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COMMUNICATIONS TECHNOLOGY SATELLITE - UNITED STATES EXPERIMENTS AND DISASTER COMMUNICATIONS APPLICATIONS

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EL SATELITE DE TECHNOLOGIA EN COMUNICACIONES - E.U. EXPERIMENTOS Y APLICACIONES DE COMUNICACIONES EN CASO DE DESASTRES

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ABSTRACTO

El Satelite Experimental de Technologia en Comunicaciones (CTS), tambein llamado Hermes, emplea un transmisor de alta potencia en las frequencias de 14 y 12 GHz para transmitir y recibir comunicaciones de banda ancha (television) y banda estrecha (voz, información y data). En este programa conjunto, Canada y los Estados Unidos han conducido una variedad de experimentos en comunicaciones. Este reporte se basa en los experimentos y miniexperimentos conducidos por los E.U. con el CTS usando antenas de 0.6m a 50m en diametro en los terminales. Estos experimento son bosquejados en este reporte y el empleo del CTS en caso de desastres simulados ó reales es resumido.

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ABSTRACT

The experimental Communications Technology Satellite (CTS), also called Hermes, uses a high-power transmitter and 12- and 14-GHz frequencies for wideband (two- and one-way television) and narrowband (voice, data) communications. In the joint program, both Canada and the United States have conducted a variety of communications experiments. This report concentrates on U.S. CTS experiments and miniexperiments that use ground antennas from 0.6 to 5 meters in diameter. The U.S. CTS experiments program is synopsized in this report. The use of CTS for simulated and actual disasters is summarized.

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INTRODUCTION

There exists abundant information pertinent to the Communications Technology Satellite (CTS), or Hermes, and to the experiments that have been and are being conducted. For example, the CTS experiments conducted by the United States to November 1977 are reviewed in reference 1. The CTS spacecraft is discussed in references 2 and 3. A paper on experiments to explore the 12- and 14-gigahertz communications satellite has recently been presented (ref. 4). Some experiments have explored the use of a communications satellite for disaster applicability.

Each year disasters exact an enormous toll in lives, economic losses, and human suffering. This toll results, in part, from deficiencies in preparedness, warning, and relief. These deficiencies can be alleviated by improved communications. The use of CTS for disaster relief communications is discussed in reference 5. Background information pertinent to disaster communications via satellite, including the requirements and descriptions of the Intelsat system and experimental satellites, is given in reference 6.

The United Nations conducted a regional seminar on the use of satellite technology for disaster applications at the Instituto de Pesquisas Especiais in Sao José dos Compos, Sao Paulo, Brazil, in October 1978. This report is a written version of an oral presentation given at the seminar. Accordingly, it classifies by altitude some of the craft discussed at the seminar, provides information on the CTS spacecraft, gives an overview on the CTS mission and U.S. CTS experiments, and describes some Earth terminals used in the experiments. A few specific experiments are discussed in four of the five categories of CTS experiments. Finally, some disaster applications and disaster simulations that have been conducted with CTS are described. Although this report repeats some material contained in previous reports, it has been published as a record of the seminar presentation.

Other presentations at the United Nations seminar discussed remote sensing results from airplanes and spacecraft. Figure 1 classifies these craft by altitude. The altitudes range from those of airplanes, which are at quite low altitudes, to those of various satellites - Landsat, a NOAA (National Oceanic and Atmospheric Administration) spacecraft; GOES (Geostationary Operational Environmental Satellite); Intelsat (International Telecommunications Satellite); and CTS (Communications Technology Satellite). (Abbreviations and acronyns are defined at their first use and in the appendix.) Airplanes and the Skylab, Landsat, and NOAA satellites are at subgeosynchronous altitudes. The GOES, Intelsat, and CTS satellites are in geosynchronous orbits (35 700 km above the equator). As such, their rotational period is 24 hours per day and they appear fixed in space relative to a point on the surface of the Earth.

A wealth of information on the visual and photographic results of the Skylab 4 mission (Nov. 16, 1973 to Feb. 8, 1974) is contained in reference 7. Landsat 3 (launched Mar. 5, 1978) is discussed in reference 8. (Landsat was called the Earth Resources Technology Satellite (ERTS) before launch.) From research results to date, reference 8 also assesses what the Landsat multispectral data can be made to reveal, the extent to which these data correspond to data requirements, and the use of the data. NOAA satellite and aeronautical activities in 1977 are synopsized in reference 9, which also lists the U.S. environmental satellites launched between 1960 and 1977. (The Landsat and GOES satellites were known as Synchronous Meteorological Satellites (SMS) before launch (ref. 10).) An integrated guide for use in remote sensing and in environmental education, training, and applications, etc., is contained in reference 11. The Intelsat system is discussed in reference 12. As noted in figure 1, Intelsat and CTS are communications satellites. Communications satellites are discussed in references 13 and 14.

Some of the material in the report was obtained from periodic meetings with U.S. experimenters. Where possible, a reference is cited.

CTS SPACECRAFT

The Communications Technology Satellite is a joint effort of the United States and Canada. This joint effort stems from a Memorandum of Understanding between the two nations signed in April 1971. CTS, or Hermes, is a three-axis-stabilized satellite with heliotracking solar arrays. It uses 14 gigahertz for the uplink and 12 gigahertz for the downlink (fig. 2), hitherto unused frequencies. On board the spacecraft are two 20- and one 200-watt transmitter. The 200-watt transmitter is used with relatively small antennas at one ground location for communiction with another ground location. CTS provides opportunities for scientists, the private sector, and agencies of the United States and Canadian Governments to use a communications satellite for technological and societal experiments.

The location of CTS in the frequency spectrum is given in figure 3, which also shows the frequencies for U.S. terrestrial applications of AM and FM radio and UHF television. Intelsat uses C-band (4 to 6 GHz). The Japanese Broadcast

Satellite Experiment (BSE), launched in 1978 (ref. 15), operates - as does CTS - at 12 and 14 gigahertz.

CTS was launched from Cape Canaveral, Florida, by a Delta 2914 on January 17, 1976 (fig. 4). On January 29, 1976, it was placed into geosynchronous orbit above the equator at 116° west longitude (west of South America). An artist's depiction of this location is given in figure 5. Reference 16 gives details of the spacecraft. The transponder, a combined receiver and transmitter, is located in the spacecraft main body (i.e., between the solar arrays, fig. 2). The receive frequency (terrestrial uplink) is 14 gigahertz; the transmit frequency (downlink) is 12 gigahertz. The two super-high-frequency (SHF) antennas on board the spacecraft (fig. 2) are gimbaled and pointed on command from the ground. This antenna-pointing permits coverage of different regions in the Western Hemisphere. Proper antenna-pointing is required to complete a communications link between Earth terminals at different locations.

The SHF antennas on CTS are used for communications experiments. The nominal 3-decibel beam width is $2\frac{1}{2}^{\circ}$. The SHF antenna footprints (coverage) are shown in figure 6(a) for the 48 contiguous states and in figure 6(b) for Alaska. The footprint contours ($2\frac{1}{2}^{\circ}$ beam width) represent a constant 3-decibel loss in received signal strength. Within a footprint the loss is less than 3 decibels. Each antenna footprint in the 48 contiguous states (fig. 6(a)) is about 1600 kilometers wide and encompasses a time zone.

MISSION AND EXPERIMENTS OVERVIEW

The United States (NASA) and Canadian (Department of Communications (DOC)) mission for CTS is summarized in figure 7, beginning with the launch. After the spacecraft was placed into orbit and checked out, technology experiments were conducted. Then the communications experiments program was begun. This program continued through 1976 and 1977 and is still under way in 1978. It is planned to terminate U.S. communications experiments on June 30, 1979. This termination may be followed by another series of technology experiments associated with the spacecraft.

Depicted in figure 7 are the different eclipses (E_1 to E_8) that occur when the Earth comes between the Sun and the spacecraft. The satellite is eclipsed by the Earth daily during the eclipse seasons. Each day the satellite is in shadow for a maximum of 72 minutes. During 1976, the spacecraft SHF system had to be shut down for safety during the eclipse seasons. In 1977 and 1978, except during direct shadowing and about an hour before and after eclipse, communications experiments were conducted normally.

The alternate-day usage of the satellite is also shown in figure 7. In the Memorandum of Understanding the United States and Canada agreed to use the spacecraft on alternate days. In October 1978, for example, the United States used CTS on Mondays, Wednesdays, and Fridays. During this period, Canada used CTS on Tuesdays, Thursdays, and Saturdays. Sunday usage alternated between the two countries on a weekly basis.

To explore the uses of communications satellites at 12 and 14 gigahertz, U.S. experimenters are making a variety of experiments using both the 20- and the 200-watt transmitter on CTS. The experiment categories include health care, community, education, technology, and special. Government agencies, educational institutions, and industry are all represented as experimenters. The five categories and the associated experiments are shown in figure 8. The number after each item is the U.S. experiment number. There is a particular organization and a principal investigator associated with each of the experiments that are numbered in figure 8 (table I).

The ground locations for the United States experiments range from the Atlantic seaboard to the Pacific seaboard and include Alaska. The experiment locations are shown in figure 9. There are 29 uplink terminals, including 10 portable terminals and 51 receive-only terminals, including four beacon receivers. Thus, there are 80 Earth terminals in the U.S. that are used with CTS. U.S. experiments use both wideband and narrowband signals. The wideband signals are used for television; the narrowband signals are used for voice, data, and facsimile transmission. Some experiment arrangements permit two-way television; others permit only one-way television. Information on the frequency plan is given in reference 16 (p. III-12).

In addition to these experiments a wide variety of miniexperiments or demonstrations have been conducted in the U.S. with CTS. These demonstrations, which are listed in table II, began in May 1976. The locations for the miniexperiments are shown in figure 10.

As of September 22, 1978, five experiments have been completed and 18 are active (table I). One-hundred miniexperiments have been completed (table II).

EARTH TERMINALS

As noted in figure 9, there are 80 CTS Earth terminals in the U.S. The Earth terminals either used at or supplied by the NASA Lewis Research Center are shown in figure 11 and include both transportable and stationary terminals. Additional information on the Lewis wideband transmit-and-receive terminal (top right in fig. 11), which has a 4.8-meter-diameter antenna, is given in reference 16 (p. VIII-16).

The portable Earth terminal (PET), which has a 2.4-meter-diameter antenna, is used for two-way conference communications (fig. 12). The PET has traveled over 66 000 kilometers. The transportable Earth terminal (TET), which has a 3-meter-diameter antenna, receives television signals and transmits or receives narrowband signals (fig. 13). Additional information on the PET and the TET is given in reference 17. As shown in table II, the PET and the TET have been used in a multitude of miniexperiments.

At the Communications Research Center (CRC) in Ottawa, spacecraft control and health are maintained via command and telemetry links. Spacecraft antenna-pointing to Earth terminals is accomplished by the Ottawa ground station according to planned times and boresight allocations. The U.S. experiments are controlled on a real-time basis at the Lewis experimenters' coordination center (fig. 14). Lewis communicates by voice link with CRC. Lewis also receives CTS telemetry data, which are processed and displayed to verify that the CTS spacecraft configuration is appropriate for the intended user. The U.S. experimenter coordinates his own ground stations.

