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NASA Contractor Report 165532

AN OVERVIEW OF THE COMMUNICATIONS TECHNOLOGY  
SATELLITE (CTS) PROJECT

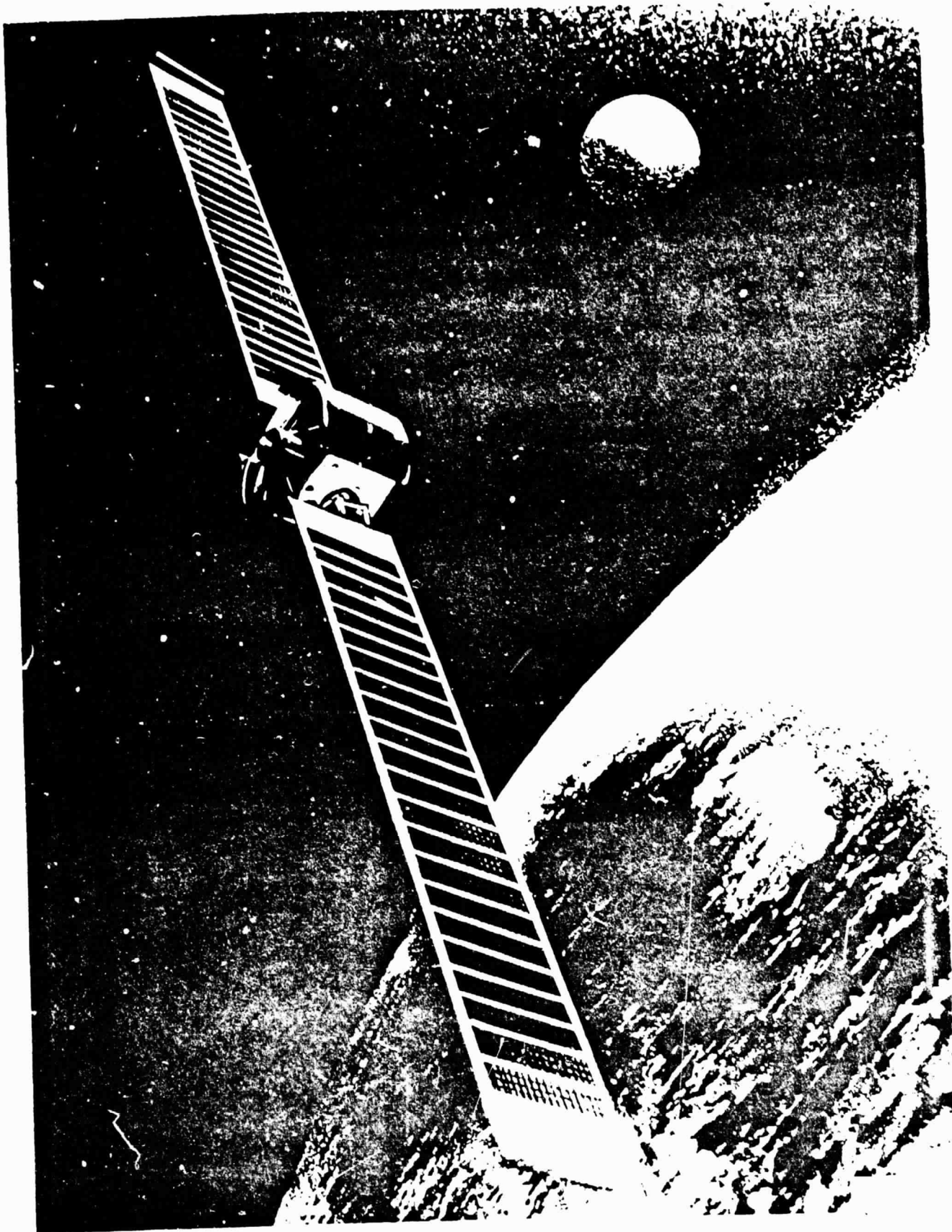
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William Rapp, Dail Ogden, and Darcy Wright  
Public Service Satellite Consortium  
Denver, Colorado



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Artist's concept of CTS on station

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## EDITOR'S NOTE

This report is a compilation of Communication Technology Satellite planning activities, operational activities, and final activity reports. The information in this document was compiled from previous NASA and Canadian Department of Communication reports, NASA User Bulletins, NASA User Meetings, and from planning documents and final reports of U. S. CTS Experimenters.

Acknowledgment is made to the many editors, principal investigators, and evaluators whose reports were incorporated into this document. Care was exercised on the selection of materials which were included. However, all facts and figures could not be verified and are included as they were printed in previous documents. This report contains a minimum of technical information. It is primarily a report on what was learned during the CTS planning and operational phases of the experiments, and, most importantly, details the contribution that satellite communications can make in benefiting society in a cost-effective manner.



## I. INTRODUCTION

The Communications Technology Satellite (CTS) project officially began on April 20, 1971 with the joint signing of an agreement between the United States National Aeronautics and Space Administration (NASA) and the Canadian Department of Communications (DOC). The authority for this joint U.S.A. and Canadian effort was Public Law 85-568 of July 29, 1958.

The Communications Technology Satellite was designed to operate at the 14/12 GHz Band. This followed several years of successful experimentation and demonstrations on the Applications Technology Satellite-6 (ATS-6) which operated at the 4/6 GHz Band.

The principal technological objectives of the CTS program were to:

- Develop and flight test a power amplifier tube having greater than 50% efficiency with a saturated power output of 200W at 12GHz.
- Develop and flight test a light-weight extendible solar array with an initial power output greater than 1 KW.
- Develop and flight test a 3-axis stabilization system to maintain accurate antenna boresight positioning on a spacecraft with flexible appendages.
- Conduct satellite communications systems experiments using the 12 and 14 GHz bands and low-cost transportable ground terminals.

Under the agreement Canada undertook to design, build and operate the spacecraft while the United States agreed to provide the launch vehicle,

the high-power traveling-wave-tube amplifier, spacecraft environmental test support, and the operational launch support to place the spacecraft in synchronous orbit. Both countries agreed to carry out experiment 1 programs in communications. NASA's Lewis Research Center (LeRC) and DOC's Communications Research Center (CRC) were designated as the two responsible agencies. In May 1972, an agreement was signed between Canada and the European Space Research Organization (ESRO), now the European Space Agency (ESA), under which ESRO agreed to provide two 20W traveling-wave-tube amplifiers and a parametric amplifier, and to develop an extendible solar blanket and associated solar cells.

NASA in the U.S.A. and DOC in Canada invited agencies and organizations to submit proposals for communications experiments. Use of the spacecraft was then allocated to approved experimenters, or users, with each country sharing the use of CTS/Hermes equally on an alternate-day-basis.

The satellite was launched on January 17, 1976 by a Thor Delta 2914 launch vehicle. The CTS was designed to operate for two years, and to produce an effective isotropic radiated power (EIRP) of nearly 58.1 dBw, a power significantly greater than that provided by then existing spacecraft and representative of levels that could be used by future broadcasting satellites.

NASA provided all launch operations to place the satellite in a geosynchronous orbit at 116° W. longitude, and then turned control over to CRC on January 29, 1976.

The stated objectives were most important in advancing the technology of satellite communications in the scientific communities of both nations.

This report will discuss the important aspects of these technological advances, but will focus largely on the user experiments conducted by the United States experimenters.

The United States experimenters conducted a variety of programs designed to demonstrate the feasibility, desirability, and cost effectiveness of satellite communications. These experiments will be discussed in detail in Chapter XI.

The prior ATS-6 experiments demonstrated that satellite communication technology can provide a variety of public service functions and can broadcast with equal success into extremely remote areas, as well as densely populated areas. A variety of medical, health, education and training programs were beamed into remote Alaskan villages, to towns and cities in the Rocky Mountain states, and many target populations throughout Appalachia. The ground terminals were operated successfully by native villagers, teachers, nurses and students. The success of these early demonstration projects generated considerable interest on the part of state and local governments, medical and health organizations, educational groups, and community and special service groups. The success of the ATS-6 technology and the support and interest of many diverse groups served to promote the development of the CTS project. At the same time that United States public service groups were voicing their requests for further communication experiments, a similar thrust was developing in Canada. The combined interest of the United States and Canadian groups demonstrated a need for further experimentation which led to the development of the Communication Technology Satellite/Hermes projects.

II. BACKGROUND AND PURPOSE OF THE COMMUNICATIONS  
TECHNOLOGY SATELLITE PROGRAM

COMMUNICATIONS PROGRAM OVERVIEW

The Applications Technology Satellite (ATS) program included the development and utilization of six satellites. Four of these satellites (ATS-1, 3, 5, and 6) were successfully placed in synchronous orbit. The ATS program explored ways to increase the power of satellites, tested new orbit stabilization and attitude control technology, and experimented with S-Band, C-Band and L-Band frequencies. Among the benefits derived from such new technologies was that it made it possible to develop smaller, less expensive earth stations. Additionally, the ATS program allowed a variety of users in both the public and private sectors the opportunity to experiment with satellite communications, with an eye toward developing and improving their operations in the future.

ATS-6

The Applications Technology Satellite #6 (ATS-6) was a very successful forerunner to the CTS program. The ATS-6 was launched into geosynchronous orbit on May 30, 1974. The ATS-6 was a multi-purpose spacecraft equipped for more than twenty technical and societal experiments. Several of the larger experiments conducted on the ATS-6 included:

A. The Health, Education, Telecommunications (HET) Experiments.

These were the result of a cooperative effort by NASA and HEW. There were six major programs conducted in education and health care. These were:

1. The Appalachian Regional Commission Project which delivered its programs in the Southeastern part of the United States.
  2. The Satellite Technology Demonstration which was conducted by the Federation of Rocky Mountain States. This demonstration had two distinct programs:
    - (a) Educational and training programs delivered in the eight Rocky Mountain States.
    - (b) A broadcast and engineering component. Services from the broadcast and engineering component were also utilized by other HET experimenters.
  3. The Veterans Administration Experiments.
  4. The Washington-Alaska-Montana-Idaho Experiments (WAMI).
  5. The Alaska Education Experiment.
  6. The Alaska Health Services Experiment.
- B. The Position Location and Aircraft Communications Experiment (PLACE). This was an experiment to obtain engineering data relative to feasibility of using satellites for aircraft traffic control and for maritime satellite systems.
- C. The Millimeter Wave Propagation Experiment. This was an experiment to evaluate propagation characteristics of space-to-earth links at 20 GHz and 30 GHz during measured meteorological conditions.
- D. The SITE Project. This was a joint satellite program between India and the United States. This program involved the repositioning of the ATS-6 over Africa for one year to provide satellite programming in India. The India project was an experiment to determine the feasibility of delivering mass communication instructional programming via satellite in developing countries.

It was the demonstrated successes achieved in the ATS-6 Communications projects that led Canada and the United States to the development of the CTS/Hermes Project.

#### EVALUATION OF THE CTS AS A JOINT U.S./CANADIAN VENTURE

In his opening remarks at the CTS/Hermes symposium held in Ottawa, Canada, November 29, 1977, J. H. Chapman referred to a meeting with Dr. Richard Marsten, then Director of Communications Programs in NASA, in 1970. At this first meeting, the planning for what was to become CTS and Hermes was begun. Canada and the United States jointly determined the broad outlines of the program. At this early point, the then European Space Research Organization (ESRO) agreed to participate in the program. ESRO provided three key technology experiments as a part of the CTS/Hermes program. These experiments consisted of two 20W traveling-wave-tube amplifiers, a parametric amplifier, and the development of an extendible solar blanket and associated solar cells.

#### EXPERIMENTAL PROPOSALS SOLICITED

In 1971, when NASA and DOC invited agencies and organizations to submit proposals for communications experiments, DOC and NASA established a Joint Working Group (JWG) to facilitate work with the communication and technology experimenters. The function of JWG was to: (a) define experiment objectives, (b) evaluate user plans and proposals, (c) determine spacecraft configurations for the conduct of experiments, (d) examine and correlate experimental

use of the spacecraft, and (e) determine instrumentation requirements for monitoring, retrieval, reduction, and evaluation of experimental data. JWG reviewed, evaluated, and approved a variety of communication and technology experimenters. NASA and DOC assigned spacecraft time for experimenters on a 50/50 basis. An alternate day schedule for Canadian experimenters and U. S. experimenters was approved.

TABLE II-1. - TIME-SHARING ALLOCATION

Time period	Days of week <sup>a</sup>	
	U. S.	Canada
Initial experiments period	(b)	(b)
May 9, 1976 - July 3, 1976 <sup>c</sup>	Mon., Wed., Fri.	Tues., Thurs., Sat.
July 4, 1976 - October 2, 1976	Tues., Thurs., Sat.	Mon., Wed., Fri.
October 3, 1976 - January 1, 1977	Mon., Wed., Fri.	Tues., Thurs., Sat.

<sup>a</sup>Start of day, 04:00 est; Sundays alternate.

<sup>b</sup>Technical experiments and communication experiment (CE): Start, Feb. 22, 1976 (launch, Jan. 13, 1976).

<sup>c</sup>Communication experiment full time, May 9, 1976.

#### CAPABILITY OF THE SPACECRAFT

The Hermes/CTS satellite which was launched on January 17, 1976, and placed in a synchronous orbit was then the world's most powerful communications satellite. The key component was a transmitting tube 10 to 20 times more powerful than that of any other satellite. Because of this powerful transmitter on the satellite, much smaller and less expensive ground receiving equipment could be used. This ability to utilize small and inexpensive ground equipment made the CTS an especially attractive technique for reaching rural and isolated communities.

The main body of the spacecraft was cylindrical with two flattened sides. In the main body was the apogee kick motor. Two wing-link solar arrays which extended from the sides of the cylinder provided 1,250 watts of power. The CTS was stabilized in space by means of a momentum wheel-hydrazine reaction control system. The CTS was equipped with a 200 watt transmitter which operated at high frequencies. It broadcast voice and television signals to many small low-powered ground stations which were often located in remote areas of the U. S. and Canada.

#### THE TECHNICAL ASPECTS OF THE COMMUNICATIONS SUBSYSTEM

The CTS communications subsystem consisted of two steerable antennas, a high-power TWT and power conditioner, driver TWTs, and a high-sensitivity high-gain receiver.

##### Transponder

A block schematic of the SHF transponder switched to its primary mode is shown in Figure 1.



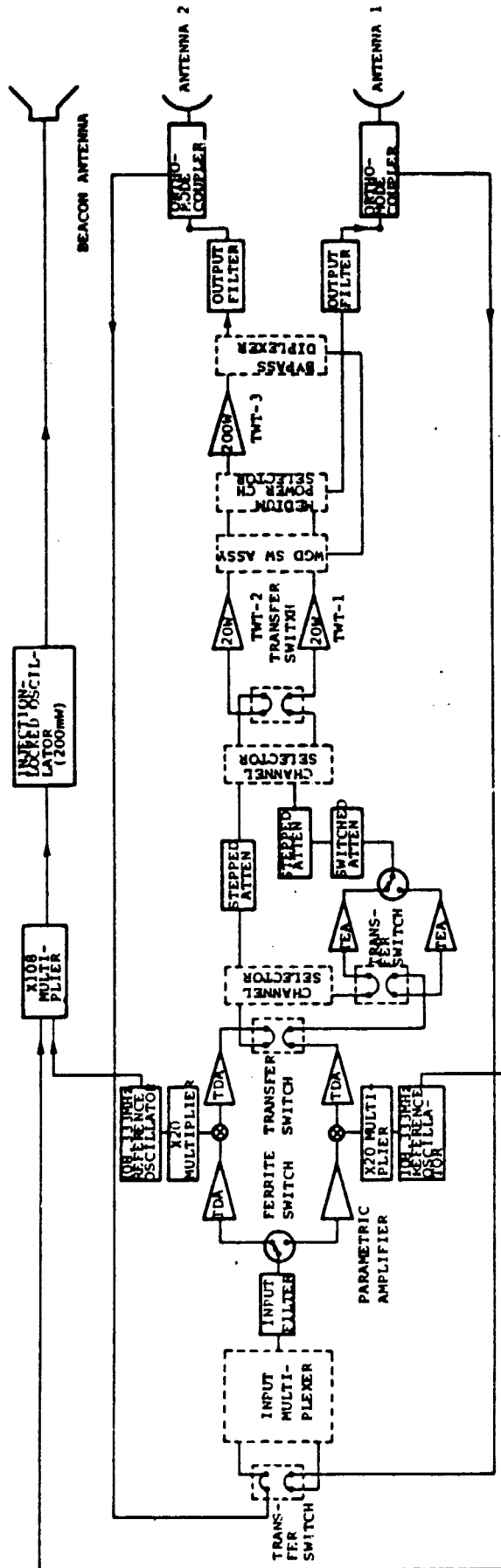


FIGURE 1. Block Schematic of Communications Transponder and Beacon

The transponder had two 85 MHz pass bands, for transmitting in the 11.7~12.2 GHz band, and for receiving in the 14.0~14.3 GHz band.

In the primary mode, the transponder receive 14 GHz television signals from the up-link terminal via antenna No. 1, amplified, frequency translated to 12 GHz, and then amplified and re-radiated the television signals through antenna No. 2 to remote terminals. In this mode, the 20W TWT was used as a driver amplifier for the 200W TWT which drove antenna No. 2. The transponder could simultaneously receive 14 GHz television signals from a terminal via antenna No. 2, amplify and frequency translate the signals to 12 GHz, and then amplify the signals with the 20W TWT and re-radiate the television signals through antenna No. 1 to another terminal.

Back-up modes permitted interchange of the 20W TWTs or replacement of the 200W with the 20W TWT. In the backup modes the communications capabilities were reduced.

Either of the crystal-controlled reference oscillators for the receiver of the transponder system described above also provided, after suitable multiplication, the drive for a CW beacon. The beacon transmitted at 11.7 GHz via an earth coverage horn antenna. This beacon was suitable for RF propagation experiments and for use as a tracking aid.

The principal components in the transponder were as follows:

1. Input multiplexers.
2. A parametric amplifier with a noise temperature of 1000°K was used as a preamplifier. A redundant tunnel diode amplifier could be switched in should the need warrant.
3. Frequency translators consisting of 108.33 MHz reference oscillators, multiplier chains, and mixers.

4. Amplifier stages using tunnel diodes and Transferred Electron Amplifiers (TEA).
5. Two 20W TWTs.
6. A 200W TWT.
7. Output multiplexers and filters.

### The Transmitter

The transmitter had two major components. One was a travelling wave tube (TWT) employing multistage depressed collection of the spent electron beam and capable of producing a 200W RF output. The other component was the power processor which, in addition to supplying power at appropriate voltages to the tube, also provided command and closed-loop control and protection functions for the tube.

