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UNITED STATES SOCIETAL EXPERIMENTS VIA THE COMMUNICATIONS TECHNOLOGY SATELLITE

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ABSTRACT

The Communications Technology Satellite (CTS) is a cooperative experimental program of the United States and Canadian governments. CTS uses a high-power transponder at the hitherto unused frequencies of 14/12 GHz for two-way television and voice communication. The United States and Canada have agreed to share equally in the use of CTS. The U.S. program includes a variety of societal experiments. The ground stations for these experiments are located from the Atlantic to the Pacific. This paper summarizes the satellite communications capabilities and the antenna coverage for the U.S. Emphasis is placed on the U.S. societal experiments in the areas of education, health care, and community and special services; nine separate experiments are discussed.

INTRODUCTION

The Communications Technology Satellite (CTS) is a cooperative experimental program of the United States and Canadian governments. CTS is the first satellite devoted to communications experiments at the 14/12-GHz frequency, which is allocated to space services. A high-power (200 W) and/or low-power (20 W) transponder is used. NASA has responsibility for the U.S. portions of the program; the Department of Communications (DOC) has Canadian responsibility. NASA and DOC have agreed to use the orbiting satellite on a 50-50 time-shared basis to conduct communications experiments subsequent to launch.

An announcement of flight opportunity with CTS was issued by NASA in August 1972 to prospective U.S. experimenters. Following review of the proposals that were submitted, NASA accepted certain experiments, including a number of technical and societal experiments. The ground stations for these experiments are located from the Atlantic to the Pacific. Reports and/or papers have been published on CTS and on some of the experiments.

Both CTS and the ground terminals in the U.S. and Canada were reviewed in 1975.[1,2] One of the key CTS technical experiments is that associated with the high-power transmitter (200 W) on the satellite; prelaunch information is given in reference 3. (CTS was launched from Cape Canaveral on January 17, 1976.)

Technical expertise is required for any experiment that must interface with a satellite in the 14/12-GHz frequency. There are experiments wherein the satellite is the means to the end. For others the experiment serves both societal and technical purposes. Among the dual-purpose experiments is the sharing of courses between Stanford University (in California) and Carleton University (in Ottawa), with CTS as the vital link.[4] In addition to the college course sharing (societal), compressed digital video communication will also be tested (technical). In the societal area, more nearly equal access to library information for people in the Mountain Plain States of the U.S. is also being explored.[5] The communicational needs in the vast regions of Canada, including progress in and plans for television coverage have been pointed out.[6] In addition, the problem of maintaining satisfactory and cost-effective communications in businesses with decentralized management is being attacked.[7]

In this paper the CTS capabilities for the U.S. are discussed. Experiments in the areas of education (2 experiments), health care (3), and community and special services (4) are described. The information presented is intended to give an idea of the current U.S. experiments program in the societal areas.

Periodic meetings have been held with CTS U.S. experimenters. Some of the material contained herein was obtained from the experimenters during these meetings. Where possible a reference is cited.

THE SPACECRAFT AND ITS U.S. COVERAGE

Spacecraft

The CTS, a three-axis stabilized spacecraft, was launched on January 17, 1976. On January 29, 1976, it was placed in synchronous orbit above the equator at 116° West longitude (west of South America). It is used to perform an extensive series of communications experiments primarily for the U.S. and Canada. The in-orbit configuration, 16.1 m in length, is shown in figure 1. (Ref. 1 contains further details of the spacecraft.)

The transponder, a combined receiver and transmitter, is located in the main body of the spacecraft (i.e., between the solar arrays). The receive frequency (uplink) is 14 GHz. The transmit frequency (downlink) is 12 GHz. One of the most important communications advances incorporated in CTS is the high-power transmitter (a 200-W traveling wave tube (TWT) that is part of the transponder).[8,3] This high power enables experiments to be made with a modest investment in ground receiving equipment.

The CTS is the second satellite to be designed and operated in space that permits television reception with small ground terminals (i.e., antenna diameter <7.5 m). The first such satellite was the ATS-6.[9] Both CTS and ATS-6 are listed in table I, which gives pertinent information on some synchronous communications satellites. The CTS uses a 200-W transmitter and a 0.71-m-diameter antenna. ATS-6 uses a 15-W transmitter and a 9.1-m-diameter antenna. One of the key ATS-6 experiments (Health, Education, Telecommunications Experiment (HET)) was conducted at a downlink frequency of 2.6 GHz. Both CTS and ATS-6 have effective isotropic radiated powers (EIRP) greater than 50 dBW, which enables small-diameter earth antennas to be used. Earth terminal costs are a function of the spacecraft EIRP and are affected by antenna diameter (a smaller antenna being less expensive).

