite service by simple domestic installations and in particular those possessing small antennae.

84APB Community reception (in the broadcasting-satellite service)

The reception of emissions from a space station in the broadcasting-satellite service by receiving equipment, which in some cases may be complex and have antennae larger than those used for individual reception, and intended for use:

- by a group of the general public at one location; or

- through a distribution system covering a limited area.

84AP.1

In the broadcasting-satellite service, the term "direct reception" shall encompass both individual reception and community reception.

In the current International Frequency Allocation Table (ITU, 1976), the frequency bands allocated to fixed- and/or broadcasting-satellite service in Region 2 are listed in Table 4.1. However, it should be noted that some of the frequency bands listed in Table 4.1 are not allocated to satellite services. These are frequency bands which are not now allocated to satellite services, but are being recommended for allocation in the future.

Table 4.1. Frequency Bands Currently Allocated to Fixed-Satellite and Broadcasting-Satellite Services in Region 2. (Bands Shared With Other Services are Indicated)

Frequency GHz	Fixed-Satellite*	Broadcasting Satellite	Other-Satellite	Terrestrial	Remarks
2.50-2.535	S-E	X		X	
2.535-2.55		X		X	
2.55-2.655		X		X	
2.655-2.67	E-S	X		X	
2.67-2.69	E-S	X		X	
3.40-3.41	S-E			X	
3.41-3.50	S-E			X	
3.50-3.70	S-E			X	
3.70-4.20	S-E			X	
4.4-4.7	E-S			X	
5.725-5.850				X	
5.85-5.925				X	
5.925-6.425	E-S			X	
6.425-6.925				X	
7.25-7.30	S-E				
7.30-7.45	S-E			X	
7.45-7.55	S-E		X	X	
7.55-7.75	S-E			X	
7.90-7.975	E-S			X	
7.975-8.025	E-S				
8.025-8.175	E-S		X	X	
8.175-8.215	E-S		X	X	
8.215-8.40	E-S		X	X	

*E-S (Earth-to-space); S-E (space-to-Earth).

Table 4.1. (Cont.)

Frequency GHz	Fixed-Satellite	Broadcasting Satellite	Other-Satellite	Terrestrial	Remarks
10.70-10.95				X	
10.95-11.2	S-E			X	
11.2-11.45				X	
11.45-11.7	S-E			X	
11.7-12.2	S-E	X		X	
12.2-12.5				X	
12.5-12.75	E-S			X	
12.75-13.25				X	
14.0-14.2	E-S			X	
14.2-14.3	E-S			X	
14.3-14.4	E-S		X		
14.4-14.5	E-S			X	
17.7-17.9	S-E			X	
17.9-18.7	S-E				
18.7-19.7	S-E				
19.7-20.2	S-E				
20.2-21.2	S-E		X	X	
27.5-29.5	E-S			X	
29.5-30.0	E-S				
30.0-31.0	E-S				
40.0-41.0	S-E				
41.0-43.0		X			
43.0-45.0			X		
50.0-50.2	E-S				
50.2-50.4	E-S				
50.4-51.0	E-S				
51.0-51.4			X		

Table 4.1. (Cont.)

Frequency GHz	Fixed-Satellite	Broadcasting Satellite	Other-Satellite	Terrestrial	Remarks*
76.0-79.0					N/A
79.0-80.0					N/A
80.0-81.0					N/A
81.0-84.0					N/A
84.0-86.0		X			
92.0-95.0	E-S				
102.0-105.0	S-E				
140-142	E-S				
150-151	S-E				
151-152	S-E				
152-164					N/A
164-165					N/A
201.5-217					N/A
220-221	X				
221-225	X				
225-227	X				
227-229	X				
229-230	X				
265-275	X				

*N/A - Not Allocated.

The Radio Regulations of the ITU provide the primary guidelines for coordinated international use of the radio frequency spectrum. These Regulations are in the form of a treaty between the member nations of the ITU. As such, there are no powers of enforcement. The effectiveness of the Radio Regulations depends entirely on voluntary compliance by the member nations. Further, the Regulations apply only to the coordination between national adminstrations, and place no restrictions on frequency use within an individual nation, so long as no harmful interference is caused in neighboring nations.

This is illustrated by comparing Table 4.2 to Table 4.1. Table 4.2, a listing of the same frequency bands as are listed in Table 4.1, shows the allocation of these frequency bands in the United States. For example, note that the frequency bands from 3.4 GHz to 3.7 GHz are allocated in Region 2 to Fixed-Satellite Services and Terrestrial Services, while in the U.S. these bands are allocated to Terrestrial Services, only. Also, within the U.S., some frequency bands are allocated for exclusive use by Government (G) users, some for exclusive use by non-Government (NG) users, and others are shared by both Government and non-Government users. The sharing and non-sharing of frequency bands is indicated in the "remarks" column of Table 4.2.

Table 4.3 shows the suggested frequency allocations to the fixed-satellite service and broadcasting-satellite service contained in the Third Notice of Inquiry of FCC Docket No. 20271. This table is followed by Table 4.4 which shows the suggested frequency allocations contained in the Fifth Notice of Inquiry.

With the present broad review of the allocation of frequencies, there are multiple requests for use of nearly every sub-band of frequencies. For a thorough discussion of these requests, the reader is referred to the Third NOI (FCC, 1976) and the Fifth NOI (FCC, 1976) of Docket No. 20271 where the comments and reply-comments of interested parties are summarized. Those wishing to do an in-depth review can obtain access to the comments and reply-comments which are on file and available at the FCC.

Table 4.2. In the U.S. Frequency Bands Currently Allocated to Fixed-Satellite and Broadcasting-Satellite Services. (Bands Shared With Other Services are Indicated)

Frequency GHz	Fixed-Satellite†	Broadcasting Satellite	Other-Satellite	Terrestrial	Remarks
2.50-2.535	S-E*	X		X	NG *footnote NG102
2.535-2.55		X		X	NG
2.55-2.655		X		X	NG
2.655-2.67	E-S*	X		X	NG *footnote NG102
2.67-2.69	E-S*	X		X	NG *footnote NG102
3.40-3.41				X	G, NG
3.41-3.50				X	G, NG
3.50-3.70				X	G, NG
3.70-4.20	S-E			X	NG
4.4-4.7				X	G
5.725-5.850				X	G, NG
5.85-5.925				X	G, NG
5.925-6.425	E-S			X	NG
6.425-6.625				X	NG
6.625-7.125	S-E			X	NG
7.25-7.30	S-E				G
7.30-7.45	S-E			X	G
7.45-7.55	S-E		X	X	G
7.55-7.75	S-E			X	G
7.90-7.975	E-S			X	G
7.975-8.025	E-S				G
8.025-8.175	E-S		X	X	G
8.175-8.215	E-S		X	X	G
8.215-8.40	E-S		X	X	G

†E-S (Earth-to-space); S-E (space-to-Earth)

Table 4.2. (Cont.)

Frequency GHz	Fixed-Satellite	Broadcasting Satellite	Other-Satellite	Terrestrial	Remarks
10.70-10.95				X	NG
10.95-11.2	S-E*			X	NG, *Internt'l only
11.2-11.45				X	NG
11.45-11.7	S-E*			X	NG, *Internt'l only
11.7-12.2	S-E	X		X	NG
12.2-12.5				X	NG
12.5-12.75	E-S			X	NG
12.75-13.25				X	NG
14.0-14.2	E-S*			X	G, NG *NG only
14.2-14.3	E-S*			X	G, NG *NG only
14.3-14.4	E-S*		X		G, NG *NG only
14.4-14.5	E-S*		X	X	G, NG *NG only
17.7-17.9	S-E			X	NG
17.9-18.7	S-E			X	NG
18.7-19.7	S-E			X	NG
19.7-20.2	S-E				NG
20.2-21.2	S-E				G
27.5-29.5	E-S			X	NG
29.5-30.0	E-S				NG
30.0-31.0	E-S				G
40.0-41.0	S-E			X	G, NG
41.0-43.0		X*		X	G, NG *NG only
43.0-45.0			X	X	G, NG
50.0-50.2	E-S			X	G, NG
50.2-50.4	E-S			X	G, NG
50.4-51.0	E-S			X	G, NG
51.0-51.4			X		G, NG

Table 4.2. (Cont.)

Frequency GHz	Fixed-Satellite	Broadcasting Satellite	Other-Satellite	Terrestrial	Remarks
76.0-79.0				X	G, NG
79.0-80.0				X	G, NG
80.0-81.0				X	G, NG
81.0-84.0				X	G, NG
84.0-86.0		X*		X	G, NG *NG only
92.0-95.0	E-S*			X	G, NG *92-93 GHz, G only
102.0-105.0	E-S*			X	G, NG *102-103 GHz, G only
140-142	E-S*			X	G, NG *140-141 GHz, G only
150-151	S-E*			X	G, NG *G only
151-152	S-E			X	G, NG
152-164				X	G, NG
164-165				X	G, NG
201.5-217				X	G, NG
220-221	X			X	G, NG
221-225	X			X	G, NG
225-227	X			X	G, NG
227-229	X			X	G, NG
229-230	X			X	G, NG
265-275	X			X	G, NG

G - Government
NG - Non-Government

Table 4.3. Frequency Bands Recommended in the 3rd Notice of Inquiry for Allocation to Fixed-Satellite and Broadcasting-Satellite Services in Region 2. (Recommended Band Sharing with Other Services is Indicated)

Frequency	Fixed-Satellite*	Broadcasting Satellite	Other-Satellite	Terrestrial	Remarks
2.50-2.535	S-E	X		X	
2.535-2.55		X		X	
2.55-2.655		X		X	
2.655-2.67	E-S	X		X	
2.67-2.69	E-S			X	
3.40-3.41	S-E		X	X	
3.41-3.50	S-E			X	
3.50-3.70	S-E			X	
3.70-4.20	S-E			X	
4.40-4.70	E-S			X	
5.725-5.850				X	
5.85-5.925				X	
5.925-6.425	E-S			X	
6.425-6.925	E-S			X	
7.25-7.30	S-E				
7.30-7.45	S-E			X	
7.45-7.55	S-E		X	X	
7.55-7.75	S-E			X	
7.90-7.975	E-S			X	
7.975-8.025	E-S				
8.025-8.175	E-S		X	X	
8.175-8.215	E-S		X	X	
8.215-8.40	E-S		X	X	

*E-S (Earth-to-space); S-E (space-to-Earth)

Table 4.3. (Cont.)

Frequency GHz	Fixed Satellite	Broadcasting Satellite	Other-Satellite	Terrestrial	Remarks
10.70-10.95	S-E			X	
10.95-11.2	S-E			X	
11.2-11.45	S-E			X	
11.45-11.7	S-E			X	
11.7-12.2	S-E	X		X	
12.2-12.5				X	
12.5-12.75	E-S			X	
12.75-13.25	E-S		X	X	
14.0-14.2	E-S		X	X	
14.2-14.3	E-S		X	X	
14.3-14.4	E-S				
14.4-14.5	E-S		X	X	
17.7-17.9	S-E			X	
17.9-18.7	S-E		X	X	
18.7-19.7	S-E			X	
19.7-20.2	S-E				
20.2-21.2	S-E		X		
27.5-29.5	E-S			X	
29.5-30.0	E-S				
30.0-31.0	E-S		X		
36.0-37.0	X		X		
40.0-41.0	X		X	X	
41.0-43.0		X		X	
43.0-45.0	X		X		

Table 4.3. (Cont.)

Frequency GHz	Fixed-Satellite	Broadcasting Satellite	Other-Satellite	Terrestrial	Remarks
50.0-50.2	X			X	
50.2-50.4	X			X	
50.4-51.0	X		X	X	
51.0-51.4	X		X	X	
76.0-79.0	X		X	X	
79.0-80.0	X		X	X	
80.0-81.0	X			X	
81.0-84.0	X			X	
84.0-86.0		X		X	
92.0-95.0	X			X	
102.0-105.0	X		X	X	
140-142	X			X	
150-151	X			X	
151-152	X		X	X	
152-159	X		X	X	
159-164	X			X	
164-165	X			X	
201.5-213	X		X	X	
213-217	X			X	
220-221				X	
221-225	X			X	
225-227	X			X	
227-229	X			X	
229-230				X	

Table 4.3. (Cont.)

Frequency GHz	Fixed Satellite	Broadcasting Satellite	Other-Satellite	Terrestrial	Remarks
265-271	X			X	
271-275	X		X	X	

Table 4.4. Frequency Bands Recommended in the 5th Notice of Inquiry for Allocation to Fixed-Satellite and Broadcasting-Satellite Service in Region 2. (Recommended Band Sharing with Other Services is Indicated)

Frequency GHz	Fixed-Satellite*	Broadcasting Satellite	Other-Satellite	Terrestrial	Remarks
2.50-2.535	S-E	X		X	
2.535-2.55		X		X	
2.55-2.655		X		X	
2.655-2.67	E-S	X		X	
2.67-2.69	E-S	X	X	X	
3.40-3.41	S-E		X	X	
3.41-3.50	S-E			X	
3.50-3.70	S-E		X		
3.70-4.20	S-E			X	
4.40-4.70	E-S			X	
5.725-5.850	S-E			X	
5.85-5.925	S-E			X	
5.925-6.425	E-S			X	
6.425-6.925	E-S			X	
7.25-7.30	S-E				
7.30-7.45	S-E			X	
7.45-7.55	S-E		X	X	
7.55-7.75	S-E			X	
7.90-7.975	E-S			X	
7.975-8.025	E-S				
8.025-8.175	E-S		X	X	
8.175-8.215	E-S		X	X	
8.215-8.40	E-S		X	X	

*E-S (Earth-to-space); S-E (space-to-Earth)

Table 4.4. (Cont.)

Frequency GHz	Fixed-Satellite	Broadcasting Satellite	Other-Satellite	Terrestrial	Remarks
10.70-10.95	S-E			X	
10.95-11.2	S-E			X	
11.2-11.45	S-E			X	
11.45-11.7	S-E			X	
11.7-12.2	S-E	X		X	
12.2-12.5		X		X	
12.5-12.75	E-S			X	
12.75-13.25	E-S		X	X	
14.0-14.2	E-S		X	X	
14.2-14.3	E-S			X	
14.3-14.4	E-S				
14.4-14.5	E-S		X	X	
17.7-17.9	S-E			X	
17.9-18.7	S-E		X	X	
18.7-19.7	S-E			X	
19.7-20.2	S-E				
20.2-21.2	S-E		X		
27.5-29.5	E-S			X	
29.5-30.0	E-S				
30.0-31.0	E-S		X		
36.0-37.0			X		
40.0-41.0	S-E		X	X	
41.0-43.0		X		X	
43.0-45.0	E-S		X		

Table 4.4. (Cont.)

Frequency GHz	Fixed-Satellite	Broadcasting Satellite	Other-Satellite	Terrestrial	Remarks
50.0-50.2	E-S			X	
50.2-50.4	E-S		X	X	
50.4-51.0	E-S		X	X	
51.0-51.4	E-S		X	X	
76.0-79.0	S-E		X	X	
79.0-80.0	S-E			X	
80.0-81.0	E-S			X	
81.0-84.0	E-S		X	X	
84.0-86.0		X		X	
92.0-95.0	E-S			X	
102.0-105.0	S-E			X	
140-142	S-E			X	
150-151	S-E		X	X	
151-152	S-E			X	
152-164	S-E			X	
164-165	S-E		X	X	
201.5-217	E-S			X	
220-221				X	
221-225	S-E			X	
225-227	S-E		X	X	
227-229	S-E			X	
229-230			X	X	
265-275	E-S			X	

Some specific frequency bands which relate to fixed- and/or broadcasting-satellite services are discussed in the following paragraphs. The frequency bands of interest here are those listed in Tables 4.1 through 4.4, with particular attention being given to those frequency bands below about 50 GHz. In this discussion, reference will be made to a number of footnotes. These footnotes fall into four specific categories:

International Footnotes - These footnotes come from the Radio Regulations, Geneva, Edition of 1976. These footnotes consist of three digits sometimes followed by one or more letters.