### TWT Specifications

1. Weight, 13 kg.
2. Size, 51cm x 25 cm x 25 cm.
3. Efficiency
  - a. The interaction efficiency of the TWT prior to beam collection in the MDC was 30 percent minimum at saturation.
  - b. The TWT exceeded 50 percent in overall electrical efficiency at an RF power output of 200 watts.
4. RF and power characteristics
  - a. Center frequency 12.0805 GHz.
  - b. RF power output at saturation was 200 watts minimum within the passband. The power delivered to a load with a VSWR at 1.25 was 200 watts or more.
  - c. Three dB small signal bandwidth 85 MHz minimum, 250 MHz maximum.

- d. Saturated gain in passband 33 dB minimum.
- e. The TWT had a noise figure of 40 dB maximum.

## 5. Mechanical and thermal characteristics

- a. The TWT body thermal design employed a common heat bus. The bus was connected by a heat conductor to a baseplate on the spacecraft; the VCHPS radiator was connected to the south panel structure and contained the heat pipe reservoir.
- b. The MDC cooling was by direct radiation.
- c. The MDC was enclosed in a vacuum envelope.
- d. The vacuum envelope was capable of being opened to space vacuum by command from the ground.

The concepts permitted a major improvement in the electrical efficiency of a TWT. The successful demonstration of the TWT on the CTS represents an advance in TWT technology which has great significance in the design of high-power communications satellites of practical size.

The unused power of the TWT rejected as waste heat produced severe thermal problems. Demonstration of the CTS that most of the heat could be rejected by direct radiation from the multi-stage depressed collector was an important experimental goal.

The power processor had two power inputs. The main bus from the solar array supplied a minimum of 471 watts at  $67 \pm 7$  volts. The 28 volt bus supplied 16 watts at  $28 \pm 0.3$  volts during sunlight for the cathode heater and the instrumentation, and 5 watts of spacecraft battery power at  $27 \pm 0.3$  volts during eclipse operation for the cathode heater instrumentation. Forty-six instrumentation measurements and 16 command channels were provided.

The more significant transmitter experiment package (TEP) characteristics which were evaluated or demonstrated during spacecraft operations are:

1. Efficiencies of the collector, overall TWT, VCHPS performance, and power processor at different RF power levels under actual operating conditions.
2. TWT gain, bandwidth, and frequency stability under space environment conditions.
3. System noise loading.
4. Effects of distortion, noise, and intermodulation on television picture quality. Picture quality was evaluated with transmission test set equipment and subjectively.
5. Fundamental data on the operation of high-power, high voltage systems in space was also obtained.

#### Antenna System

The transponder had two, gimballed, 71 cm diameter antennas with paraboloid reflectors. Each antenna provided a single 2.5 degree beam of circular cross-section for the simultaneous transmission and reception of orthogonal linearly polarized signals. Isolation between the two polarizations was at least 25 dB. The electrical boresight of each antenna could be positioned anywhere within a 14.5 degree cone relative to the satellite forward deck. Transmit and receive gains were approximately equal with minimum transmission values of 33.2 dB within the beams, and 36.2 dB along the electrical axes. First and second side lobe levels were -14 dB and -25 dB respectively.

The beam pointing error relative to a reference mounting surface was less than  $\pm 0.1$  degrees. This was a stringent requirement and called for

considerable care in the thermal and mechanical design of the antennas and their gimbals and actuators. The overall boresight pointing accuracy was  $\pm 0.2^\circ$ .

## THE ELECTRICAL POWER SUBSYSTEM

### General

Body-mounted solar cells and two Ni-Cd batteries powered the spacecraft prior to deployment of the extendible solar array. The extendible array had a power output of 1260 watts for an Equinox launch at beginning of life, and an output of 1000 watts at Summer Solstice after two years.

Radiation damage to solar cells reduced the initial power output by six percent after six months, and 14 percent after two years. For the particular period in the sunspot cycle, and for the particular shielding thickness used, solar flare protons and trapped electrons were equally damaging. Two percent power loss was allowed for cell breakage, and one percent for adhesive darkening due to particle and ultra-violet irradiation. A degradation factor of 17 percent was allowed for the two-year mission.

Both batteries were required to complete the spacecraft acquisition sequence in synchronous orbit. During eclipse periods, one battery provided sufficient power for those equipments which operated continuously; e.g., TT&C subsystem, the momentum wheel, sensors, and certain heaters.

### Body-Mounted Array

Approximately 5070, 2 x 2 cm, 0.2 mm thick, silicon solar cells provided an average power output of 75 watts at 29V while the spacecraft was spinning. One thousand nine hundred and fifty cells were mounted on the enclosures for the extendible array which were jettisoned prior to array deployment.

### Extendible Array

Power was supplied on two buses with initial outputs of 1040 watts at 67 volts for the experiments, and 220 watts at 29 volts for housekeeping.

The two sails were each 6.2 meters long and 1.3 meters wide, and carried a total of 26,250 solar cells. The N/P, one or two ohm-cm, 0.2 mm, 2 x 2 cm, cells had 0.1 mm Cerium-doped cover glasses, and welded interconnections, and were mounted on a Kapton flexible substrate. Packing efficiency was 0.93. Each of the two Kapton blankets was divided into 27 active and three blank panels, and were extended "concertina" fashion. Nominal operating temperature for the solar cells was +55°C and at this cell temperature the nominal efficiency at beginning of life was 10.5 percent. Minimum predicted eclipse temperature was -214°C.

The two sails of the array were rotatable about the spacecraft pitch axis, and sensors mounted on the sails automatically controlled the drive mechanism so that the solar cell side of the sails always faced the sun.

DC currents from the solar cells, and signals from accelerometers and strain gauges were transferred from each sail via a 46-channel wet lubricated gold-on-gold slip ring assembly. The slip rings rotated at the rate of one revolution per day in incremental steps of 0.125°.

The power to weight ratio was 85 watts/kg for the blankets. For the complete array subsystem, including jettisonable covers (but not including solar cells on these covers), slip rings, deployment and tracking and drive mechanisms, the ratio was 26 watts/kg.

### Batteries

Each Ni-Cd battery consists of 27 five Amperhour cells, and these were mounted in metal blocks for heat sinking. The batteries could be reconditioned by

discharging to a specified level at a predetermined rate. The batteries were normally charged continually at a C/20 rate where C is the ampere hour capacity at 25°C. Means were provided to charge at higher rates up to C/10.

### TELEMETRY, TRACKING AND COMMAND SUBSYSTEM

A pair of redundant S-Band transponders compatible with the STDN unified S-Band system provided for tracking, ranging, command, and telemetry. The ground-to-spacecraft link (up-link) consisted of digital command data and ranging signals. The spacecraft-to-ground (down-link) consisted of spacecraft telemetry data and ranging signals. Range and range rate information was obtained by comparison of the up-link and down-link ranging tones. The up-link frequency was between 2025 MHz and 2120 MHz, and the down-link between 2000 MHz and 2300 MHz.

Command signals were in a PCM/FSK/AM format. A binary command code keyed a subcarrier oscillator between two selected frequencies lying between 7 KHz and 12 KHz. The command code bit rate was 700 bits per second. Synchronization was accomplished by amplitude modulating the subcarrier at the bit rate frequency.

Redundant command receivers and redundant decoders provided 245 fully redundant command channels. The system was designed so that the addressed decoder automatically selected the receiver with the strongest signal.

The telemetry system was designated as PCM/FM/PM, in which pulse code modulation (PCM) frequency modulated an FM subcarrier oscillator which in turn phase modulated the transmitter. The PCM bit rate was 1536 bits per second with 192 eight bit words per frame. Two sampling rates were provided; one sample per second, and one sample per 32 seconds. Subcommutation techniques were used to provide the slow sampling rate. Redundant PCM encoders and two watt transmitters, each selectable by ground command, were utilized to provide added reliability.



Two antennas were needed to provide sufficient coverage during all portions of the mission. A conical-beam circularly-polarized antenna, located on the forward platform, was used when the spacecraft was on station in synchronous orbit and in its three-axis mode of attitude control. This antenna, with its axis parallel to the spacecraft yaw axis, provided a boresight gain of 3 dB for telemetry and 2 dB for command. A circularly polarized belt array located around the aft end of the spacecraft thrust tube provided a toroidal-shaped antenna pattern. Before the extendible array was deployed, the minimum gain in the plane containing the roll and pitch axes was -3 dB for telemetry and -5 dB for command. The outputs of the belt array and conical beam antennas combined to provide a near-cardioid pattern for command.

## SPACECRAFT COMMUNICATIONS CAPABILITY

### Antenna Transmission Coverage

The two 2.5 degree beamwidth SHF antennas were steered to cover different parts of Canada and the United States (including Alaska and Hawaii) to support various CTS communication experiments.

### Communications Capability

In the prime transponder configuration, only a small fraction of the output power of the 20W TWT drove the 200W TWT and its antenna. The remainder of the output of the TWT drove the second antenna. The communications capability was, of course, bounded by the combination of powers and bandwidths available. As an example, the 200W TWT, when feeding antenna 2, provided an overall 1 db bandwidth of 85 MHz. A mixture of a frequency-modulated color TV signal, a frequency-modulated sound broadcast signal, and up to 10 channels of voice signals, could then be transmitted simultaneously from a single ground station via the CTS transponder to a variety of remote terminals. At the same time it was possible

to transmit a color TV signal from the remote transmission station to the first ground station via the transponder with its 20W TWT feeding antenna 1. In each case the received signal quality was appropriate to the user involved.

The CTS was capable of providing an EIRP of up to 59 dBW. Taking into account back-off required in the TWT to reduce intermodulation levels when transmitting multiple signals, a TV signal, for example, might typically use 50W of the 200W TWT's radiated power. Under these conditions, approximately 25W of radiated power was available for a sound broadcast signal and 160mW for each voice channel. Allowing 4 dB attenuation for the combined effects of down-link precipitation and tropospheric fading, the 206.3 dB for path loss, the final received power at the receiver terminals of a 2.4 meter diameter antenna was -111 dBW. This provided a 46 dB color TV video signal-to-noise ratio (TASO Grade 1.5). The power received by the first ground station from the remote TV transmission terminal was -107 dBW. This provided a network quality video signal-to-noise ratio of 54 dB.

Special precautions were taken to minimize local oscillator FM noise in the SHF transponder. This was important in the transmission and reception of voice and FM broadcast signals.

#### TYPES OF EXPERIMENTS AND USERS

There were five general categories of user experiments. They were:

##### Health Care

Biomedical Communications

Health Communications

Decentralized Medical Education

### Community Services

Library Networking

Video Teleconferencing

Public Broadcast Services Regional Networking

### Education

Curriculum Sharing

Career Education

Elementary and Adult Education

### Technology

Transmitter Experimental Package

Link Characterization

Digital Communications

Small Terminal Development

### Special Services

Emergency Communications

Video Conference

Ice Information

New Communications

There were 35 first-year experimental proposals submitted to NASA of which 28 were accepted. There were also 48 demonstration or mini-experiments accepted. In evaluating a proposed experiment, the Proposal Evaluation Committee examined the technical content, compatibility with the spacecraft, the validity of the experiment, the experimenter's evaluation plan, the experimenter's spacecraft utilization plan, the financial plan, and finally the plan for final evaluation and publication of the results.

The guidelines for being an experimenter on the CTS/Hermes satellite required that the experimenter obtain funds for the experiment and for ground

equipment from outside sources. NASA provided the time on the spacecraft without charge to approved experimenters. This single requirement for experimenters to provide funding proved to be a stumbling block for a number of experimenters. These experimenters were approved and had developed plans for very worthwhile experiments, but were unable to secure funding. It is unfortunate that at the time that CTS experimenters were seeking external funding from agencies, industry and foundations that these very funding sources were "drying up."

This publication will cover in Chapter VI the details of each of the completed approved experiments and, to a lesser degree, the approved experimenters that carried out extensive planning efforts, but were denied the opportunity to get their experiment on the spacecraft due to inability to secure adequate financing.

## PLANNING AND DEVELOPMENT OF THE CTS U.S. PROGRAM

### Objectives of CTS Program

The objectives of the CTS Program were: to advance the technology of the spacecraft and the related ground equipment; to develop systems applicable to operating a high-radiated-RF-power satellite; to demonstrate new technology applications and components that would be applicable to future commercial communications satellites. The project was designed to include communication experiments by user groups from industry, government, education and health organizations in both the United States and Canada.

### Technical Objectives

Specific objectives include demonstrations of:

A 12-GHz traveling-wave-tube (TWT) with 50 percent efficiency

and with a nominal RF output of 200 watts and the associated power processor required to convert the solar array power into an acceptable form to operate the TWT.

The operation of an unfurlable solar-cell array delivering over 1 kW of useful power to the spacecraft.

A three-axis stabilization system to maintain antenna boresight pointing accuracy to  $\pm 0.1^\circ$  in pitch and roll and  $\pm 1^\circ$  in yaw on a spacecraft with large flexible appendages.

Color television transmission at 12 GHz from a satellite to small, low-cost ground terminals.

Uplink television transmission at 14 GHz from small terminals.

Audio broadcast to very small ground terminals.

Two-way voice communication, wideband data transmission, and data relay.

#### CTS PLANNING SCHEDULE TIMELINE

In August of 1972, NASA invited agencies and organizations to submit proposals for communications experiments. Potential users applied for either an experiment or a demonstration. An experiment required data collection and publication and had a year's duration. A demonstration proposed to utilize the spacecraft from a few days to several weeks. A pre-proposal briefing was held in Washington, D.C. in October of 1972. At this meeting, additional guidance was provided by NASA representatives to prospective users.

## EXPERIMENTS APPROVED

Proposals were reviewed by NASA's CTS User Proposal Evaluation Committee. This committee was composed of personnel from NASA Headquarters, Lewis Research Center, Goddard Space Flight Center, and NASA Consultants. The Director of Communications Programs at NASA Headquarters was the approval authority for experiments. As of October 1977, there had been 35 proposals made to NASA, and acceptance of 28. In October 1977, of the 28 accepted proposals, one experiment was completed, nineteen were active, three were pending, and five had been withdrawn. As of October 1977, there had been 48 mini-experiments. Beginning in October 1973, a series of users meetings was begun. These meetings were designed to facilitate the mutual obligation of the users and NASA to carry out the approved experiment. The user was responsible for providing the resources necessary to implement and report the experiment. One of the main user responsibilities was to provide the ground terminals for the transmission and reception of the signal. The user was also responsible for personnel to operate and maintain the equipment. Each user provided a Principal Investigator, a Technical Manager, and an Evaluation Coordinator.

NASA provided experimental program management, information, technical consultation, and allocated the spacecraft 12-14 GHz communications system at no charge to the user.

The U. S. CTS Users Meetings were held as follows:

TABLE II-2  
HERMES U.S. USERS MEETINGS

MEETING NUMBER	DATES	LOCATION
1	October 30, 31, 1973	LeRC, Cleveland, Ohio
2	January 23, 24, 1974	NASA Hq., Washington, D.C.
3	March 27, 28, 1974	LeRC, Cleveland, Ohio
4	May 21, 22, 1974	Ames, Mountain View, California
5	July 24, 25, 1974	LeRC, Cleveland, Ohio
6	October 3, 1974	Denver, Colorado
7	November 19, 20, 1974	Ottawa, Canada
8	January 28, 29, 1975	GSFC, Greenbelt, Maryland
9	April 8, 9, 1975	Ames, Mountain View, California
10	June 10, 11, 1975	LeRC, Cleveland, Ohio
11	August 19, 20, 1975	LeRC, Cleveland, Ohio
12	October 29, 30, 1975	COMSAT, Clarksburg, Maryland
13	January 15, 17, 1976	KSC, Cape Canaveral, Florida
14	April 27, 28, 1976	Ames, Mountain View, California
15	August 3, 4, 1976	LeRC, Cleveland, Ohio
16	November 17, 18, 1976	Westinghouse, Baltimore, Maryland
17	February 8, 9, 1977	Ames, Mountain View, California
18	May 25, 26, 1977	GSFC, Greenbelt, Maryland
19	September 27, 28, 1977	WAMI, Seattle, Washington
20	March 7, 8, 1978	Ames, Mountain View, California
21	September 19-21, 1978	Wingspread (Racine), Wisconsin
22	April 18, 19, 1979	Denver, Colorado

In the United States experiments, each user was responsible for providing all of the terminal equipment associated with their experiment. NASA provided engineering data for several low cost terminal concepts designed to demonstrate the effectiveness of different terminal configurations. This engineering data allowed the user to utilize the ground station configuration most suited to their experimental communication requirements. The following table illustrates the characteristics of several of the ground stations that were used.

TABLE II-3. - CHARACTERISTICS OF SEVERAL EXISTING AND PLANNED U.S. SHF TERMINALS (12 TO 14 GHz)

Terminal	Antenna				Receiver		System gain/ temperature ratio, dB/K	Transmitter power, W	Antenna control
	Diameter		Peak gain (12 GHz), dB	Three-decibel beam width, deg	Preamplifier	Total sys- tem noise tempera- ture, K			
	m	ft							
Cleveland (NASA)	5	16	52	0.4	TDA <sup>a</sup>	800	24	1250	Step track
Rosman (NASA)	5	16	53	.4	(b)	450	26	1250	Autotrack
TV receive only; two-way voice	3	10	48	.6	TDA <sup>a</sup>	900	18	500	Remote motor drive
Two-way voice	1.2	4	40	1.5	TDA <sup>a</sup>	900	10	20	Manual adjust- ment
Two-way voice	.6	2	34	3.0	TDA <sup>a</sup>	900	4	20	Fixed

<sup>a</sup>Tunnel diode amplifier.

<sup>b</sup>Uncooled paramplifier.

As indicated in Table II-3 above, a variety of terminal configurations were used by U. S. experimenters.