The frequency plan for the CTS 14/12-GHz transponder, including the 11.7-GHz beacon signal, is given in figure 2. In the primary mode, signals received from the earth by antenna 1 in receive band 1 (RB1) are frequency translated and transmitted in transmit band 1 (TB1) by the 200-W TWT through antenna 2 to earth terminals. Simultaneously, signals may be received from earth terminals by antenna 2 in receive band 2 (RB2), frequency translated, and transmitted in transmit band 2 (TB2) by the 20-W TWT through antenna 1.

Proper pointing of the two steerable super-high-frequency (SHF) antennas on the spacecraft (fig. 1) is required to complete the communications link between earth terminals. Combining antenna pointing with the use of TB1 (200 W) and TB2 (20 W) permits two-way video communications between widely separated earth terminals.

The spacecraft, including antenna pointing, is controlled by DOC from a telemetry, tracking, and command station located at the Communications Research Centre (CRC) near Ottawa. Control and coordination of U.S. experiments are handled by the NASA Lewis Research Center. During in-orbit operations the single U.S. point of contact with the Communications Research Centre is at the Lewis Research Center. The Lewis Research Center, in turn, is the point of contact for each U.S. experimenter.

U.S. Coverage

The SHF antennas on CTS are used for communications experiments. The nominal 3-dB beamwidth is $2\frac{1}{2}°$. The SHF antenna footprints (coverage) are shown in figure 3(a) for the 48 contiguous states and in figure 3(b) for Alaska. The contours ($2\frac{1}{2}°$ beamwidth) represent a constant loss (3 dB) in signal strength. Within a contour (footprint) the loss is less than 3 dB.

The 48 contiguous states (fig. 3(a)) can be covered by CTS with three distinct boresight locations (three SHF antenna pointings). Thus, as a rule of thumb, one footprint covers one time zone for the contiguous states. One can visualize antenna 1 being boresighted on the east coast and antenna 2 being boresighted on the west coast, permitting reception inside these two footprints. Two-way television communication can be made between selected earth terminals in these east and west coast footprints using TB1 and TB2.

The contour for Alaska is different (fig. 3(b)) because of its northwesterly location relative to the spacecraft (at the equator and 116° W). The 5° elevation angle cutoff gives the ground location where the angle between the incoming spacecraft signal (e.g., TB1) and the horizon is 5°. Angles less than 5° are usually precluded because the communications reliability suffers from multipath effects and possibly from intervening obstacles.

There are errors associated with boresighting (pointing) the spacecraft antenna because of thermal distortion, telemetry, spacecraft location, spacecraft orientation, etc. These errors reduce the effective 3-dB footprint (e.g., by a few hundred miles in width). Loss contours for a boresight in Oklahoma are given in figure 4 for losses of 3 to 9 dB. Spacecraft antenna pointing errors can be offset by requiring a few dB increase in margin for the link calculations.

U.S. SOCIETAL EXPERIMENTS

In the U.S. each experimenter (or user) is responsible for providing the ground station equipment and broadcasting materials and for operation, maintenance, and reporting of results. There are more than a dozen U.S. experimenters using or planning to use the CTS. Their experiments are in both the societal and technical categories, they are enumerated in table II by category, title, etc. Using CTS requires the proper combination of spacecraft transponder, antenna pointing, ground terminal equipment, and broadcasting material.

The experiments use CTS in a fashion conceptualized in figure 5. Locations A, B, and n are in North America, specifically in the U.S. and Canada. Location n must be in the same footprint as location B. As examples, one-way television (wide-band signal) or one-way voice (narrow-band signal) communications would be possible from an appropriate transmitting system at earth location A to appropriate receiving systems at locations B and n. If there were also a transmitter at location B, two-way television or two-way voice communications could be accomplished between locations B and A. And the signals from A could be received at n (but not the signals from B).

Locations for user transmitters and receivers are given in figure 6. The types of RF signals and the locations of the A, B, and n sites are listed in table III, as specified to NASA at this time.

Education

Two experiments in the education category are in progress: international sharing of college courses, and teacher training for the elementary and secondary grades.