EXPERIMENTS

As noted previously (fig. 8 and table I), a variety of experiments are being conducted in the U.S. with CTS. Many miniexperiments (fig. 10 and table II) have also been conducted. A few of these are discussed in this section to illustrate how the experimental satellite has been and is being used.

Health

In the health category, one of the experimenters is the U.S. Veterans Administration (VA). The VA, with its 172 hospitals, operates the largest health-care system in the U.S. Since 1974, the VA has been conducting experiments in space communications, first with the Applications Technology Satellite (ATS) series and more recently with the CTS satellite. The VA is studying the use of satellite-aided information transfer for diagnostic, therapeutic, educational, and administrative purposes. They are trying to find the most effective cost-efficient way to bring the best possible medical care to every patient regardless of his location.

The concept of the VA CTS experiment is depicted in figure 15. One 2-meter-diameter antenna is provided at each of the 30 sites. A portable terminal with a 3-meter-diameter antenna is also used. Thirty-eight hospitals are participating, eight of which are non-VA centers, in 12 states (including Alaska). The interactive transmissions encompass the following activities (ref. 18):

(1) Teleconsultations
(2) Weekly VA National Medical Satellite Journal for professionals in the health-care delivery fields
(3) Management teleconferences
(4) Continuing education for professional certification
(5) Allied health programming
(6) Patient education

Education

In the education category, one of the experiments is completed. The concept is given in figure 16. In this experiment, engineering classes and seminars at Stanford University in California were televised to Carleton University, 4000 kilometers away in Ottawa, Canada, and conversely, with good results. The primary program content was regularly scheduled engineering courses, with each institution selecting offerings normally unavailable to its own students. Joint seminars were conducted on communications policy issues and satellite communications technology. There were also special discussion seminars, student couseling, and problem sessions (ref. 19).

Community

In the community category, an experiment in videoconferencing via satellite has explored ways to open the U.S. Congress to the people. The concept is shown in figure 17. The experiment was designed (1) to explore Congressmens' needs for better ways to communicate with constituents and (2) to satisfy policymakers' needs for better data on the potential benefits and costs of using emergent telecommunications technology to provide public services (ref. 20). Twelve subexperiments have been conducted as part of this videoconferencing program for Congress. Many of these subexperiments used the portable Earth terminal (fig. 12).

The participants in the experiments have included representatives and Senators, high school students, local city officials, public witnesses, psychologists, hospital officials, Indian leaders, agricultural and energy leaders, and senior citizens.

A purpose of the experiment was to test the potential for using satellite communications in Congressional hearings. To this end, a videoconference was held between Senator Adlai Stevenson and other members of the Subcommittee on Science, Technology, and Space convened in Washington, D.C., and public witnesses in Springfield, Illinois. The senators were in the Dirksen Senate Office Building in Washington, D.C. (fig. 18). The public witnesses were in a courtroom in the Federal Building in Springfield, Illinois. The reaction of the conference participants to using an experimental satellite was excellent. They seemed to enjoy the experience and adapted quickly to the medium.

A miniexperiment in the community category was conducted in association with two American Indian tribes. The concept for the joint American Indian demonstration is shown in figure 19. The purpose of the miniexperiment was to illustrate how satellite telecommunications could be used to deliver services beneficial to Indian communities. More specifically, it included communications between tribes, between tribes and Federal agencies, and between tribes and educational institutions. The objective was demonstrated through planned activities with representative participants from the tribes, Federal agencies, and educational institutions.

The teleconferences were held between Congressmen and Indian and Government officials in Washington, D.C., and California and Indian leaders both at the Crow Agency in Montana and in Alburquerque, New Mexico. On three days in April 1978, a full duplex television link was established between a portable Earth terminal at the Crow Agency and a transportable Earth terminal at the Pueblo Cultural Center in Alburquerque, New Mexico. The Albuquerque terminal received video and audio and transmitted audio. On the second day, a similar link was established with the stationary CTS terminal at the NASA Ames Research Center in California.

Special

An experiment in the special category links some of the NASA centers via CTS. The concept is shown in figure 20. The experiment uses ground stations installed at the Lewis Research Center, Cleveland, Ohio; the Ames Research Center, Moffett Field, California; the Goddard Space Flight Center, Greenbelt, Maryland; and the Johnson Space Center, Houston, Texas. NASA Headquarters, Washington, D.C., is brought into the loop via landlines from Goddard. The ground stations at the various centers permit two-way television, voice, and data transmission between NASA centers, between NASA Headquarters and a center, and between a center and other locations (ref. 21). In addition to their use for this particular experiment, the facilities have been used in many miniexperiments.

An experiment to provide information on ice conditions along the Alaskan North Shore was conducted with CTS. The various communication elements associated with the experiment are depicted in figure 21. The Coast Guard's side-looking airborne radar (SLAR) aircraft surveyed the ice conditions along the coast of Alaska from Wainwright to Barter Island. The radar data were transmitted from the aircraft to the NASA Lewis Research Center by a continuous, real-time, ultra-high-frequency uplink transmission to the GOES satellite, a downlink to the Wallops Island, Virginia, ground station, and the special dedicated telephone lines to Lewis. The radar data were also transmitted to Barrow, Alaska, by a continuous-line-of-sight, real-time downlink transmission and to the U.S. Coast Guard icebreaker Glacier by facsimile transmission. At Lewis the data were recorded on magnetic tape and used to genate a high-quality radar image. This image was facsimile-transmitted from Cleveland to Barrow, Alaska, via CTS and to the U.S. Navy fleet weather facility in Suitland, Maryland.

The signals were received at Barrow on a 0.6-meter-diameter antenna atop a telephone pole (fig. 22). A larger antenna (1.2-m diam) was also used in a miniexperiment (no. 10, table II).

A radar image depicting typical ice conditions is presented in figure 23. The radar image (bottom of figure) shows the 110-kilometer-wide radar swath of the SLAR aircraft. The graphics (top of figure) show the interpretation of the SLAR image and give the ice information. The radar image shows nearshore ice conditions in the Beaufort Sea. The various shades of grey correspond to the intensity of backscattering microwave radiation from the SLAR.

Light-toned, white areas indicate high-intensity backscattering radiation, as might be expected from such ice features. Dark-toned, black areas indicate low-intensity backscattering radiation such as that from open water or smooth-surface ice sheets (ref. 22).

The United Nations asked NASA if CTS could be used to provide simultaneous interpretation during the U.N. conference on technical cooperation among developing countries. The U.N. conference was to be held in Buenos Aires, Argentina; interpreters were to be at U.N. Headquarters in New York. The purpose of the experiment was to demonstrate how satellite communications could connect U.N. Headquarters with other parts of the world.

To implement the experiment, the NASA Lewis portable Earth terminal and personnel were located at U.N. Headquarters in New York. A Comsat terminal (1.8-m diam), personnel, and suitable electronic equipment were located in Buenos Aires, Argentina (figs. 24 and 25). During the experiment, which was conducted in September 1978, the picture and voice of a speaker in the plenary session of the conference in Buenos Aires were transmitted via CTS to New York. Five interpreters in New York observed the speaker and interpreted his speech into the official U.N. languages (Chinese, English, French, Russian, and Spanish). The interpretations were returned to Buenos Aires via CTS for transmission to the audio headsets of the delegates attending the conference. Simultaneous with the interpretation, copies of speeches were sent via CTS and facsimile equipment to New York for translation. The translated versions of the documents were returned the next day to Buenos Aires (no. 96, table II).

The United Nations switchboard through which the signals to and from CTS were processed is shown in figure 26. The staff members of the U.N. Outer Space and Affairs Division were briefed inside the portable Earth terminal (fig. 27). The coordination center for the miniexperiment was at U.N. Headquarters (fig. 28). Not visible on the figure are other pieces of equipment such as television monitors, telecopiers, and facsimile machines. Good quality of the television signal received from Buenos Aires is shown in figure 29. The photograph was taken from an Advent screen at U.N. Headquarters.

During the experiment, a switch was made from interpretation in Buenos Aires to interpretation in New York via satellite. The delegates at the conference in Buenos Aires were not advised of the switch and they were not aware of it. The technical performance of the video and audio systems was evaluated as excellent.

After the miniexperiment an evaluation meeting was held between the interpreters in Buenos Aires and the participants in New York on two-way television via CTS. The New York participants are shown in figure 30. The Buenos Aires interpreters are shown in figure 31; here again, the photograph was taken from an Advent screen in New York.

DISASTER APPLICATIONS

There have been quite a few utilizations of CTS for emergency simulations. For example, in July 1976, a demonstration was held at the request of the U.S. Forest Service with the assistance of the American Red Cross. In February 1977, a simulated disaster exercise for the possible flooding of the Ohio River Valley was held in conjunction with the American Red Cross in Cincinnati, Ohio, and the National Disaster Headquarters in Alexandria, Virginia. In July 1977, a hurricane disaster exercise was held in Houston and Corpus Christi, Texas. These simulations are discussed in reference 5.

Flood Control

Another application of satellite technology was demonstrated in response to a request from the U.S. Army Corps of Engineers. An interactive teleconference was held between Corps of Engineers personnel in Omaha, Nebraska; Vicksburg, Mississippi; and Washington, D.C. The subject of the conference was hydro-meteorological and water control conditions of the Mississippi River and tributary subbasins (no. 93, table II). The concept of this miniexperiment is shown in figure 32. One of the transmissions is shown in figure 33. A chart showing the streamflow distribution in the Mississippi River Basin was readily transmitted via CTS from Vicksburg; commented on by participants in Washington, D.C., and Omaha; and responded to by participants in Vicksburg.

Airport Emergency Simulation

In May 1978, CTS was used in a medical training exercise in emergency management of an airport catastrophe. Suitable terminals and CTS were used to link Maryland's Baltimore-Washington International Airport and the Burn Center at Brook Army Medical Center in San Antonio, Texas. The concept for the simulation is shown in figure 34. In the simulated accident an out-of-control aviation-fuel tank truck strikes a taxiing commercial jet liner and flames engulf both. Two hundred passengers and 15 crew members are on the plane and one person is in the fuel truck. Many people are burned and injury casualties result. The airplane and the tank truck are shown in figure 35; fire trucks in figure 36, the "victims" in figure 37, and further detail on one "victim" in figure 38. The "victim" in figure 38 was on camera and this picture was being transmitted via CTS to the Brook Army Medical Center in Texas. There were direct communications between the paramedics at the scene of the disaster and the burn treatment specialists in Texas. The specialists diagnosed via their television monitor (fig. 39) and prescribed treatment for the "victim."

The miniexperiment was judged an outstanding success by the participants. The patient assessment made during the simulation by physicians in Maryland and physicians in Texas for the same group of patients varied by only 3 percent.

Johnstown Flood Disaster

In July 1977, the American Red Cross requested emergency communications for the flood disaster at Johnstown, Pennsylvania. The 1.2-meter-diameter Comsat terminal, which was in Texas at the time of the request, was flown by commercial airliner to Pittsburgh, Pennsylvania, and transported on a small van to Johnstown. Thirty hours after the request, the terminal was operating with CTS (ref. 5).