## LAUNCH

The satellite was launched on January 17, 1976, by a Thor Delta 2914 launch vehicle. The launch followed a standard Delta synchronous orbit profile. NASA provided all of the launch operations, placed the satellite

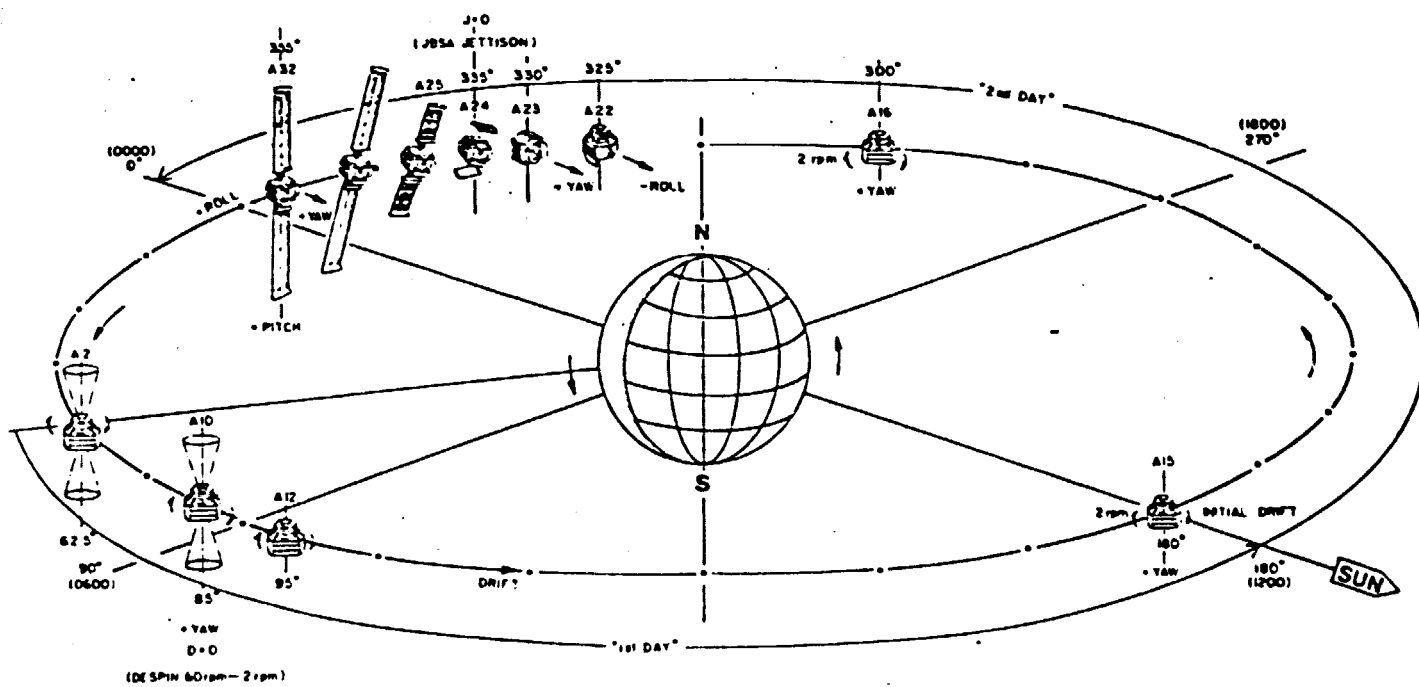


on location at 116° W. longitude and spinning at a rate of 60 rpm. On January 29, 1976, control of the satellite was turned over to the Communications Research Center (CRC) in Canada.

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**SPACECRAFT CHECKOUT**

To place the spacecraft in operation and to perform a checkout of all systems, the following sequence was followed:



**ATTITUDE ACQUISITION EVENTS PROFILE**

**FIGURE 2. Launch profile of Hermes.**

The satellite was first despun by using the low thrust hydrazine thrusters. The satellite was then turned 90° so that the communications antennas on the front of the satellite faced the earth. Two sections of

the body-mounted array covers were jettisoned and the two flexible solar arrays were extended by stainless steel booms. At this point, the satellite appeared as in Figure 3.

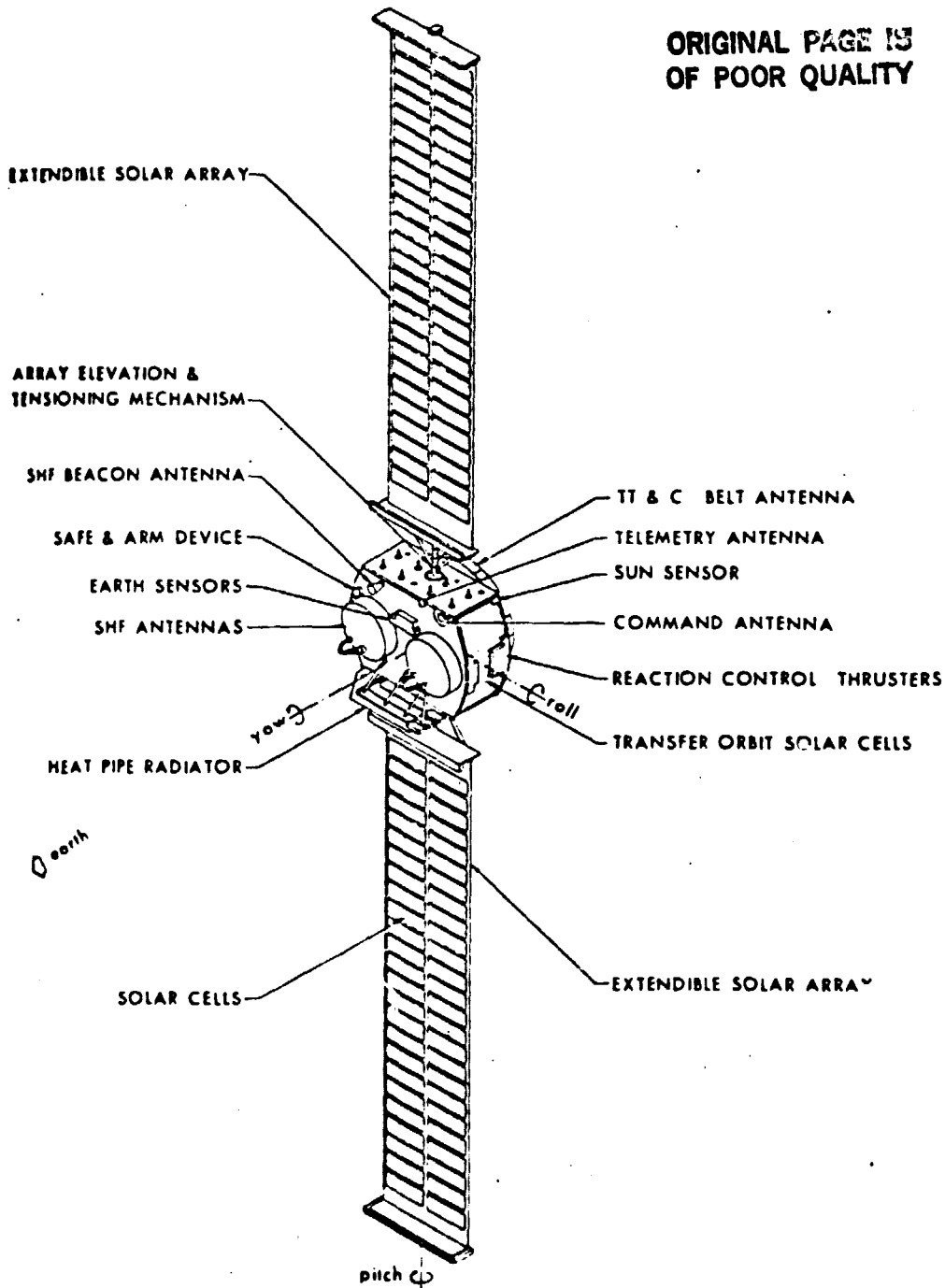
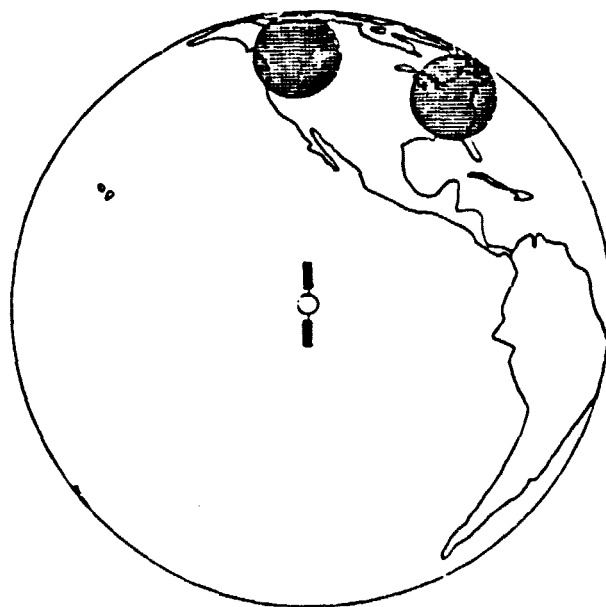


FIGURE 3. Hermes spacecraft in orbit.

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The solar arrays were then turned toward the sun to provide electrical power. The satellite was carefully oriented, the momentum wheel was spun up and the 3-axis stabilization system was activated. The solar arrays initially provided 1365 W of power.

The location of the spacecraft at 116° W was selected to provide coverage for Northern Alaska, Newfoundland, Canada, and most of the Continental U.S.A. The SHF antennas could be independently pointed to any spot visible from the satellite. Figure 4 shows the earth as seen from the satellite at 116° W and illustrates how two beams could be used simultaneously.



EARTH VIEWED FROM SYNCHRONOUS ALTITUDE

116 DEGREES WEST LONGITUDE

FIGURE 4. SHF antenna footprints.

North American coverage is illustrated in Figure 5. Typically, one of these beams would be 200 W and the other the 20 W beam.

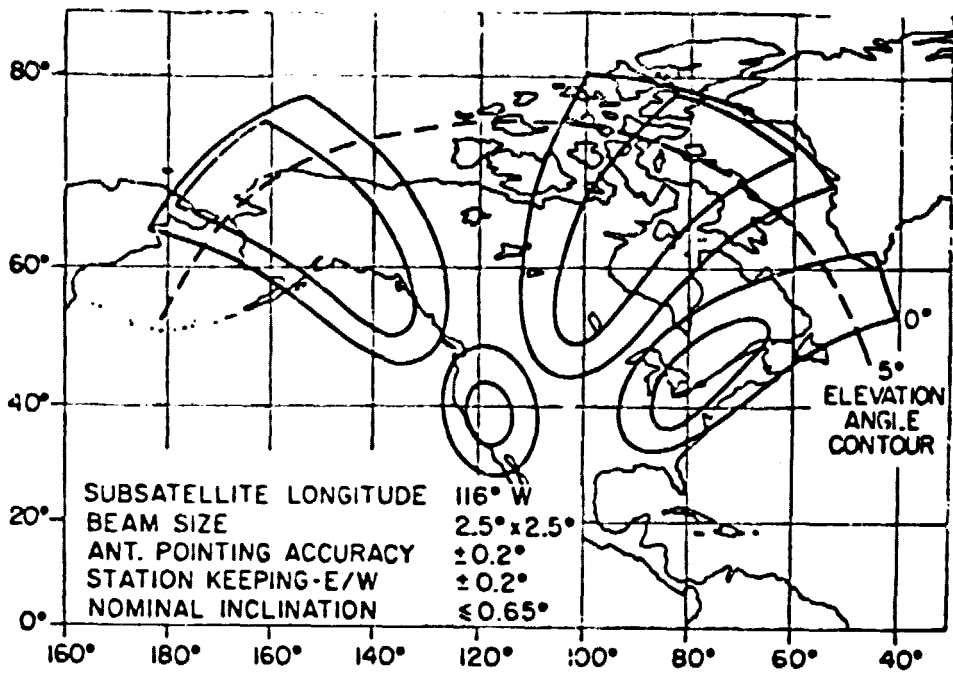


FIGURE 5. Typical SHF coverage patterns.

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Figure 6 shows a typical communication system configuration.

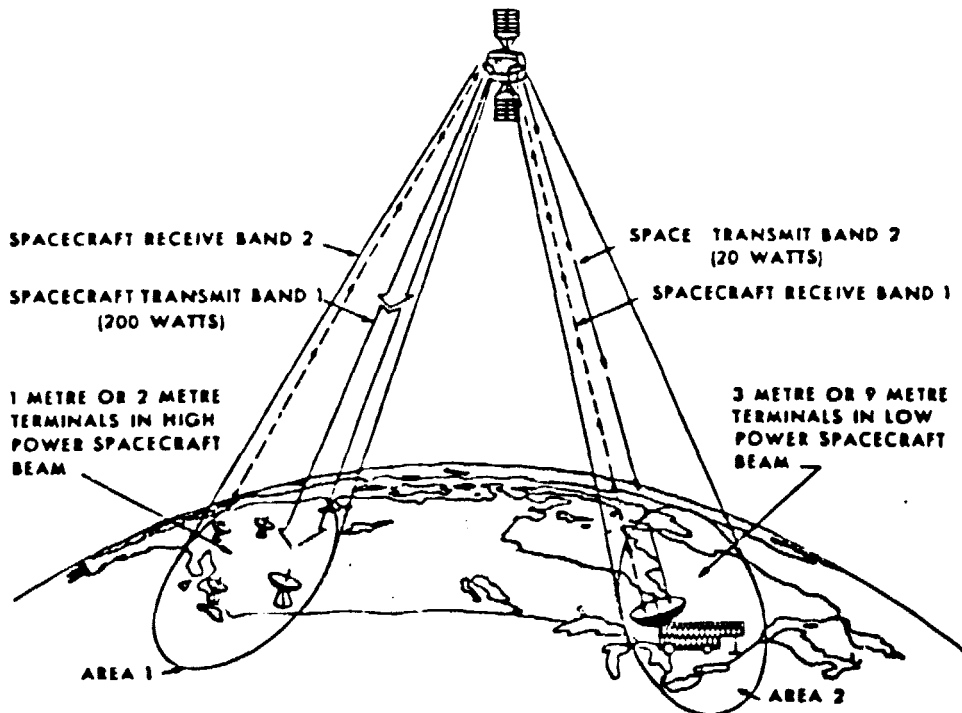


FIGURE 6. Typical communication system configuration.

Figure 7 illustrates the ground terminal sites used during the two-year mission.

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FIGURE 7. Ground terminal sites during the two year mission.

#### EXPERIMENTATION

Experiments were conducted in both the United States and Canada. The experimental capabilities of the CTS/Hermes spacecraft allowed the following general kinds of experiments:

T. V. Broadcast

Educational T. V. with voice or data return

T. V. origination from remote locations

Two-way T. V. for teleconferencing

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Telephony (two-way voice)

Radio program broadcasting

Digital communications

Experimental time division multiple access (TDMA)

During the period from January 17, 1976 through January 17, 1978, approximately 50 communication experiments were carried out. The satellite was available almost continuously for experimentation during the two-year period. Several exceptions were when the spacecraft experienced the spring and fall equinox eclipses of 1976. During this period, the spacecraft went on battery power for housekeeping functions, but the SHF transponders were shut off. By 1977 enough experience had been gained that communications experiments were continued through both eclipse seasons. On May 21, 1976, D.O.C. and NASA joined in a ceremony ending the checkout and experiment operations mode. See Figure 8 for the time line of operation January 17, 1976, through January 17, 1978.

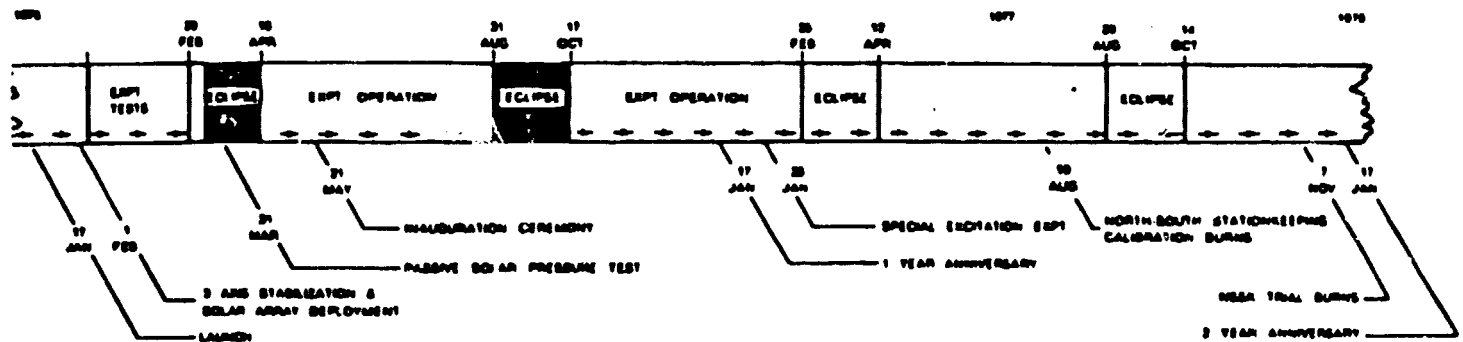


FIGURE 8. Hermes Mission Timeline 1976-78 - Major Events.

### III. C.T.S. SPACECRAFT

#### 200 WATT TWT (TEP)

The Transmitter Experiment Package (TEP) had a measured rf output of 233 watts and an overall efficiency of 50.75% at a centerband frequency of 12.080 GHz. The operating bandwidth of the TEP was 85 MHz. The technical objectives of the TEP were:

1. To demonstrate in space an amplifier operating with an efficiency  $\geq$  40 percent and a saturated rf output power  $\geq$  180 watts at a frequency of 12 GHz.
2. To demonstrate reliable high-efficiency performance for a transmitter experiment package for two years in a space environment.
3. To obtain fundamental data for further advancement in the state-of-the-art of high-power microwave amplifier operations in space.

#### TRANSMITTER EXPERIMENT PACKAGE

The transmitter experiment package consisted of a nominal 200 watt Output Stage Tube (OST), a supporting Power Processing System (PPS), and a Variable Conductance Heat Pipe System (VCHPS).

The communication requirements designed for TEP are as shown in Table III-1.

TABLE III-1.

TEP COMMUNICATIONS REQUIREMENTS

Minimum Output Power (Average Across Band), Watts	180
Efficiency Goal, Percent	50
Gain, Saturated, dB	30 +2-1
Band Width, GHz	12.038 - 12.123
Differential Gain, dB	± 1.5
Maximum Gain Ripple, dB Peak to Peak	5
Maximum Group Delay, Nanoseconds Peak to Peak	8
Noise Figure, dB	40
Maximum Load, VSWR	1.25
Design Life, Years	2

POWER PROCESSING SYSTEM

Electrical Power for operating the TEP was delivered at nominal supply voltages of 76 VDC and 27.5 VDC respectively. The PPS performed the following functions for the TEP operations:

1. Developed proper operating voltages.
2. Regulated supply voltages.
3. Provided fault sensing and protection.
4. Provided command control and sequencing for remote operation.



The Variable Conductance Heat Pipe System was used to remove heat and to maintain controlled operating temperatures.

RESULTS OF EARLY TEP PERFORMANCE

Up to August 8, 1977, TEP had been operated a total of 8,830 hours. Tests showed that special care had to be taken to accommodate the widely varying heat rejection rates due to the large power consumption of TEP. Tests results relating to TEP performance during this period are as shown in Table III-2.