U.S. Footnotes - These footnotes, consisting of the letters US followed by one or more digits, denote stipulations applicable to both Government and non-Government stations.

Government Footnotes - These footnotes, each consisting of the letter G followed by one or more digits, denote stipulations applicable only to Government stations.

Non-Government Footnotes - These footnotes, each consisting of the letters NG followed by one or more digits, denote stipulations applicable only to non-Government stations.

4.1.1. 2.50 GHz to 2.69 GHz

In Region 2, this band of frequencies is allocated to the FIXED, MOBILE (except aeronautical mobile), and BROADCASTING-SATELLITE services on a coequal basis. Two sub-parts of this band are also allocated, on a coequal basis, to the FIXED-SATELLITE service, 2.5 GHz to 2.535 GHz space-to-earth and 2.655 GHz to 2.690 GHz earth-to-space.

The limits for use of these frequencies by the broadcasting-satellite service are stated in ITU footnote 361B, as follows:

> 361B. The use of the band 2,500-2,690 MHz by the broadcasting-satellite service is limited to domestic and regional systems for community reception and such use is subject to agreement between the administrations concerned and those having services, operating in

accordance with the Table, which may be affected (see Resolutions Nos. Spa2-2 and Spa2-3). The power flux density at the Earth's surface shall not exceed the values given in Nos. 470NH-470NK.

The specific limits of the power flux density at the Earth's surface are stated in paragraphs 470NI and 470NK of the Radio Regulations (ITU, 1976) as follows:

470NI - a) The power flux density at the Earth's surface produced by emissions from a space station in the broadcasting-satellite service for all conditions and for all methods of modulation shall not exceed the following values:

-152 dBW/m^2 in any 4 kHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;

$-152 + \frac{3(\delta - 5)}{4}$ dBW/m^2 in any 4 kHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane;

-137 dBW/m^2 in any 4 kHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

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

470NK - c) The power flux density values given in No. 470NI are derived on the basis of protecting the fixed service using line-of-sight techniques. Where a fixed service using tropospheric scatter operates in the band mentioned in No. 470NJ 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 using tropospheric scatter to 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.

Within the United States, the use of this band by broadcasting-satellite services is further limited by NG footnote, NG101 (OTP, 1977), which states:

> 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.

The limits for use of this band of frequencies by the fixed-satellite service are stated in international footnote 364E (ITU, 1976):

> 364E - The use of the bands 2500-2535 MHz and 2655-2690 MHz by the fixed-satellite service is limited to domestic and regional systems and such use is subject to agreement between the administrations concerned and those having services operating in accordance with the Table, which may be affected (see Article 9A). In the direction space-to-Earth, the power flux density at the Earth's surface shall not exceed the values given in No. 470NE.

The power flux density limits for the fixed-satellite service are stated in paragraph 470NE (ITU, 1976):

> 470NE - a) The power flux density at the Earth's surface produced by emissions from a space station or reflected from a passive satellite for all conditions and for all methods of modulation shall not exceed the following values:
>
> -154 dBW/m^2 in any 4 kHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;

$-154 + \frac{\delta - 5}{2}$ dBW/m^2 in any 4 kHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane;

-144 dBW/m^2 in any 4 kHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

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

The use of these frequencies by the fixed-satellite services in the United States and its territories are specified in footnote NG102 (OTP, 1977):

NG102 - The frequency bands 2500-2535 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.

As noted earlier, these frequencies are shared, on a coequal basis, with the fixed and mobile (except aeronautical mobile) services. These services include tropospheric scatter radio-relay, line-of-sight radio relay, and point-to-multiple-point radio-relay. Within the United States, however, the use of this band by tropospheric scatter systems is prohibited (footnote US205, (OTP, 1977)). Certain frequencies within this band are assigned, on a primary basis, to operational fixed stations in the public safety services by footnote NG47 (OTP, 1977). This footnote also specifies, "All other frequencies in this band for terrestrial operations are available for assignment only to stations in the instructional television fixed service." The most extensive use of this band in the United States is for the instructional television fixed service.

One difficulty in this band is that the adjacent band, 2.69 GHz to 2.70 GHz, is allocated to the radio astronomy service which must be protected from harmful interference. This is a topic of intense contention in the preparations for the 1979 WARC, as reflected in the notices of inquiry on FCC Docket No. 20271. In the third NOI (FCC, 1976) the broadcasting-satellite service had been deleted in the band 2.67 GHz to 2.69 GHz, and the radio astronomy service was added as a sharing service. However, in the fifth NOI (FCC, 1977b), the broadcasting-satellite service was again included as an allocated service sharing this band. One potential problem is the possible out-of-band emissions from a satellite in the broadcasting-satellite service spilling over into the protected radio astronomy band.

4.1.2. 3.4 GHz to 3.7 GHz

In the table of allocations for Region 2, this band of frequencies is subdivided into two bands, as follows:

3.4 to 3.5 GHz	FIXED-SATELLITE (Space-to-Earth)
	RADIOLOCATION
	Amateur
3.5 to 3.7 GHz	FIXED
	FIXED-SATELLITE (Space-to-Earth)
	MOBILE
	RADIOLOCATION.

In the United States, these bands are shared by Government users, on a primary basis, and non-Government users, on a secondary basis. They are allocated for Government use as follows:

3.4 to 3.5 GHz	RADIOLOCATION
3.5 to 3.7 GHz	RADIOLOCATION
	AERONAUTICAL RADIONAVIGATION (Ground-based)

and for non-Government use as follows:

3.4 to 3.5 GHz	Radiolocation
	Amateur
3.5 to 3.7 GHz	Radiolocation.

In the current proceedings on FCC Docket No. 20271, there have been numerous requests that this band be allocated to the fixed-satellite service in the U.S. An analysis of the potential for sharing this band (and the bands 4.4 to 4.7 GHz and 5.725 to 5.925 GHz) is contained in Appendix 5 of the Fifth NOI of FCC Docket No. 20271 (FCC, 1977b). The FCC notes that "highly coordinated sharing criteria will need to be developed if the Fixed-Satellite Service is to successfully share the 3400-3700 MHz, 4400-4700 MHz, and 5725-5925 MHz band with other services which are required to satisfy other national needs." There are now about 150 frequency assignments in this band, mostly high power radars for military use. This number is expected to increase. Also, the Federal Aviation Administration plans to purchase a number of low-power airport surveillance radars for operation in this band.

4.1.3. 3.70 GHz to 4.20 GHz

This band is currently allocated in Region 2, on a coequal basis, to FIXED, FIXED-SATELLITE (Space-to-Earth), and MOBILE Services. While in the U.S., the band is designated for non-Government use only, for the FIXED and FIXED-SATELLITE (Space-to-Earth) Services.

This is one of the primary frequency bands used for long-haul, line-of-sight radio relay and is the down-link frequency used by the current generation of U.S. and Canadian domestic satellites and the Intelsat satellites. No changes are contemplated for this band.

4.1.4. 4.40 GHz to 4.70 GHz

This band of frequencies is currently allocated in Region 2 on a coequal basis to the FIXED, FIXED-SATELLITE and MOBILE Services. However, in the U.S. this band is restricted to Government use only, and is allocated to FIXED and MOBILE Services.

As noted earlier, this was one of the bands included in the analysis presented in Appendix 5 of the Fifth NOI on FCC Docket No. 20271 (FCC, 1977b). This frequency band is widely used by the military services for fixed, land-mobile and aeronautical-mobile systems, including high-power tropospheric scatter systems.

Though there is considerable pressure for fixed-satellite use of this band in the U.S., there is no change contemplated in the international allocation.

4.1.5. 5.725 GHz to 5.925 GHz

This band of frequencies is currently allocated in Region 2 and in the U.S. to the RADIOLOCATION service on a primary basis, and to the Amateur service on a secondary basis. In accordance with footnote US34 (OTP, 1977), the only authorized non-Government use of this band is by amateurs. In the Fifth NOI (FCC, 1977b), it is recommended that this band also be allocated to the fixed-satellite service.

As noted earlier, this was one of the frequency bands included in the analysis presented in Appendix 5 of the Fifth NOI (FCC, 1977b). There are currently about 300 assignments in this band. The users are primarily radiolocation radars and weather radars. The radiolocation radars are both fixed and mobile. Shared use of this band by the fixed-satellite service would require a high degree of coordination.

4.1.6. 7.25 GHz to 7.75 GHz

In Region 2 and in the U.S., this band (except for a 50 MHz band from 7.25 to 7.30 GHz which is allocated to the FIXED-SATELLITE service, only) is shared, on a coequal basis, by FIXED, MOBILE and FIXED-SATELLITE (Space-to-Earth) services. In the U.S., this band is used exclusively by Government users. No change is contemplated in the allocation of this band.

4.1.7. 7.90 GHz to 8.40 GHz

This band is the companion band to the 7.25 to 7.75 GHz band. In the fixed-satellite service this band is the earth-to-space link and is used exclusively by Government users. No change in allocation of this band is contemplated.

4.1.8. 10.70 GHz to 11.70 GHz

This band of frequencies is divided into 4 subbands which in Region 2 and the U.S. are allocated as follows:

	Region 2	U.S.
10.70-10.95	FIXED MOBILE	FIXED
10.95-11.20	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE	FIXED FIXED-SATELLITE (Space-to-Earth)
11.20-11.45	FIXED MOBILE	FIXED
11.45-11.70	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE	FIXED FIXED-SATELLITE (Space-to-Earth)

In the Fifth NOI (FCC, 1977b), it is recommended for Region 2 that the MOBILE service be deleted in the bands 10.70 to 10.95 GHz, 11.20 to 11.45 GHz, and 11.45 to 11.70 GHz, and that the FIXED-SATELLITE service be added in the bands 10.70 to 10.95 GHz and 11.20 to 11.45 GHz.

These bands are currently quite heavily used for line-of-sight radio relay systems by non-Government users in the U.S. The U.S. assignment of frequencies in the fixed-satellite service in bands 10.70 to 10.95 GHz and 11.45 to 11.70 GHz is limited to international operations, only. It is proposed in the Fifth NOI (FCC, 1977b) that these limitations be included in any future rulemaking proceedings relative to the band 10.7 to 11.7 GHz.

4.1.9. 11.70 GHz to 13.25 GHz

This band of frequencies is divided into four subbands which in Region 2 and the U.S. are allocated as follows:

	Region 2	U.S.
11.7-12.2	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE except aeronautical mobile BROADCASTING BROADCASTING-SATELLITE	FIXED-SATELLITE BROADCASTING-SATELLITE Mobile
12.2-12.5	FIXED MOBILE except aeronautical mobile BROADCASTING	FIXED
12.5-12.7	FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE except aeronautical mobile	FIXED FIXED-SATELLITE (Earth-to-Space)
12.7-12.75	Same	FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE
12.75-13.25	FIXED MOBILE	FIXED MOBILE

This band of frequencies, 11.7 to 13.25 GHz, is allocated to non-Government users in the U.S.

The final allocation of this band, and the bands 10.7 to 11.7 GHz and 14.0 to 14.5 GHz, is very unsettled. Several proposals were received by the FCC in response to the Third NOI (FCC, 1976). With the exception of a 100 MHz band from 14.3 to 14.4 GHz, these frequencies are all shared with terrestrial services; which include fixed, mobile, radiolocation and radio-navigation services.

The changes in the table of frequency allocations for Region 2 which are proposed in the Fifth NOI (FCC, 1977b) of FCC Docket No. 20271 are:

11.7 to 12.2 GHz: delete FIXED and BROADCASTING service, and reduce the MOBILE service from a primary to a secondary allocation.

12.2 to 12.5 GHz: add BROADCASTING-SATELLITE service.

12.5 to 12.75 GHz: no change.

12.75 to 13.25 GHz: add FIXED-SATELLITE service (Earth-to-Space) and SPACE RESEARCH (deep space only) (Space-to-Earth).

4.1.10. 14.0 GHz to 14.5 GHz

This band of frequencies is divided into four subbands, which in Region 2 and the U.S. are allocated as follows:

	Region 2	U.S.
14.0 to 14.2	FIXED-SATELLITE (Earth-to-Space) RADIONAVIGATION	FIXED-SATELLITE (Earth-to-Space) RADIONAVIGATION Space Research (Earth-to-Space)
14.2 to 14.3	Same	FIXED-SATELLITE (Earth-to-Space) RADIONAVIGATION
14.3 to 14.4	FIXED-SATELLITE (Earth-to-Space) RADIONAVIGATION-SATELLITE	FIXED-SATELLITE (Earth-to-Space) RADIONAVIGATION-SATELLITE
14.4 to 14.5	FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE	FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE Space Research (Space-to-Earth)

In the U.S., these frequencies are shared by Government and non-Government users; however, by footnote US207 (OTP, 1977), only non-Government operation is authorized in the fixed-satellite service.

Changes in the table of frequency allocations for Region 2 which are proposed in the Fifth NOI (FCC, 1977b) of FCC Docket No. 20271 are:

14.0 to 14.2 GHz: add Space Research as a secondary allocation.

14.2 to 14.3 GHz: No change.

14.3 to 14.4 GHz: delete RADIONAVIGATION-SATELLITE.

14.4 to 14.5 GHz: add Space Research (Earth-to-Space) as a secondary allocation.

It is expected that the major expansion in satellite communications in the next five to ten years will be in these frequency bands between 10.7 GHz and 14.5 GHz. As discussed in Section 2 of this report, experimentation is now in progress in these bands on the CTS; and planning is progressing on two commercial, U.S. domestic systems for launch in the early 1980's. These systems will operate in the fixed-satellite service.

At the recent World Administrative Radio Conference on broadcasting satellites (ITU, 1977), agreement was reached on a frequency channel (uplink at 14 GHz, downlink at 12 GHz) and orbit slot assignment plan for ITU Regions 1 and 3. A specific plan for Region 2 was not agreed to, however, such a plan is to be developed by 1982. Thus, it is likely that systems in the broadcasting-satellite service will be operating in these bands within the next ten to twenty years.

Under current allocation arrangements for Region 2 (ITU, 1977) the fixed-satellite and broadcasting-satellite services are to share the frequency bands 11.7 to 12.2 GHz for the space-to-earth link and the 14.0 to 14.5 for the earth-to-space link. However, there are concerns about the compatibility of these two services sharing the same frequencies. This issue is being addressed in the current proceedings on FCC Docket No. 20271, but indications in the Fifth NOI (FCC, 1977b) are that it is far from being settled.

4.1.11. 17.7 GHz to 21.2 GHz and 27.5 GHz to 31.0 GHz

These two bands of frequencies will be discussed together. These bands are not yet in use in operational systems, but experimentation is underway which is expected to lead to operational use. In Region 2 and the U.S., these frequencies are currently allocated as follows:

	Region 2	U.S.
17.7 to 19.7	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE
19.7 to 21.2	FIXED-SATELLITE (Space-to-Earth)	FIXED-SATELLITE (Space-to-Earth)

In the United States, the frequency bands 17.7 to 19.7 GHz and 19.7 to 20.2 GHz are allocated to non-Government use and the band 20.2 to 21.2 GHz is allocated to Government use.

	Region	U.S.
27.5 to 29.5	FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE	FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE
29.5 to 31.0	FIXED-SATELLITE (Earth-to-Space)	FIXED-SATELLITE (Earth-to-Space)

In the U.S., the bands 27.5 to 29.5 GHz and 29.5 to 30.0 GHz are allocated to non-Government use and the band 30.0 to 31.0 GHz is allocated to Government use.