The concept for the flood disaster communications is shown in figure 40. Two narrowband channels (a few kHz each) were provided, via CTS, between Johnstown, Pennsylvania, and Clarksburg, Maryland. The signals were routed into the commercial telephone network from Clarksburg and fed into Red Cross Headquarters in Washington, D.C. The communications link was maintained for 2 days until the Johnstown telephone system was sufficiently restored. The small terminal carried voice and facsimile traffic for the American Red Cross disaster relief unit to the Washington Red Cross Headquarters and many other points.

The field center was in a school building in the Johnstown area (fig. 41). The Comsat terminal was set up outside the school building (fig. 42). Some scenes of the Johnstown area during the flood are shown in figures 43 to 45. CTS was used to transmit requests for emergency supplies, nurses, and volunteers and to notify the relatives of flood victims. It was also used to transmit situation maps. For a brief period on July 25, 1977, the satellite link was the only means of communications into and out of the Johnstown area.

CONCLUDING REMARKS

A variety of experiments have been conducted with the Communications Technology Satellite. The United States experiments have included disaster simulations, as well as an actual disaster. The locations for the experiments and the miniexperiments ranged from the Atlantic seaboard to the Pacific seaboard and included Alaska and South America (Buenos Aires). Earth terminals with antenna diameters from 0.6 to 5 meters have been used.

The CTS experiments have proved that the technology to provide viable, direct-to-user, duplex television communications from any point in the hemisphere exists today. Furthermore, there are needs that can only be satisfied with this type of communications. CTS experiments and miniexperiments have shown that CTS is useful in various disaster applications. For example, two-way television can be used for predisaster planning by appropriate organizations; and two-way audio, teletype, and facsimile and one-way video transmission have been demonstrated in disaster assessment and relief.

APPENDIX - ABBREVIATIONS AND ACRONYMS

AM	amplitude modulation
ATS	Application Technology Satellite
BSE	Broadcast Satellite Experiment of Nippon Hoso Kyokai (Broadcasting Co. of Japan)
Comsat	Communications Satellite Corp.
CRC	Communications Research Centre (Canada)
CTS	Communications Technology Satellite (Hermes)
DOC	Department of Communications (Canada)
FM	frequency modulation
GOES	Geostationary Operational Environmental Satellite
Intelsat	International Communications Satellite Consortium
NOAA	National Oceanic and Atmospheric Administration
PBS	Public Broadcasting System
PET	portable Earth terminal
Salinet	Satellite Library Information Network
SECA	Southern Educational Communications Association
SHF	superhigh frequency (3 to 30 GHz)
SLAR	sidelooking airborne radar
SMS	Synchronous Meteorological Satellite (now GOES)
TEP	transmitter experiment package
TET	transportable Earth terminal
UHF	ultrahigh frequency (300 to 3000 MHz)
VA	Veterans Administration

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TABLE I. - U.S. COMMUNICATIONS EXPERIMENTS WITH CTS

Experiment	Title	Organization	Principal investigator
[a]TEP	TEP/SHF technology	NASA Lewis Research Center	R. Alexovich
[a]1	Communication link characteristics	NASA Goddard Space Flight Center	L. Ippolito
[b]4	College curriculum sharing	NASA Ames Research Center	D. Lumb
[a]4A	Mobile analysis and telecommunications	NASA Ames Research Center	B. Gibbs
[a]6	Transportable Earth terminal	Comsat Corp.	J. Kaiser
[a]7	Biomedical communications	Lister Hill	E. Henderson
[c]9	Satellite library information network	Salinet	M. Goggin
[a]11	Health communications	Veterans Administration	R. Shamaskin
[c]12	Appalachian education satellite - project II	Appalachian Regional Commission	H. Morse
[a]13	Communication support for decentralized education	Washington-Alaska-Montana-Idaho (W'AMI)	M. R. Schwarz
[a]15	Communication in lieu of transportation	Westinghouse Electric Corp.	H. Nunnally
[a]16	Project Interchange	Archdiocese of San Francisco	D. Green
[c]17	Health education television	Association of Western Hospitals	K. Johnson
[a]18	Interaction techniques for intra-NASA applications	NASA Goddard Space Flight Center	J. Chitwood
[a]19	Satellite distribution	Southern Education Communications Association	R. Glazier
[a]20	Advanced Ground Receiver Equipment Experiment	Goddard Space Flight Center and Broadcasting Company of Japan	J. Miller
[a]21	Public service satellite experiment	Public Service Satellite Consortium	R. Mott
[b]22	Alaska North Shore ice information	NASA Lewis Research Center	R. Gedney
[c]23	Experimental participation cost study	Protronics	M. Gratzl
[a]24	Digitally implemented communications experiment	NASA Lewis Research Center and Comsat Corp.	H. Jackson
[b]25	Congressional videoconferencing	George Washington University	F. Wood
[b]26	Project Adjunct	Satellite Business Systems	C. Rush
[c]27	Women's satellite services	National Women's Agenda	J. Zimmerman
[a]28	Long base interference (cosmic radiation sources)	University of Illinois	G. Swenson
[a]29	University graduate level studies	Varian Associates	R. Shuken
[a]30	Terminal of tomorrow	Federal Communications Commission	I. Galane

[a]Final acceptance.
[b]Complete.
[c]Pending status.

TABLE II. - U.S. COMMUNICATIONS MINIEXPERIMENTS (DEMONSTRATIONS) WITH CTS

Number	Date	Event	Demonstration request	Experimenter[a]	Location
1	5/6/76	Institute of Electrical and Electronics Engineers Joint Meeting	--------	15	Baltimore, Md.; Lima, Ohio
2	5/10, 12, 14, 17 19, 21/76	Kalamazoo Bicentennial	--------	L18/TET	Kalamazoo, Mich.
3	5/20/76	CTS Inauguration and Christening	--------	CRC/Lewis	Ottawa, Canada; Cleveland, Ohio
4	6/14/76	International Communications	--------	18/CRC	Philadelphia, Pa.
5	6/16/76	Conference on Open Learning	--------	21/18	Lincoln, Nebr.
6	6/23/76	Parametric Amplifier Review	--------	15/L18	Baltimore, Md.; Cleveland, Ohio
7	7/4/76	The Glorious Fourth	--------	6/Lewis/NBC	Yellowstone Park, Wyo.
8	7/10/76	Scottish Games	--------	19/(6)	Columbia, S.C.
9	8/3, 5, 7, 10, 12, 13, 14/76	Public Communication via Satellite	--------	L18/TET	Chicago Science Museum, Chicago, Ill.
10	8/25/76	Public Communication via Satellite	--------	L18	Barrow, Ak.
11	10/29/76	Grade School Program	--------	L18/TET	Pecatonica, Ill.
12	11/1, 3, 5, 8, 10, 12/76	Public Communication via Satellite	--------	L18/TET	Rockford, Ill.
13	11/17/76	U.S. Users Meeting 16	--------	L18/15	Cleveland, Ohio; Baltimore, Md.
14	12/7/76	N.Y.C. Board of Education	1	G18	New York, N.Y.
15	1/25/77	Moot Court	--------	15	University of Maryland; Ohio Northern
16	1/27/77	NASA Conference	--------	G18	Mt. View, Calif; Greenbelt, Md.
17	1/29/77	Legal Continuing Education Seminar	13	A18	Hastings College, Calif.
18	2/8/77	U.S. Users Meeting 17	--------	L18/A18/4	Cleveland, Ohio; Mt. View, Calif.
19	3/1/77	Mayors Conference	16	21/PET	Washington, D.C.; San Jose, Calif.
20	3/3-10/77	Crisis Management Conference	14	L18/PET	Syracuse University; CRC, Ontario, Canada
21	3/12/77	Symposium	12	A18	Mt. View, Calif.; Greenbelt, Md.
22	3/15, 17/77	Equal Employment Opportunity Spacemobile	--------	L18/TET	Cleveland, Ohio; Chicago, Ill.
23	3/24/77	Viking Presentation	--------	L18/CRC	Cleveland, Ohio; Ottawa, Canada
24	3/31/77	Rural Health Conference	--------	13/PET	Seattle, Wash.; Bethesda, Md.
25	4/13/77	Exceptional Children Convention	--------	21/PET	Atlanta, Ga.; SECA
26	4/19-21/77	Annual Southern Educational Communications Association Conference	--------	19/TET	Gulf Shores, Ala.
27	5/23/77	Health Sciences Conference	--------	21/TET	Indiana University; HEW, Baltimore, Md.
28	5/25/77	U.S. Users Meeting 18	--------	L18/G18	Cleveland, Ohio; Greenbelt, Md.
29	6/1/77	Special Education Conference	34	21/TET	University of Kentucky
30	6/9, 10/77	International Symposium	46	7	Mt. View, Calif.; Montreal, Canada
31	6/10, 15/77	Employment Conference	42	G18/1/II	Hot Springs, Ga.; Albany, N.Y.
32	6/17/77	Public Service Satellite Consortium Workshop	36	21/II	Vail, Colo.
33	7/7-19/77	Medical Workshop	39	21/PET/TET	University of Alabama
34	7/21/77	National Oceanic and Atmospheric Administration Conference	44	21	Seattle, Wash.; Maryland; Colorado
35	7/25, 26/77	Disaster Relief	--------	6	Johnstown, Pa.
36	7/31 - 8/9/77	Boy Scout Jamboree	49	20	Moraine Park, Pa.
37	8/4/77	Co-op Conference	19	18	Greenbelt, Md.; Mt. View, Calif.
38	8/23/77	Governors Conference	5	13/PET	Idaho, Montana, Washington, Alaska

[a]A18 denotes a Ames experiment; G18 denotes a Goddard experiment; L18 denotes a Lewis experiment; etc.

TABLE II. - Continued.