TABLE III-2.  
OBSERVED TEP PERFORMANCE CHARACTERISTICS

	February 8 - June 13, 1976 Average Standard Deviation		June 13, 1976 August 8, 1977 Average Standard Deviation	
SATURATED EFFICIENCY, PERCENT				
CB (Center band freq., 12.080 GHz)	51.52	1.85	50.75	1.75
UBE (Upper band edge freq., 12.123 GHz)	37.0	1.22	37.80	3.34
LBE (Lower band edge freq., 12.038 GHz)	38.5	1.22	38.14	1.01
SATURATED RF OUTPUT, WATTS				
CB	241.1	8.68	233.4	7.26
UBE	151.3	6.96	151.4	11.51
LBE	185.7	5.76	185.5	1.09
SATURATED TEP POWER, WATTS				
CB	469.9	6.6	463.9	8.12
UBE	406.1	5.7	401.9	1.81
LBE	482.6	8.8	475.3	9.46
BODY CURRENT, mA				
CB, SATURATED	6.43	0.27	6.32	0.34
CB, 100W	2.37	0.15	2.56	0.11
DC	1.64	0.10	1.62	0.05
BEAM CURRENT, mA	76.35	--	76.2	--

## SHF ANTENNA SYSTEM AND BEAM COVERAGE

The SHF Antenna System consisted of two steerable parabolic reflectors with single feeds which incorporated linear, orthogonally polarized receive and transmit functions. The electrical axis of each antenna was steerable in any direction  $8.5^\circ$  from a line parallel to the spacecraft yaw axis and passing through the vertex of the reflector. Beam width of the antennas was  $2.5^\circ$ . The transmit gain was 36.9 dB on axis. Isolation between transmit and receive channels was more than 25 dB. The antennas were steerable in increments of  $0.12^\circ$  at a slew rate of  $3^\circ$  per minute. Six channels of telemetered data on the antenna system were transmitted to the ground and eleven antenna subsystem commands were received by the spacecraft.

## SHF BEACON

The SHF Beacon operated at 11.7 GHz and provided a convenient signal source to locate and lock onto the spacecraft. The SHF Beacon operated at two power levels 200 or 12 mW on command.

The Beacon consisted of four assemblies:

- i. An Injection Locked Oscillator which provided required power conditioning, command control and the telemetry signal.
2. A Reference Signal Generator which translated the 50 mW signal from the SHF Transponder local oscillator.
3. A Switchable Circulator Assembly.
4. A Horn Antenna Assembly.

## SHF COMMUNICATIONS TRANSPONDER

The SHF Transponder was designed to be compatible with the NASA world-wide Satellite Tracking and Data Network (STDN). The purpose of this transponder was to aid in the telemetry, tracking and command system functions. The main components of the transponder were two transmitters and two receivers, a data encoder and decoder, and a software matrix for sending and receiving command signals.

## IV. GROUND OPERATIONS

### DOWNLINK TECHNICAL DESCRIPTION AND REQUIREMENTS

Communication experiments for the CTS were designed to investigate the feasibility of smaller diameter antennas, modest cost, and location close to the user.

### VIDEO

The Wideband Video Signal was processed through the CTS spacecraft by the Lewis Ground Station. A sample uplink calculation for the Lewis Ground Station is shown in table IV-1.

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**TABLE IV-1. - SAMPLE UPLINK CALCULATION FOR  
LEWIS GROUND STATION  
[Uplink frequency, 14.2 GHz.]**

Characteristic	Spacecraft receiver noise temperature, K	
	1315	2315
<b>Terminal:</b>		
Transmitter power (1250.0 W), dBW	30.97	30.97
Feed loss, dB	-2.00	-2.00
Antenna gain (4.88 m (16.0 ft)), 0.31° half-power beam width (HPBW)	54.53	54.53
Effective Isotropic Radiated Power (EIRP), dBW	83.50	83.50
Antenna pointing error (0.05°), dB	-0.26	-0.26
Margin, dB	-3.00	-3.00
Propagation loss (23 074 statute miles; latitude, 41.4°; relative longitude, 35.1°), dB	-207.22	-207.22
Atmospheric loss (0.100% outage; CCIR Rainfall Region 2), dB	-2.23	-2.23
Polarization loss, dB	-0.25	-0.25
<b>Spacecraft:</b>		
Feed loss, dB	-0.00	-0.00
Antenna gain (0.70 m by 0.70 m (2.3 ft by 2.3 ft); 2.15 by 2.15 HPBW)	37.68	37.68
Antenna pointing error (0.38°), dB	-0.31	-0.31
Received carrier power, dBW	-92.03	-92.03
Noise power density, dBW/Hz	-197.41	-194.96
Bandwidth, dB (Hz) (27.0 MHz)	-123.10	-120.04
Carrier-power/receiver-noise ratio, dB	31.02	28.56

In a typical downlink power calculation derived from table IV-2, combining losses and gains, the ground terminal carrier-power/receiver-noise ratio was 24.56 dB. This quantity converts to a signal noise ratio of 58.91 dB at the television monitor which produced a television picture of excellent quality.

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**TABLE IV-2. - SAMPLE DOWNLINK CALCULATION FOR  
LEWIS GROUND STATION**

[Downlink frequency, 12.1 GHz.]

Characteristic	Spacecraft receiver noise temperature, K	
	1315	2315
<b>Spacecraft:</b>		
Output tube power (200 W), dBW	23.01	23.01
Feed loss, dB	-0.00	-0.00
Antenna gain (0.70 m by 0.70 m (2.3 ft by 2.3 ft); 2.52 by 2.521 + PBW), dB	36.28	36.28
Effective Isotropic Radiated Power (EIRP), dBW	59.29	59.29
Antenna pointing error (0.38°), dB	-0.22	-0.22
Margin, dB	-3.00	-3.00
Propagation loss (23 074 statute miles; latitude, 41.4°; relative longitude, 35.1°), dB	-205.81	-205.81
Atmospheric loss (0.100% outage; CCIR Rainfall Region 2), dB	-1.52	-1.52
Polarization loss, dB	-0.25	-0.25
<b>Terminal:</b>		
Feed loss, dB	-1.00	-1.00
Antenna gain (4.88 m (16.0 ft); 0.30° HPBW)	53.12	53.12
Antenna pointing error (0.05°), dB	-0.18	-0.18
Received carrier power, dBW	-99.58	-99.58
Noise power density (T=800 K), dBW/Hz	-199.57	-199.57
Bandwidth, dB (Hz) (27.0 MHz)	74.31	74.31
Terminal receiver noise power, dBW	-125.26	-125.26
Uplink noise contribution (C/N, 31.02; 28.6 dB), dB	0.95	1.50
Terminal net noise power, dBW	124.14	123.45
Terminal carrier-power/receiver-noise ratio, dB	24.56	23.87
FM improvement (M=2.00), dB	21.58	21.58
Noise weighting factor (CCIR), dB	10.20	10.20
Preemphasis improvement, dB	2.40	2.40
Signal/noise ratio, dB	58.91	58.05

## TYPICAL FM VIDEO RECEIVER

The typical user experimental receiver consisted of an outdoor mixer-down converter and an indoor intermediate-frequency receiver. The receiver provided either baseband or VHF-AM output, or both, and could accommodate one or more audio sub-channels. A tunnel diode amplifier was included with the outdoor unit to improve receiver sensitivity.

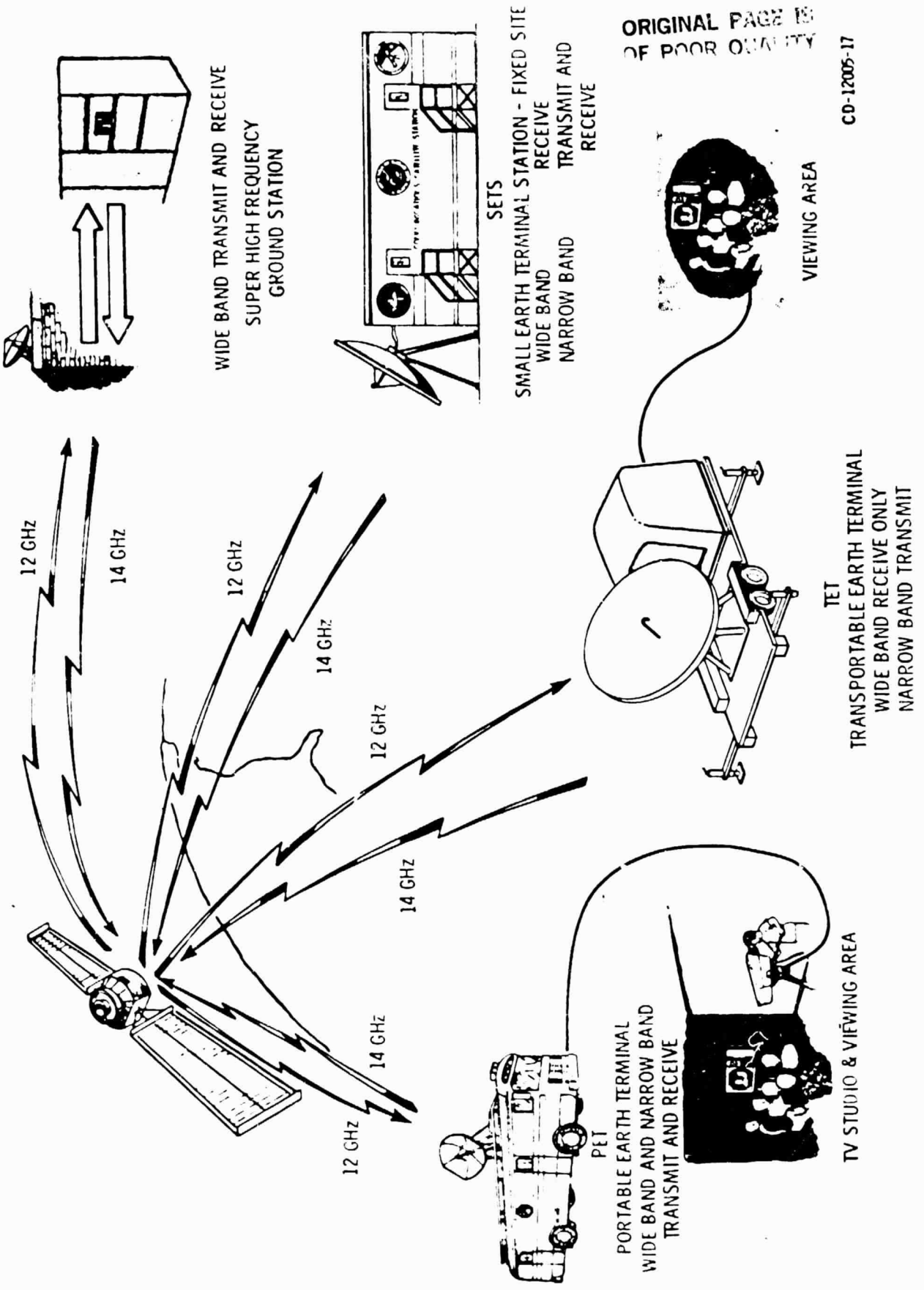
The Small Earth Terminal Station at Lewis is principally used to test and evaluate experimental systems and low-cost wideband receive hardware. The facility also provides narrowband (voice) transmit and receive capability for use with CTS.

The station is at a fixed site and utilizes eight parabolic reflector-type antennas ranging in size from 2 to 15 feet in diameter. It has wideband receive systems that are fixed frequency (low-cost) or variable frequency. Also available is capability for voice or facsimile transmission using narrowband equipment. Housed at the station are color monitors, video tape recorders and other audio/video equipment.





# CTS and The Experimental Earth Terminals



WIDE BAND TRANSMIT AND RECEIVE  
SUPER HIGH FREQUENCY  
GROUND STATION

SETS  
SMALL EARTH TERMINAL STATION - FIXED SITE  
WIDE BAND  
NARROW BAND  
TRANSMIT AND  
RECEIVE

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CO-12005-17

VIEWING AREA

TET  
TRANSPORTABLE EARTH TERMINAL  
WIDE BAND RECEIVE ONLY  
NARROW BAND TRANSMIT

PET  
PORTABLE EARTH TERMINAL  
WIDE BAND AND NARROW BAND  
TRANSMIT AND RECEIVE

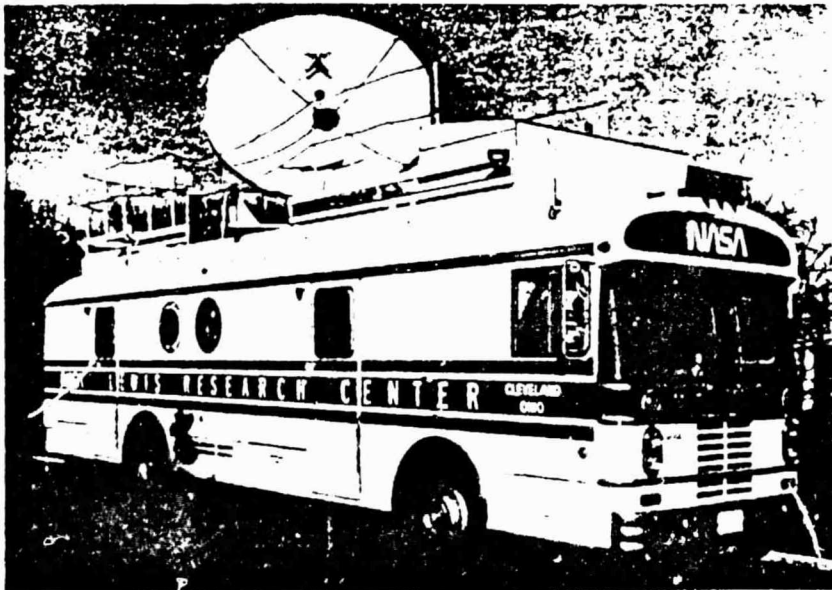
TV STUDIO & VIEWING AREA

## PET - PORTABLE EARTH TERMINAL

PET is a portable satellite communications terminal that was designed by NASA/Lewis. PET is a 35 foot bus equipped with a teleconference room and satellite transmitting and receiving equipment. An 8 foot parabolic antenna is mounted on the roof. PET, which was operated by NASA/Lewis, was loaned to experimenters for satellite communications experiments.

Interior equipment includes color television cameras, color monitors, audio equipment, video tape recorders, 12 GHz receiving equipment and a 500 Watt 14 GHz transmitter.

PET's on-board power is supplied by two 12 kw generators, one for operations and one for housekeeping. Equipment may also be run using on-site power.

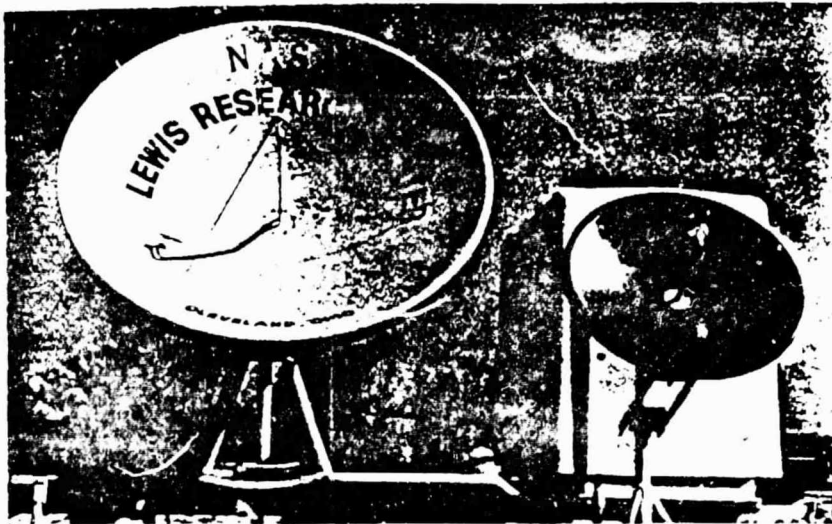


TET - TRANSPORTABLE EARTH TERMINAL

TET is a 20-foot trailer designed by Lewis as a transportable satellite communications terminal. It is equipped with an electronics shed which houses satellite transmitting (voice only) and receiving (video and audio) equipment. TET has two parabolic antennas, one 4-foot and the other 10-foot in diameter. This facility too is operated by Lewis and loaned for satellite communications experiments.

Electronics equipment used includes color monitors, microphones, video tape recording apparatus, and associated signal distribution devices.

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## V. CTS USERS

The major categories of users were: Education, Health Care, Community and Special Services and Technology. The following approved experiments will illustrate the types of users and disciplines which were represented.

### EDUCATION EXPERIMENTS

- College curriculum sharing among universities with a demonstration of digital video compression techniques for both bandwidth and power reduction.
- Teacher upgrading by improving teaching skills and development of instructional units and making graduate education available to teachers.
- Health education programs using live and videotaped techniques for use by hospitals and health-care facilities.
- Exchange of materials and teaching techniques related to computer-aided instruction between diverse areas of the country.
- Investigation of telecommunication systems requiring only limited human support and providing data on career development, employment, job preparation, and counseling.

### HEALTH CARE EXPERIMENTS

- Conducting biomedical clinical and continuing medical experiments among thirty V. A. hospitals.
- Demonstration of the feasibility of information exchange between

research institutions and the medical community; evaluation of the broadband teleconference as a means of continuing education among health-care professionals.

- Investigation of techniques for improving administration and teaching procedures for decentralized medical education.

#### EXPERIMENTS IN COMMUNITY AND SPECIAL SERVICES

- Feasibility of a satellite library information network to improve individual and organizational capabilities for assessing and disseminating information.
- Development of techniques for transmission of special services programs world-wide; conversion of analog data to digital for wideband transmission of time-compressed audio at video format speeds.
- Determination if a large and geographically dispersed industrial organization can substitute video and audio communication for travel.

#### TECHNOLOGY EXPERIMENTS

- Evaluation of attenuation and signal degradation due to absorption and scattering induced by atmospheric precipitation; measurement and characterization of earth-based, man-made signals which could interfere with the uplink frequency band.
- Demonstration of the suitability of transportable earth terminals to relay communications to and from a disaster area.

## EXPERIMENTERS' RESPONSIBILITIES

Each experimenter had a Principal Investigator whose responsibilities were to:

- Carry out the experiment as approved.
- Work closely with the technical manager and evaluation coordinator to keep the experiment on its time schedule.
- Obtain necessary funding to carry out the experiment as planned.
- Stay informed on all information issued through UEBs. (User Experiment Bulletins.)
- Attend all CTS User Meetings.
- Maintain contact with the CTS Program Manager regarding progress and problems related to the experiment.

The Technical Manager's responsibilities were to:

- Work closely with the NASA LEWIS CTS Project Technical Manager to develop the ground station technical capability.
- Stay informed through UEBs and User Meetings of technical changes and requirements.
- Develop ground station requirements and supervise installation and operation.