College Curriculum Sharing. - Experiment 4 checkouts with CTS began in February 1976. In this experiment, engineering classes and seminars at Stanford University in California will be televised to Carleton University 2500 miles away in Ottawa, Canada, and vice-versa. The primary program content will be regularly scheduled engineering courses, with each institution selecting offerings normally unavailable to its own students. Joint seminars are being planned on communications policy issues and satellite communications technology.

The communication capabilities will permit operation in two primary modes. One mode allows classes to be transmitted simultaneously from Stanford to Carleton and from Carleton to Stanford with audio feedback for each class. This will be done through a single digital stream in each direction, wherein the audio is digitalized and multiplexed with the digital video. A second mode of operation provides full duplex vidio for two-way video teleconferencing experiments, such as special discussion seminars, student counseling, and problem sessions.

A key portion of the experiment will be the testing of video compression. The method used is a Hadamard transform, which concentrates most of the useful information into typically one-eighth of the original signal. This concentrated, or compressed, information is transmitted by CTS to the receiving station, where it is transformed back to a television picture.[4,10]

Project Interchange. - Experiment 16 checkouts with CTS begain in March 1976. Programs will originate from the Archdiocese of San Francisco Educational Television Center in Menlo Park. They will be sent by microwave to the NASA Ames Research Center about 5 miles away, where they will be transmitted to the CTS satellite. The CTS satellite will relay the programs to special receivers in San Francisco, Los Angeles, and Chico, which will televise them over existing television stations and cable systems to schools where teachers are assembled for the presentations.

An important feature is the feedback facilities, which will enable teachers, sitting in their schools, to exchange information, ask and answer questions, and even present graphs, drawings, and other materials during a program's discussion period. The response capability among teachers hundreds of miles apart can be accomplished through use of private telephone lines and facsimile machines. Teacher's comments will be channeled by means of a private telephone line through the Archdiocese of San Francisco Educational Television Center to the NASA Ames facility and beamed by CTS to all participants.

Health Care

Biomedical Communications. - Experiment 7 initial checkouts with CTS are planned for early 1977. The experimental network will consist of a number of full duplex television earth terminals (perhaps six) and one transportable terminal. The transportable terminal will be installed i a large van to permit flexibility in location and programming. Consideration is being given to implementing programs in the following biomedical disciplines:

(1) Nursing - predictive (baby and parent); and nurse practitioner education
(2) Health statistics - medical records; policy/program conference; expansion of training program; and analysis of impact of te ecommunications
(3) Dentistry - improved communications; and dental education
(4) Conferences - national conferences of tumor and allergy scientists
(5) Blood diseases - blood research; professional and lay education; and work and conference summaries
(6) Lung diseases - national research and demonstration centers; heart and lung institute meeting; and recruitment of research personnel

Health Communications. - Experiment 11 initial checkouts with CTS are planned for early 1977. The Veterans Administration, with its 171 hospitals, operates the largest health-care system in the U.S. Significant experience in the exchange of medical information was gained at 10 of these hospitals in the Appalachian region through use of ATS-6.[11]

In the utilization of CTS, emphasis will be on two-way video transmissions linking hospital to hospital, studio to hospital, and hospital to medical teaching center. Five new experimental categories, each taking advantage of the satellite's unique capabilities, are to be undertaken by the VA through weekly broadcasts using CTS to interconnect thirty VA hospitals in the Western United States. The categories are individual (discrete) telecommunications; a weekly national medical journal for physicians, dentists, nurses, and others interested in current professional developments taking place in all parts of the country; diagnostic, data, and library extension; continuing education for professional certification (television and radio hospital originations); and allied health programming.

The ground systems will include CTS downlink receivers at each of the 30 participating hospitals and a portable uplink transmitter. Mobile production capabilities will enable origination of programming from any of the hospitals over the 11-state area.

Communication Support for Decentralized Education. - Experiment 13 initial checkouts with CTS are planned for the first half of 1977. The WAMI (Washington, Alaska, Montana, Idaho) experiment will investigate the practical use of satellite telecommunications in a program that decentralizes basic medical science education into four state universities; it conducts part of the clinical training in 13 communities in the Northwest area. The University of Washington School of Medicine (UWSM) will conduct four subexperiments with the faculty and first-year students at universities in the four states and with physicians, fourth-year students, and residents at selected community clinics. A fifth subexperiment involves state government officials and health-care consumers.