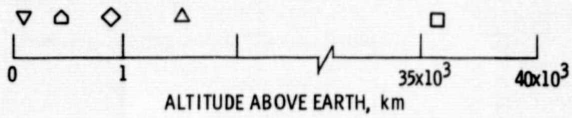
Number	Date	Event	Demonstration request	Experimenter[a]	Location
39	8/23 - 9/6/77	Medical Clinics	6 - 11	13/PET	Idaho, Montana, Washington
40	8/30/77	American Hospital Convention	32	21/TET	Atlanta, Ga.
41	9/11/77	Send-Receive Satellite Demonstration	56	21/A18	New York, N.Y.; Ames Research Center, Calif.
42	9/27/77	U.S. Users Meeting 19	--------	L18/13	Cleveland, Ohio; Seattle, Wash.
43	9/27/77	Rehabilitation Conference	47	21/TET	Wyoming, Virginia, SECA
44	10/9/77	Intelcom 77 - Medical Seminar	55	7/PET	Atlanta, Ga.
45	10/10/77	Intelcom 77 - Plenary Session	50	G18/PET	Atlanta, Ga.
46	10/10/77	Intelcom 77 - Educational	51	G18/PET	Atlanta, Ga.
47	10/11/77	Intelcom 77 - Canadian Transmission	64	Lewis Project Office/ PET	Atlanta, Ga.
48	10/14/77	American Dietetic Association Conference	61	21	Bethesda, Md.
49	10/28/77	Bureau of Reclamation Meeting	58	21	Edna, Tex.
50	11/7/77	Medical Center Conference	65	G18	Hershey, Pa.
51	11/20-23/77	Satellite Arts Project	38R1	G18	NASA Goddard Space Flight Center, Md.; NASA Ames Research Center, Calif.
52	11/21/77	Social Work Symposium (ATS-6)	69	21	San Diego, Calif.; Appalachia
53	12/12/77	American Medical Association Science Meeting	59R1	11/PET	Miami Beach, Fla.
54	1/10-22/78	Health Education Program	21R3	21/PET	Medical Unuversity, Charleston, S.C.
55	1/13/78	Teleconference Demonstration	73	21	Menlo Park, Calif.
56	1/28, 29/78	Continuing Medical Association	66	21/PET	Birmingham, Ala.
57	1/7/78	Stereo Simulcast	67R1	19/PET	Columbia, S.C.
58	2/2/78	Explorer Twenty-Year Anniversary	84	I /TET	Huntsville, Ala.
59	2/7-9/78	Education Curriculum Sharing - Industry and University Research	75 - 78	A18/PET	Greensboro, N.C.
60	2/8/78	American Library Association Conference	71	G18	Owings Mills, Md.
61	2/11/78	Teleconference on Offshore Oil Drilling	31R2	21	San Diego, Calif., NASA Goddard Space Flight Center, Md.
62	2/14/78	American Association for Advanced Science Annual Meeting	62	21/PET	Washington, D.C.
63	2/14/78	Advancement of Students in Science and Technology Forum	68	21/PET	Washington, D.C.
64	2/23/78	Institute of Electrical and Electronics Engineers Joint Meeting	63	G18	NASA Goddard Space Flight Center, Md.
65	2/25, 28/78	Continuing Education Conference	54	21/PET	Indianapolis, Ind.
66	3/7/78	U.S. Users Meeting 20	EP-30	L18	NASA Lewis Research Center, Ohio: NASA Ames Research Center, Calif.
67	3/9-30/78	Shuttle Remote Management System Conference	EP-32	J18	NASA Johnson Space Center, Tex.; Communication Research Centre, Canada
68	3/17/78	Health Care Conference	89	21/PET/TET	Chicago, Ill.
69	3/23/78	Interview with Dr. A. Calio	EP-33	A18	NASA Headquarters; NASA Ames Research Center
70	3/28/78	National Oceanic and Atmospheric Administration Teleconference	95	21/I	Boulder, Colo.
71	3/30/78	Marshall Space Flight Center Symposium	90R2	21/II	NASA Marshall Space Flight Center, Ala.; NASA Lewis Research Center, Ohio
72	4/19, 14/78	American Indian Conference	85R4	Lewis Project Office/ PET/TET/4	Albuquerque, N. Mex.; Crow Agency, Mont.

[a]A18 denotes a Ames experiment; G18 denotes a Goddard experiment; L18 denotes a Lewis experiment; etc.

TABLE II. - Concluded.

Number	Date	Event	Demonstration request	Experimenter[a]	Location
73	4/24,27/78	American Institute of Aeronautics and Astronautics Conference	EP-29	24/PET	San Diego, Calif.
74	4/26/78	Agency for International Development Teleconference	EP-35	L18	NASA Headquarters; NASA Lewis Research Center
75	4/26/78	Southern Baptist Convention	83	21/I/II	Ft. Worth, Tex.; Nashville, Tenn.
76	4/26/78	Elementary Student Program	94	Lewis Project Office	NASA Goddard Space Flight Center, Md.; NASA Lewis Research Center, Ohio
77	4/27/78	Congress Teleconference	EP-36	25/PET	San Diego, Calif.; Washington, D.C.
78	4/28/78	Agency for International Development Teleconference	EP-35	L18	NASA Headquarters; NASA Lewis Research Center
79	5/3/78	California State Rehabilitation Conference	99	A18	NASA Headquarters; NASA Ames Research Center
80	5/8,10/78	Frost Prevention Teleconference	93R1	Headquarter's program/PET	Disney World, Fla.; NASA Goddard Space Flight Center, Md.; NASA Ames Research Center, Calif.
81	5/10/78	Interview with Representative D. Fuqua	EP-37	25/PET	Disney World, Fla.; Washington, D.C.
82	5/12/78	Airport Disaster Simulation	87	Lewis Project Office/TET/6	Baltimore, Md.; San Antonia, Tex.; Albuquerque, N. Mex.
83	5/17,19/78	Family Symposium	81	7	Bethesda, Md.; Seattle, Wash.; Denver, Colo.; Palo Alto, Calif.
84	6/7/78	Asian-Pacific Conference	72	A18	Washington, D.C.; San Francisco, Calif.
85	6/19,21/78	American Medical Association Convention	92	11/VA Mob.	Veterans Administration Hospital, St. Louis, Mo.
86	6/28/78	Teachers Workshop	EP-44	L18/G18	NASA Lewis Research Center, Ohio; Goddard Space Flight Center, Md.
87	6/28/78	Interview with Representative H. Reuss	EP-45	25/PET	NASA Headquarters, Washington, D.C.; Milwaukee, Wis.
88	6/28/78	Agency for International Development Conference	EP-39	L/8	NASA Headquarters, Washington, D.C.; NASA Lewis Research Center, Ohio
89	7/6/78	State Legislators Conference	EP-46R1	25/7	NASA Headquarters, Washington, D.C.; Denver, Colo.
90	7/8/78	American Association of School Administrators Conference	97	21/TET	NASA Headquarters, Washington, D.C.; Minneapolis, Minn.
91	7/8/78	UNICON Science Fiction Conference	100	21/PET	Ames Research Center, Calif.; Silver Springs, Md.
92	7/27/78	Interview with Representative James Hanley	EP-47	25/PET	NASA Headquarters, Washington, D.C.; Syracuse, N. Y.
93	8/10,15/78	River Control Conference	107	Lewis Project Office/PET/I	Vicksburg, Miss.
94	8/17/78	Science Education Seminar	98	G18/TET/I	Buffalo, N.Y.
95	8/24/78	Satellite Connectivity Discussion	EP-51R1	A18	NASA Ames and Lewis Research Centers
96	9/5-9/78	United Nations Technical Conference		Headquarter's program/PET	New York, N.Y.; Buenos Aires, Argentina
97	9/12-14/78	American Hospital Association Conference	108R1	21/TET	Augusta, Me.
98	9/14/78	Medical Interaction Conference	116	21/TET	Hanover, N.H.; Augusta, Me.
99	9/19,20/78	Joint U.S.-Canadian Experimenters Conference and Users Meeting 21	112R1	Lewis Project Office/PET	Racine, Wis.; Ottawa, Canada; NASA Lewis Research Center
100	9/22/78	Shuttle Safety Meeting	113R1	7	California; Maryland

[a]A18 denotes a Ames experiment; G18 denotes a Goddard experiment; L18 denotes a Lewis experiment; etc.



	CRAFT	ALTITUDE, km	ORBITAL PERIOD
▽	AIRPLANES	<30	-------
⌂	SKYLAB	435	93 min
◇	LANDSAT	917	103 min
△	NOAA-5	1 511	116 min
□	GOES, CTS, INTELSAT	35 700	24 hr

Figure 1. - Altitude classification of some craft discussed at United Nations seminar. (CTS and Intelsat are communications satellites.

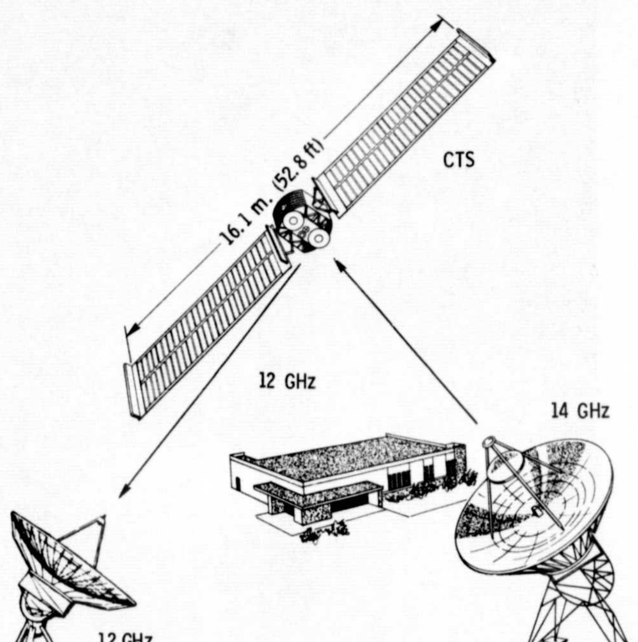


Figure 2. - Communications technology satellite (CTS) and ground terminals.

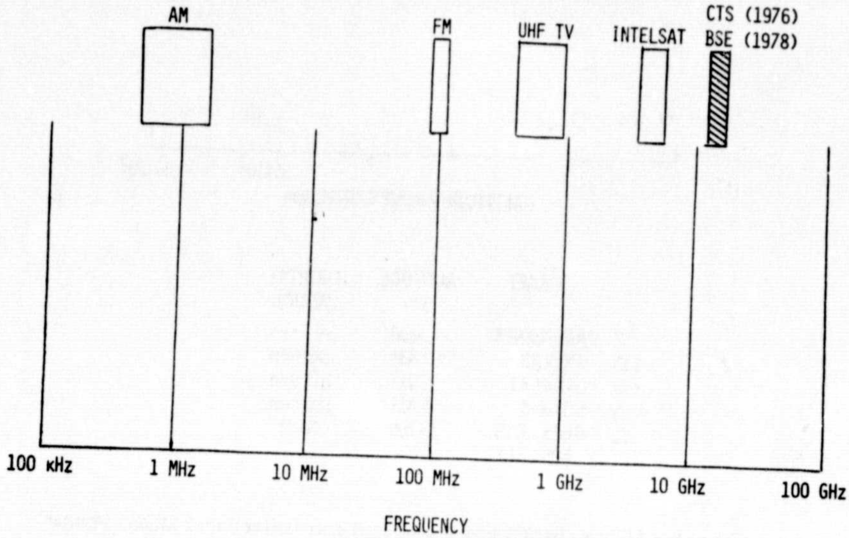


Figure 3. - Common carrier and satellite frequencies.

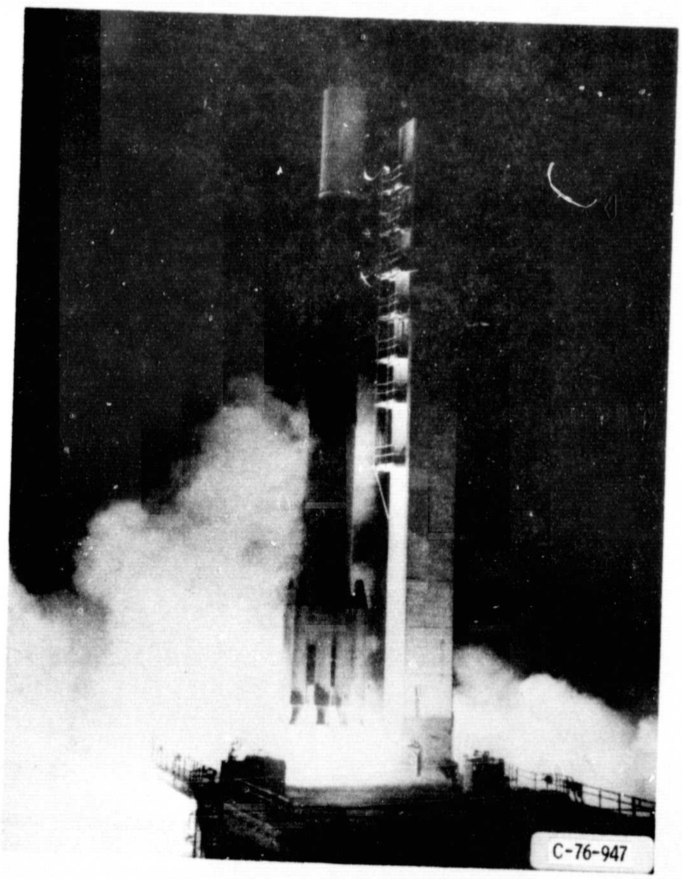


Figure 4. - CTS launch - January 17, 1976.