Several modifications are proposed in the Fifth NOI (FCC, 1977b). It is proposed that METEOROLOGICAL SATELLITE (Space-to-Earth) be added to the subband 17.9 to 18.7 GHz, and that MOBILE-SATELLITE (Space-to-Earth) and Standard Frequency Satellite (Space-to-Earth), a secondary allocation, be added to the subband 20.2 to 21.2 GHz. Similarly, it is proposed that MOBILE-SATELLITE (Earth-to-Space) and Standard Frequency Satellite (Earth-to-Space), a secondary allocation, be added to the subband 30.0 to 31.0 GHz.

Following the 12/14 GHz bands, these are the next likeliest frequency bands to be utilized for satellite communications. Experiments are now being conducted at frequencies of 19 and 28 GHz using transmitters on board the COMSTAR satellites of the COMSAT General Corporation. These satellite transmitted signals are being used to study the attenuation and depolarization effects of the atmosphere, rain, etc., at these frequencies.

4.1.12. 40.0 GHz to 45.0 GHz

This band of frequencies is divided into three subbands, which in Region 2 and the U.S. are allocated as follows:

	Region 2	U.S.
40 to 41	FIXED-SATELLITE (Space-to-Earth)	FIXED FIXED-SATELLITE (Space-to-Earth) MOBILE
41 to 43	BROADCASTING-SATELLITE	FIXED BROADCASTING-SATELLITE MOBILE
43 to 45	AERONAUTICAL MOBILE-SATELLITE MARITIME MOBILE-SATELLITE AERONAUTICAL RADIO-NAVIGATION-SATELLITE MARITIME RADIO-NAVIGATION SATELLITE	AERONAUTICAL MOBILE AERONAUTICAL MOBILE-SATELLITE MARITIME MOBILE MARITIME MOBILE-SATELLITE AERONAUTICAL RADIONAVIGATION AERONAUTICAL RADIONAVIGATION-SATELLITE MARITIME RADIO-NAVIGATION

43 to 45 (cont.)	Region 2	U.S.
		MARITIME RADIO-NAVIGATION-SATELLITE

In the U.S., these frequencies are shared by both Government and non-Government users, except the BROADCASTING-SATELLITE service, 41 to 43 GHz, is allocated to non-Government users, only. The modifications to the table of frequency allocations which are proposed in the Fifth NOI (FCC, 1977b) would change the allocations for Region 2 to read as follows:

40 to 41	FIXED-SATELLITE (Space-to-Earth) FIXED MOBILE MOBILE-SATELLITE (Space-to-Earth)
41 to 43	BROADCASTING-SATELLITE FIXED MOBILE
43 to 45	FIXED-SATELLITE (Earth-to-Space) MOBILE-SATELLITE (Earth-to-Space)

As is indicated in Tables 4.1, 4.2, 4.3, and 4.4, there are a number of bands of frequencies allocated to satellite communications between 50 GHz and 275 GHz. Though there are some experiments being conducted at these frequencies, their utilization by operational systems is likely to be some years in the future. Thus, the allocations in these frequency bands will not be discussed in detail in this report.

5. ANALYSIS OF COSTS OF LEASED-CHANNELS FROM TERRESTRIAL AND SATELLITE COMMON CARRIERS

In previous sections of this report we have discussed the growth of satellite communications and some of the technical characteristics of satellite communication systems. In this section we take a look, from a user point of view, at the satellite telecommunications offerings of the satellite common carriers. First, we will briefly discuss the satellite common carriers, then present some tariff information on the cost of private-line service offered by terrestrial and satellite common carriers. The private-line service, as used here, is a dedicated communication service leased on a full-time basis.

The private-line service cost information presented here is from tariffs on file with the FCC. These data are as of December 1977, and may change as new tariffs are filed by the common carriers.

5.1. Domestic Satellite Common Carriers

In the U.S. domestic satellite communications system, some of the common carriers own and operate satellites and earth stations; while others own only earth stations and lease satellite transponders from other common carriers. The U.S. domestic common carriers are discussed briefly in the following paragraphs.

5.1.1. RCA American Communications, Inc.

RCA American Communiations, Inc., own and operate the two SATCOM satellites which provide 24 transponder channels each, by use of orthogonal polarization discrimination. The common-carrier services provided include:

- Point-to-point private-line channels for voice, data, facsimile, and various wide-band services.
- Leased transponders to other common carriers.
- Leased transponders to other entities, such as for TV program distribution to CATV systems.

5.1.2. Western Union Telegraph Co.

Western Union owns and operates the two WESTAR satellites which provide 12 transponder channels each. The common-carrier services provided include:

- Point-to-point private-line channels for voice, data, facsimile, and various wide-band services. The tariff schedules available include single- and multiple voice channels and wide-band channels of 48 kHz, 240 kHz, and 1.2 MHz. Synchronous digital channels at data rates of 9.6 kbps and 56.0 kbps are available between New York and Los Angeles.
- Leased transponders to other common carriers.
- Leased transponders to other entities, such as the Corporation for Public Broadcasting, for TV and radio networks.

5.1.3. American Telephone and Telegraph Co./General Telephone and Electric Co.

The AT&T and GTE, together, constitute the sole leasee of the COMSTAR satellites that are owned and operated by the COMSAT General Corporation. There are two COMSTAR satellites which have 24 transponder channels each, by use of orthogonal polarization discrimination. AT&T/GTE are restricted by the FCC from offering private line satellite services, at least until after 1979. The satellites are used by AT&T/GTE to augment the terrestrial network and to extend it to areas such as the state of Hawaii. The services offered are the same as those offered via the terrestrial network.

5.1.4. RCA Alaska Communications Inc.

The RCA Alascom is the designated long-lines common carrier for the state of Alaska. RCA Alascom leases transponder channels from RCA Americom. The services provided include:

- Interconnection between Alaska and the contiguous 48 states via earth stations on the U.S. west coast.
- Multi-channel and wideband interconnection between major population centers in Alaska.

- Television network distribution to Alaska.
- Thin-route, single-carrier-per-channel communications channels to small, "bush" stations.

5.1.5. American Satellite Corporation (ASC)

American Satellite owns earth stations that are interconnected via satellite transponders leased from other domestic satellite companies. ASC provides point-to-point communications channels for voice, data, facsimile, and various wideband applications. The common-carrier services provided include:

- Single and groups of voice-frequency channels between specific major population centers. These channels are available to the general public on a leased private-line basis.
- Point-to-point multichannel service via dedicated earth stations available to Government and private parties. An example is the recently announced service for the Boeing Computer Service between Seattle, WA, Wichita, KA, and Philadelphia, PA, to provide 56 kbs data service between computers.
- TV program distribution service to CATV and pay-TV systems.

5.1.6. Southern Pacific Communications Co. (SPCC)

Southern Pacific is a specialized common carrier. SPCC provides two-point private-line service to major metropolitan areas via leased satellite facilities and via landline extensions to reach selected off-network points. The services offered by SPCC are single- and multiple-voice frequency channels.

5.2. Satellite and Terrestrial Telecommunication Costs

The telecommunications channel cost information included in this study is based on the tariffs filed by AT&T long-lines and the domestic satellite common carriers. In the case of the terrestrial service, the rates are listed as cost per mile per channel per month. There are price breaks on mileage between rate centers (for example, for a voice grade line the cost is as follows: first 15 mi, $1.80 per mi; next 10 mi, $1.50 per mi;...101 to 1000 mi, $0.66 per mi) and on the number of channels leased by a single user.

In presenting these data on telecommunications costs, it has been assumed that the communications terminals are in the primary area of the rate center of the terminating exchange. For a termination outside the primary area, the local state rates apply and these can vary widely. The telecommunication channel cost information for the terrestrial system includes: (1) the monthly cost for the interconnect between the carrier exchange and the user premises, (2) the monthly cost for the user termination, and (3) the monthly cost for the interexchange mileage. Similarly, the telecommunication channel cost information for the satellite systems include: (1) a local access charge for the interconnect between the carrier facility and the user premises, (2) a channel termination charge, and (3) the satellite channel charge, based roughly on mileage between terminals.

Six domestic satellite common carriers were discussed in Section 5.1. Telecommunication channel cost information is presented here for only four of these six domestic satellite common carriers. Of the other two, AT&T/GTE do not provide private-line satellite services and RCA Alascom provides services only to a specific area. The other four domestic satellite common carriers provide private-line, leased-channel services to many major metropolitan areas throughout most of the U.S.

The tariffs filed by the domestic satellite common carriers are not listed on a cost per mile basis as the terrestrial tariffs are. Rather, the tariffs are listed as a specific dollar cost between specific city-pairs. Although there is some distance dependence in the cost between city-pairs, there is a large variation in the distance between cities which are tariffed at the same dollar cost per month.

A summary of these intercity tariffed rates and the mean distance between cities to which the specific rate applies is listed in Table 5.1. The rate shown is for a single voice-grade dedicated full-duplex channel leased on a month-to-month basis (termination charges are not included). These intercity rates

Table 5.1. Domestic Satellite Common-Carrier Inter-City Tariffs for City-Pairs

Rate ($/channel/ month)	Distance between cost centers (mean and sample standard deviation)				
	ASC	RCA	SPCC	WU	Composite
1100	[2] 2392 21				[2] 2392 21
1000	[7] 2311 214	[8] 2437 88	[19] 2295 218	[27] 2237 232	[29] 2252 231
900	[2] 2192 90	[1] 1220	[1] 2129	[1] 2129	[3] 1869 565
750	[4] 1497 348	[4] 1557 280	[20] 1372 235	[27] 1407 292	[29] 1401 282
700	[4] 1480 118	[5] 1302 411	[4] 1480 118	[4] 1480 118	[5] 1302 411
650		[1] 648			[1] 648
600	[2] 1305 91	[2] 1305 91	[2] 1305 91	[2] 1305 91	[2] 1305 91
500	[9] 745 169	[4] 777 118	[27] 758 169	[55] 732 157	[56] 731 156

were taken from: (1) American Satellite Corporation tariff filing F.C.C. No. 1, (2) RCA American Communications, Inc., tariff filing F.C.C. No. 1, (3) Southern Pacific Communications Company tariff filing F.C.C. No. 2, and (4) Western Union Telegraph Company tariff filing F.C.C. No. 261. The rate for a voice-grade dedicated channel ranges between $500 and $1100 per channel per month. In Table 5.1, for each common-carrier and each rate filed, the mean distance between cities (upper number) and the sample standard deviation (lower number) for city-pairs are listed. The number in the upper left corner of each box is the number of city-pairs in that company's tariff.

The right-hand column in Table 5.1 is a composite of the city-pairs tariffed by all carriers. Where service is provided between specific city-pairs by more than one carrier, the distance between these cities is included only once in the composite column. For example, at the $500 rate, there are 56 city-pairs included in the composite column and 55 for Western Union. Only one additional city-pair is served by one or more of the other three common carriers. Where a specific rate applies to only one city-pair, a sample standard deviation is not shown.

The data in the composite column of Table 5.1 are also presented in graphical form in Figure 5.1. The mean distances in miles are plotted versus the per channel per month cost in dollars. The sample standard deviation is plotted as error bars about the mean distance. The number of city pairs represented by each point is shown for each rate. These data show a definite trend of higher channel cost with increasing distance, but they also show the wide range of distances included at each rate and the great overlap of the distance between cities for the different tariff rates.

The continuous curve labeled "terrestrial" in Figure 5.1 represents the cost per month of one voice-grade channel as a function of distance. These data include only the intercity mileage charge as tariffed by AT&T.

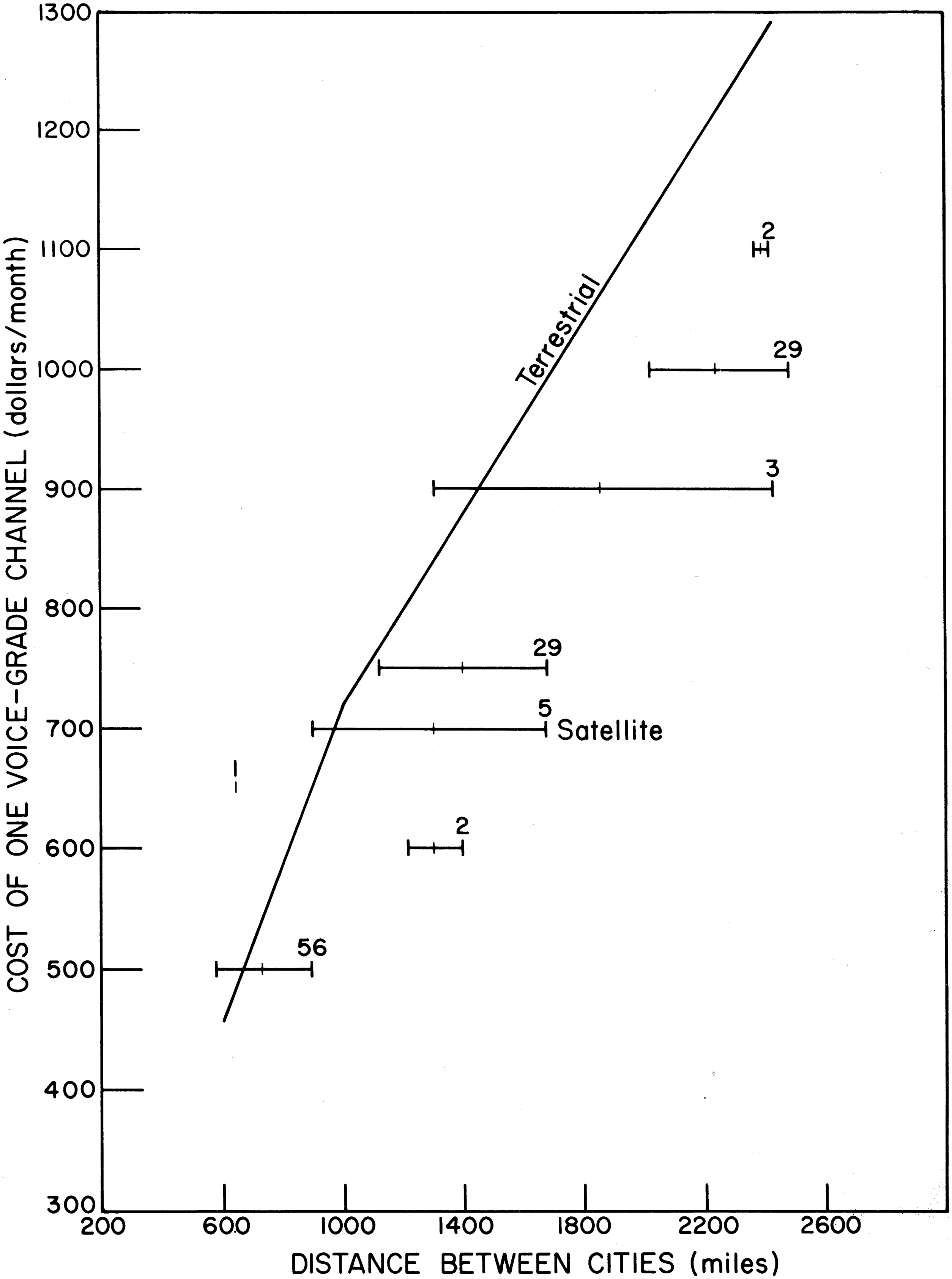

Figure 5.1. The dependence of cost on distance of a voice-grade channel offered by terrestrial and satellite common carriers.

The quantity discount rates applicable to leased voice-grade channels provided by domestic satellite common carriers are listed in Table 5.2. Note that there are differences in the discount rates used by the various carriers.

Table 5.2. Quantity Discounts on Groups of Voice-Grade Channels Leased

Number of Channels	Percentage Discount			
	ASC	RCA	SPCC	WU
6-11	10		10	10
12-23	20	20	20	20
24-59	30	30	30	30
60-239	35		32.5	35
240 & over				40

In Figure 5.2, tariffed cost information is shown for terrestrial and satellite voice-grade service offered by the common carriers. The terrestrial tariff rates are those offered by AT&T for single and multiple voice-grade channels, with the channel-equivalent bandwidth plotted on the horizontal scale. Though the bandwidth is shown as a continuous function, it should be thought of as being in units of 4000 Hz, the nominal bandwidth of a voice-grade channel. These tariff rates are shown for channel distances of 100, 500, 1000, 2000 and 3000 miles.