One subexperiment, an Independent Learning Program, will deliver continuing medical education by satellite to National Health Service Corps physicians and others practicing in isolated communities. In another component, Regional Sharing of Faculty and Resources, highly specialized faculty, available only at the medical school, will present clinical correlations of basic science principles that medical students are studying on three other campuses.

In the Admissions and Recruitment of Minorities portion of the experiment, applicants will be interviewed by admissions committees from the four states to determine if enough information about an individual can be obtained by two-way satellite audio/video communications to evaluate his or her suitability for a medical career. In addition, minority and female high school and undergraduate college students, their parents, teachers, counselors, and premedical advisors will participate in interactive programs conducted by UWSM medical faculty, minority clinicians, and admission committee members.

Another subexperiment, Utilization of the Consultation Process, exploits patient referral as an educational research activity for local physicans and students at the WAMI community clinical training sites. The referring physicians, assisted by medical students and resident physicians in specialty training, will present patients to consulting physicians at the University of Washington Medical Center. Proper procedure for referral and followup care will be demonstrated, and continuing education programs related to improved patient care will be presented.

The subexperiment that deals with Satellite Communication in the Legislative Process will attempt to improve the data available to the four states' legislators who are responsible for regional health care and education decisions. Consumer participation by satellite will be arranged for a WAMI four-state governors' conference and various legislative hearings.

WAMI is planning to use the Lister Hill Center (experiment 7) earth terminals located in Fairbanks, Alaska; Seattle and Pullman, Washington; Boise, Idaho; and Missoula and Bozeman, Montana.

Community and Special

Satellite Library Information Network. - Experiment 9 is scheduled to begin checkouts with CTS in the latter part of 1976. Supplying the informational needs of areas in the Rocky Mountain region is one of the goals of SALINET (Satellite Library Information Network). SALINET is a consortium of libraries, a library school, and regional agencies with headquarters at the University of Denver Graduate School of Librarianship. Through use of CTS, SALINET plans to offer training programs for community librarians working in small towns that may lead to more effective library service in these communities.

SALINET also hopes to eventually develop video programming to inform individuals of existing information resources; to work at the community level through video programming, providing information to help town and municipal businesses and officials make the necessary decisions to solve critical problems; and to serve as a conduit for compressed bibliographic data requested through the satellite system by participating libraries.

Satellite Distribution. - Experiment 19 initial checkouts with CTS are scheduled for late 1976. The Southern Educational Communications Association (SECA) project is an experiment to distribute programming to member stations in the Southeastern United States. The program material is principally oriented for instructional use in elementary and secondary schools or for evening distribution to the adult audience. Secondary experiments are proposed in the exchange of program material over widely scattered regions of the United States and in the distribution of quality and multichannel audio and radio material throughout the same region.

The experiment will initially use NASA uplink equipment at Rosman, North Carolina. All receiving equipment will be located at the individual SECA stations (table III, n); Columbia-Rosman program lines will be provided.

Transportable Earth Terminal. - COMSAT (experiment 6) began checkouts with CTS in February 1976. This experiment is intended to show that a highly transportable, small, earth terminal can quickly establish reliable communications, through CTS, between the site of a disaster and relief and coordination agencies. For this experiment COMSAT has fabricated a lightweight earth terminal that can be transported to a disaster area by a small van, a helicopter, or even a small boat. On arrival, the terminal can be set up by two persons and be operational in less than an hour.

The small terminal includes a rugged metalized fiberglass antenna 1.2 meters (4 ft) in diameter mounted on a sturdy, lightweight tripod. Some of the electronics are on the tripod; the remainder are contained in several lightweight boxes. An alternating-current power generator operable on gasoline or liquid propane gas is also provided. The other end of the communications link consists of an earth terminal using a 4.56-meter (15-ft) diameter antenna mounted on a modified boat trailer. For most parts of the experiment, this terminal will be located at the COMSAT Laboratories in Clarksburg, Maryland. Communications messages will be relayed between the terminal at the COMSAT Laboratories and the American Red Cross Headquarters in Washington, D.C., through the telephone system. The COMSAT Laboratories terminal can be moved to other locations.