Figure 5. - Artists' depiction of CTS satellite location in geo-synchronous orbit.

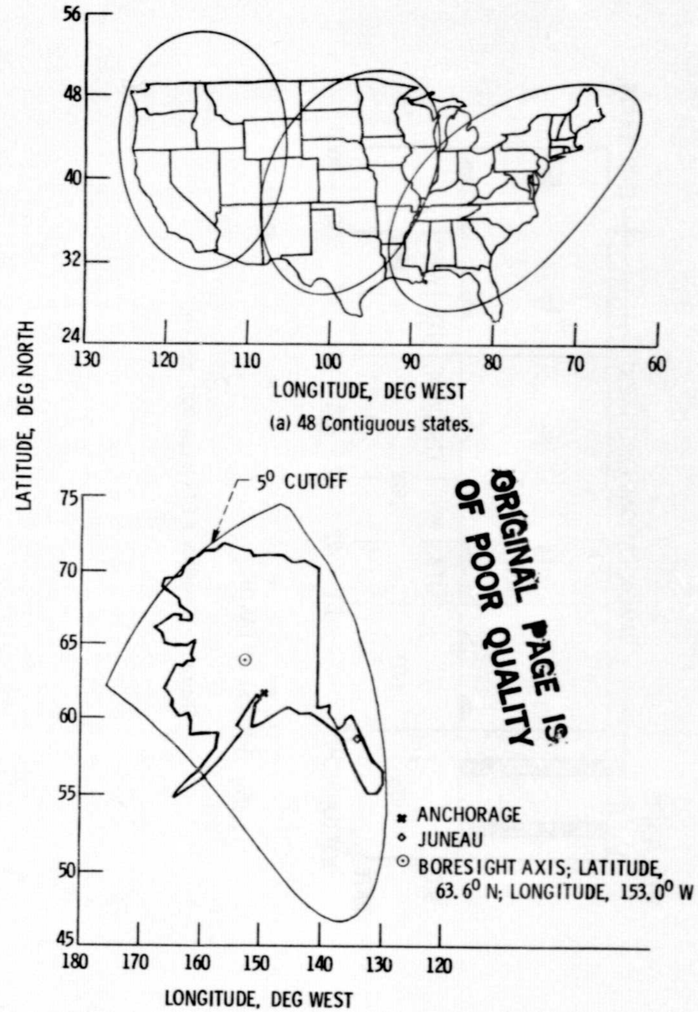


Figure 6. - Three-decibel antenna footprints for U. S. from CTS SHF antennas.

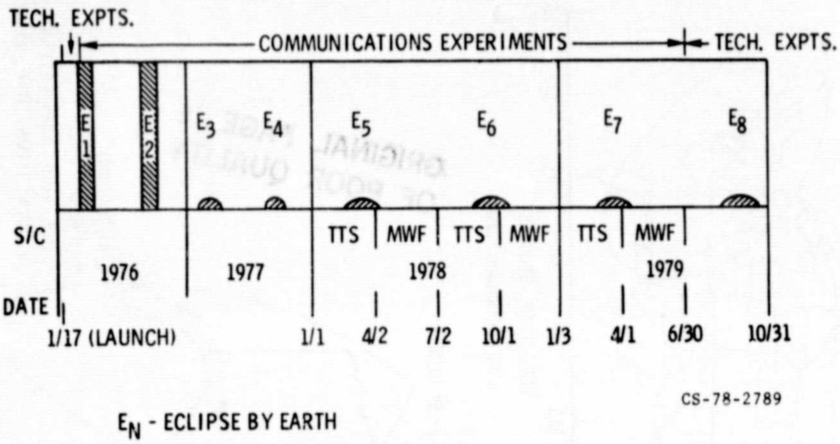


Figure 7. - Summary of CTS NASA-DOC mission.

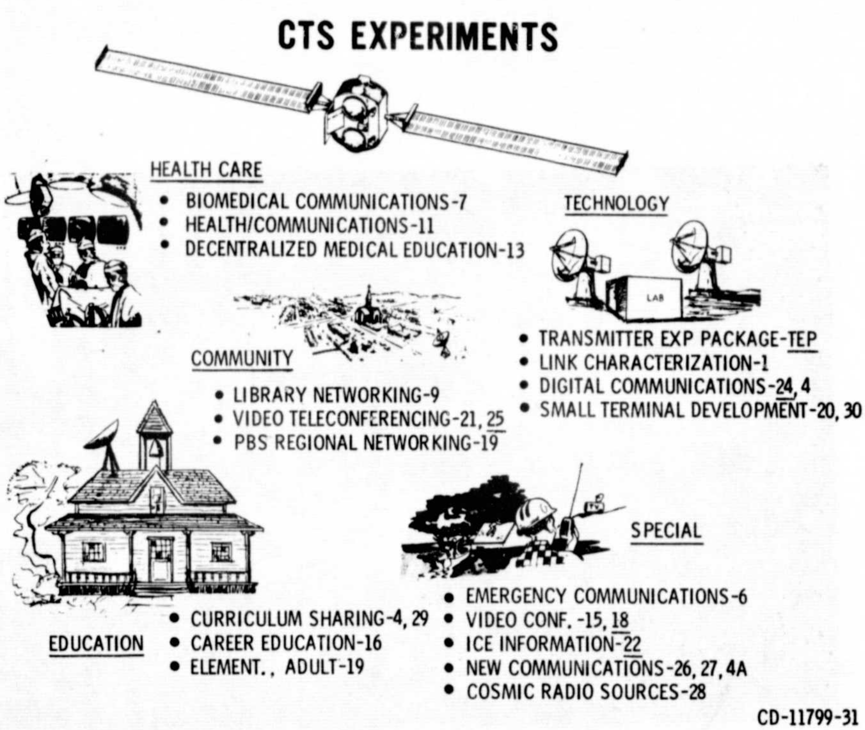


Figure 8. - Categories of U. S. CTS experiments.

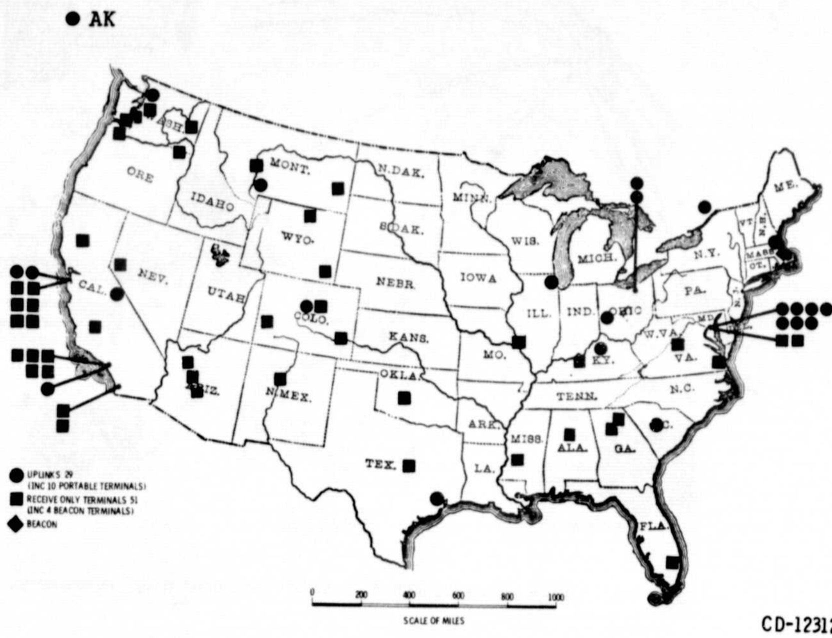


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Figure 9. - Earth terminal locations for U. S. CTS experiments.

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Figure 10. - Earth terminal locations for U. S. CTS miniexperiments.

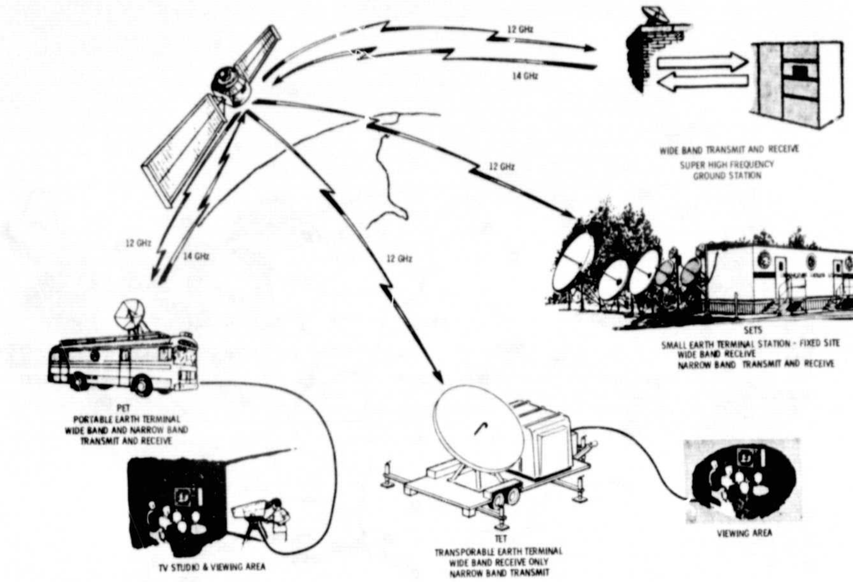

Figure 11. - NASA Lewis experimental Earth terminals used in CTS experiments.