The Evaluation Coordinator's responsibilities were to:

- See that the evaluation component was carried out as proposed in the approved experiment plan, and to produce the required experimental documentation for the experiments.

## NASA EXPERIMENT USER'S SERVICES

### Evaluation Working Groups (EWG)

The Evaluation Working Group was a mechanism whereby the Evaluation Coordinators for each experiment could share ideas and experiences, and where appropriate, plan joint research and dissemination efforts.

### Technical Working Group (TWG)

The Technical Working Group was established to provide an effective interchange of technological information among and between the experiments and the Program and Project offices. Technical Managers from each of the experiments composed the Technical Working Group.

### User Experiment Bulletins (UEBs)

User Experiment Bulletins were information bulletins issued monthly to experimenters and NASA CTS project participants. UEBs contained information pertinent to CTS experimenters.

### C.T.S. Users Meetings

C.T.S. Users Meetings were instituted to conduct a periodic review of experiments. These meetings were convened every 2 or 3 months to exchange information, delineate mutual responsibilities of NASA and experimenters, and to assign actions necessary to carry out projects.

### Use of PLANET Computer Conferencing

Day-to-day exchange of information between experimenters and NASA Lewis was carried on, utilizing the PLANET computer conferencing capability. This system was utilized daily in managing the many facets of the experimental programs.

## VI. CTS U.S. EXPERIMENTS

The following materials summarize twenty completed experiments and fourteen experiments which were uncompleted or withdrawn.

The summaries were abstracted from user proposals, minutes of user meetings, and final reports. Readers will note that the summaries of some of the experiments are reported more extensively than others. This is the result of the amount of project materials available to the editor rather than a subjective evaluation of the experiment.

It is the intent in this section to provide the readers with a composite overview of the CTS experimentation and to demonstrate the depth and diversity of the experiments.



## EXPERIMENT 1

TITLE: Communication Link Characterization Experiment  
(CLCE)

DISCIPLINE: Technology

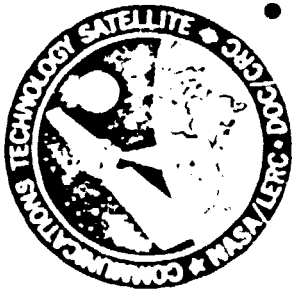
ORGANIZATION: NASA/Goddard Space Flight Center

OBJECTIVE: Evaluate attenuation and signal degradation due to absorption and scattering induced by precipitation; measure and characterize earthbased man-made signals which could interfere with uplink.

PRINCIPAL INVESTIGATOR: Dr. Louis Ippolito

ACTUAL START: 2/76

COMPLETION: 12/78

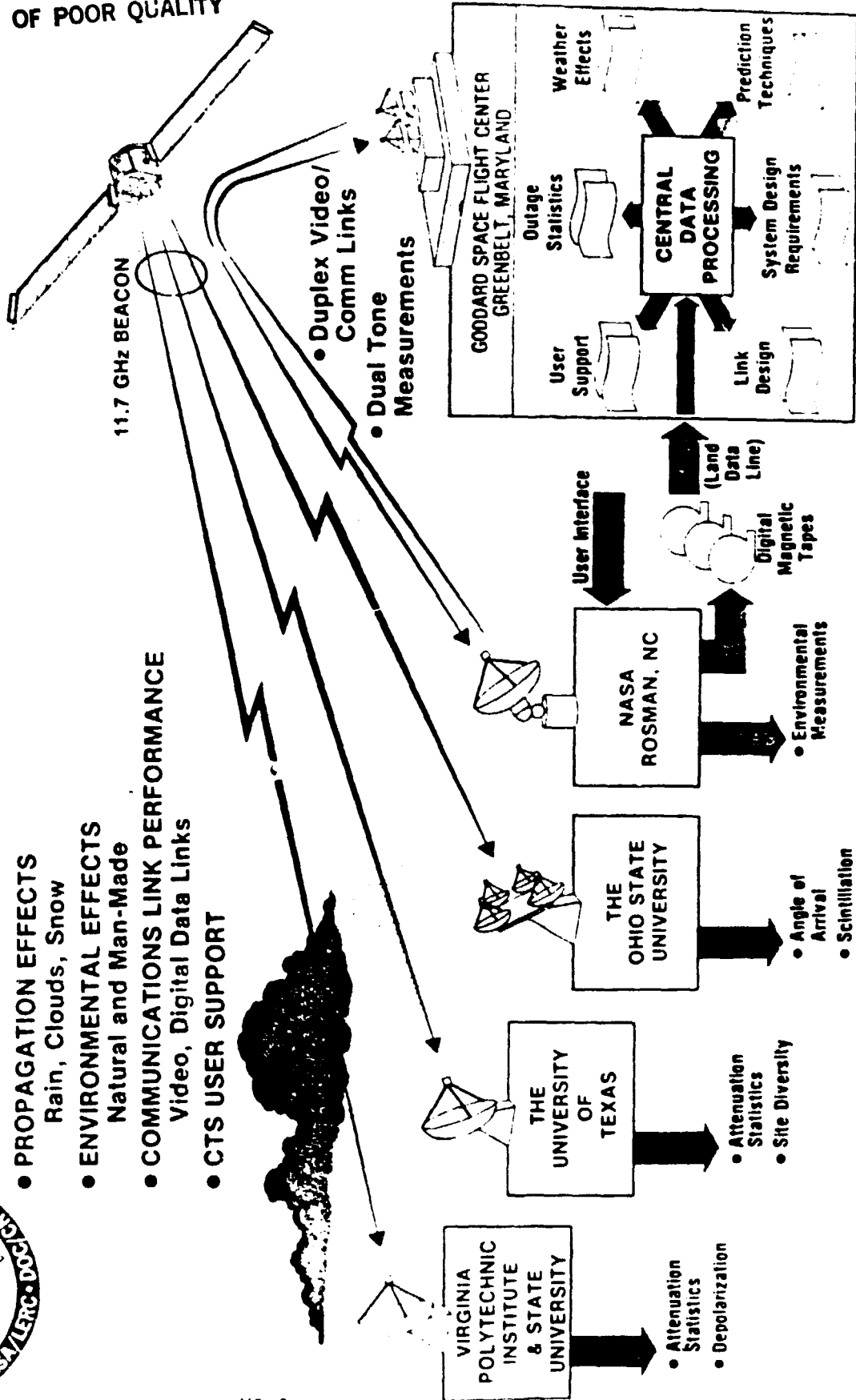


# CTS COMMUNICATIONS LINK CHARACTERIZATION EXPERIMENT

Principal Investigator: Louis J. Ippolito, Goddard Space Flight Center, Greenbelt, Maryland

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- PROPAGATION EFFECTS  
Rain, Clouds, Snow
- ENVIRONMENTAL EFFECTS  
Natural and Man-Made
- COMMUNICATIONS LINK PERFORMANCE  
Video, Digital Data Links
- CTS USER SUPPORT



PURPOSE AND OBJECTIVES

The Goddard Space Flight Center of the National Aeronautics and Space Administration developed an experiment designed to measure and characterize the radio frequency links of the SHF transponder on the Communications Technology Satellite (CTS) for the benefit of all CTS User Experimenters. The experiment addressed the problems of both natural phenomena and man-made components of the electromagnetic environment which could adversely affect the reliability of CTS user communications links. The experiment was used to collect data on communication link quality to ensure that all CTS users would have sufficient margin to provide high quality transmissions.

The basic propagation phenomena of importance in the CTS frequency bands, (14.0-14.3 GHz up-link, 11.7-12.2 down-link), include attenuation and signal degradation due primarily to absorption and scattering induced by precipitation. These effects were measured and evaluated in the propagation measurements area of the Communication Link Characterization Experiment.

ABSTRACT

The Goddard Space Flight Center (GSFC) conducted an experiment with the Communications Technology Satellite (CTS) designed to measure and evaluate the effects of rain and other propagation phenomena at 11.7 GHz.

This experiment was one of a series of propagation experiments conducted by GSFC utilizing orbiting satellite beacons to evaluate the effects of the earth's atmosphere on earth-space transmissions above 10 GHz. Continuous observations of the CTS beacon were made June of 1976 to December 1978. Extensive measurements of monthly, seasonal, annual, and multi-year distributions of rain rate and attenuation were developed and evaluated, and compared with published prediction models.

A comparison of rain rate for the calendar years 1976, 1977, and 1978 shows very similar distributions, with differences of only a few percent in the range of 1 to .001 percent rain rate exceedance. The measured three-year rain rate distribution was compared with three published prediction models.

A comparison of monthly and seasonal 11.7 GHz attenuation distributions shows large differences between the calendar years 1977 and 1978; however, the annual distributions were very similar. The attenuation exceedance for .01 percent of the year was 14.5 dB for 1977 and 16 dB for 1978. The results indicate that a 10 dB rain margin at GSFC would have produced 1.4 hours of outage in 1977 and 1.5 hours in 1978.

The measured attenuation distributions were compared with several published attenuation prediction models and a modified CCIR SPM Model was found to give the best agreement, with an RMS error of 1.4 dB in the 1 to .01 percent region. An empirical effective path length for calculating attenuation distributions from the measured rain rate distribution was developed, which shows excellent agreement for long term attenuation prediction studies.

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## SUMMARY AND CONCLUSIONS

### Greenbelt Monthly Attenuation Data

The data presented for the Greenbelt station was measured over a period of from October 1978 to June 1979. The 28.56 GHz attenuation data is presented for the above period and the 11.7 GHz data is presented for the period of November 1978 to June 1979.

For this reporting period the largest amount of precipitation fell in the month of May 1979. The  $T_0$  value ( $R > 0$  mm/hr) was 4781 minutes and this corresponds to 10.7% of the total monthly period. A number of thunderstorms also occurred during this month which caused relatively high values of attenuation. Due to the limited dynamic range of the 28.56 GHz receiver it was determined that an A value of 10 dB was exceeded for 0.5% of the total monthly period which corresponds to 223 minutes of the month.

A summary of the monthly attenuation (A) statistics is shown in Table VI-1 for the reporting period at three percentage values. For the reporting period, measurable A values for the 11.7 GHz frequency was only obtained during May and June. Because of the thunderstorm activity, worst month statistics for the Greenbelt area occurred during the month of May.

TABLE VI-1  
SUMMARY OF MONTHLY ATTENUATION STATISTICS - GREENBELT STATION

1978	T(R) MINUTES	PERCENTAGE VALUES ATTENUATION IN DB		
		0.1%	0.01%	0.005%
<u>28.56 GHz ATTENUATION STATISTICS</u>				
OCTOBER	1166	7	13.75	14 (.009)
DECEMBER	2110	5.8	12 (.022)	>12
<u>1979</u>				
JANUARY	3985	7	10 (.05)	>10*
APRIL	1450	6	8 (.012)	>8
MAY	T(R) = 903 T(A) = 3742	4 (1.0)	10 (0.5)	>10
JUNE	T(R) = 623.6 T(A) = 3023	5 (1.0)	8 (0.64)	>8
<u>11.7 GHz ATTENUATION STATISTICS</u>				
MAY	903	8	14	>14
JUNE	623.6	1	1.8	2 (.0048)

\*Low attenuation limit due to the severely restricted dynamic range of the 28.56 GHz receiving system.

Greenbelt Long Term 11.7 GHz Attenuation Data

The measurement time period for A was June 1976 to June 1979, a total of 37 months. Table VI-2 gives a listing of the percentage values for the distributions for various time periods within the 37 months. Because of the interleaving time periods, the A values at the respective percentage values are very similar. From the data, it could be concluded that fade levels above 26 dB at the 11.7 GHz frequency can be considered rare events. Hence, these levels need only be considered at very stringent service times for the system.

TABLE VI-2  
SUMMARY OF LONG TERM ATTENUATION STATISTICS  
FOR 11.7 GHz FREQUENCY - GREENBELT STATION

NO. OF MOS.	TIME PERIOD	T(R) MINUTES	PERCENTAGE VALUES ATTENUATION IN dB			
			0.1%	0.01%	0.002%	0.001%
25	Jul 1976 thru Jul 1978	15566	2	12	26	>30
28	Jul 1976 thru Oct 1978	22512.5	2	14	26	30
19	Jan 1977 thru Jul 1978	10630.5	2	14	27.5	>30
12	Jan 1977 thru Dec 1977	5783.9	2	14	27.5	>30
12	Aug 1977 thru Jul 1978	9898.5	2	16	27	>30
36	Jul 1976 thru Jun 1979	34359	1.7	12	26	29.5
12	Jul 1978 thru Jun 1979	14505.8	1.5	14	27	28
12	Jan 1978 thru Dec 1978	11732	2	16	27	30

An attempt was made to relate worst month statistics to yearly statistics which can be computed from accepted methods. The relationships were developed

in the form of ratios: (1) Percentage ratios for a constant (A) value, (2) (A) ratios for a constant percentage value. Neither ratio type remained constant over the overall measurement range of A. The value of the former ratio depends on the degree of similarity between the slopes of the yearly and monthly distributions. These slope values tend to be similar past an A of about 5 dB. The latter ratio value tends to peak at a percentage of about .075 and decrease on either side of .075.

#### Greenbelt Monthly and Long Term Rain Rate Statistics

The monthly rain rate statistics between November 1978 through June of 1979 are presented in Table VI-3. The long term statistics encompass a period from January 1976 to June 1979. Distributions for various inter-leaving time periods have been computed from the overall time period. A summary of the results of the monthly and long term periods are given in Table VI-3.



TABLE VI-3

SUMMARY OF RAIN RATE STATISTICS FOR THE GREENBELT AREA

MONTHLY PERIODS					
PERIOD	T(R) MINUTES	PERCENTAGE VALUES RAIN RATE IN MM/HR			
		0.1%	0.01%	0.001%	
<u>1978</u>					
NOVEMBER	978.9	10	15	23 (.002)	
DECEMBER	2110	12	23	47	
<u>1979</u>					
JANUARY	3983	20	47	130	
FEBRUARY	1401	13	23	48	
MARCH	981.8	12	32	58	
APRIL	865.4	13	30	59	
MAY	903.5	35	97	157	
JUNE	623.6	18	67	185	
NO. OF MOS.	PERIOD	LONG TERM PERIODS			
12	YEARLY (1976)	11502	23	68	115
12	YEARLY (1977)	7880	18	55	128
12	YEARLY (1978)	11732	13	50	115
42	JANUARY 1976 TO JUNE 1979	39825.1	15	60	117
36	JULY 1976 TO JUNE 1979	35049.7	15	60	125
12	JULY 1978 TO JUNE 1979	14506	14	50	110

A large amount of the intense yearly precipitation was measured in the May through August period. The minimum amount of intense precipitation was measured in February and the maximum in August. The form of the precipitation in the winter months is characterized by long periods of very light rain and/or drizzle. Hence, low T(A) values are obtained during these periods. From the yearly cumulative distributions for 1976, 1977 and 1978, it was concluded that, in general, a more intense form of precipitation occurred in 1977 even though the period of precipitation was about 4000 minutes less than it was in 1976 and 1978.

#### Thunderstorm Characteristics

Computerized rain rate and attenuation time history were obtained for two thunderstorms that occurred during the month of May. In the first storm, three intense cells moved through the elevated beam which caused an outage time of 30 minutes for the 28.56 GHz frequency at an A level of 9 dB. At the 11.7 GHz frequency an outage of 10 minutes occurred at an A of 4 dB. The intense rain causing these fades moved through the beam at a location which was not within the rain rate measurement region. In the second storm, the intense rain cells did follow a path over the rain measuring region and rates  $> 100$  mm/hr was measured. For this storm, the intense cell moved through the beam without a general buildup of precipitation preceding it. In both storms the slopes of the fade intervals were pronounced showing that the rain cells have definite dimensions with large rain rate gradients.

In comparing area and point rain rate values it was found that excellent correlation between the above factors is obtained for low and moderate rainfall rates. During thunderstorms where wind turbulence is a factor, a larger dispersion between point and area rain rates is obtained as would be expected. Computerized scatter plots of ten second mean values of A versus

rain rate for short term precipitation periods show no functional relationship exists between the factors due to an absence of a trend in the scatter plot.

#### Best Fit Analysis

An attempt was made to determine the degree of fit of the measured attenuation and rain rate data to the Log-Normal, Weibull and Rice-Holmberg distributions. For the rain rate data the Log-Normal distribution tends to consistently underpredict the measured distribution in all cases for  $R > 20$  mm/hr. The Weibull distribution with a shape factor (B) of 0.6 tends to over-predict at low values of R and produces a reasonable fit at  $R > 50$  mm/hr. The Rice-Holmberg distribution which employs a series of exponential functions gives the best overall fit.

For the attenuation data, the Log-Normal function produces an acceptable fit at A values  $< 9$  dB. Above this range the Weibull function with a B of 0.6 gives a better fit. It appears that at least two exponential functions are required to adequately fit the measured distribution. These functions can be defined by the shape factor B which must be a function of attenuation.

#### Path Length Analysis

The results of a continuing study of determining path length (L) as a function of rain rate for an elevated radio path are presented. Rain rate and (A) pair values are employed in determining this functional relationship. Five monthly periods and six long term periods were utilized for determining the L (R) factor. No trend from the standpoint of time periods was noticed in the data. The degree of variation of L (R) with R depend on the relative distribution of the A and R factors across the measured limits. It has been concluded that the L (R) factor should not be a critical function of R. The factor should gradually increase as R decreases and only increase at a faster rate for R values less than about 5 mm/hr. Wide variations of L (R) with R

occur when high A values are measured with corresponding low measured values of R. In these cases, it is difficult to obtain an accurate measure of the path average rain rate because of the heterogeneous nature of the rain environment. In order to balance this discrepancy, the L (R) factor must be increased in order to maintain the functional relationship between A and rain rate which is  $A = aR^bL$ .

#### Frequency Scaling

Three different methods of scaling the 11.7 GHz A value to the 28.56 GHz A value were evaluated with respect to measured data. These techniques are empirical scaling, specific attenuation scaling and Gaussian rain distribution scaling. From the above methods, the computed ratio value falls in the range of about 4 to 6 with a decrease in the ratio value as the respective A values increase. Ratio values for the latter techniques depend on the assumed value of the rain cell dimension,  $l_0$ . Assuming this cell dimension decreases as A increases give results that agree with the other methods. Limited samples of concurrent A measurements show that the ratio value is in the range of 4 or 5 to 1. These values generally agree with the computed results.

## EXPERIMENT 4

TITLE: College Curriculum Sharing

DISCIPLINE: Education and Technology

ORGANIZATION: NASA/Ames Research Center,  
Carleton University (First Year Only)  
Stanford University (First Year Only)

OBJECTIVE: Expand scope of curriculum by sharing classes among universities and countries; demonstrate digital video compression techniques for band-width and power reduction.