The communications link will consist of three frequency-modulated voice-quality channels equivalent to ordinary telephone channels. The communications carried over these channels will consist of one regular telephone channel, a high-speed teletype channel, and a facsimile graphics channel. This permits the simultaneous use of the telephone, sending of printed messages by teletype, and transmission of sketches or drawings on the facsimile equipment. The teletype machines have magnetic tape features that allow messages to be typed in advance. These can then be sent at 300 words per minute

Communications in Lieu of Transportation. - Westinghouse Electric Corp. (experiment 15) began checkouts with CTS in February 1976. In an attempt to lessen the need for costly air travel, while still bringing participants face to face, Westinghouse has developed an experiment to use satellite teleconferencing in lieu of transportation. The earth terminals will link the Defense and Electronic Systems Center in Baltimore, Maryland, through CTS, with the Aerospace Electrical Division in Lima, Ohio. Each location is equipped with a small earth terminal to both send and receive conference video/audio signals.[7] The ground systems will consist of full-duplex FM analog television transmitting and receiving facilities located in Baltimore, Maryland, and Lima, Ohio. The facilities will employ a 3-meter (10-ft) parabolic antenna at Lima and a 4.56-meter (15 ft) antenna at Baltimore.

REFERENCES

(1) Lewis Research Center, "CTS Reference Book," NASA TM X-71824, October 1975.

(2) D. L. Wright and J. W. B. Day, "The Communications Technology Satellite and the Associated Ground Terminals for Experiments," paper 75-904, presented at AIAA Conference on Communications Satellites for Health/Education Applications, Denver, Colo., July 21-23, 1975.

(3) E. F. Miller, J. L. Fiala, and I. G. Hansen, "Performance Characteristics of the 12 GHz, 200 Watt Transmitter Experiment Package for CTS," NASA TM X-71773, September 1975.

(4) H. E. Hudson, P. D. Guild, D. C. Coll, and D. R. Lumb, "College Curriculum Sharing via CTS," paper 75-905, presented at AIAA Conference on Communications Satellites for Health/Education Applications, Denver, Colo., July 21-23, 1975.

(5) M. K. Goggin and R. Katz, "Satellite Used for Information Access and In-Service Training for Libraries," paper 75-908, presented at AIAA Conference on Communications Satellites for Health/Education Applications, Denver, Colo., July 21-23, 1975.

(6) A. E. Casey-Stahmer and B. C. Blevis, "Canadian Experiments in the Social Applications of Satellite Telecommunications," paper 75-907, presented at AIAA Conference on Communications Satellites for Health/Education Applications, Denver, Colo., July 21-23, 1975.

(7) H. Nunnally and A. Kahn, "Satellite Teleconferencing Experimentation Oriented to Private Industry Applications," paper 75-906, presented at AIAA Conference on Communications Satellites for Health/Education Applications, Denver, Colo., July 21-23, 1975.

(8) L. D. Braun and M. V. O'Donovan, "Characteristics of a Communications Satellite Transponder," Microwave Journal, Vol. 17, December 1974.

(9) A. A. Whalen and W. A. Johnston, Jr., "ATS-6 - A Satellite for Human Needs," paper 75-900, presented at AIAA Conference on Communications Satellites for Health/Education Applications, Denver, Colo., July 21-23, 1975.

(10) D. R. Lumb, K. S. Down, and J. J. Sites, "University Resources Sharing Using the CTS," IEEE Internal Conference on Communications, Session 1, paper 6, Philadelphia, Penna., June 14, 1976.

(11) R. B. Shamaskin and D. E. Caldwell, "Advanced Biomedical Applications to Satellite Communications," Communications Satellites for Health/Education Applications, Denver, Colo., July 21-23, 1975.

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TABLE I. - SYNCHRONOUS COMMUNICATIONS SATELLITES

Spacecraft					Earth antenna diameter, m
Designation[a,b]	Launch date	Power transmitter, W	Frequency transmitter, GHz	Antenna diameter, m	
ATS-1	Dec. 1966	8	4.0	Dipole	12.0
ATS-3	Nov. 1967	8	↓	0.18	12.0
ATS-5	Aug. 1969	8	↓	.3	12.0
Intelsat IV	Jan. 1971	6	↓	1.2	30.0
Anik-I	Nov. 1972	5	↓	1.5	7.9
Anik-II	Apr. 1973	5	↓	1.5	7.9
ATS-6 (HET)	May 1974	15	2.6	9.2	3.0
Anik III	May 1975	5	4.0	1.5	----
CTS	Jan. 1976	200	12.1	.7	3.0
BSE	1978	100	12.0	----	3.0

[a]ATS - Applications Technology Satellite.
[b]BSE - Broadcast Satellite Experiment (Japan).