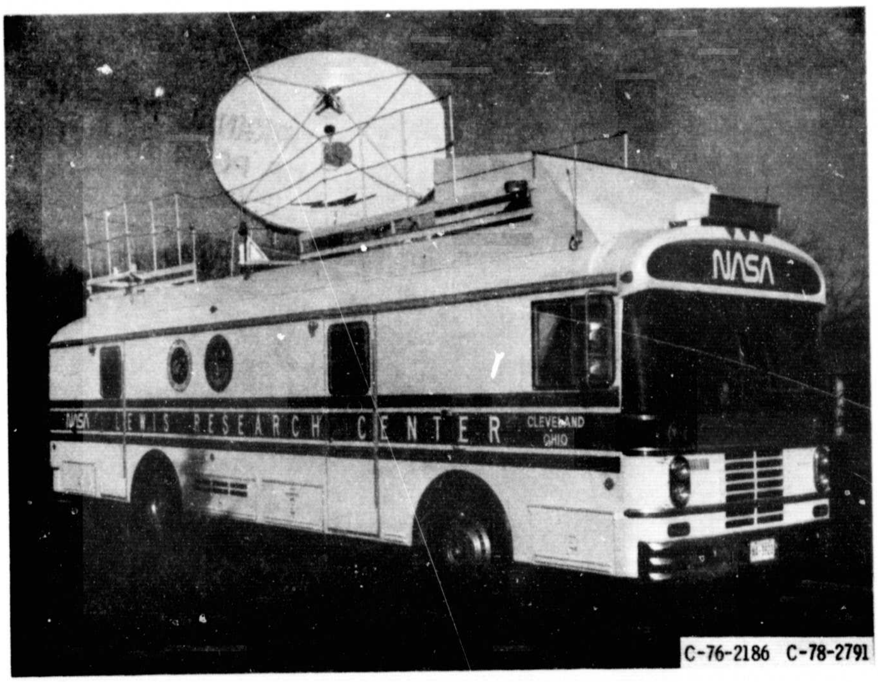

Figure 12. - Portable Earth terminal configured for operation with CTS. Antenna diameter, 2.4 meters.

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Figure 13. - Transportable Earth terminal. Antenna diameter, 3 meters.

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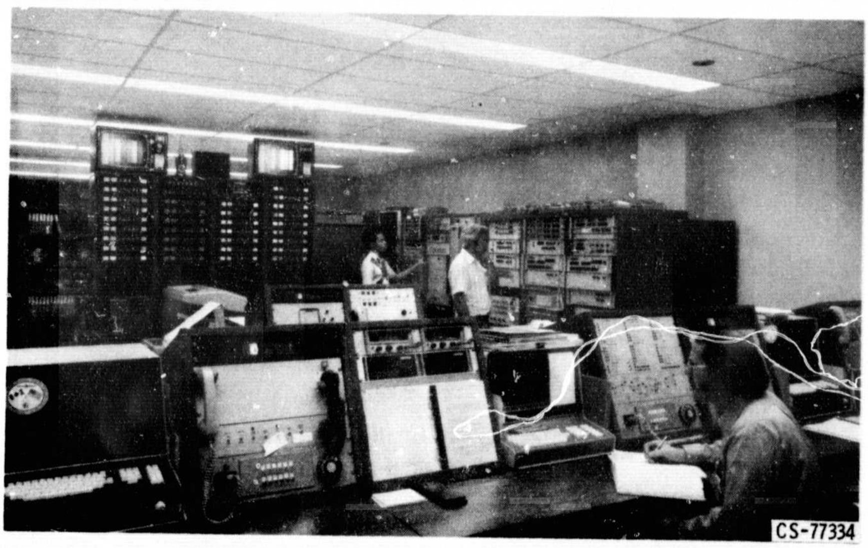

Figure 14. - CTS experimenters' coordination center at NASA Lewis Research Center.

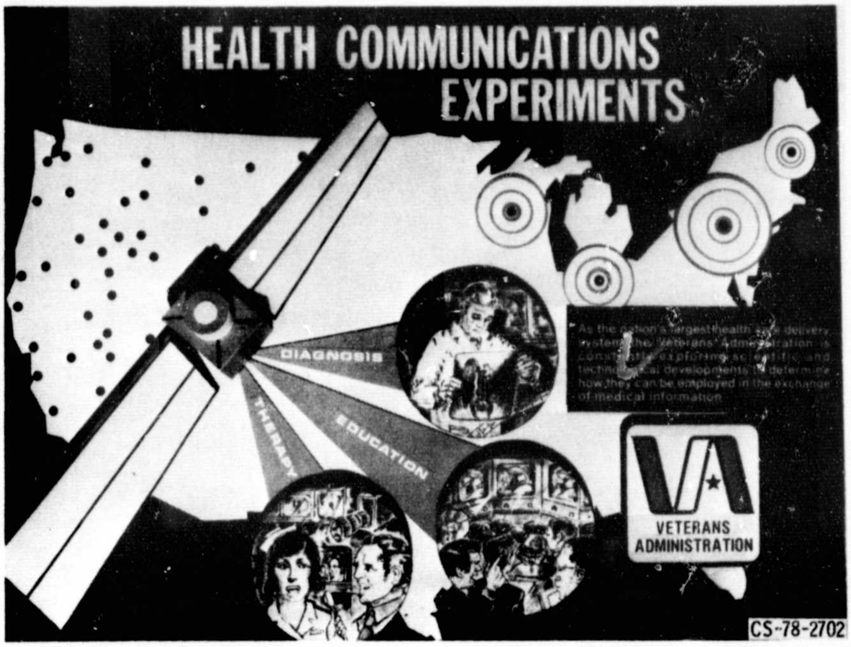

Figure 15. - Veterans Administration health communications experiment (experiment 11, table I).

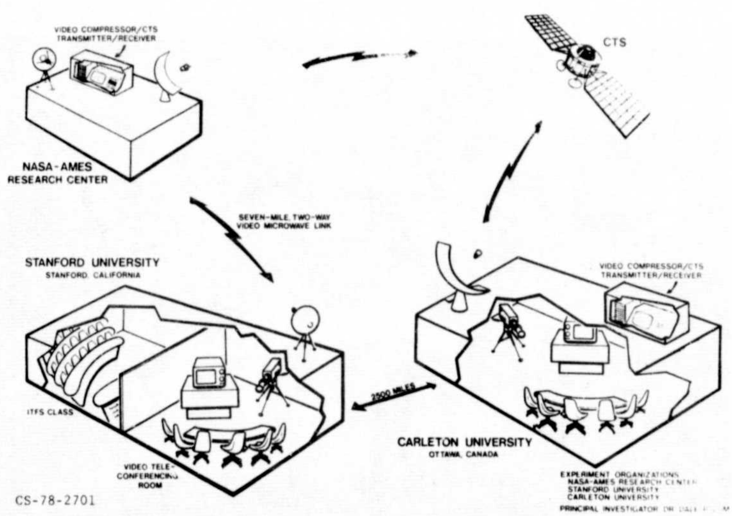

Figure 16. - Digital video college curriculum sharing experiment (experiment 4, table I).

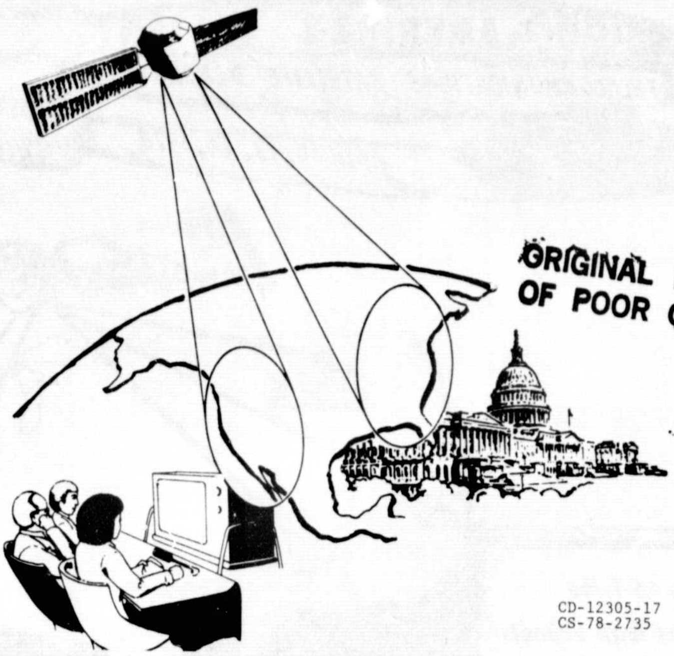

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Figure 17. - Congressional videoconferencing experiment (experiment 25, table I).

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Figure 18. - Senate hearings - Teleconference between Springfield, Illinois, and Dirksen Senate Office Building (photo), Washington, D.C.

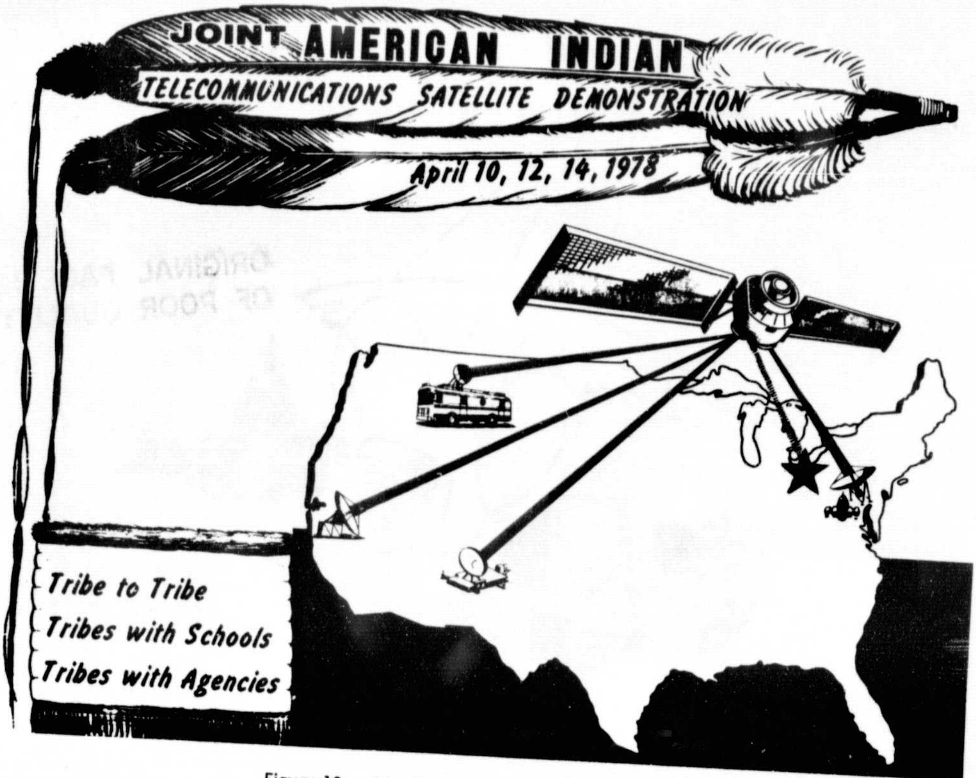

Figure 19. - American Indian conference miniexperiment.

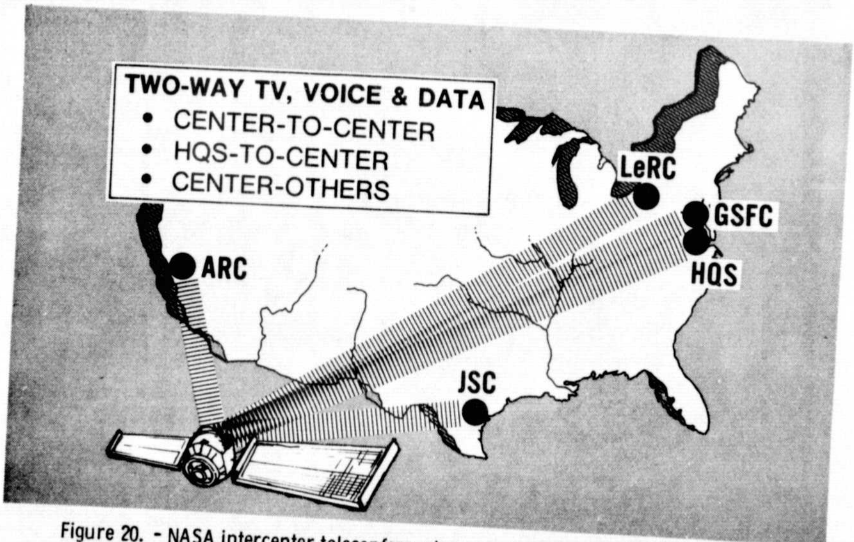

Figure 20. - NASA intercenter teleconferencing experiment (experiment 18, table I).