The satellite tariff rates shown in Figure 5.2 are for inter-city rates of $500, $750 and $1000 for a single voice-grade channel per month. The channel mileages shown are the mean, composite mileage listed in Table 5.1. At the wider bandwidths, the quantity discount for groups of voice-grade channels are included. The percentage discounts used are those listed for Western Union in Table 5.2.

The terrestrial cost information does not reflect bulk-channel rates which were possible with the TELPAC rates of a few

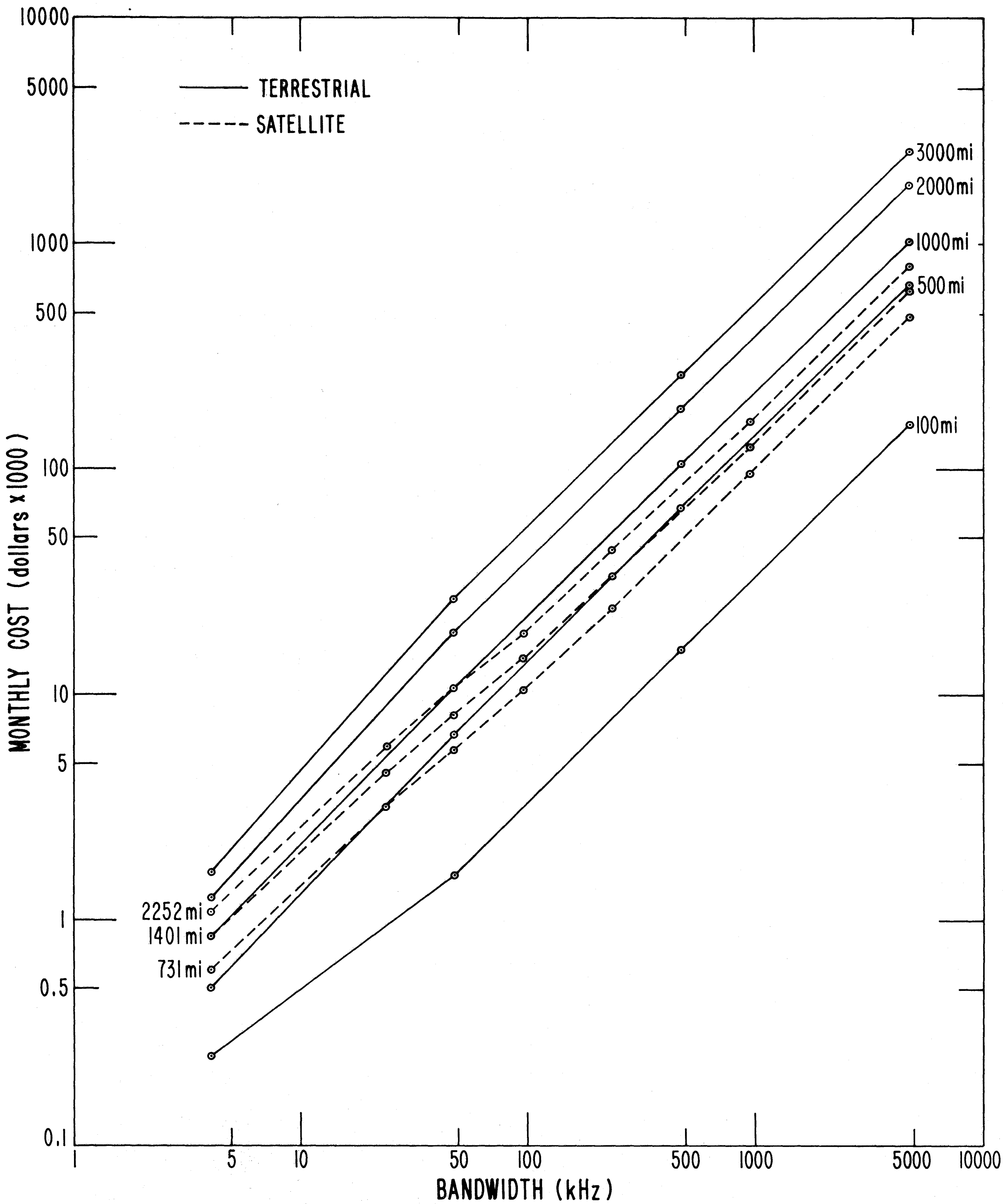

Figure 5.2. Costs of terrestrial and satellite analog telecommunications channels, costs vs. channel bandwidth as a function of distance.

months ago. The TELPAC service has been challenged by the FCC and is currently in limbo. Present operating TELPAC services are continuing but no new services can be started.

The cost of digital telecommunications channels in terrestrial and satellite communications systems are presented in Figure 5.3. The terrestrial system data are for the AT&T Dataphone Digital Service® (DDS). The tariff data for the DDS service include digital data rates ranging from 2.4 kbps to 1.344 Mbps. These data are plotted in Figure 5.3 for distances of 100, 500, 1000, 2000 and 3000 miles. In addition to the mileage charge, these data include the terminal charge, the system interface charge and the data access line charge.

Digital data service is not yet widely offered by the satellite common carriers. The only carrier which has a tariff schedule is Western Union. Western Union has filed tariffs for digital communication data rates of 9.6 kbps and 56.0 kbps, however, this service is available only between New York and Los Angeles. The distance between these cities is 2443 miles. These data are shown in Figure 5.3.

6. SUMMARY AND CONCLUSIONS

This report has addressed some of the past, current, and planned activities relating to the U.S. domestic satellite communications services, both fixed-satellite services and broadcasting-satellite services. Since there is not yet a domestic U.S. broadcasting-satellite service, the primary emphasis was on the fixed-satellite service.

The development of the U.S. domestic satellite common-carrier systems was traced and the current status was presented. The general technical characteristics of the current-generation communication satellites were included.

The technical design of these satellite communication systems requires the use of relatively large earth station antennas for applications which involve relatively large bandwidths.

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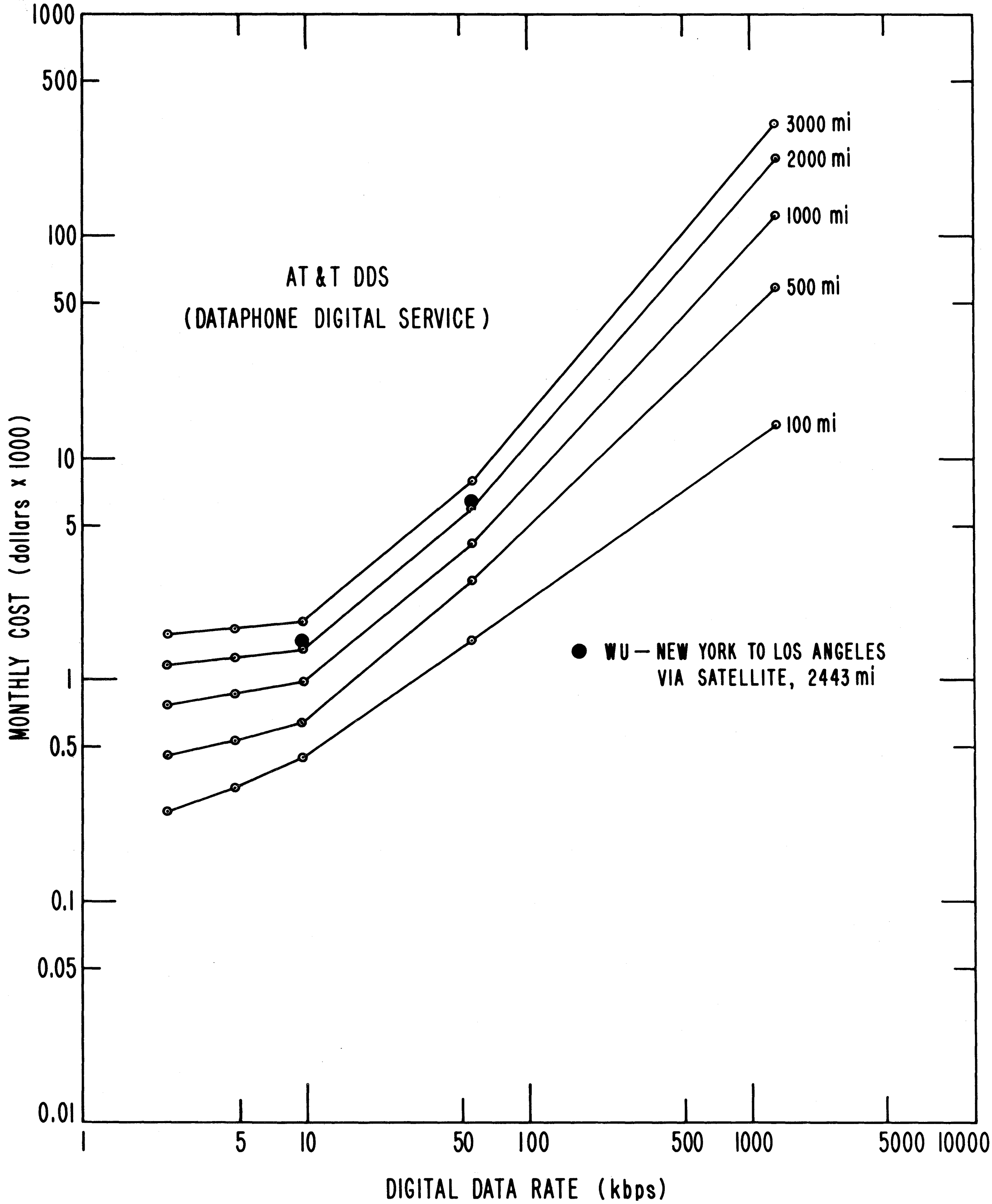

Figure 5.3. Costs of terrestrial and satellite digital telecommunications channels, cost vs. data bit rate as a function of distance.

Typical minimum earth station antenna diameter for transmitting is in the range of 10 to 15 meters. However, for a receive-only TV application, the earth station antenna diameter is typically 4.5 to 10 meters, depending on geographical location and the required TV picture quality. Finally, for a narrow-band (5 kHz) use, application has been made to the FCC for receive-only earth stations using antennas with a diameter of 3 meters.

An important aspect in considering the potential for growth of small antenna earth station systems is the regulatory and frequency allocation climate in which such systems can develop. The frequency allocation aspects were addressed in Section 4. The frequency band having the greatest potential for accommodating small antenna earth station systems is the 12/14 GHz band. However, if this band develops (as it appears to be developing) in the same manner as the 4/6 GHz band has developed, the small antenna earth station system development will be foreclosed in the 12/14 GHz band also. The future growth potential for satellite communication systems is one of the very important problems that needs serious consideration during preparation for the 1979 WARC.

Finally, some tariff information on the cost of private-line service offered by terrestrial and satellite common carriers was presented. The capital equipment investment requirements for satellite communications is not dependent on the distance between the earth locations being served. However, the tariff rates on file with the FCC are distance-dependent. This distance-dependence of the tariff rates appears to be based on a competitive pricing strategy, rather than on the cost of providing the service.

7. ACKNOWLEDGMENTS

The author acknowledges the valuable assistance of Mr. Earl C. Bolton in the collection of much of the data presented in this report.

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APPENDIX

This appendix contains a listing of domestic earth stations for the 50 United States that had been licensed by October 1977.

The earth stations are listed in the first column sequentially by station license number, starting with WB 20 for earth stations east of the Mississippi River and KB 20 for stations west of the Mississippi River. The name of the station applicant is listed under the station license number. The name of the city nearest (or the area served by) the earth station is listed in column two. The geographical coordinates of the earth station are in column three.

The transmitter output power, in watts, and effective isotropic radiated power (EIRP), in dBW, of the earth station are listed in columns four and five, respectively. The values listed are maximum licensed values. The stations for which these columns are blank are licensed for receive operation, only.

The earth station antenna gain for both transmit and receive, as appropriate, is listed in column six. The first number is the operating frequency band (e.g., 4 indicates the receive band at 4 GHz and 6 indicates the transmit band at 6 GHz) and following the dash is the antenna gain in dB at the indicated frequency. The number of antennas at the earth station and the antenna size(s) are listed in column seven. In most cases, the antenna diameter is stated in meters (M). In some cases, the antenna diameter is followed by a V or an H or both. This indicates the antenna polarization, V indicates vertical and H indicates horizontal.

The noise temperature of the receiver preamplifier is listed in column eight. The noise temperature is shown in Kelvin. This information is not listed for all stations.

For many of the stations, the satellite through which the earth station is expected to communicate is listed in column nine.

The station license numbers with no information indicate station applications that had not yet received their DSE license.

Table A.1. Licensed Domestic Earth Stations in the United States, October 1977

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WB 20 WU	Glenwood, NJ	41°12'43"N 74°29'38"W	3k	83	4-54.7 6-57.7	2-15M	(55°) 85°k	Westar 1 & 2
WB 21 delete								
WB 22 Gen Elect.	Valley Forge, PA	40°05'32"N 75°24'11"W	3k 300w	83	4-48.5 6-52.4	8M(26.5)	141°	ANIK Westar 1 & 2 Satcom 1 & 2
WB 23 delete								
WB 24 WU	Estill Fork, AL	34°54'30"N 86°09'46"W	3k	83	4-54.7 6-57.7	2-15M V	55° 85°	Westar 1 & 2
WB 25 WU	Lake Geneva, WI	42°37'18"N 88°25'55"W	1.5k	83	4-54.7 6-57.7	2-15M V	55° 85°	Westar 1 & 2
WB 26 Scientific Atlanta	Doraville, GA	33°54'47"N 84°14'25"W	Rcv only		4-50.5	10M H	117°	ANIK 1, 2, 3 Satcom 1 Westar 2
WB 27 AM. Sat. Corp.	Vernon Valley, NJ	41°13'24"N 74°30'06"W	3k	85	4-50.5 6-52.5	10M V	56°	ANIK 1, 2 Westar 1, 2
WB 28 Dismissed 3-12-76								
WB 29 RCA	Valley Forge, PA	40°05'32"N 75°24'12"W	3k	84.6	4-50.8 6-53.0	10M V	69°	Satcom 1, 2
WB 30 AT&T	Hawley, PA	41°27'51"N 75°07'48"W	3k	92.3	4-60.4 6-62.8	3-30M V/H	79°	Comsat Gen 1, 2, 3
WB 31 AT&T	Hanover, IL	42°18'36"N 90°21'27"W	3k	92.3	4-60.4 6-62.8	2-30M V/H	79°	Comsat Gen 1, 2, 3
WB 32 AT&T	Woodbury, GA	32°56'12"N 84°32'21"W	3k	92.3	4-60.4 6-62.8	2-30M V/H	79°	Comsat 1, 2, 3
WB 33 GTE	Metamora, IN	39°23'57"N 85°13'30"W	3k	92	4-59.6 6-62.5	2-30M V	53°	NSS 1, 2
WB 34 GTE	Indiantown Gap, PA	40°28'31"N 76°33'53"W	3k	92	4-59.6 6-62.5	2-30M V	53°	NSS 1, 2
WB 35 GTE	Homosassa, FL	28°51'18"N 82°32'00"W	3k	92	4-59.6 6-62.5	2-30M V/H	53°	NSS 1, 2 Comsat 1, 2, 3