PRINCIPAL INVESTIGATOR: Dr. Dale Lumb

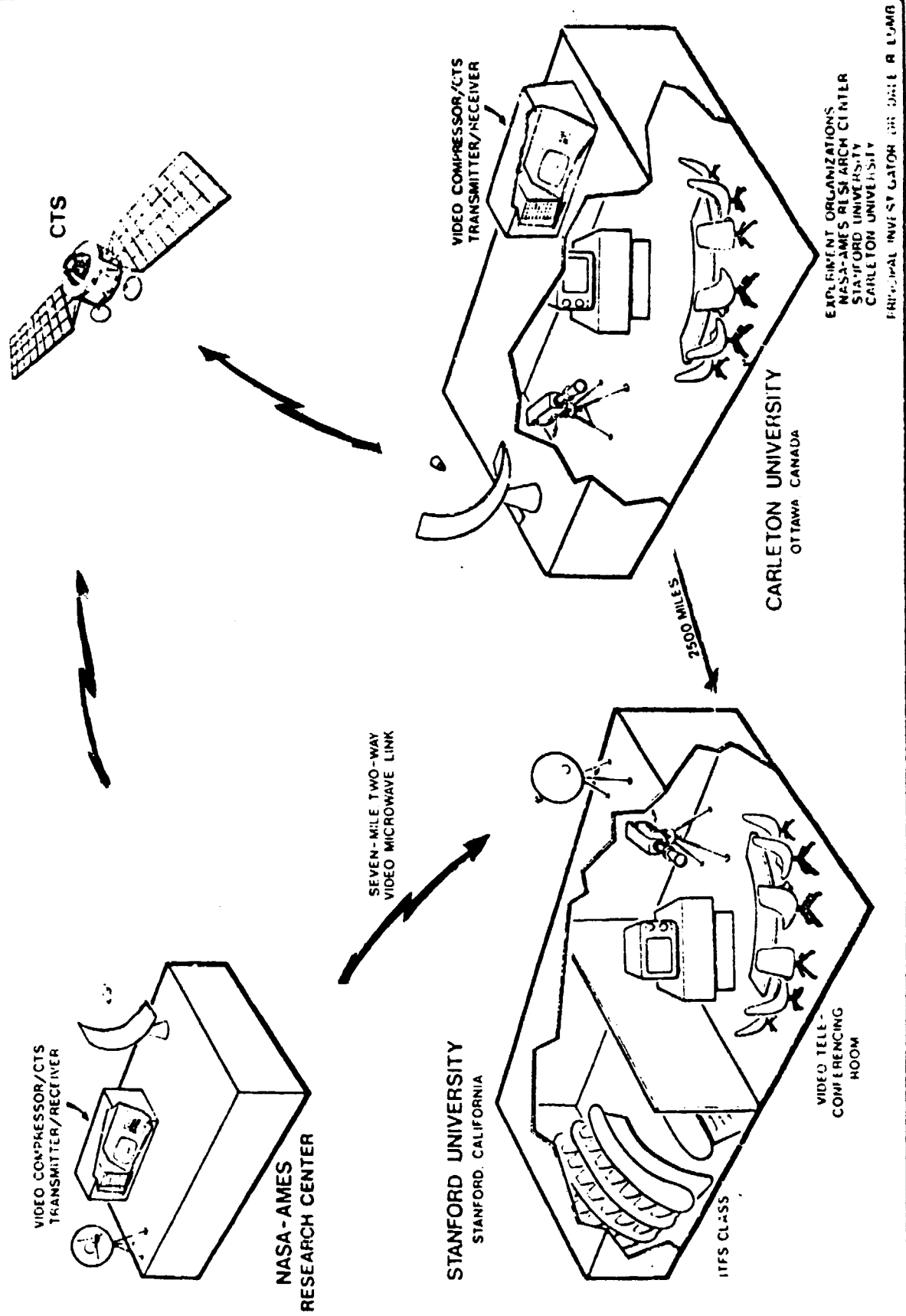
ACTUAL START: First Year Start - 10/76

COMPLETION: First Year Completion - 11/77

ACTUAL START: Second Year Start - 11/77

COMPLETION: Second Year Completion - 11/78

# CTS DIGITAL VIDEO COLLEGE CURRICULUM SHARING EXPERIMENT



## PURPOSE

A curriculum-sharing experiment which enabled students in one university to take courses in another, thousands of miles away, via satellite, was tested with the Communications Technology Satellite (CTS).

Engineering classes and seminars at Stanford University in California were televised to Carleton University 2,500 miles away in Ottawa, Canada, and vice-versa. In addition, scientists and engineers at NASA/Ames Research Center, location of the experiment's west coast earth station, engaged in three-way video conferences with the two participating universities.

The experiment featured real-time digital video compression with channel error correction coding to reduce transmission bandwidth and power requirements.

The CTS experimenters demonstrated the economic feasibility of using video relay satellites not only for curriculum sharing, but also for continuing adult and professional education, and for holding conferences without participants having to travel.

## PROJECT RATIONALE

During the next ten years, domestic communication satellites will dramatically increase communication capacity in North America. As Canada's

Anik satellite has demonstrated, satellites can reach virtually any geographic location. It will be increasingly possible to link institutions or special interest groups around the country by interconnecting cable television and instructional television networks by means of satellite and microwave links. Further impetus will be provided by video compression techniques which have the potential for substantially reducing the cost of video transmission by decreasing the amount of redundant information being transferred, and consequently increasing the effective capacity of the video channel.

These advances have many implications for education. Students and faculty will be able to share their expertise with their counterparts at distantly located institutions, and to interact with them in teaching sessions and conferences. Specialized interest groups scattered around the country will be able to participate in seminars and discussions through the interconnection of various systems utilizing video, sub-video, and audio channels.

Although this potential exists, little evidence was available with which to evaluate the prospects for the application of this new technology.

Questions which needed to be answered included:

1. What is the potential demand for these services?
2. What are the advantages of satellite links as opposed to current means of circulating video material on tapes and cassettes?
3. What variables determine the least cost mix of satellite costs and ground costs?
4. How important is real-time feedback?
5. What administrative problems are likely to emerge as a result of time zone differences and institutional variations (e.g., class scheduling, length of terms, accreditation, grading, logistics of materials distribution, variations in student backgrounds)?



6. Are these systems potentially cost effective?

These and other questions prompted the discussions between individuals from the Wired City Laboratory at Carleton University, the video processing research group at the Ames Research Center, and individuals associated with the Stanford Instructional Television Network.

Although there was considerable common interest among these individuals, each group had its own priorities. The Stanford Instructional Television Network had an established operational system broadcasting live lectures from the Stanford campus via a heavily utilized four-channel broadcast television system to 1,500 student viewers in industrial and academic sites throughout the San Francisco-Oakland Bay region. For them, this experiment enabled their network to be extended 2,500 miles to Ottawa. The effectiveness and practicality of such an extension was of clear interest. At the Ames Research Center, the principal interest was the development and demonstration of high quality audio and visual signal processing systems enabling signals to be transmitted with a significant reduction of the information transmission requirements but not of image quality. In Carleton's Wired City Laboratory, interests included the use of real time interactive television as a communications media for education as well as the use of reduced bandwidth television in teleconferencing applications.

The common theme was an examination of "real world" applications, sources or problems, and costs associated with satellite use for curriculum sharing. Therefore, the focus of evaluation was not so much on learning effectiveness, but on the acceptability of technical quality, the assessment of this educational method by students and faculty, the effectiveness of variations in presentation of material and interaction, the suitability of administrative procedures, the projected economic viability of an operational system, and policy implications of an operational system.

## SPECIFIC GOALS

The specific goals of the experiment were to:

1. demonstrate the ability to expand the scope of instruction by sharing classes between universities that have different emphasis and orientations,
2. devise and evaluate a variety of techniques for the presentation of remote instruction, feedback of student interaction for the user aspect of the curriculum sharing experiment,
3. experiment with diverse techniques and styles of programming to determine cost-beneficial methods of using a satellite link for curriculum sharing,
4. develop strategies for resolving administrative and class management problems created by curriculum sharing between diverse universities. Problem areas that were identified included course accreditation, non-concurrent class times, scheduling across time zones, and classes with different time durations,
5. develop and demonstrate a cost-effective video compression system in conjunction with efficient channel coding and modulation,
6. evaluate the subjective quality of video compression techniques as applied to this teleconference application,
7. demonstrate the effectiveness and practicality of the proposed channel and source coding techniques in reducing satellite bandwidth and power requirements for video users, and
8. determine the effects of rain attenuation and other perturbations of the proposed high data rate digital link at 12-14 GHz.

## EXPERIMENTAL PROCEDURE

Engineering classes and seminars at Stanford University in California were televised to Carleton University 2,500 miles away in Ottawa, Canada, and vice-versa. The primary program content was regularly scheduled engineering courses, with each institution selecting offerings normally unavailable to its own students. Joint seminars, "using the technology to learn about the technology," focused on communication policy issues and issues and topics on satellite communications.

The communication capabilities permitted operation in two primary modes. One mode allowed classes to be transmitted simultaneously from Stanford to Carleton and from Carleton to Stanford with audio feedback for each class. This was done via a single digital stream in each direction, where the audio was digitalized and multiplexed with the digital video. The second mode of operation provided full duplex video for two-way video teleconferencing experiments such as special discussion seminars, student counseling, and problem solving.

A key portion of the experiment was the testing of video compression. The method used transformed the television picture to a different form which concentrated most of the useful information into just one-eighth of the original signal. This concentrated, or compressed, information was transmitted through the satellite to the receiving station where it was transformed back to the original.

## SUMMARY

### Impact of the System

The link was available for the first scheduled lecture, signal quality was good, and such difficulties as did exist could be attributed to equipment on the ground. This was encouraging because the lecture series had to start at the times dictated by the academic programs of the two universities, and the initial weeks when the lectures were videotaped and exchanged through the mail were an unmitigated disaster. Aside from the lack of spontaneity and the inability to "talk back" to a videotape, the uncertainties in the mail meant that the lectures could not be shown at the other end of the system neither on a regular basis nor in the proper sequence. If all this had no other effect, it did make obvious the advantages--perhaps the essential advantages--of the satellite link.

However, as the season progressed into early winter and weather conditions in Ottawa deteriorated, difficulties were experienced. The first, and most objectionable, of these difficulties was the occasional loss of synchronization. In this situation, the video image "broke-up" into a meaningless pattern and there was an accompanying roar of sound in the audio channels. The picture break-ups occurred on the transmissions from Stanford to Carleton, and while the transmissions from Carleton to Stanford did not experience these difficulties, the audio disturbance pervaded the whole system.

By the winter term, the problem of synchronization loss was severe--sufficient to cause a high level of student comment--and not clearly associated with the weather.

The effects of these technical problems on the process of educational communications is not entirely clear. The phenomena may well have been more

disturbing to the experimenters and the system operators than to the participants. It seemed evident that the disturbances in the audio channels were much more aggravating than the video disturbances and audio problems were more severe than video difficulties. In addition to the disturbances associated with picture break-up, the audio channels also suffered from sufficient echo return that "push-to-talk" microphones were required during teleconferences. This was due to problems "on the ground" which remained unresolved until almost the end of the exchange.

#### Reactions of the Lecturers

Notwithstanding the technical problems, classes on the system continued with very little real disruption. The reactions of the lecturers were varied. The Stanford instructors were experienced lecturers on their existing instructional television network and having a few additional students 2,500 miles away, rather than 10 miles away, was not particularly obvious to them. Most of their students were either in the classroom or in the general vicinity of Stanford and attending via television. For the Carleton lecturers the experience was much more novel and, although there had been some previous experience with the use of television technology in the classroom, neither had had previous experience in lecturing to remote students. All the lecturers exhibited vastly different styles of presentation, and this suggests that a television teaching system does not impose a particular lecture style on the instructor. The system does, however, open up possibilities for the development of new lecturing styles not possible when the only technology available is a blackboard and a piece of chalk.

One of the lecturers during the Fall term was an experienced practitioner of that most common of lecture styles: he talked, walked, gestured, and wrote the occasional heading on the blackboard. Another was a meticulous

user of some of the technology available--the over-head camera and the video disk. He put a great deal of effort into the preparation of the graphics used in his lectures and the course proceeded at a quite accelerated pace. Two of the lecturers used a piece of paper under the overhead camera, basically as a blackboard. That is, they began usually with a blank piece of paper and developed their material as they lectured. One in particular made very extensive use of this approach while the other devoted somewhat more time to expositions of the usual lecture type and to the discussion of prepared material. The fifth instructor tended to defy categorization as he tended to use the system to its fullest in a variety of ways. In fact, by use of the overhead camera he was able to engage in teaching "routines" not otherwise possible.

The Carleton professors found that the preparation time required was high, even excessive. It seemed to be generally agreed in discussions between the lecturers at the two universities that this was primarily a "start-up" problem and that when experience was gained, lectures delivered over the television system were no more demanding than usual.

#### Student Attitudes

Initial analysis of the reactions of the students attending these courses is that the television and satellite system is virtually transparent to them, except when it impedes that which they would like to do. Their main concern is the course, the course materials, seeing the professor at the other end, and seeing the notes that he is writing or the graphic material which he is explaining. While they preferred face-to-face lectures, an overwhelming majority would have been happy to take the courses through a satellite system if access to the courses was otherwise denied them.

While a few preferred the anonymity associated with the use of television, most students appreciated opportunities for casual discussions with

the lecturer. It is interesting that attempts to arrange discussions between individual students at Carleton and the lecturers at Stanford failed due to an unwillingness on the part of the students. That is, of course, a common enough occurrence when both the students and the lecturer are on the same campus.

The two student groups--those at Stanford and those at Carleton--appear to have been quite different. Most Carleton students were practicing professionals attending university courses on a part-time basis, or full-time students who had returned to university after a period of professional experience. Stanford students, on the other hand, usually proceed from undergraduate school, where they invariably had high academic standing, directly into graduate work. The academic regime at Stanford is demanding, and there is probably considerable concern about grades on the part of the students. This is not a primary concern of many of the special and part-time students at Carleton.

Interaction between the students and the lecturers using the audio feedback facilities appears to follow patterns very similar to the regular classroom situation. That is to say, the amount of in-class discussion between the lecturer and students depends very much on the style and personality of the lecturer and his way of presenting the material. As is usual in most classroom settings--given the kinds of courses which were exchanged--most of the time is devoted to the lecturer's monologue. However, after a period of time students and lecturers did enter into more verbal interactions. At times this was quite extensive. A few special sessions that were arranged, particularly for discussion, were quite successful, but it may be that the ability to be able to interrupt may be more important than the interruption itself.

### The Operational Situation

The mechanics of turning the system on and off every day became a smooth routine, and that suggests that the technical problems of an operational system would not be severe. Many more difficulties exist in meshing the academic processes of two separate institutions, although in an operational setting experience alone would alleviate the situation. It would appear that course administration, such as handling assignments, examinations, marking and so on should be handled locally, particularly in light of the severe difficulties experienced in exchanging textual materials. The shipment of books, class notes, and similar items, was a continual harassment. Vigorous efforts to have these materials available beforehand, together with adequate facsimile transmission equipment, should suffice to eliminate most difficulties.

Time zone differences could be a problem but in this case this was not so. Fortunately Stanford courses given in the afternoon occur in the early evening at Carleton, and it is a Carleton practice to offer the engineering graduate courses in the late afternoon and evening to allow the participation of part-time students. It should be said, however, that Friday evening lectures did not have great appeal in Ottawa.

The experiences are perhaps best summarized in terms of the potentials for an operating system. Technical operations were smoothly accomplished and the functional aspects of performance inadequacies were not large. In any event, they are not intrinsic to the system. In particular, the compressed television system was certainly sufficient given adequate care with the graphics. More refined methods of course management are needed, but the provision of facsimile facilities and some opportunity for the lecturing and tutorial staff to have periodic conferences would go a very long way. It would seem in the long run that the demands on the lecturers would not be excessive, and the students would be satisfied to attend courses by means of television if this made more interesting courses available to them.



## AN ASSESSMENT OF THE EXPERIMENT

In assessing this experiment, one must be careful to differentiate between those elements which relate to the planning and conduct of the experiment, and those which bear on the exchange of courses between universities by satellite. The latter is the real purpose of the exercise. The former may be of interest to those planning further projects of this kind.

Since it was not possible to arrange special training for the lecturers, and since sufficient resources were not available to enable the most ideal administration and planning for the event, it was decided to let the normal processes of the university take care of the administrative and academic problems that arose during the course of the curriculum exchange. In this way, the impact of the exchange was made obvious and, hopefully, some measure (however qualitative and subjective) of the success of normal procedures in handling special problems of distance teaching via video via satellite was made. The result of this process has been described previously, and we consider this "experimental method" to be appropriate.

Financially, the project was under-funded when viewed as a whole, particularly in the light of the complications of the physical separation of the participants, and the complex nature of the enterprise. There is no doubt that the cancellation of the Department of Communications' Educational Technology Programme had a decidedly adverse effect on this project. While no direct support from that source was assured, it was assumed that at Carleton the "Educational Communications Project" would produce an environment, experienced personnel, and support resources to enable more extensive instructional innovations and evaluations than turned out to be possible.

Stanford's failure to obtain contract funding for their involvement severely hampered their participation. Indeed, had it not been for the voluntary participation, the Stanford element of the project would have collapsed.

Even with the most abundant financing, some of the detailed objectives and goals could not have been obtained. In early planning, we assumed an impossible mix of elements of experiments and trials. Of course, the first assumes restrictive--and unrealistic--controls, while the second implies the absence of such controls but greater reality. We had both, as must all projects of this type.

Technically the project was demanding and 90% successful. Unfortunately, the imperfections of the system impacted rather severely on the instructional activity, and could not be remedied in the time frame of the experiment. The ongoing, operational nature of the curriculum exchange made it impossible to stop and conduct the necessary diagnostic studies. This too is an intrinsic element of such endeavours.

The major difficulties in the operation of a system for melding the capabilities of a number of institutions via course exchange by satellite are not to be found in the technical operation of the system, nor in the academic operation of the courses themselves. While care must be taken with respect to some of the elements of those processes, more significant difficulties are to be found in the inevitable mis-matches between the universities involved. Different academic traditions and different student groups with individual needs and requirements pose the more significant hazards to the success of an operational course exchange program.

There is much to be gained from the integration of resources and from the bringing together of the academic community, particularly those who are remote from the major population centers. Communications satellites offer a practical means for this integration, perhaps the only means.