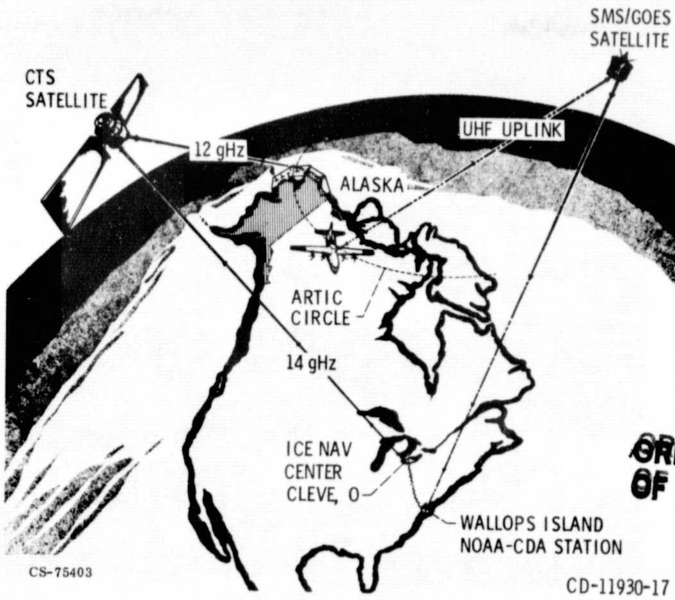

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Figure 21. - Alaska North Shore ice information (experiment 22, table I).

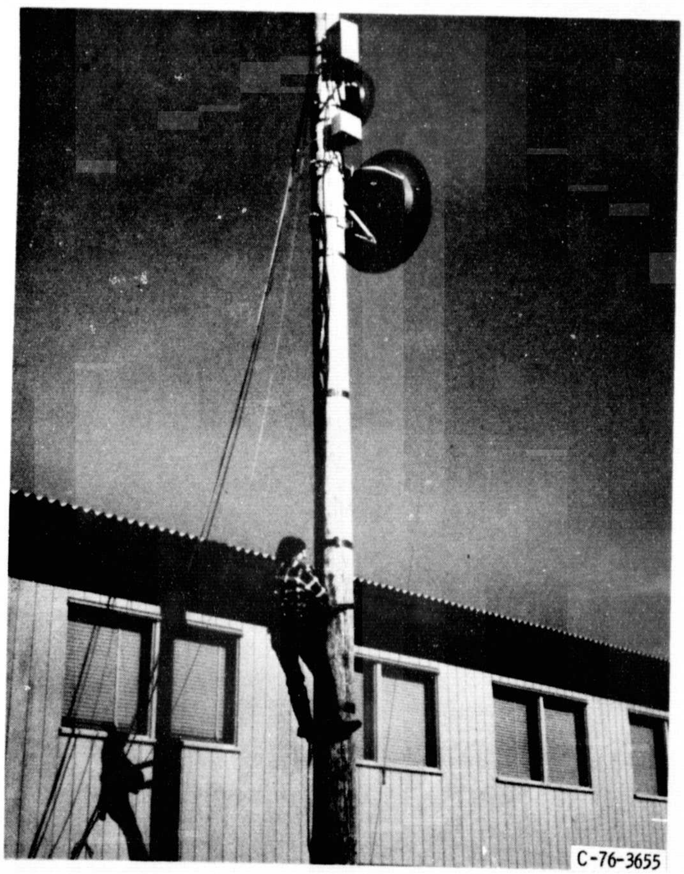

Figure 22. - Antenna installation in Barrow, Alaska, for ice information demonstration.

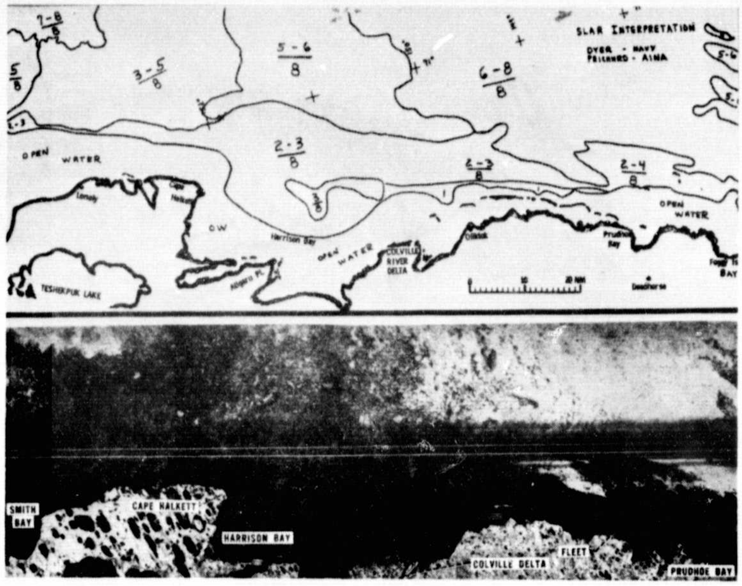

Figure 23. - Example of results from Alaska ice formation experiment.

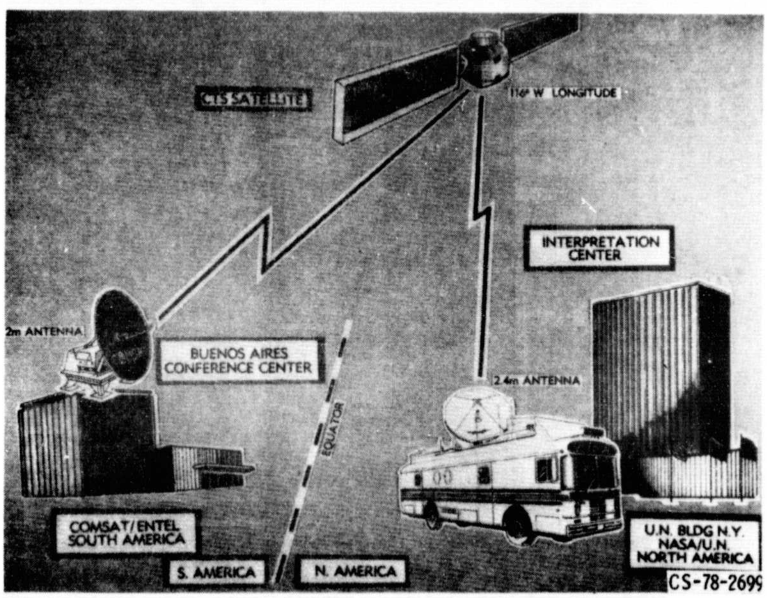

Figure 24. - U.N. remote interpretation miniexperiment.

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Figure 25. - Portable Earth terminal at U.N. General Assembly Building for U.N. remote interpretation miniexperiment.

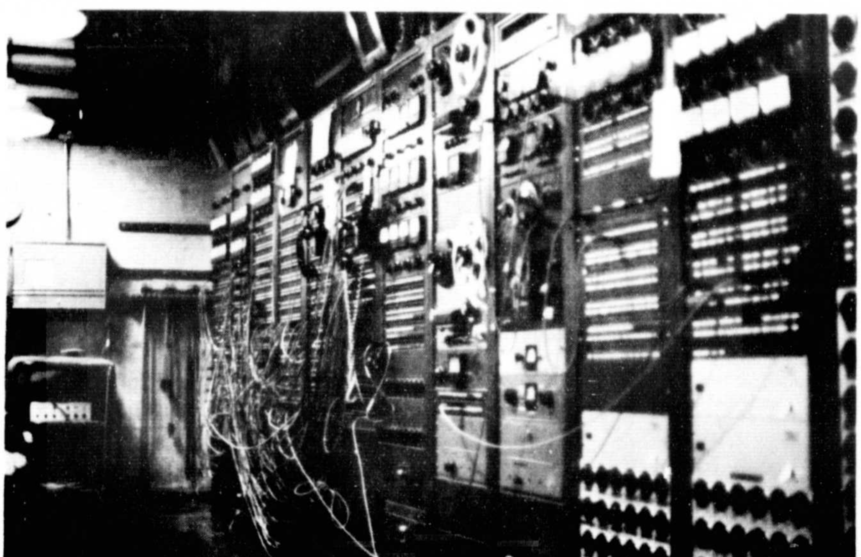

Figure 26. - U.N. switchboard.

Figure 27. - U.N. staff aboard portable Earth terminal for briefing.

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Figure 28. - U.N. coordination center in New York during remote interpretation demonstration.

Figure 29. - Video reception in New York from Buenos Aires during remote interpretation demonstration.

Figure 30. - Evaluation meeting via duplex television between Buenos Aires interpreters and U.N. management (shown) in New York.

Figure 31. - Video reception in New York of Buenos Aires interpreters during evaluation meeting held via duplex television.

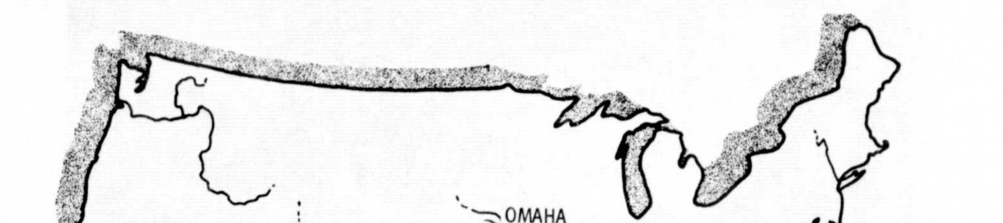

Figure 32. - Mississippi river basin flood control miniexperiment.

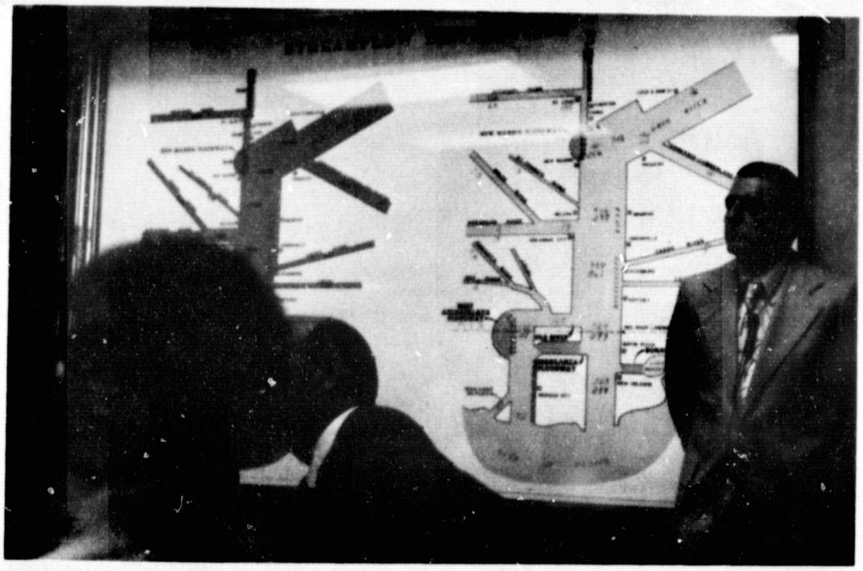

Figure 33. - U. S. Army Corp of Engineers representatives at Vicksburg, Mississippi, during Mississippi river basin flood control miniexperiment.