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WB 36 Comsat Gen.	Southbury, CT	41°27'05"N 73°17'21"W	3k	85	4-52.8 6-56.0 4-50.4 6-53.5 1.5-38.0	1-13M V/H 1-10M V/H	100 120	Comsat 1, 2, 3, 4
WB 37 Am Sat Corp	Loring AFB, ME	47°00'07"N 68°00'11"W	300w	66.5	6-54.0	10M V		Westar 1, 2
WB 38 PBS		Transpor- table	3		4-48.2 6-51.6	8M linear	120°	Any
WB 39 Cities Sv. Oil Co.	High Isl. Area, G. of Mex.	28°09'56"N 93°45'19"W	40w	40.6	4-42.7 6-45.5	1 4.5M V/H	205°	Westar 1, 2
WB 40 Dow Jones	Orlando, FL	28°26'48"N 81°24'49"W	Rcv only		4-50.5	1-10M H	110°	Westar 1, 2
WB 41 Dow Jones	Chicopee, MA	42°09'50"N 72°33'11"W	30w	63	6-54.0	1-10M V		Westar 1, 2
WB 42 Micro Cable d/b/a FL Cablevision	Fort Pierce, FL	27°26'28"N 80°23'17"W	Rcv only		4-49.7	1-10M V/H	400°	Westar 1, 2 RCA Satcom 1, 2
WB 43 Gen Elect.	Dayton Beach, FL	29°11'33"N 81°04'13"W	3k	88.2	4-48.2 6-51.6	1-8M V/H	141°	Westar 1, 2 Satcom 1, 2
WB 44 Ft. Smith TV Cable	Fort Smith, AR	35°21'12"N 94°25'55"W			4-49.7	1-10M V/H	400°	Westar 1, 2
WB 45 S. Fla. Cable	Bonita Springs, FL	26°21'26"N 81°44'28"W			4-49.7	1-10M V/H	398°	Westar 1 Satcom 1
WB 46 AM TV & Comm Corp	Jackson, MS	32°22'24"N 90°09'10"W			4-49.7	1-10M V/H	363°	Westar 1, 2 Satcom 1, 2
WB 47 Teleprompter	Fairmont, WV	39°30'45"N 80°09'45"W			4-49.7	1-10M V/H	372°	Westar 1, 2 Satcom 1, 2
WB 48 Teleprompter	Mobile, AL	30°42'12"N 88°07'03"W			4-49.7	1-10M V/H	372°	Westar 1, 2 Satcom 1, 2

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WB 49 Teleprompter	Tuscaloosa, AL	33°11'55"N 87°29'07"W			4-49.7	1-10M V/H	372°	Westar 1, 2 Satcom 1, 2
WB 50 Owensboro, Cablevision	Owensboro, KY	37°46'30"N 87°09'42"W			4-50.4	1-10M V/H	306°	Westar 1, 2 Satcom 1, 2
WB 51 Cox Cable Comm	Saginaw, MI	43°25'42"N 83°57'53"W			4-50.0	1-10M V/H	316°	Westar 1, 2 Satcom 1, 2
WB 52 Teleprompter	Gadsden, AL	34°02'59"N 85°59'19"W			4-50	1-10M V/H	363°	Westar 1, 2 Satcom 1, 2
WB 53 Tower Com Syst Corp	Newark, OH	40°00'52"N 82°22'44"W			4-51	1-10M V/H	310°	Westar 1, 2 Satcom 1, 2
WB 54 Teleprompter	Rock Island, IL	41°29'05"N 90°35'07"W			4-50	1-10M V/H	363°	Westar 1, 2 Satcom 1, 2
WB 55 Added Attractions	West Lafayette, IN	40°27'17"N 86°55'38"W			4-51	1-10M V/H	307°	Westar 1, 2 Satcom 1, 2
WB 56 United Cable TV	Carpentersville, IL	42°09'42"N 88°19'02"W			4-44	1-4.5M	273°	Westar 1, 2 Satcom 1, 2
WB 57 Teleprompter	West Palm Beach, FL	26°37'53"N 80°12'07"W			4-50	1-10M V/H	363°	Westar 1, 2 Satcom 1, 2
WB 58 Erie Co. CATV	Erie, PA	42°06'42"N 79°58'42"W			4-51	1-10M V/H	309°	Westar 1, 2, Satcom 1, 2
WB 59 Summit Cable Service	Winston Salem, NC	36°03'38"N 80°16'05"W			4-50	1-10M V/H	398°	Westar 1, 2 Satcom 1, 2
WB 60 Liberty Comm	Birmingham, AL	33°25'03"N 86°49'56"W			4-49.7	1-10M V/H	372°	Westar 1, 2 Satcom 1, 2

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WB 61	Void							
WB 62 Teleprompter	South Shore, KY	38°43'33"N 82°57'46"W			4-50	1-10M V/H	398°	Westar 1, 2 Satcom 1, 2
WB 63 Teleprompter	Florence, AL	34°48'52"N 87°39'03"W			4-50	1-10M V/H	398°	Westar 1, 2 Satcom 1, 2
WB 64 Cable Haven TV	Manahawkin, NJ	39°43'00"N 74°15'10"W			4-50	1-10M V/H	398°	Westar 1, 2 Satcom 1, 2
WB 65 Am. Video Corp	Pompono Beach, FL	26°14'59"N 80°07'28"W			4-51	1-10M V/H	162°	Westar 1, 2 Satcom 1, 2
WB 66 Eastern Shore CATV	Berlin, MD	38°20'50"N 75°11'21"W			4-51	1-10M V/H	273°	Westar 1, 2 Satcom 1, 2
WB 67 Nilcom, Inc.	Belvidere, IL	42°13'08'N 88°49'16"W			4-51	1-10M V/H	140°	Westar 1, 2 Satcom 1, 2
WB 68 Consolidated Cable Utilities Corp.	Aurora, IL	41°42'07"N 88°18'48"W			4-50	1-10M V/H	347°	Westar 1, 2 Satcom 1, 2
WB 69 Teleprompter	Superior, WI	46°42'20"N 92°04'33"W			4-50	1-10M V/H	398°	Westar 1, 2 Satcom 1, 2
WB 70 Eastern Micro-wave	Hooksville, PA	40°34'37"N 80°27'24"W			4-50	1-10M V/H	347°	Westar 1, 2 Satcom 1, 2
WB 71 AM TV & Comm	Winter Park, FL	28°36'33"N 81°19'28"W			4-47.9	1-10M V/H	400°	Westar 1, 2 Satcom 1, 2
WB 72 Storer Cable TV	Sarasota, FL	27°20'26"N 82°27'56"W			4-50	1-10M V/H	270°	Westar 1, 2 Satcom 1, 2
WB 73 Teleprompter	Huntsville, AL	34°42'07"N 86°31'02"W			4-50	1-10M V/H	398°	Westar 1, 2 Satcom 1, 2
WB 74 RCA AM Comm	Greenbelt, MD	38°59'55"N 76°50'24"W	400w	63	4-50.5 6-53.0	1-10M V/H	112°	Satcom 1 & 2

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WB 75 Greater Hart-ford CATV	Manchester, CT	41°48'14"N 72°30'28"W			4-50.0	1-10M V/H	398°	Wester 1, 2 Satcom 1, 2
WB 76 Rollins Cable Vue	No. Branford, CT	41°22'06"N 72°48'38"W			4-49.7	1-10M V/H	268°	Westar 1, 2 Satcom 1, 2
WB 77 Courier Cable Co	Buffalo, NY	42°56'46"N 78°49'36"W			4-49.7	1-10M V/H	234°	Westar 1, 2 Satcom 1, 2
WB 78 River City Cable TV	Calark County, KY	38°24'27"N 85°50'34"W			4-51.0	1-10M V/H	276°	Westar 1, 2 Satcom 1, 2
WB 79 RVS Cablevision Corp.	Brookfield, WI	43°01'58"N 88°09'06"W			4-51.0	1-10M V/H	316°	Westar 1, 2 Satcom 1, 2
WB 80 ITT Space Communication	Ramsey, NJ	41°05'10"N 74°08'31"W			4-43.0	1-4.5M V/H	100°	Westar 1, 2 ANIK 1, 2
WB 81 RCA Global Comm	Vernon Valley, NJ	41°12'06"N 74°37'36"W			6-53.2	10M		
WB 82 United Video, In., 9-21-76 xfer to L. Flinn, Sr.	Christian County, Ill. Taylorville, Ill. also see KB-94	39°30'41"N 89°15'01"W			4-51.0	1-10M V/H	273°	Westar 1, 2 Satcom 1, 2
WB 83 Dow Jones & Co.	So. Brunswick NJ	40°22'11"N 74°35'12"W			4-51.0	1-11M H	100°	Westar 1, 2
WB 84 Harris Corp., Elec. Syst. Div	Palm Bay, FL	28°01'57"N 80°35'50"W	3K	88	4-52.1 6-55.2	1-11M V/H	107°	Westar 1, 2
WB 85 Cablevision of Augusta	Augusta, GA	33°28'18"N 82°01'40"W			4-50.5	1-10M V/H	262°	Westar 1, 2 Satcom 1, 2

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WB 86 Potomac Valley TV Co.	Cumberland, MD	39°38'58"N 78°45'41"W			4-52.0	1-11M V/H	279°	Westar 1, 2 Satcom 1, 2
WB 87 Video Service Co.	Morristown, IN	39°38'47"N 85°40'55"W			4-50.0	1-10M V/H	255°	Westar 1, 2 Satcom 1, 2
WB 88 AM TV & Comm Corp.	Charleston, WV	38°17'16"N 81°36'03"W			4-50.0	1-10M V/H	251°	Westar 1, 2 Satcom 1, 2
WB 89 AM Cablevision of Carolina	Savannah, GA	31°59'05"N 81°04'45"W			4-50.0	1-10M V/H	251°	Westar 1, 2 Satcom 1, 2
WB 90 Cox Cable Comm, Inc.	Roanoke, VA	37°16'15"N 79°58'21"W			4-50.0	1-10M V/H	398°	Westar 1, 2 Satcom 1, 2
WB 91 Fairchild Space & Elec. Co.	Germantown, MD	39°11'30"N 77°15'50"W	2W	49.8	4-43.7 6-46.8	1-4.5M V/H	250°	Westar 1
WB 92 Armstrong Utilities, Inc.	Ashland, OH	40°50'45"N 82°20'50"W			4-50.2	1-10M, V/H	264°	Westar 1, 2 Satcom 1, 2
WB 93 Teleprompter	Danbury, CT	41°21'47"N 73°26'38"W			4-50.0	1-10, V/H	398°	Westar 1, 2 Satcom 1, 2
WB 94 Teleprompter	Johnstown, PA	40°18'51"N 78°53'50"W			4-50.0	1-10M V/H	326°	Westar 1, 2 Satcom 1, 2
WB 95 Comsat Gen Corp	Reston, VA	39°56'59"N 77°22'23"W	1W	33.5	6-34.5	1-4ft. V/H	---	ANIK 1, 2
WB 96 Hampton Roads Cablevision	Newport News, VA	37°05'28"N 76°27'16"W			4-50.6	1-10M V/H	276°	Westar 1, 2 Satcom 1, 2
WB 97 Palmer Broad-casting Co.	Naples, FL	26°03'00"N 81°42'16"W			4-51	1-10M V/H	162°	Westar 1, 2 Satcom 1, 2

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WB 98 Harris Corp. Elec. Syst Div	Melbourne, FL	28°05'02"N 80°37'02"W	3K	88	4-52.1 6-55.2	1-11M Cir	107°	Westar 1, 2
WB 99 Danville Cable-vision Co.	Danville, VA	36°37'46"N 79°24'49"W			4-50.2	1-10M V/H	263°	Satcom 1, 2
WD 20 Multi-Channel TV Cable	Mansfield, OH	40°42'59"N 82°32'46"W			4-50.0	1-10M V/H	318°	Satcom 1, 2
WD 21 Western Tele-Comm, Inc.	Knoxville, TN	36°00'03"N 83°57'05"W			4-51.0	1-10M V/H	197.5°	Westar 1, 2 Satcom 1, 2
WD 22 Satellite Service, Inc.	Troy, AL	31°46'39"N 85°59'22"W			4-50.6	1-10M V/H	278°	Satcom 1, 2
WD 23 Racine Telecable	Racine, WI	42°40'07"N 87°49'52"W			4-50	10M		
WD 24 CPI Sat Telecomm	Springfield, IL	39°45'06"N 89°34'38"W			4-50.6	1-10M V/H	288°	Westar 1, 2 Satcom 1, 2
WD 25 Tele Cable of Columbus	Smiths, AL	32°35'10"N 85°06'19"W			4-50.0	1-10M V/H	282°	Satcom 1, 2
WD 26 Wheeling Antenna Co.	Wheeling, WV	40°02'04"N 80°40'22"W			4-50.5	1-10M V/H	264°	Satcom 1, 2
WD 27 Beach Cable-vision	Panama City, FL	30°12'11"N 85°50'30"W			4-44	4.5M		
WD 28 COMSAT General Corp.	Hogestown, PA	40°15'08"N 77°01'17"W	1W	33.5	6-34.5	1-4ft V/H	---	ANIK 1, 2

Station	Location	Coordinates	Power Max	EIRP dBW	Gain dB	Antenna	T	Satellite
WD 29 COMSAT General Corp.	Carsonville, PA	40°27'37"N 76°45'06"W	1W	33.5	6-34.5	1.2M V/H	---	ANIK 1, 2
WD 30 COMSAT General Corp.	Sunbury, PA	40°50'04"N 76°49'37"W	1W	33.5	6-34.5	1.2M V/H	---	ANIK 1, 2
WD 31 Exxon Comm Co	Off-shore Drill riggs	Transport-able Atlant Pasc G of M & Alaska	50W	43.3	4-43.7 6-46.8	1-4.5M V/H	108.5°	Satcom 1, 2
WD 32 Exxon Comm Co WD 33 Exxon Comm Co	Off-shore Drill riggs	Transport-able Atlant Pasc G of M & Alaska	50W	43.3	4-43.7 6-46.8	1-4.5M V/H	108.5°	Satcom 1, 2
WD 34 RCA Am Comm, Inc WTCG-TV	Atlanta, GA Distribution	33°51'00"N 84°28'56"W	3K	81	4-50.5 6-53.5	1-10M V/H	274°	Satcom 1, 2
WD 35								
WD 36 Florida Central Cost ETV	Orlando, FL	28°33'54"N 81°12'46"W			4-48	10M		
WD 37								
WD 38								

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WD 39								
WD 40								
WD 41 Cable TV Co.	Wilmington, NC	34°13'36"N 77°55'14"W			4-50.6	1-10M V/H	276°	Satcom 1, 2
WD 42 Kankakee TV Cable Co.	Kankakee, IL	41°08'16"N 87°53'42"W			4-51.0	1-10M V/H	268°	Satcom 1, 2
WD 43 Grosswicks, Ind	Pt Pleasant Beach, NJ	40°05'55"N 74°07'17"W			4-50.5	10M V/H	294°	Westar 1, 2 Satcom 1, 2
WD 44 Sat Bus. Syst.	Franklin Lakes, NJ	40°59'02"N 74°12'27"W	2K	6-84 14-92.1	12-53.9 14-55.5	5M 1	225°	
					4-51.0 12-60.1 14-61.6	10M cir	225-12 100-4	
					4-51.0 6-54.5	10M 1	4-100°	
WD 45 Gaithersburg, CATV	Gaithersburg, MD	39°07'25"N 77°11'07"W			4-43.5	4.5M V/H	125°	Satcom 1, 2
WD 46								