## EXPERIMENT 6

TITLE: Transportable Emergency Earth Terminal

DISCIPLINE: Special Services

ORGANIZATION: COMSAT Laboratories

OBJECTIVE: Demonstrate suitability of transportable earth terminals to relay communications to and from a disaster area.

PRINCIPAL INVESTIGATOR: Dr. Joachim Kaiser

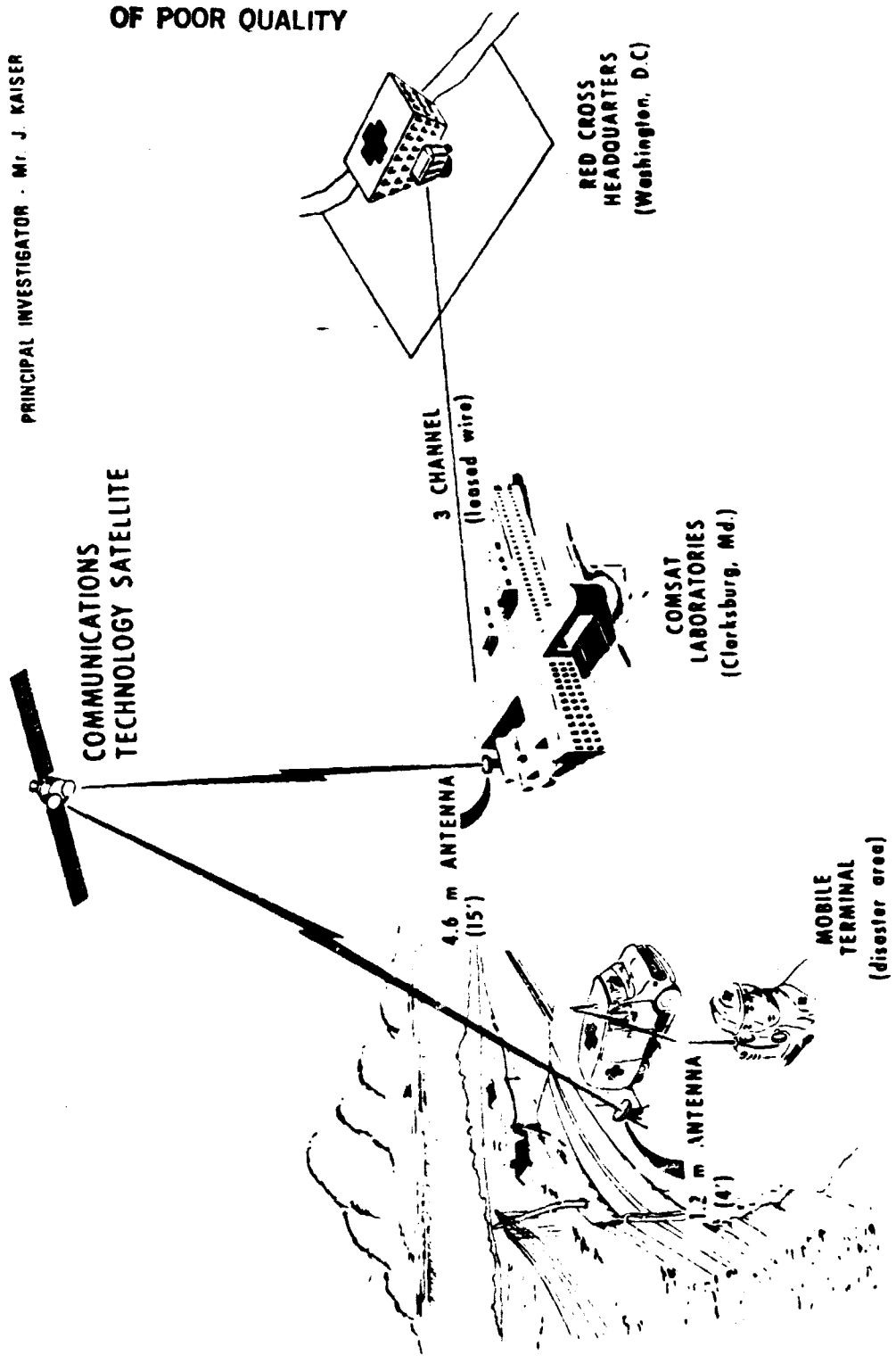
ACTUAL START: 5/76

COMPLETION: 6/79

# COMSAT TRANSPORTABLE EMERGENCY EARTH TERMINAL EXPERIMENT

PRINCIPAL INVESTIGATOR - Mr. J. KAISER

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## PURPOSE

The purpose of the Transportable Emergency Earth Terminal experiment, conducted by the Communications Satellite Corporation, was to show that, as a result of the synergism of technologies which then existed, a lightweight earth terminal which could be mobilized quickly to respond to disasters could be fabricated. Such a terminal would be capable of providing reliable emergency communications via satellite from the disaster area to distant relief agencies.

Even in the U. S. there were disaster situations in which the requirements for increased and more reliable emergency communications were very real. These more stringent requirements were due to the severity of the disaster, the remoteness of the area, and the increased demands for communications, especially for coordination and administration. COMSAT intended to demonstrate that satellite communications could fill these requirements.

## OBJECTIVES

The objectives of the demonstration were divided into three categories: technical, operational, and economic. The technical objectives were as follows:

- a. to design a terminal to reliably fit the requirements of the demonstration;

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- b. to procure simple, low-cost, off-the-shelf components and hardware when possible;
- c. to package the terminal for ruggedness and mobility;
- d. to conduct wideband communications tests at 11 and 14 GHz;  
and
- e. to gather data on propagation and attenuation properties at the higher frequencies.

There were three basic operation objectives:

- a. to demonstrate a quick reaction to emergency communications requirements;
- b. to utilize many types of transportation, such as truck, boat, helicopter, and light plane; and
- c. to gain working experience with many disaster organizations.

The economic objectives were the following:

- a. to keep detailed and accurate records of the actual cost of the demonstration;
- b. to show that emergency disaster communications via satellite are desirable and economically compatible with other disaster communications services; and
- c. to determine the applicability of a highly mobile earth terminal to other international and domestic requirements, such as peacekeeping efforts and video and audio news coverage.

## ABSTRACT

The COMSAT experiment was designed to explore the feasibility of providing communications via satellite in disasters or emergencies when normal communications are disrupted. During the experiment, other uses of small earth terminals were also explored.

For this experiment, COMSAT designed and constructed a number of earth terminals. The two basic terminals consisted of a tripod mounted 1.2-m transportable terminal and a fixed 4.6-m terminal located at COMSAT Laboratories in Clarksburg, Maryland. The electronic components for the 1.2-m terminal were also used with a 2-m and a 2.4-m reflector and associated feeds on a variety of mounts for special purposes.

Two completely self-contained 2.4-m road transportable earth terminals were built by COMSAT for CTS project "Prelude" Experiment No. 24, jointly conducted by SBS and COMSAT. These terminals were also used for special experiments performed under COMSAT Experiment No. 6. This report describes the activities of Experiment No. 6 from April 1976 to June 1979.

The 1.2-m transportable earth terminal and the 2.4-m trailer mounted earth terminal were licensed to be deployed anywhere within the continental U.S. and to be operated with a maximum transmitter power of 20 W. The 4.6-m terminal operated as a fixed station at COMSAT Laboratories in Clarksburg, Maryland, with a maximum transmitter power of 200 W.

A wide variety of experiments were conducted ranging from the basic experiments in disaster communications to the transmission of digital color T.V. in a video conference, and finally an experiment in the synchronization of two primary time standards (master clocks) via CTS.

## EVALUATION OF THE COMSAT EXPERIMENTS

At the beginning of the experiments, NASA desired that each experiment be evaluated in terms of its usefulness to the public and possible future service. During the early disaster communications exercises, the participants attempted to meaningfully evaluate the satellite communications system. This evaluation attempt was a failure for several reasons. The participants in the exercise were predominately local Red Cross volunteers who dispersed immediately after the conclusion of the exercises, and very few of the evaluation forms were returned. During the actual disasters, the participants were too preoccupied with the relief work at hand to complete any questionnaires. However, there were a number of informal debriefings and discussions held with the American Red Cross personnel of the Washington Headquarters. The following observations resulted from these discussions.

The satellite communications link at Johnstown was most valuable and effective in restoring the communications, particularly during the time when the local telephone exchange was completely out of commission, and the satellite link was the only means of communications in and out of the flood stricken area. The two telephone lines adequately handled most of the traffic in and out of the Red Cross relief headquarters in Johnstown. The use of a facsimile machine to transmit situation maps showing the location of the most devastated areas was helpful to planners at the National Red Cross Headquarters in Washington.

The communications links functioned better outbound from Johnstown than into Johnstown from an organizational point of view. That is,



outgoing calls could be placed directly by the Red Cross personnel at the Johnstown earth terminal, but incoming calls had to be routed from the calling party to two telephone numbers at COMSAT Laboratories. These numbers were not generally known to many of the agencies who wanted to contact the Red Cross in Johnstown. This was both an advantage and a disadvantage, in that it kept unofficial inquiries from clogging the channels, but also complicated matters for persons who had valid reasons to call Johnstown.

It was concluded that considerable planning is required for the effective use and application of any future satellite emergency communications system. The exercises in Texas and Cincinnati, Ohio, indicated that hard copy communications, such as teletype and facsimile, are a real asset in disaster relief communications.

Approximately 39 hours of operation were conducted on all of the aspects of the Transportable Emergency Earth Terminal experiment. Some of the terminals were used in conjunction with other experiments and the hours of operation were reported under those experiments.

It is concluded from these experiments that disaster relief communications via satellite is valuable. The CTS has been an excellent vehicle for advancing the satellite communications technology, particularly in the applications of small earth terminals to communications directly from the users premises. The CTS and all of the experiments have accelerated the development of earth terminal components for the 12/14-GHz frequencies.

## EXPERIMENT 7

TITLE: Biomedical Communications

DISCIPLINE: Health Science

ORGANIZATION: Lister Hill National Center for  
Biomedical Communications

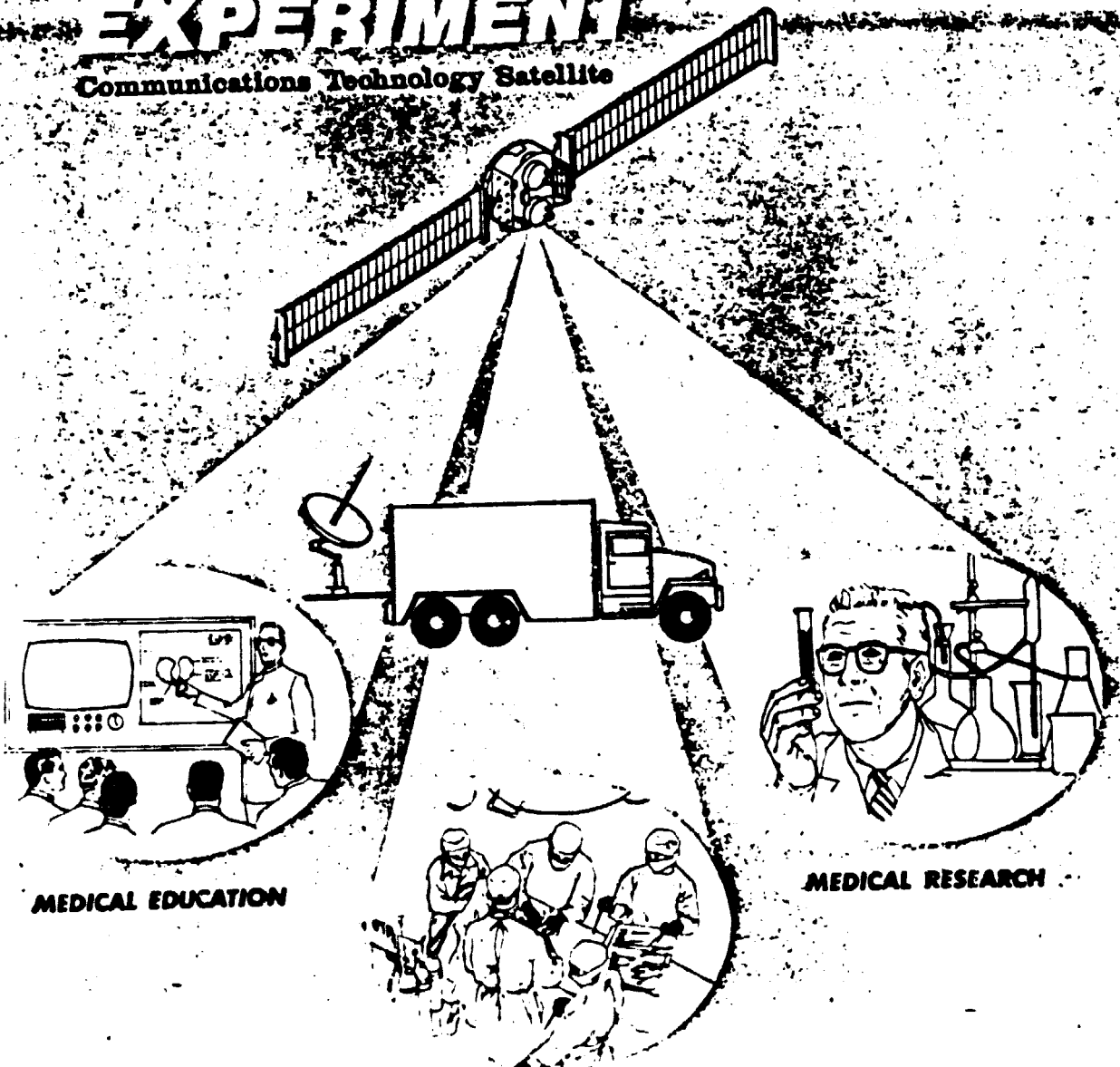
OBJECTIVE: Promote wide dissemination of information  
between research institutions and the medical  
community; evaluate broadband teleconferencing  
to support continuing education among health  
care professionals.

PRINCIPAL INVESTIGATOR: Mr. Earl Henderson

ACTUAL START: 6/77

# **BIO MEDICAL COMMUNICATIONS EXPERIMENT**

**Communications Technology Satellite**



**MEDICAL EDUCATION**

**MEDICAL RESEARCH**

**HEALTH CARE**

**U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE**  
Public Health Service

## PURPOSE

US-7 was "designed to provide interactive video communications between medical seminars, medical educational programs, special medical presentations, and medical professionals located within the National Institute of Health. This program was planned as a preliminary design and evaluation phase in the development of a National Broadband Biomedical Communication Network (BBCN)."

To further define the purpose of their experiment, Lister Hill outlined the following plan:

1. Knowledge Development
2. Prevention
3. Improving the Health/Care System
4. Assuring the Quality of Health Care
5. National Health Insurance
6. Tracking and Evaluation
7. Management

## OBJECTIVES

Major objectives of the experiments included technical developments, information transfer and medical education parameters. Technically, the project developed and evaluated:

1. Broadband material distribution systems and techniques.
2. Addressable medical security systems for doctor-patient privacy.
3. Cost-effective color videotransmission and reception systems.
4. Low cost error correcting systems for data transmission.

As an aid to future document distribution systems, the experiment evaluated cost-effective techniques for the distribution of medical literature and audio visual material.

In support of continuing education programs for health professionals, the project:

1. Evaluated medical professionals' acceptance of teleconferences by satellite as a tool to support continuing education programs.
2. Evaluated interactive video transmissions as an effective substitute for in-person participation in medical seminars.

General objectives for US-7 were the promotion of:

1. faculty sharing,
2. continuing education for health professionals,
3. dissemination of research results,
4. information dissemination on health-related topics, and
5. teleconference techniques.

## CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

The conclusions cited here are drawn from the range of results obtained from the CTS biomedical applications and data collected on technical parameters.

1. For the first time, large numbers of people were exposed to communications satellite technology in biomedical applications.
2. Satellite technology is highly reliable and is capable of providing high quality audio and video for:
  - a. face-to-face interaction,
  - b. graphic presentations and discussions,
  - c. demonstrations of techniques, and
  - d. didactic lectures.
3. Geographic distances do not affect telecasts. This was reinforced by effective studio echo suppression and network management.
4. Satellite communications provide opportunities for resource sharing between institutions.
5. Satellite communications enable many students and professionals to interact with leading researchers and clinicians.
6. Satellite-mediated instruction is as effective for learning as other modes, including in-person instruction.
7. Two-way video is not needed for most didactic lectures. The extent of learning is not significantly different for two-way

audio-video than for one-way audio-video with return audio.

One-way video with two-way audio provides a satisfactory level of interaction.

8. Two-way video is not needed except when the exchange of visual information is needed: medical procedure demonstrations, graphic material reviews and complex problem solving.
9. Commercial television production standards (e.g., sophisticated equipment and a large professional support staff) are not needed for effective teleconferences or teaching programs.
10. Satellite video communications can be used effectively by teleconference and teaching participants with little specialized training.
11. Commercial satellite-mediated video teaching and teleconference costs become very reasonable when distributed over large numbers of users, but the opportunity for interaction with presenters is inversely related to the number of participants.
12. Based on designed levels of performance, the network demonstrated adequate link margins, and consequently high-quality reception of color video and audio signals, under both one-way and simultaneous two-way modes of operation.
13. The link margins experienced were adequate to fully compensate for the adverse weather conditions encountered over the year for which detailed data were available.
14. The specifications on important ground terminal elements such as the high power transmitter and low noise receiver could be relaxed with no perceptible degradation in performance. Substitutions could lower costs. Automated antenna tracking was convenient but not necessary.

15. A satisfactory and cost effective solution was found for the echo problem.
16. The ground station equipment was highly reliable, although two items, the klystron and the phase-lock oscillator, needed more maintenance than expected.
17. Malfunction of ground station or studio elements at non-Public Health Service sites, often due to incomplete checkout or inadequate calibration, caused the greatest loss of scheduled program time in 1978.
18. Although the CTS's communication subsystem was well suited for simultaneous interaction between two sites anywhere in North America, it was not designed to allow interaction with three sites. For example, site A in one footprint could not transmit to both Site B in the same footprint and to site C in the other footprint covering another part of the country. This problem was solved by having C combine its own video signal with A's signal in a "split-screen" format, and retransmit the composite back to A and B. This allowed B to see both sides of conversations.
19. Programs were successfully conducted involving Seattle, Bozeman, and Fairbanks in one footprint. This demonstrated that wider communication than had been expected was possible.
20. It was found that, with some perceptible degradation, the high powered band could be shared between two video signals. Several programs were successfully conducted using this feature which was not originally designed into the system.



The effectiveness and reliability of communications satellite technology have been demonstrated in a variety of biomedical applications and settings. What factors are likely to affect the future role of this technology in biomedical information transfer?