TABLE II. - U.S. COMMUNICATIONS EXPERIMENTS FOR CTS

Category	Experiment number, N	Title	Organization	Principal investigator
Societal				
Education	4	College Curriculum Sharing	Ames, Stanford, Carleton	Lumb
	16	Project Interchange	ASF	Gibbs
Health care	7	Biomedical Communications	Lister Hill	Henderson
	11	Health Communications	VA	Shamaskin
	13	Communication Support for Decentralized Education	WAMI	Schwarz
Communications and special services	9	Satellite Library Information Network (SALINET)	SALINET	Goggin
	19	Satellite Distribution	SECA	Morris
	6	Transportable Earth Terminal	COMSAT	Kaiser
	15	Communications in Lieu of Transportation	Westinghouse	Nunnally
Technical				
	1	Communication Link Characterization	GSFC	Ippolito
	18	Interactive Technology for Intra-NASA Application	GSFC	Chitwood
	20	Advanced Ground Receiving Equipment Experiment	GSFC/NHK	J. Miller
	T	TEP/SHF Technology	Lewis	Alexovich

TABLE III. - TYPES OF SIGNAL AND TERMINAL LOCATIONS FOR CTS U.S. EXPERIMENTS

Experiment number, N (see table II)	Signal[a]	Terminal location (see fig. 5)		
		A[b]	B[b]	n
4	WB2, NB2	Carleton University	NASA Ames wmt Stanford University	--------------------
16	WB1, NB2	Menlo Park wmt Ames	------------------	San Francisco, Los Angeles, and Chico, Calif.
7	WB2, NB2	Alaska, Colo., Fla., Ga., Idaho, Mass., Md., Mo., Mont., Ohio, S.C., Tex., Wash.		--------------------
11	WB2, NB2	Ariz., Calif., Colo., Idaho, Mont., N. Mex., Nev., Oreg., Utah, Wash., Wyo.		--------------------
13	WB2, NB2	Wash., Ark., Mo., Idaho		--------------------
9	WB1, NB2	Not yet specified.		Rocky Mountains (5 to 10 sites)
19	WB1	NASA and Rosman, N.C.	------------------	Ga., Ky., La., Miss., N.C., S.C., Tenn., Tex., Va.
6	NB2	Clarksburg, Md.	Selected sites.	--------------------
15	WB2	Baltimore, Md.	Lima, Ohio	--------------------

[a]WB - wide band (television); NB - narrow band (voice); 1 - one way; 2 - two way.

[b]wmt - with microwave to.

Figure 1.

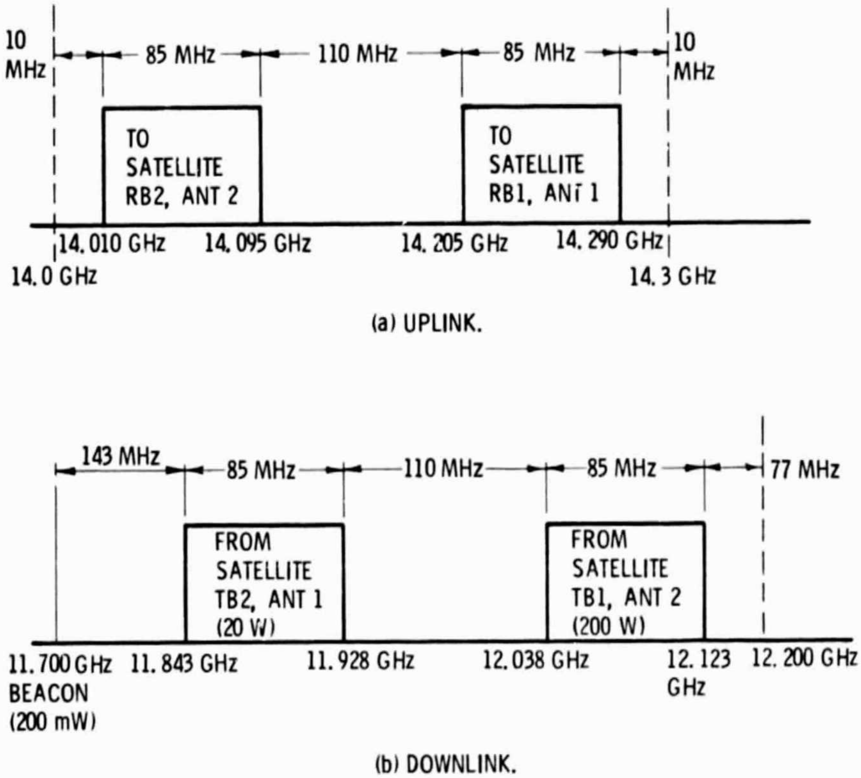

Figure 2. - 14/12-Gigahertz frequency plan, primary mode.