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WD 47 TelCable of Sparterburg	Sparterburg, SC	34°59'11"N 81°54'09"W			4-50	10M		
WD 46 SBS	Poughkeepsie, NY	41°39'09"N 73°56'35"W	3K	90	4-50.5 6-54.3	11M V/H	100°	
WD 48 RCA Corp.	Hightstown, NJ	40°17'27"N 74°33'38"W			4-43	4M V/H	80°	Satcom 1, 2
WD 49 RCA Corp.	Princeton, NJ	40°19'55"N 74°37'52"W			4-44.3	4M V/H	210°	Satcom 1, 2
WD 50 Tuolumne Telephone Co.	Peru, IL	41°20'34"N 89°06'42"W			4-44	4.5M		
WD 51 TN Cablevision	Oak Ridge, TN	36°02'04"N 84°15'15"W			4-50	10M		
WD 52 Colony Satel-lite Services	Woburn, MA	42°27'18"N 71°10'44"W			4-51	10M		
WD 53								
WD 54 Pub. Bcstg Coun. of Central NY	Syracuse, NY	43°12'14"N 76°12'17"W				10M		
WD 55 SC ETV Commission	Columbia, SC	37°07'10"N 80°56'16"W			4-50	10M		
WD 56 NJ Pub. Bcstg.	Trenton, NJ	40°16'57"N 74°41'11"W			4-50	10M		
WD 57 WHYY	Philadelphia, PA	39°57'29"N 75°12'46"W			4-49	10M		
WD 58 Christian Broadcasting Network	Virginia Beach, VA	36°48'07"N 76°11'40"W			4-50.5	10M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WD 59 Uni of Maine	Orono, ME	44°53'49"N 68°39'59"W			4-50	10M		
WD 60 Board of Regents Uni of WI	Madison, WI	43°03'16"N 89°28'42"W			4-49	10M		
WD 61 Milwaukee Area District Board of Vocational Technical & Adult Education	Milwaukee, WI	43°14'56"N 87°58'48"W			4-50	10M		
WD 62 IL Valley Public Telecommunica- tions	Peoria, IL	40°41'54"N 89°36'51"W			4-50	10M		
WD 63 Board of Regents for Education St. of RI & Providence Plantation	Providence, RI	41°08'16"N 71°28'24"W			4-50	10M		
WD 64 Northern MI Uni	Marquett, MI	46°33'38"N 87°24'25"W			4-50	10M		
WD 65 Delta College	University Center, MI	43°33'43"N 83°58'55"W			4-50	10M		
WD 66 KY St. Board of Education	Lexington, KY	38°01'25"N 84°30'01"W			4-49	10M		
WD 67 Michiana Public Bcstg.	Elkhart, IN	44°44'46"N 86°00'29"W				10M		
WD 68 Southwest IN Public TV	Chandler, IN	38°01'27"N 87°21'42"W			4-49	10M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WD 69 Vincennes Uni	Vincennes, IN	38°41'02"N 87°31'17"W			4-50	10M		
WD 70 Uni of NC	Chapel Hill, NC	35°52'03"N 79°09'44"W			4-50	10M		
WD 71 Public Bcstg. of Northwest PA	Erie, PA	42°02'35"N 79°09'44"W			4-49	10M		
WD 72 Metropolitan Indianapolis TV	Indianapolis, IN	39°53'57"N 86°12'04"W			4-50	10M		
WD 73 Board of Education of Jefferson County	Louisville, KY	38°11'55"N 85°41'08"W			4-50.1	10M		
WD 74 Central MI Uni	Mount Pleasant, MI	43°34'32"N 84°46'27"W			4-50	10M		
WD 75 Central VA ETV	Richmond, VA	37°30'45"N 77°36'04"W			4-50	10M		
WD 76 Rochester Area TV	Rochester, NY	43°13'09"N 77°31'45"W			4-50	10M		
WD 77								
WD 78 Board of Trustees Southern IL Uni	Carbondale, IL	37°42'54"N 89°13'33"W			4-50	10M		
WD 79 Chicago ETV	Chicago, IL	41°58'45"N 87°43'05"W			4-50	10M		
WD 80 Lake Central School Corp.	St. John, IN	41°28'02"N 87°28'21"W			4-50	10M		

Station	Location	Coordinates	Power EIRP Max	dBw	Gain dB	Antenna	T	Satellite
WD 81 PA State Uni	University Park, PA	40°48'19"N 77°51'33"W			4-50	10M		
WD 82 Beckly Antenna Co.	Beckly, WV	37°48'08"N 81°13'58"W			4-50	10M		
WD 83 Southern Tier ETV Assn.	Binghamton, NY	42°01'45"N 75°56'21"W			4-50	10M		
WD 84 Board of Trustees Pensacola Jr. College	Pensacola, FL	30°28'58"N 87°12'06"W			4-50	10M		
WD 85 SC ETV	Rock Hill, SC	34°56'10"N 80°59'30"W			4-50	10M		
WD 86 Long Island EVT Council	Garden City, NY	40°53'02"N 73°14'59"W			4-50	10M		
WD 87 Storer Cable of Carolina Inc.	James Island, SC	32°43'38"N 76°56'41"W			4-50	10M		
WD 88								
WD 89 Board of Control Grand Valley St. College	Allendale, MI	42°57'36"N 85°53'44"W			4-50	10M		
WD 90 Board of Trustees MI St. Uni	East Lansing, MI	42°43'43"N 84°29'34"W			4-50	10M		
WD 91 Greater Cincinnati TV	Cincinnati, OH	39°12'38"N 84°29'17"W			4-50	10M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WD 92 Northeastern ETV of OH	Kent, OH	40°54'19"N 80°54'36"W			4-49	10M		
WD 93 South Central Educational Broadcasting	Hershey, PA	40°17'06"N 76°38'53"W			4-49	10M		
WD 94 SC ETV	Sumter, SC	33°55'19"N 80°20'27"W			4-50	10M		
WD 95 American TV & Communications	Delaware, OH	40°17'26"N 83°03'19"W			4-50	10M		
WD 96 Jackson Community Antenna	Jackson, TN	35°39'50"N 88°47'23"W			4-49.7	10M		
WD 97								
WD 98 Statesburo CATV	Statesburo, GA	32°26'14"N 81°44'37"W			4-50.5	10M		
WD 99 Spanish International Communications Corp.	Miami, FL	25°57'27"N 80°12'43"W			4-50	10M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WE 20								
WE 21 Cox Cable Communications	Pensacola, FL	30°28'13"N 87°14'45"W			4-50	10M		
WE 22 Radio Bcstg. Co	Philadelphia, PA	40°00'17"N 75°12'10"W			4-39	4.5M		
WE 23 AL ETV Commission	Birmingham, AL	33°23'50"N 86°34'52"W			4-49	10M		
WE 24 Charlott-Meklen-burg Board of Education	Charlott, NC	35°12'24"N 80°47'13"W			4-50	10		
WE 25 TN St. Board of Education	Chatanooga, TN	35°06'05"N 85°14'14"W			4-49	10M		
WE 26 WV Educational Bcstg. Authority	Beckly, WV	37°47'06"N 81°06'47"W			4-50	10M		
WE 27								
WE 28 Montgomery Cable TV	Prattville, AL	32°28'31"N 86°27'58"W			4-44	5M		
WE 29 Cablevision Co. of Anniston	Anniston, AL	33°36'54"N 85°52'23"W			4-47	6M		
WE 30 Uni of GA	Athens, GA	33°56'41"N 83°22'39"W			4-50	10M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WE 31 Ball St. Uni.	Muncie, IN	40°12'25"N 85°24'14"N			4-50	10M		
WE 32 Western NY ETV	Buffalo, NY	42°56'27"N 78°49'28"W			4-	10M		
WE 33 OH Uni	Athens, OH	39°19'41"N 82°06'01"W			4-50	10M		
WE 34 WV Board of Regents	Morgantown, WV	39°38'49"N 79°58'30"W			4-50	10M		
WE 35								
WE 36 Uni of VT	Colchester, VT	44°30'15"N 73°08'59"W			4-50	10M		
WE 37 Northeastern PA ETV Association	Jenkins Township, PA	41°17'34"N 75°46'28"W			4-	10M		
WE 38 TeleCable of Kokomo, Inc.	Kokomo, IN	40°25'12"N 86°06'18"W			4-50	10M		
WE 39								
WE 40 Teleprompter	Greenwood, SC	34°11'52"N 82°05'27"W			4-	4.5M		
WE 41 Teleprompter	Dothan, AL	31°14'30"N 85°21'10"W			4-44	4.5M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WE 42 Teleprompter	Ironwood, MI	46°28'45"N 90°08'51"W			4-44	4.5M		
WE 43 Teleprompter	Middletown, CT	41°35'22"N 72°31'56"W			4-44	4.5M		
WE 44 Satellite Systems Corp.	Ft. Campbell, KY	36°37'48"N 87°26'20"W			4-44	4.5M		
WE 45 Community Foundation of South FL	Miami, FL	25°54'47"N 80°09'35"W			4-	10M		
WE 46 Ozark Cablevision	Ozark, AL	31°26'58"N 85°39'31"W			4-44	4.5M		
WE 47 Tower Communication System Corp.	Ashland, KY	38°28'11"N 82°44'32"W			4-	5 M		
WE 48 Southern Cablevision Inc.	Fort Meyers, FL	26°38'53"N 81°51'12"W			4-51.5	10M		
WE 49 Cape Cable TV	Orleans, MA	39°06'43"N 94°40'17"W			4-50.4	10M		
WE 50 Home Entertainment Co.	Seymour, CT	41°21'43"N 73°06'48"W			4-44	5M		
WE 51 Trustees of IN Uni	Bloomington, IN	39°08'32"N 86°29'43"W			4-50	10M		
WE 52 Oneonta Telephone Co.	Oneonta, AL	33°56'43"N 86°28'37"W			4-	5M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WE 53 Liberty TV Cable Inc.	Athens, GA	33°54'51"N 83°23'15"W			4-47	6M		
WE 54 Decatur Tele-Cable Corp.	Decatur, AL	34°32'35"N 86°58'00"W			4-44	5M		
WE 55 Manistee TV Cable	Manistee, MI	44°13'51"N 86°18'23"W			4-44	5M		
WE 56 North Lauderdale Cablevision	North Lauderdale, FL	26°13'06"N 80°13'16"W			4-	4.5M		
WE 57 Bowling Green St. Uni.	Lima Bowling Green, OH	41°22'17"N 83°28'29"W			4-50	10M		
WE 58								
WE 59 Clinton Cable-vision	Clinton, SC	34°29'10"N 81°52'10"W			4-	5M		
WE 60								
WE 61 Liberty TV Cable Co.	Adrian, MI	41°56'22"N 83°59'00"W			4-44	5M		
WE 62 Matrix Enter-prise	Sugarlimb, TN	35°46'14"N 84°18'21"W			4-43.5	4.5M		
WE 63 Polk Cablevision	Lakeland, FL	27°56'08"N 81°58'09"W			4-49	10M		

Location	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WE 64 Comcast Corp.	Paducah, KY	37°03'52"N 86°37'40"W			4-44	6M		
WE 65 Comcast Corp.	Meridian, MS	32°21'53"N 88°37'54"W			4-44	6M		
WE 66 WV Educational Bcstg. Authority	Huntington, WV	38°29'42"N 82°12'00"W			4-49	10M		
WE 67 Metropolitan Pittsburgh Radio Bcstg.	Pittsburgh, PA	40°26'46"N 79°56'43"W			4-50	10M		
WE 68 TN St. Board of Education	Knoxville, TN	35°57'07"N 83°55'36"W			4-49	10M		
WE 69 Board of Regents St. of FL	Gaineville, FL	29°42'35"N 82°23'42"W			4-50	10M		
WE 70 St. Board of Regents of FL	Tampa, FL	28°03'24"N 82°24'43"W			4-50	10M		
WE 71 Westinghouse Bcstg.	Panama City, FL	30°13'50"N 85°38'47"W			4-44	5M		
WE 72								
WE 73 Demopolis CATV	Demopolis, AL	32°29'46"N 87°50'25"W			4-44	6M		
WE 74								

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WE 75 Rentavision of Brunswick	Brunswick, GA	31°09'38"N 81°28'47"W			4-49.7	10M		
WE 76 Tel-Media Co.	Ashtabula, OH	41°55'05"N 80°33'27"W			4-	6M		
WE 77 National Cable Co.	East Lansing, MI	42°40'50.7"N 84°27'37"W			4-44	4.5M		
WE 78 Selma Tele-Cable	Selma, AL	32°27'30"N 87°01'28"W			4-44	5M		
WE 79 Gulf Coast Bellare CTV	Bellaire, TX	29°42'27"N 95°28'01"W			4-44.3	6M		
WE 80 Catawba Valley Comm.	Hickory, NC	35°43'43"N 81°19'17"W			4-44	5M		
WE 81								
WE 82 Board of Regents FL. St. Univ.	Tallahassee, FL	30°21'28"N 78°53'14"W			4-49	10M		
WE 83								
WE 84								
WE 85								

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WE 86								
WE 87								
WE 88 Microwave TV	Jesup, GA	31°38'47"N 81°58'59"W			4-44	5M		
WE 89 General Electric Cablevision	Anderson, IN	40°06'33"N 85°40'52"W			4-44	5M		
WE 90								
WE 91 Columbia Cable TV	Columbia, SC	34°00'06"N 81°01'00"W			4-44	5M		
WE 92								
WE 93 Clearview Cable TV	Valdosta, GA	30°51'39"N 83°19'03"W			4-44	5M		
WE 94								
WE 95								
WE 96 Alert Cable TV	Georgtown, SC	33°25'58"N 79°16'16"W			4-44	5M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
WE 97 Jacksonville TV Cable	Jacksonville, NC	34°48'42"N 77°26'48"W			4-45.5	6M		
WE 98 Teleprompter	Sault Ste. Marie, MI	46°27'39"N 84°18'54"W			4-44	4.5M		
WE 99 Teleprompter	Iron Mountain, MI	45°49'01"W 88°03'02"W			4-44	4.5M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KB 20	deleted							
KB 21 GE Radio Service Corp	Pleasanton, CA	37°37'02"N 121°49'51"W	3K	83	6-52.4 4-48.5	8M V	141°	ANIK
KB 22 WU Telegraph Co	Steele Valley, CA	33°45'29"N 117°18'54"W	1.5K	83	4-54.7 6-57.7	15.2M V/H 15.2M V/H	55° 85°	Westar 1, 2
KB 23 WU Telegraph Co	Ceder Hill, TX	32°34'42"N 96°58'56"W	1.5K	83	4-54.7 6-57.7	15.2M V/H 15.2M V/H	55° 85°	Westar 1, 2
KB 24	deleted							
KB 25 AM Satellite Corp.	Murphy, TX	32°59'53"N 96°37'44"W	3K	85	4-50.5 6-52.5	10M V/H	56°	Westar 1, 2
KB 26 AM Satellite Corp.	Nuevo, CA	33°47'46"N 117°05'12"W	3K	85	4-50.5 6-52.5	10M V/H	56°	Westar 1, 2
KB 27 RCA Am Comm	Moorpark, CA	34°19'31"N 118°59'41"W	3k 400	87.7	4-53.2 6-56.9	8M 1	112.4°	Satcom 1, 2
KB 28 RCA Am Comm	Point Reyes, CA	38°05'45"N 122°56'45"W	3k 400	83	4-50.8 6-53.0	10M 1	69°	Satcom 1, 2
			1.5k		4-52.0 6-56.0	13M 1	100°	

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KB 29 RCA AM Comm	Lena Point, AK	58°23'26"N 134°45'02"N	3k	88	4-50.6 6-54.7	10M V/H	72.5°	Satcom 1, 2
KB 30 AT&T	DeLuz, CA	33°27'22"N 117°18'03"W	3k	92.3	4-60.4 6-62.8	3-30M V/H	79°	Comstar 1, 2, 3
KB 31 AT&T	Three Peaks, CA	38°08'52"N 122°47'38"W	3k	92.3	4-60.4 6-62.8	2-30M V/H	79°	Comstar 1, 2, 3
KB 32 GTE Satellite Corp	Triunfo Pass, CA	34°04'51"N 118°53'44"W	3k	92	4-59.6 6-62.5	3-30M V/H	53°	Comstar 1, 2, 3
KB 33 GTE Satellite Corp	Pupukea Oahu, HI	21°40'27"N 158°02'05"W	3k	92	4-59.6 6-62.5	3-30M V/H	53°	Comstar 1, 2, 3
KB 34 Comsat Gen Corp	Santa Paula, CA	34°24'05"N 119°04'26"W	3k	85	4-52.8 6-56.0 4-50.4 6-53.5	8M 10M	120° 120°	Comstar 1, 2, 3, 4
		add operation with Marisat at 1.5GHz						
KB 35 RCA Alas Comm	Putuliqayuk River, AK	70°15'34"N 148°36'32"W	400w	72	4-51.0 6-54.5	10M V/H	118°	Satcom 1, 2
KB 36 RCA Alas Comm	Valdez, AK	61°07'56"N 146°20'20"W	400w	70	4-51.0 6-54.5	10M V/H	109°	Satcom 1, 2
KB 37 Am Satellite Corp	Fairchild AFB, WA	47°42'05"N 117°34'40"W	300w	66.5	6-54	10M V/H		Westar 1, 2
KB 38 Am Satellite Corp	Offutt AFB, NE	41°07'55"N 95°54'59"W			4-50.4	10M V/H	90°	Westar 1, 2
KB 39 Am Satellite Corp	Anterville Beach Naval Fac., CA	40°33'47"N 124°20'56"W	50w	70.5	6-54	11M V/H		Westar 1, 2