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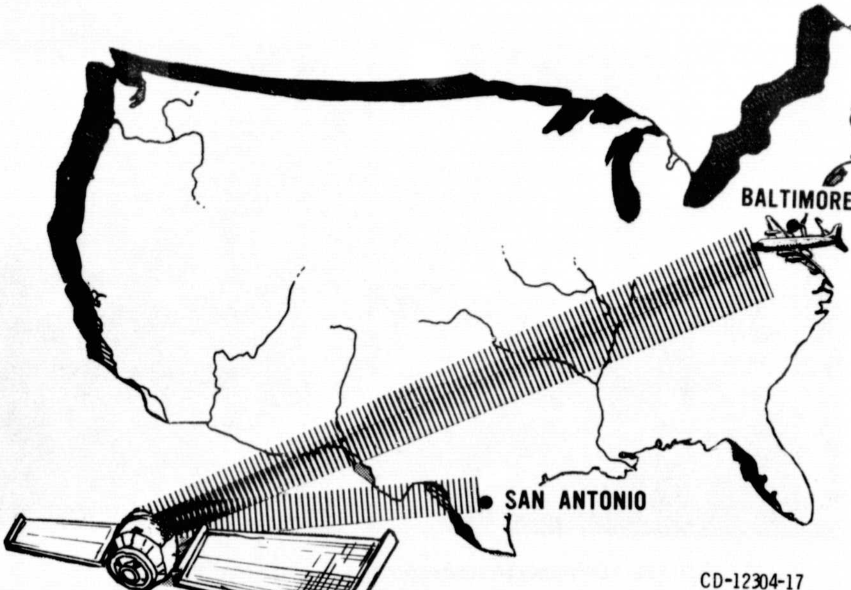

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Figure 34. - Airport disaster simulation.

Figure 35. - Scene at Baltimore-Washington International Airport during disaster simulation.

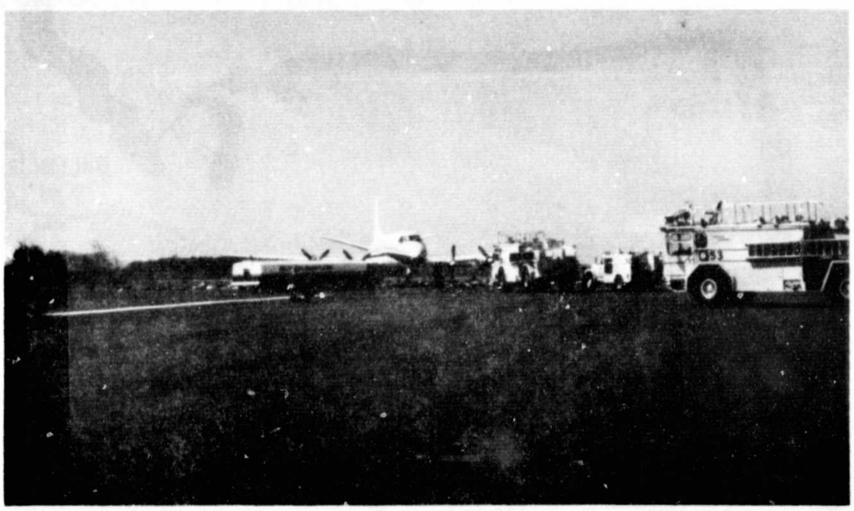

Figure 36. - Emergency procedures during simulated airport disaster.

Figure 37. - "Victims" of simulated airport disaster.

Figure 38. - Paramedic in contact with San Antonio Burn Center at Brook Army Medical Center during simulated airport disaster, with television camera used to aid remote diagnosis.

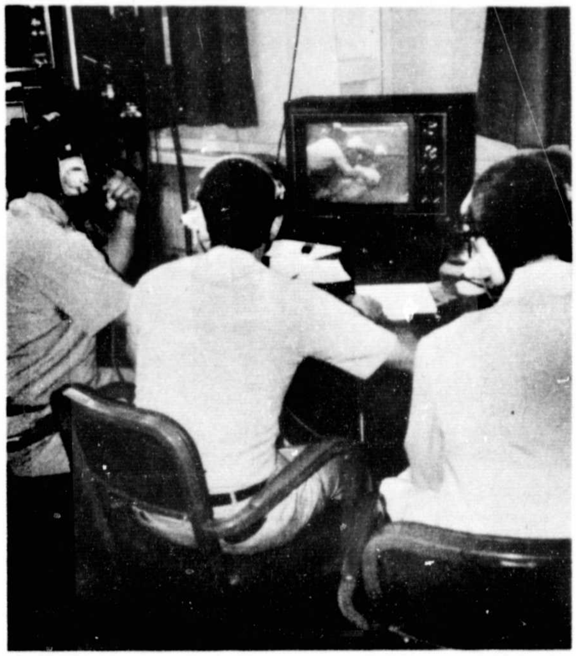

Figure 39. - Part of San Antonio Burn Center medical team supporting airport disaster simulation.

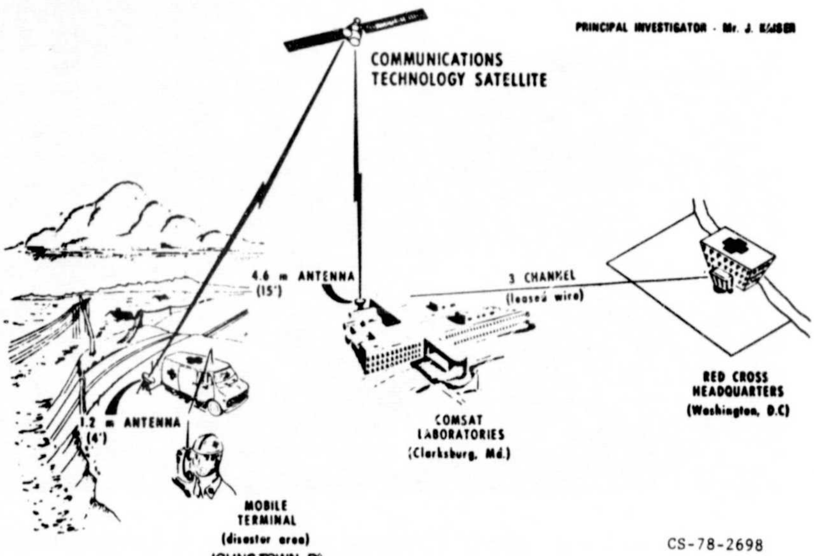

Figure 40. - Comsat transportable Earth terminal experiment (experiment 6, table I) - Johnstown flood disaster.

Figure 41. - Field center established in Johnstown, Pennsylvania, during flood disaster.

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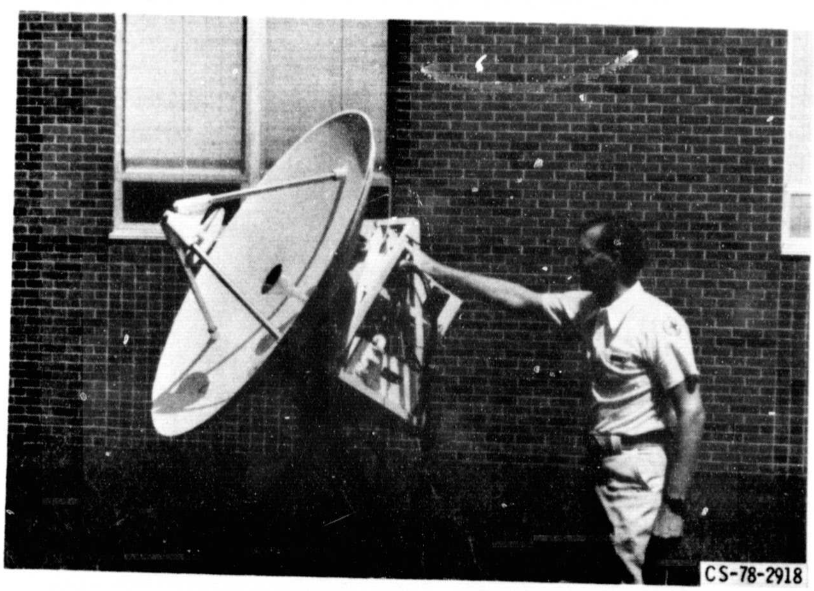

Figure 42. - Comsat transportable Earth terminal used in Johnstown flood disaster.

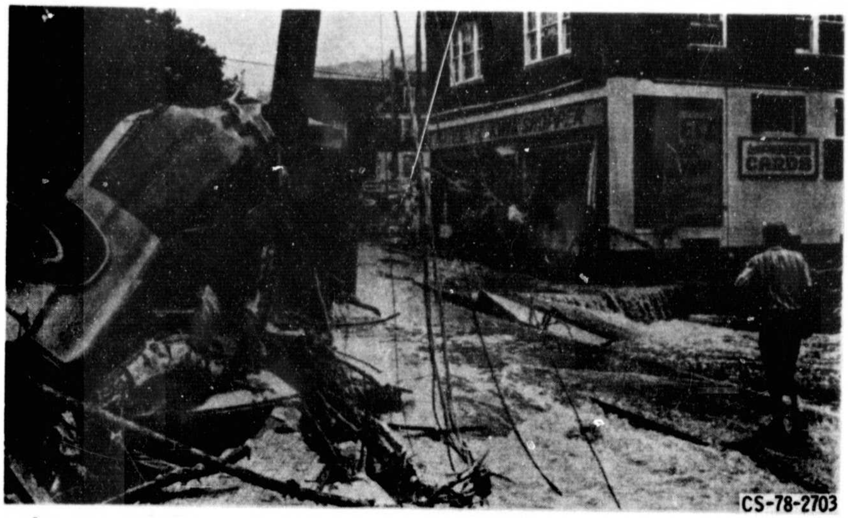

Figure 43. - Local newspaper picture of Johnstown flood damage.

Figure 44. - Johnstown flood damage.

E-9935

Figure 45. - Aerial view of Johnstown flood damage.

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16. Abstract

The experimental Communications Technology Satellite (CTS), also called Hermes, uses a high-power transmitter and 12- and 14-GHz frequencies for wideband (two- and one-way television) and narrowband (voice, data) communications. In the joint program, both Canada and the United States have conducted a variety of communications experiments. This report concentrates on U.S. CTS experiments and miniexperiments that use ground antennas from 0.6 to 5 meters in diameter. The U.S. CTS experiments program is synopsized in this report. The use of CTS for simulated and actual disasters is summarized.

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