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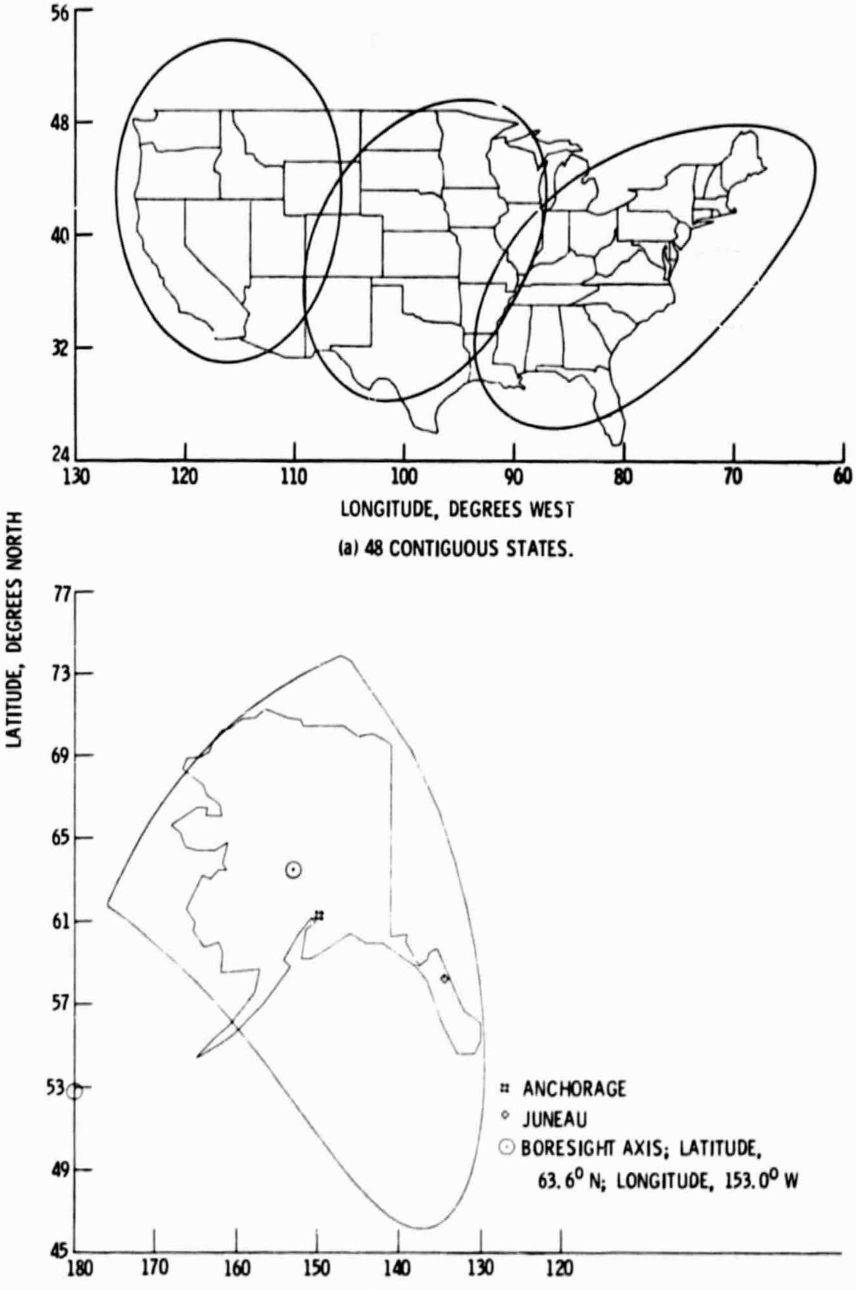


Figure 3. - Three-decibel contours for U. S. from CTS SHF antenna.