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KB 40 Am Satellite Corp	Moffett NAS, CA	37°24'41"N 122°02'18"W	30w	48	4-51.5 6-54	11M V/H	90°	Westar 1, 2
KB 41 RCA Alas Comm	Bethal, AK	60°47'40"N 161°41'30"W	400w	69.2	4-50.9 6-54.7	10M V/H	135°	Satcom 1, 2
KB 42 RCA Alas Comm	Nome, AK	64°29'50"N 165°24'05"W	400w	69	4-50.9 6-54.7	10M V/H	145°	Satcom 1, 2
KB 43 Alas Comm	Pipe Line Pump Sta. 4, AK	68°25'21"N 149°21'24"W	100w	66.5	4.43 6-46.5	4.5M V/H	98.2°	Satcom 1, 2
KB 44 RCA Alas Comm	Pipe line Pump Sta. 5, AK	66°48'45"N 150°39'56"W	100w	66.5	4-43 6-46.5	4.5M V/H	97°	Satcom 1, 2
KB 45 Alas Comm	Cordova, AK	60°32'49"N 145°44'48"W	400w	67.3	4-50.6 6-54.7	10M V/H	105°	Satcom 1, 2
KB 46 Alas Comm	Yakutat, AK	59°32'24"N 139°44'06"W	300w	66.5	4-50.6 6-54.7	10M V/H	106°	Satcom 1, 2
KB 47 Vumore Co. of Laredo	Laredo, TX	27°32'37"N 99°30'29"W			4-49.7	10M V/H	400°	Westar 1, 2 Satcom 1, 2
KB 48 Gill Cable	San Jose, CA	37°21'44"N 121°54'12"W			4-49.7	10M V/H	304°	Westar 1, 2
KB 49 Tulsa Cable TV	Tulsa, OK	36°05'58"N 95°54'05"W			4-51	10M V/H	270°	Westar 1, 2 Satcom 1, 2
KB 50 Teleprompter	Eugene, OR	44°02'56"N 123°07'22"W			4-49.7	10M V/H	372°	Westar 1, 2 Satcom 1, 2
KB 51 Teleprompter	Tacoma, WA	47°15'01"N 122°27'01"W			4-50	10M V/H	363°	Westar 1, 2 Satcom 1, 2
KB 52 Am Satellite Corp	Vallejo, CA	38°06'32"N 122°10'55"W	3k	85.5	4-50.5 6-53.0	10M V/H	55°	Westar 1, 2
KB 53 Am Satellite Corp	Monterey, CA	36°35'31"N 121°51'07"W			4-51	10M V/H	100°	Westar 1, 2
KB 54 Heritage Comm Inc	DesMoines, IA	41°39'20"N 93°35'52"W			4-51	10M V/H	306°	Westar 1, 2 Satcom 1, 2

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KB 55 Teleprompter	Asbury, IA	42°30'47"N 90°44'45"W			4-50	10M V/H	363°	Westar 1, 2 Satcom 1, 2
KB 56 Teleprompter	Rochester, MN	44°03'22"N 92°24'39"W			4-50	10M V/H	363°	Westar 1, 2 Satcom 1, 2
KB 57 Teleprompter	Great Falls, MT	47°29'35"N 111°15'23"W			4-50	10M V/H	363°	Westar 1, 2 Satcom 1, 2
KB 58 Teleprompter	Galveston, TX	29°14'03"N 94°54'33"W			4-50	10M V/H	363°	Westar 1, 2 Satcom 1, 2
KB 59 Community Cablevision	Bryan, TX	30°38'27"N 96°19'13"W			4-50	10M V/H	270°	Westar 1, 2 Satcom 1, 2
KB 60 Midwest Video	Bryan, TX	30°38'42"N 96°20'26"W			4-50	10M V/H	270°	Westar 1, 2 Satcom 1, 2
KB 61 Frontier Brd. Cast Co.	Cheyenne, WY	41°07'21"N 104°48'05"W			4-50	10M V/H	299°	Westar 1, 2 Satcom 1, 2
KB 62 Micro-Cable d/b/a Valley Telecasting	Yuma, AZ	32°51'58"N 114°25'56"W			4-50	10M V/H	270°	Westar 1, 2 Satcom 1, 2
KB 63 Teleprompter	Santa Cruz, CA	37°05'52"N 122°08'18"W			4-50	10M V/H	398°	Westar 1, 2 Satcom 1, 2
KB 64 Cox Cable Comm Inc.	Lubbock, TX	33°32'58"N 101°50'08"W			4-50	10M V/H	316°	Westar 1, 2 Satcom 1, 2
KB 65 Micor-Cable Comm Corp	Ballinger, TX	31°43'10"N 99°56'20"W			4-50	10M V/H	270°	Westar 1, 2 Satcom 1, 2
KB 66 Satellite Xmiss & Rcv Co	Hayward, CA	37°44'21"N 121°59'30"W			4-51	10M V/H	273°	Westar 1, 2 Satcom 1, 2
KB 67 RCA Alaska	Lonely, AK	70°54'35"N 153°16'51"W	50w	50	4-43.5 6-46.7	4.5M	158°	ANIK 2 Westar 2
KB 68								

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KB 69 Teleprompter	Missoula, MT	46°48'50"N 114°04'49"W			4-50	10M V/H	398°	Westar 1, 2 Satcom 1, 2
KB 70 TV Cable Service	Abilene, TX	32°25'58"N 99°45'26"W			4-51	10M V/H	273°	Westar 1, 2 Satcom 1, 2
KB 71 Added Attraction, Inc.	Grand Island, NE	40°54'59"N 98°22'08"W			4-50	10M V/H	306°	Westar 1, 2 Satcom 1, 2
KB 72 Teleprompter	El Paso, TX	31°53'07"N 106°24'49"W			4-50	10M V/H	398°	Westar 1, 2 Satcom 1, 2
KB 73 Comm Services, Inc.	Manhattan, KS	39°14'11"N 96°35'23"W			4-51	10M V/H	316°	Westar 1, 2 Satcom 1, 2
KB 74 RCA Alaska	Black River, AK	66°09'49"N 141°54'18"W	50W	50	4-43.5 6-46.7	4.5M V/H	158°	Satcom 1, 2
KB 75 Tele Cable Overland Park	Overland Park, KS	38°54'38"N 94°40'51"W			4-50	10M V/H	282°	Westar 1, 2 Satcom 1, 2
KB 76 TV Transmission	Lincoln, NE	40°49'12"N 96°38'01"W			4-50	10M V/H	270°	Westar 1, 2 Satcom 1, 2
KB 77 Cablevision Investors	Beverly Hills, TX	31°31'40"N 97°09'20"W			4-50	10M V/H	270°	Westar 1, 2 Satcom 1, 2
KB 78 Micro Cable Comm.	Kenniwick, WA	46°10'26"N 119°09'26"W			4-49.5	10M V/H	270°	Westar 1, 2 Satcom 1, 2
KB 79 Teleprompter	Pocatello, ID	42°49'02"N 112°28'07"W			4-50	10M V/H	398°	Westar 1, 2 Satcom 1, 2
KB 80 Teleprompter	Lewiston, ID	46°20'29"N 116°52'30"W			4-50	10M V/H	398°	Westar 1, 2 Satcom 1, 2

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KB 81 Teleprompter	Reno, NV	39°34'14"N 119°45'00"W			4-50	10M V/H	390°	Westar 1, 2 Satcom 1, 2
KB 82 RCA Alaska	Gilmore Creek, AK	64°58'37"N 147°31'03"W	300w	79	4-50 6-54	10M V/H	121°	Satcom 1, 2
KB 83 First TV Corp.	Maple Lake, MN	45°16'02"N 93°54'04"W			4-51.7	11M V/H	267°	Westar 1, 2 Satcom 1, 2
KB 84 Teleprompter Transmission of OR	Santa Maria, CA	34°36'32"N 120°08'44"W				10M		
KB 85 RCA Alaska	Barrow, AK	71°16'16"N 156°46'12"W	400w	71.6	4-50.9 6-53.6	10M V/H	127°	Satcom 1, 2
KB 86 Cox Cable Comm	Lamont, CA	35°15'59"N 118°54'04"W			4-50	10M V/H	398°	Westar 1, 2 Satcom 1, 2
KB 87 RCA Global	Camp Roberts, CA	35°41'09"N 120°45'11"W	35	58.2	4-50.7 6-54.1	10M V/H	178°	Satcom 1, 2
KB 88 RCA AM Comm	Transportable		3K	Spec.	4-50.8 6-53.0	10M 1	69°	Open
KB 89 RCA AM Comm	Transportable		3K	Spec.	4-50.8 6-53.0	10M 1	69°	Open
KB 90 RCA AM Comm	Transportable		3K	Spec.	4-50.8 6-53.0	10M 1	69°	Open
KB 91 RCA AM Comm	Transportable		3K	Spec.	4-50.8 6-53.0	10M 1	69°	Open
KB 92 RCA AM Comm	Transportable		3K	Spec.	4-50.8 6-53.0	10M 1	69°	Open
KB 93 Clearview TV Cable of Enum-claw	Auburn, WA	47°18'30"N 122°14'00"W			4-49.7	10M V/H	264°	Westar 1, 2 Satcom 1, 2
KB 94 United Wehco, Inc.	Marion County, TX	32°47'05"N 94°02'51"N			4-51	10M V/H	273°	Westar 1, 2 Satcom 1, 2

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KB 95 Pilot Butte Transmission Co	Green River, WY	41°31'43"N 109°27'54"W			4-51	10M V/H	267°	Westar 1, 2 Satcom 1, 2
KB 96 220 TV Inc.	St. Louis, MO	38°38'39"N 90°15'47"W			4-52	11M V/H	174°	Westar 1, 2 Satcom 1, 2
KB 97 Micro-Cal. dba Imperial Val Cable TV	El Centro, CA	32°51'30"N 115°30'47"W			4-49.7	10M V/H	270°	Satcom 1, 2
KB 98 Hobbs Cable- vision, Inc.	Hobbs, NM	32°42'07"N 103°05'21"W			4-51	10M V/H	267°	Westar 1, 2 Satcom 1, 2
KB 99 Cox Cable Comm	Spokane, WA	47°40'58"N 117°22'59"W			4-50	10M V/H	398°	Westar 1, 2 Satcom 1, 2
KD 20 Wentronics dba Comm TV Syst of Wyoming	Casper, WY	42°48'33"N 106°24'07"W			4-51	10M V/H	273°	Westar 1, 2 Satcom 1, 2
KD 21 CPI Sat Telecomm	N. Little Rock, AR	34°48'59"N 92°17'56"W			50.5	10M V/H	398°	Westar 1, 2 Satcom 1, 2
KD 22 RCA Alaska	Adak, AK	51°52'00"N 176°38'31"W	200w	70.4	4-50.9 6-53.6	10M V/H	127°	Satcom 1, 2
KD 23 Hughes Aircraft Co.	Torrance, CA	33°48'15"N 118°20'03"W			4-43.7	4.5M H	186°	Satcom 1, 2
KD 24 RCA Alaska	Kotzebue, AK	66°53'52"N 162°35'46"W	300w	64.7	4-50.9 6-53.6	10M V/H	127°	Satcom 1, 2
KD 25 Sunflower Cablevision	Lawrence, KS	38°57'21"N 95°12'28"W			4-50.5	10M V/H	270°	Westar 1, 2 Satcom 1, 2

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KD 26 RCA AM Comm	Edwards AFB, CA	34°57'31"N 117°54'45"W	3K	74	6-53.5	10M V/H	220°	Satcom 1, 2
KD 27								
KD 28 Comtronics Cable TV	Grand Junction, CO	39°03'29"N 108°35'48"W			4-51	10M V/H	275°	Westar 1, 2 Satcom 1, 2
KD 29 St. Joseph Cablevision	St. Joseph, MO	39°44'14"N 94°45'09"W			49.7	10M V/H	270°	Westar 1, 2 Satcom 1, 2
KD 30 Trans-Am Comm	Ada, OK	34°46'53"N 96°39'18"W			51.4	11M V/H	279°	Westar 1, 2 Satcom 1, 2
KD 31 Jonesboro Cable TV	Jonesboro, AR	35°48'15"N 90°45'16"W			4-51	10M V/H	398°	Westar 1, 2 Satcom 1, 2
KD 32 Clinton Cablevision	Clinton, IA	41°50'50"N 90°13'49"W			4-51	10M V/H	267°	Westar 1, 2 Satcom 1, 2
KD 33 Southwest CATV	Pharr, TX	26°13'07"N 98°10'00"			50.6	10M V/H	276°	Westar 1, 2 Satcom 1, 2
KD 34 RCA Alaska	Anchorage, AK	61°12'50"N 149°51'06"W	35	52	4-43.0 6-46.5	4.5M V/H	240°	Satcom 2
KD 35 Gaylord Broad- casting Co.	Tacoma, WA	47°14'29"N 122°28'00"W			4-51.0	10M V/H	157°	Westar 1, 2 Satcom 1, 2
KD36 Sjoberg's Inc.	Thief River Falls, MN	48°07'51"N 96°11'44"W			4-50.5	10M V/H	279°	Westar 1, 2 Satcom 1, 2
KD 37 AM Cable TV	Tempe, AZ	33°24'53"N 111°57'45"W			4-	6M V/H	316°	Westar 1, 2 Satcom 1, 2
KD 38								

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KD 39 Teleprompter	Muscoy, CA	34°09'13"N 117°19'55"W			4-50	10M V/H	398°	Westar 1, 2 Satcom 1, 2
KD 40 Comm Services, Inc.	Lake Charles, LA	30°11'55"N 93°12'56"W			4-43	4.5M	316°	Westar 1, 2 Satcom 1, 2
KD 41 Gillis G. Conoley	Taylor, TX	30°34'51"N 97°23'46"W			51.9	6M V/H	282°	Westar 1, 2 Satcom 1, 2
KD 42 RCA AM Comm	Goldstone, CA	35°20'27"N 116°52'24"W	40	45	4-50.5 6-53.0	10M V/H	115°	Satcom 1, 2
KD 43 Alpine Cable-vision	Alexandria, LA	31°21'18"N 92°23'14"W			4-50.6	10M V/H	276°	Westar 1, 2 Satcom 1, 2
KD 44								
KD 45 Western Tele-Comm.	Issaquah, WA	47°30'09"N 122°01'37"W			50.9	T 10M V/H R 10M	198°	Westar 1, 2 Satcom 1, 2
KD 46 Eastbank Cable TV	Kenner, LA	30°00'16"N 90°15'43"W			50.6	10M V/H	275°	Satcom 1, 2
KD 47 AM TV Comm	San Diego, CA	32°48'35"N 117°07'14"W			4-50	10M V/H	220°	Satcom 1, 2
KD 48 AM Cable TV, Inc.	Pampa, TX	35°32'46"N 101°00'02"W			4-51	10M V/H	250°	Satcom 1, 2
KD 49 Napa Valley Cablevision	Napa, CA	38°13'52"N 122°11'44"W			4-51	10M V/H	250°	Satcom 1, 2
KD 50 RCA Alaska	Eagle River, AK	61°17'58"N 149°26'42"W	3K	85	4-54.7 6-57.8	15M V/H	102°	Satcom 1, 2