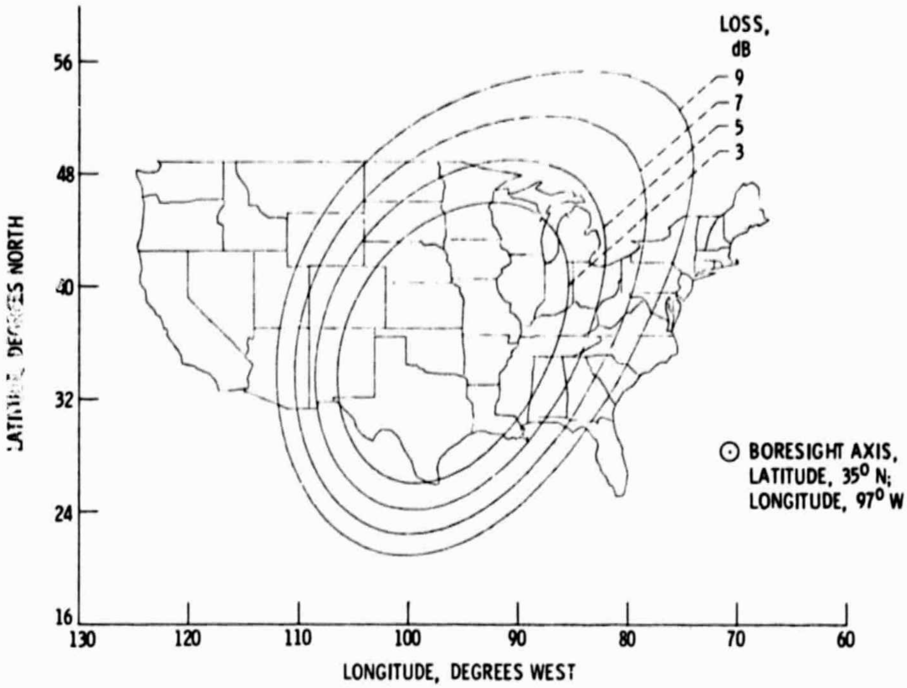
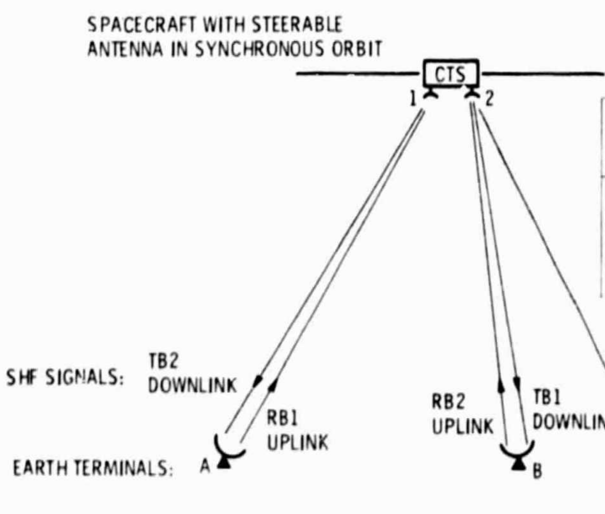


Figure 4. - Loss contours for CTS SHF antenna boresighted to Oklahoma.



	TERMINAL LOCATION		
	A	B	n
TRANSMITTING FREQUENCY	RB1	RB2	NONE
RECEIVING FREQUENCY	TB2	TB1	TB1

Figure 5. - CTS utilization for communications experiments.

EXPERIMENT, N	NAME	ORGANIZATION
1	LINK CHARACTERIZATION	GSFC
4	CURRICULUM SHARING	ARC
6	TRANSPORTABLE TERMINAL	COMSAT
7	BIOMEDICAL COMMUNICATION	HEW
9	LIBRARY NETWORK	SALINET
11	HEALTH COMMUNICATION	VA
13	DECENTRALIZED EDUCATION	WAMI
15	TELECONFERENCING	W[illegible]NGHOUSE
16	PROJECT INTERCHANGE	ARC[illegible].F.
18	INTERACTIVE TECHNIQUES	GSFC
19	SOUTHERN EDUCATION	SECA
20	ADVANCED GROUND RECEIVING	GSFC/NHK
T	TEP/SHF TECHNOLOGY	LEWIS

Figure 6. - Earth terminal locations for U. S. experiments.