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KD 51 Caddo-Bossier Cablevision	Shreveport, LA	32°26'58"N 93°47'36"W			4-50	10M V/H	219°	Satcom 1, 2
KD 52 RCA Alaska	Unalaska, AK	53°52'44"N 166°32'14"W	400w	67	4-50.9 6-53.6	10M V/H	127°	Satcom 1, 2
KD 53 Minot Cable Syst.	Minot, ND	48°12'42"N 101°17'24"W			4-50.5	10M V/H	264°	Westar 1, 2 Satcom 1, 2
KD 54 Cox Cable Comm	Aberdeen, WA	46°58'35"N 123°48'23"W			4-50	10M V/H	398°	Westar 1, 2 Satcom 1, 2
KD 55 Cox Cable Comm	El Cajon, CA	32°48'39"N 116°58'41"W			4-50	10M V/H	398°	Satcom 1, 2
KD 56 Tyler Cable TV	Tyler, TX	32°21'12"N 95°19'11"W			4-50	10M V/H	273°	Satcom 1, 2
KD 57 Newton Cable TV	Newton, KS	38°04'16"N 97°22'06"W			4-51	10M		
KD 58 Callais Cable-vision	Golden Meadow, LA	29°23'58"N 90°16'42"W			4-50.5	10M V/H	263°	Satcom 1,2
KD 59 GTE Sat. Corp.	Panmalu Oahu, HI	21°40'25"N 158°02'17"W	5K 6.3K	92	4-59.5 6-62.0	30M or cir V/H	73°	Comstar 1, 2, 3
KD 60 Comsat Gen.	Kerby, OR	42°13'55"N 123°39'45"W	1W	33.6	6-34.5	4ft V/H		ANIK 1,2
KD 61 Comsat Gen.	McLeod, OR	43°39'05"N 122°41'25"W	1w	33.5	6-34.5	4ft V/H		ANIK 1,2
KD 62 Comsat Gen.	McLeod, OR	42°40'16"N 122°40'23"W	1w	33.5	6-34.5	4ft V/H		ANIK 1, 2
KD 63 Comsat Gen.	McLeod, OR	42°39'20"N 122°42'50"W	1w	33.5	6-34.5	4ft V/H		ANIK 1, 2
KD 64 Comsat Gen.	Prospect, OR	42°43'50"N 122°30'55"W	1	33.5	6-34.5	4ft V/H		ANIK 1, 2

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KD 65								
KD 66								
KD 67								
KD 68								
KD 69								
KD 70								
KD 71								
KD 72								

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KD 73 Wester Tele- Comm, Inc.	Morrison, CO	39°38'05"N 105°10'54"W			4-51	10M V H	194°	Westar 1, 2 Satcom 1, 2
KD 74 B.C. Cable Co.	Juneau, AK	58°19'47"N 134°28'17"W			4-50.2	10M V H	267°	Satcom 1, 2
KD 75 RCA AM Comm	Rayburn, TX	30°23'11"N 94°54'26"W	400W	83.7	4-53.2 6-56.9	13M 1	112.4°	Satcom 1, 2
KD 76								
KD 77 Teleprompter	Kalispell, MT	48°12'34"N 114°19'32"W			4-43	4.57M V/H	120°	Satcom 1, 2
KD 78								
KD 79								
KD 80 American TV & Comm. Corp.	West Monroe, LA	32°32'10"N 92°09'51"W			4-51	10M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KD 81 Houma Cable- vision	Houma, LA	29°37'34"N 90°45'27"W			4-50.6	10M V H	276°	Satcom 1, 2
KD 82 Public Comm Foundation for N. Texas	Dallas, TX	32°47'47"N 96°48'41"W			4-49	10M H	283°	Westar 1, 2
KD 83 Harve Theaters	Harve, MT	48°33'36"N 108°27'08"W			4-43.5	5M		
KD 84 Harve Theaters	Billings, MT	45°46'02"N 108°27'00"W			4-43.5	5M		
KD 85 Independent School District	Austin, MN	43°40'40"N 93°00'05"W			4-44	10M		
KD 86 LA ETV	Baton Rouge, LA	30°22'23"N 91°12'18"W			4-49	10M		
KD 87 Twin City Area TV	Appleton, MN	45°10'03"N 96°00'00"W			4-50	10M		
KD 88 St. Educational Radio & TV	Des Moines, IA	41°33'47"N 93°39'18"W			4-49	10M		
KD 89 RCA AM Comm.	Lake Geneva, WI	43°37'04"N 88°26'21"W	83.7		4-51.0 6-54.5	13M L	85°	Satcom 1, 2
KD 90 San Bernadino Community College Dist.	San Bernadino, CA	34°02'38"N 117°05'52"W			4-49	10M		
KD 91 SD State Uni	Brookings, SD	44°18'52"N 97°47'14"W			4-50	10M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KD 92 AK ETV Commission	Conway, AK	35°04'28"N 92°27'19"W				10M		
KD 93								
KD 94 Fresno County Board of Education	Fresno, CA	39°49'39"N 119°51'42"W			4-50	10M		
KD 95 Springfield Community TV	Springfield, MO	37°13'08"N 93°17'05"W			4-49	10M		
KD 96 Uni of ID	Moscow, ID	46°43'27"N 117°00'37"W			4-50	10M		
KD 97	Pocatello, ID	45°51'30"N 112°25'33"W			4-50	10M		
KD 98 Hobbs Cable- vision	Hobbs, NM	32°42'01"N 103°05'25"W			4-50.5	10M		
KD 99								
KE 20 TX A&M Uni.	College Station, TX	30°36'29"N 96°20'15"W			4-50	10M		
KE 21								

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KE 22 Bosie St. Uni.	Bosie, ID	43°36'14"N 116°12'20"W			4-49	10M		
KE 23 TX Tech Uni	Lubbock, TX	33°34'53"N 101°53'20"W			4-50	10M		
KE 24 HI Public Broadcasting	Honolulu, HI	21°18'02"N 157°49'29"W			4-51	10M		
KE 25								
KE 26								
KE 27								
KE 28								
KE 29 KCCS TV Cable, Inc.	Valdez, AK	61°07'56"N 146°20'24"W			4-51	10M		
KE 30								
KE 31								

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KE 32								
KE 33								
KE 34								
KE 35								
KE 36								
KE 37								
KE 38								
KE 39 Twin City Area TV	St. Paul, MN	44°58'35"N 93°10'11"W			4-50	10M		
KE 40 Washburn Uni. of Topeka	Topeka, KS	39°03'50"N 79°58'30"W			4-50	10M		
KE 41								

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KE 42								
KE 43								
KE 44								
KE 45								
KE 46 Cablecom-General Inc.	Santa Rosa, CA	38°27'47"N 122°39'03"W				5M		
KE 47 Capital Cable Co.	Austin, TX	30°18'36"N 97°47'31"W			4-49.7	10M		
KE 48								
KE 49								
KE 50								
KE 51 Communications Services, Inc.	Windfield, KS	37°15'05"N 96°58'16"W			4-44	4.5M		
KE 52 Communications Services, Inc.	Huthinson, KS	38°03'22"N 97°57'54"W			4-44	4.5M		

Station	Location	Coordinates	Power EIRP Max	dBw	Gain dB	Antenna	T	Satellite
KE 53 Bethel Bcstg.	Bethel, AK	60°47'32"N 161°46'20"W			4-51	10M		
KE 54 Sunflower ETV	Wichita, KS	37°45'47"N 97°21'29"W			4-50	10M		
KE 55 St. of OR Acting Through St. Board	Milwaukie, OR	45°27'25"N 122°38'29"W				10M		
KE 56 Duluth-Superior Area ETV	Duluth, MN	46°47'08"N 92°08'52"W			4-49	10M		
KE 57 Ark City Cable TV Services	Arkansas City, KS	37°01'33"N 97°00'38"W			4-44	4.5M		
KE 58 Laurel Cable TV	Laurel, MT	45°40'08"N 108°46'24"W			4-43			
KE 59 Atco MO Earth Station	Columbia, MO	38°57'48"N 92°16'27"W			4-51	10M		
KE 60								
KE 61 Teleprompter	Wenatchee, WA	47°25'08"N 120°18'28"			4-44	4.5M		
KE 62								
KE 63								

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KE 64								
KE 65								
KE 66								
KE 67 Teleprompter	Ukiah, CA	39°08'55"N 123°12'18"W			4-44	4.5M		
KE 68 Teleprompter	Escanaba, MI	45°45'40"N 87°07'30"W				4.5M		
KE 69 El Reno Cable-vision	El Reno, OK	35°31'43"N 97°56'00"W			4-44	5M		
KE 70 Yukon Cable-vision	Yukon, OK	35°30'27"N 97°44'58"W			4-44	5M		
KE 71 McPherson CATV Inc.	McPherson, KS	38°21'19"N 97°39'58"W			4-44	5 M		
KE 72 South TX Educational Broadcasting Council	Corpus Christi, TX	27°39'19"N 97°33'53"W			4-49	10M		
KE 73 Southwest TX Public Broadcasting Council	Austin, TX	30°23'06"N 97°43'56"W			4-49	10M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KE 74 Central TX College	Killeen, TX	31°07'06"N 97°48'39"W			4-50	10M		
KE 75 Brigham Young Uni	Provo, UT	40°04'16"N 111°37'08"W			4-49	10M		
KE 76 Teleservice Corp of America	DeRidder, LA	30°52'09"N 93°17'20"W			4-44	5M		
KE 77 Teleprompter	Farmington, NM	36°44'53"N 108°11'51"W			4-44	4.5M		
KE 78								
KE 79 CPI Satellite Telecommunications	Texarkana, AR	33°24'58"N 93°58'42"W				6M		
KE 80 Eastern NM State Uni.	Portals, NM	34°10'27"N 103°21'03"W			4-50	10M		
KE 81 Regents NM State Uni.	Las Cruces, NM	32°16'56"N 106°45'00"W			4-49	10M		
KE 82 University of Southern CO	Pueblo, CO	38°15'46"N 104°38'06"W			4-49	10M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KE 83 Trustees Community College District	Hunting Beach, CA	33°44'00"N 118°00'01"W			4-49	10M		
KE 84 Redwood Empire Public TV	Eureka, CA	40°42'59"N 124°12'09"W			4-50	10M		
KE 85 WA State Uni.	Pullman, WA	46°43'50"N 117°09'55"W			4-50	10M		
KE 86								
KE 87 Uni. of WA	Seattle, WA	47°39'14"N 122°18'37"W			4-49	10M		
KE 88 Clover Park School Dist. #400 Pierce County	Tacoma Lakewood Center, WA	47°10'32"N 122°29'35"W			4-50	10M		
KE 89								
KE 90 Teleprompter	Palestine, TX	31°46'55"N 93°38'26"W			4-44	4.5M		
KE 91								
KE 92 Visions, Ltd.	Anchorage, AK	61°10'49"N 149°53'04"W			4-44	4.5M		
KE 93 Atoka Cablevision	Coalgate, OK	34°33'28"N 96°14'53"W			4-44	4.5M		

Station	Location	Coordinates	Power EIRP Max	dBw	Gain dB	Antenna	T	Satellite
KE 94 Atlantic Cablevision	Atlantic, IA	41°25'10"N 94°59'50"W			4-44	5M		
KE 95 Carrol Cable Co.	Carrol, IA	42°05'30"N 94°54'00"W			4-44	5M		
KE 96 El Paso Public TV Foundation	El Paso, TX	31°46'20"N 106°30'14"W			4-50	10M		
KE 97 Santa Clara County Board of Education	San Jose, CA	37°29'14"N 121°51'54"W			4-49	10M		
KE 98 Board of Regents of Uni. of AZ	Tucson, AZ	32°13'50"N 110°56'57"W			4-49	10M		
KE 99								
KF 20								
KF 21								
KF 22 Estes Park Home Theatre	Estes Park, CO	40°21'36"N 105°31'11"W			4-	4.5M		
KF 23 Rocky Mtn. Corp. for Public Bcstg.	Morrison, CO	39°38'05"N 105°10'56"W			4- 6-	10M		
KF 24								

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KF 25 Taos Cable TV	Taos, NM	36°24'27"N 105°36'16"W			4-44	4.5M		
KF 26 International TV Cable	International Falls, MN	48°35'14"N 93°24'48"W			4-44	4.5M		
KF 27 LaCrosse Westgate	Onalaska, WI	43°53'01"N 91°13'54"W			4-44.3	6M		
KF 28 Spanish International Comm.	San Antonio, TX	29°25'04"N 98°29'31"W			4-50.5	10M		
KF 29 Complete Channel TV	Madison, WI	43°03'08"N 89°28'36"W			4-44	5M		
KF 30								
KF 31 Skyline Cable	Brookings, OR	43°03'05"N 124°17'08"W			4-44	4.5M		
KF 32 Teleprompter	Leesville, LA	31°08'04"N 93°17'28"W			4-44	4.5M		
KF 33 Teleprompter	Brainard, MN	46°20'50"N 94°13'27"W			4-44	4.5M		
KF 34								
KF 35								

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KF 36								
KF 37								
KF 38 Transponder Corp.	Kansas City, MO	39°04'56"N 94°28'49"W			4-49	10M		
KF 39 See-Mor Earth Station	Sikeston, MO	36°55'08"N 89°36'55"W			4-44	4.5M		
KF 40								
KF 41								
KF 42 Kler View Cable Co.	Andarko, OK	33°03'05"N 98°14'56"W			4-44.3	5M		
KF 43 Norman Cable TV	Norman, OK	35°13'39"N 97°27'08"W			4-44	4.5M		
KF 44 TeleCable	New Iberia, LA	30°01'50"N 91°48'48"W			4-44	4.5M		
KF 45								
KF 46 Sammons Comm.	Clinton, OK	35°31'30"N 98°58'55"W			4-44	5M		

Station	Location	Coordinates	Power Max	EIRP dBw	Gain dB	Antenna	T	Satellite
KF 47 CableVision	Edna, TX	28°58'05"N 96°39'00"W			4-44	4.5M		
KF 48 Wood River Cable-Vision	Ketchum, ID	43°41'01"N 114°22'03"W			4-44	4.5M		
KF 49 Clear Lake City Cablevision	Clear Lake City, TX	29°35'49"N 95°06'21"W			4-44	6M		
KF 50 Redwood Empire Cablevision	Sea Ranch, CA	38°40'57"N 123°24'49"W			4-44	4.5M		
KF 51 American TV Comm.	Beloit, WI	42°33'11"N 88°57'43"W			4-44.5	5M		
KF 52								
KF 53								
KF 54								
KF 55								
KF 56								
KF 57								

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14. SUPPLEMENTARY NOTES

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 discusses the recent, current, and planned activities in domestic satellite communications in the United States. The present satellites in the domestic satellite service are discussed and the general technical characteristics are presented. Several uses of earth stations operating in the domestic satellite service are discussed, with particular attention given to the effect the Federal Communications Commission has had on the growth in numbers of earth stations. In conjunction with small earth stations, the impact of the antenna size and pre-amplifier noise temperature on overall earth station cost was studied.

A summary of current activities on the Federal Communication Commission Docket No. 20271, the preparation for the 1979 General World Administrative Radio Conference is presented. Particular attention was given to FIXED-SATELLITE and BROADCASTING-SATELLITE service applications in the frequency bands between 2.5 GHz and 50 GHz.

Finally, tariff cost information for domestic satellite and terrestrial telecommunications services is presented. Telecommunication services tariffs on file with the Federal Communications Commission were used in this report.

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

domestic satellite communications; low-noise amplifiers; satellite communications; small earth stations; 1979 World Administrative Radio Conference

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