1. The demand for medical information is growing. More course hours are needed for recertification and the number of states and health specialities requiring continuing medical education is increasing.
2. Satellite-mediated teaching and teleconferences have many competing alternatives.
3. The most cost-effective use of satellites may require long-term capital investments for studio facilities and terrestrial communication links.
4. Biomedical teaching and teleconferences via satellite require considerable intra- and inter-organizational cooperation.
5. Availability of fixed and mobile ground stations and terrestrial links will determine which cities, states, and regions participate in satellite-mediated biomedical communications.

Considering these factors, it was concluded that communications satellite technology will complement, but not replace, existing biomedical communications modes.

#### Recommendations

Many variations of information dissemination format, information content, communications media, and organizational participants were used in the CTS biomedical experiments. Several areas remain for further study. The following issues are recommended for further investigation:

1. Comprehensive resource requirements for satellite applications, including costs such as coordination time, training for participants, and preparation of graphic materials.
2. Resource requirements for satellite-mediated compared to other teaching modes to aid health professionals and health educators as they consider continuing education alternatives.
3. The use of communications satellites in administrative applications such as national and regional meetings for planning and budgeting for large health organizations.

TITLE: Health/Communications

DISCIPLINE: Health Care

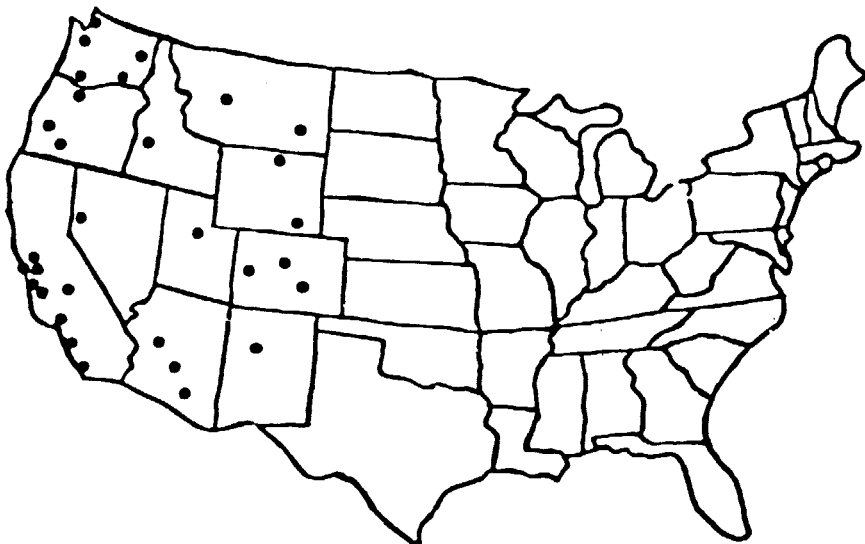
ORGANIZATION: Veterans Administration

OBJECTIVE: Refine and validate applications of satellite-based biomedical communications among thirty V.A. hospitals and surrounding communities for diagnosis, therapy and education.

PRINCIPAL INVESTIGATOR: Mr. Robert Shamaskin

ACTUAL START: 10/77

**SITES**



# HEALTH COMMUNICATIONS EXPERIMENTS

As the nation's largest health care delivery system the Veterans Administration is constantly exploring scientific and technological developments to determine how they can be employed in the exchange of medical information



PRINCIPAL INVESTIGATOR  
ROBERT B. SHAMASKIN



PHYSICIAN  
EDUCATION  
THERAPY

## PURPOSE

The V.A.'s experiment on CTS was undertaken to further examine the value of satellite communications for mediating the requirement for a free flow of information through its health care system.

## OBJECTIVES

Specifically the study had the following intents:

1. To provide health professionals, in remote as well as urban locations, with current medical information required for provision of the highest quality of medical care in easily accessible formats.
2. To demonstrate the normal uses of two-way television, audio, and other electronic messages carried by satellite should satellite communications become permanent within the V.A. system.
3. To determine the cost effectiveness of satellite transmitted communications versus conventional methods of information exchange.
4. To define potentially cost effective applications of communications satellite technology for improvement of patient care outcomes within the system of V.A. hospitals.
5. To research potential satellite uses that were not possible on ATS-6.
6. To research satellite applications which the ATS-6 experiment indicated appropriate for further research.
7. To provide information to large groups of users at one time.
8. To provide critical information to single users.

9. To study the potential non-clinical uses of satellite-technology made possible by the unique features of CTS.
10. To design and validate innovative uses of satellite technology made possible by the unique features of CTS.
11. To provide access to scarce resources, such as medical consultants, to hospitals in remote locations.
12. To define methods of making V. A. resources available to community hospitals utilizing satellite communications.
13. To ascertain the most effective means of utilizing satellite capabilities for V. A. communications.
14. To provide the agency with a report, including: an edited, independent evaluation study of the CTS project, the long-term cost of each application tested, satellite options available to the V. A. through 1988, and specific recommendations for satellite communications usage, based upon data derived from the ATS-6 and CTS experiments.
15. Wherever practicable, to utilize in-house, V. A. production facilities and provide assistance to V. A. personnel in developing communications, production and technical skills.

#### GENERAL CONCLUSIONS

1. Properly presented, continuing education programs suitable for accreditation can be delivered to V. A. health professionals in an interactive mode using satellite telecommunications.

2. Through careful definition of target audiences, especially groups of allied health professionals and nurses, programs can be designed to attract sufficiently large numbers of participants to be cost effective as compared with:
  - a. Travel to seminars and workshops (especially when only a select number of individuals are able to participate, and when taking into consideration time and salary losses of such travel);
  - b. Receiving such programs on videocassettes, considering duplicating and mailing costs and the lack of interaction.
  
3. As satellite communications become a more permanent feature, as health professionals and support personnel come to rely upon them as an accessible means of gaining information, audiences for programs will increase, making individual programs even more cost effective. This audience reliance can be gained by:
  - a. Providing specific audiences with in-depth information on series of programs, at constant hourly times, at the same time each week.
  - b. Planning programs with enough lead time (at least three months) for target audiences to include them in their schedules. (It was learned that important medical breakthroughs occur infrequently and generally over a long period of time thus dissipating the advantages of the CTS flexible programming concept.)

- c. Providing printed study guides including a summary of program contents, pre-and post-tests, pertinent graphics and printed lists, and a comprehensive bibliography.
  - d. Targeting a larger number of programs to those audiences least likely to have access to the same information; i.e.: allied health, nurses and support personnel.
  - e. Working with community relation personnel within the V. A. facility to inform non-V.A. personnel of programs that will be of interest to them.
4. Although patient consultations and management teleconferences did not prove to be cost effective in the ATS-6 or CTS experiments, nor could they economically justify satellite interconnections if they were the only purpose for such connections, they do compare favorably to travel costs for the same purposes when a satellite transmitter is already in place. For example, in a V. A. facility having a transmitter for broadcasting educational programming to other facilities, the cost of a patient consultation would be about \$200, which compares favorably to travel costs; the same would hold true for teleconferences, for which the coordinator might travel to a fixed transmitter site while other participants communicated by audio channels, already in place, from their own facilities.
- a. Patient teleconsultations proved to be effective alternatives to travel for face-to-face diagnoses



in most instances during the CTS experiments; the great majority of physicians and patients participating in the teleconsultation experiments expressed satisfaction with the medium and its ability to facilitate such consultations between distant points. Patient screening, remote diagnosis and treatment consultation were all shown to be reliable by satellite telecommunications when compared with in-person consultations made from one to seven days later.

- b. Teleconferences by Satellite demonstrated that telecommunications can serve as an alternative to transportation for some types of meetings. Familiarity among participants, regularity of meetings by the group, and other factors determined the success of the meetings attempted via CTS and could be used to predict the success of future meetings among V. A. hospital directors and other potential groups, as suggested by the text used to develop the CTS teleconferences.
5. Well produced V. A.-sponsored interactive television programs for V. A. patients and their families, and the general public, demonstrated the ability of this satellite mode to attract a large general audience (as indicated by programs presented on broadcast television stations in the San Francisco area). Although research into the

specific effect of such programming on community health or upon the "public relations" value of the programming was beyond the scope of the V.A./CTS project, many letters from viewers regarding the two public programs indicates the good will potential of such programs. A separate presentation of the same programs, on closed circuit via satellite, into V. A. hospitals, was not shown to attract a large separate audience of Veteran patients. Furthermore, patient education specialists with the V. A. did not favor such programs except for the most general kinds of health education--programming most suitable to the general public. Special programming, within the V. A. facilities, for patients only, is not felt to be an effective use of satellite telecommunications at present.

6. The magazine format: "The VA National Medical Satellite Journal," did not demonstrate a sufficiently large, separate audience to warrant this series being expanded to a larger network of V.A. hospitals, although V.A. health professionals who viewed the Journal between interactive continuing education programs generally found the content of current medical developments to be interesting, informative, and in many cases, new to them (and recommended that this format be continued in future V.A. satellite experimentation).

(The direct costs of producing the Journal for the CTS experiment were said to be "highly effective" in the evaluation report, but this was due to the fact that the Journal segments

were often produced at events and locations where the production team and facilities were developing continuing education programs. If all Journal segments were separately produced, the total cost would probably exceed the amount justified by viewer interest indicated in the experiment.)

EXPERIMENT 13

TITLE: Communication Support for Decentralized  
Medical Education

DISCIPLINE: Health Care

ORGANIZATION: University of Washington School of Medicine,  
WAMI Program

OBJECTIVE: Refine uses of satellite-based communications  
in support of teaching, administration, and  
improved patient care in multi-state medical  
education environment.

PRINCIPAL INVESTIGATOR: Mr. Roy Schwarz, M.D.

ACTUAL START: 6/77

COMPLETION: 6/79

# COMMUNICATION SUPPORT FOR DECENTRALIZED MEDICAL EDUCATION

School of Medicine, University of Washington

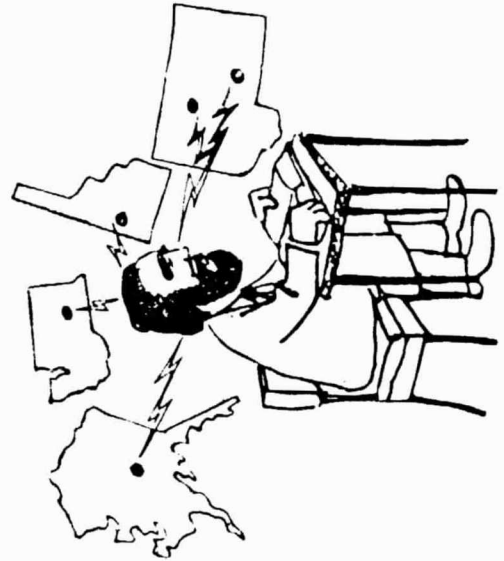
*Principal Investigator*  
**M. ROY SCHWARZ, M.D.**  
Associate Dean for Academic Affairs  
Director, WAMI Program



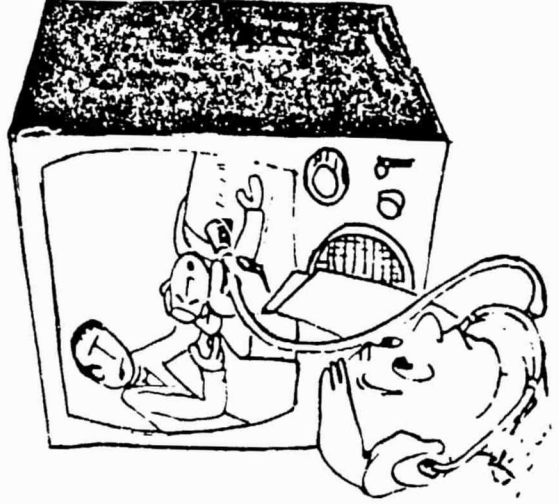
Independent Learning



Admissions and  
Minority Recruitment

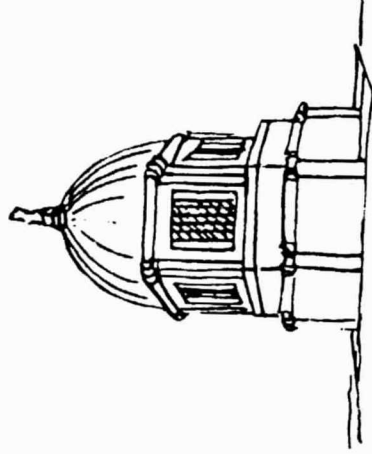


Regional Faculty Sharing



Consultation Process

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Legislative Process

PURPOSE

The WAMI Program was designed to test the feasibility of using satellite communications to further medical education, consultation and health care delivery, and to improve the administration of health-related systems.

RATIONALE

Because the University of Washington in Seattle has the only medical school in the WAMI Region, finding solutions to some of the unique health problems of this region are limited. The WAMI Program proposed in 1970 was created to meet the following four major health problems in the Pacific Northwest and Alaska:

1. Admissions to Medical School

Beginning in the late 1960's, a progressively greater number of students applied for admission to medical school without a corresponding increase in facilities. This was especially difficult for states without medical schools, since preferential access to state-supported schools has been traditionally reserved for residents. Admissions of out-of-state students had been uncertain and was expected in the face of increased resident applications to be curtailed.

2. Lack of Primary Care Physicians

In 1970, the WAMI states had too few family physicians, primary-care internists and primary-care pediatricians. This deficiency was especially severe in the more rural area of the WAMI states.

3. Maldistribution of Physicians

The majority of the physicians were located in the larger towns, leaving large, sparsely populated areas with too few health professionals. When the geographic maldistribution was coupled with an insufficient number of primary care physicians, a severe shortage was evident in the remote areas of the WAMI states.

4. Access to Education and Health Care Resources

Physicians in isolated communities had restricted access to education. Because of this, research findings are often slow in reaching patients in rural areas.

In 1970, only a limited number of tertiary healthcare facilities existed in the WAMI states. Since the University of Washington Health Science Center had a number of treatment resources, including centers in neonatology, burns and trauma, epilepsy and child development and mental retardation, a way to bring these resources to communities with needs was desirable.

The greatest challenges in establishing and maintaining the WAMI Program was the continuous need for adequate communications. The following five specific communication needs were identified if the program was to succeed:

1. Faculties and educational facilities located at widely separated locations must be shared and integrated into a meaningful whole.
2. The quality of the educational experience at the multiple universities and community training sites must be continuously coordinated and supervised.
3. Student performance must be evaluated.

4. A strong, cohesive administration to address the political, fiscal and academic problems which attend cooperative efforts must be maintained.
5. Key decision makers within state and federal governments and local communities must be informed of the needs and achievements of shared regional education on an on-going basis.

Each of these objectives involved a transfer of information among people who are widely separated, often by more than 3,000 miles.

In 1974, WAMI began experimenting with the Application Technology Satellite (ATS-6) to determine if this new technology could help meet these communication needs.

Although the experience on ATS-6 demonstrated the acceptance of interactive communications as a useful education tool, it did not provide enough data to evaluate how best the satellite information system could serve WAMI. Therefore, the CTS experiment was planned to expand, intensify and extend certain aspects of the ATS-6 experiments in addressing the communication problems involved with the WAMI program. The CTS experiment was designed to find out which areas of the WAMI program and which of the communication needs could be satisfied through satellite communications.

## OBJECTIVES

The following objectives and goals of the WAMI program were designed to obtain the necessary data to evaluate the usefulness of satellite communication for the WAMI project, which was divided into five sub-experiments:



### Legislative Process

Assessment of the feasibility of using interactive audio video satellite-mediated telecommunications to facilitate interactions among individuals and groups involved in the legislative process.

Conduct of meetings of groups and individuals so involved.  
Evaluation of the acceptability of the medium to the persons involved in these teleconferences.

Assessment of the degree to which those using the system felt it could replace conventional access to the legislative process.

Identify problems encountered in the use of this system in the real world of governance.

### Minority Recruitment

To schedule and conduct broadcasts oriented toward the recruitment of minority students into the health professions.

To inform minority students in both secondary and post-secondary teaching institutions of the career opportunities available in the various fields of health care.

To inform minority students and those educators who interact with them at the secondary and undergraduate levels of the requirements for entry into and ultimate completion of the curricula in the various health careers.

### Admissions Process

Compare medical school applicant interviews conducted via satellite with those conducted in person.

### Faculty Sharing

Present via two-way interactive satellite communications to the

University of Alaska and Montana State University first year WAMI medical students course enrichment material in the form of clinical correlations, patient interviews, didactic lectures, and student/faculty discussions in the course of Bio-chemistry, Physiology, Tissue Response to Injury, Endocrinology, and Nervous System Pathology.

Present to students enrolled in the WAMI program at Montana State University a full elective course in nutrition.

Evaluate student faculty acceptance of satellite-mediated instruction.

#### Consultation Process

Demonstrate the acceptability of regularly scheduled interactive audio/video communication for teleconsultation purposes.

Facilitate communications between physicians in need of a consultative service and the University of Washington School of Medicine Health Science Center and specialists providing that service.

Assess the comparability of teleconsultation procedures (e.g., telephone or mailed consults).

Test whether visual transmission of such information as microscopic slides, radiographs, and laboratory data on the patient under consideration can adequately be accomplished via the CTS system of telecommunications.

Demonstrate that physicians' interest can be sustained by basing continuing medical education programs on patient problems at locations remote from a university medical center.

## TASKS

### Legislative Process

Nine teleconferences involving 382 participants including federal health administrators, legislators, legislative staff members, health planners, physicians, educators, university administrators, members of accrediting bodies, and students were successfully completed during the experiment.

During some of those broadcasts, the Portable Earth Terminal belonging to NASA was made accessible to expand the number of participants that could be involved. The use of this vehicle was felt to be of the greatest importance to this sub-experiment.

Not only were the numbers of participants involved greatly expanded, but the technical complexity of some of the broadcasts were far beyond what was expected.

After each broadcast, a questionnaire was given to each participant to fill out. This would provide the data to assess the usefulness of satellite technology in the Legislative Process. A narrator response form was given to several of the officials to evaluate what the good and bad aspects of teleconferencing the Legislative Process were. A cost-effectiveness study was also done to compare travel expenses with teleconferencing expenses for the Legislative Process.

### Minority Recruitment

Seven teleconferences involving 108 participants were successfully completed over a nine month period. One of these teleconferences involved the Portable Earth Station (PET) from NASA, which enabled a larger number of students to participate.

Each participant was provided with a questionnaire to complete after each teleconference, and a final questionnaire after the completion of this sub-experiment which addressed their opinion on the use of satellite technology.

Educators analyzed the reactions of the participants during the live interactive sessions.

The ultimate tests would be an assessment of the increment of minorities and women who enter the health professions in the WAMI region, but this type of evaluation would take time not allowed for during the WAMI experiment.

#### Admissions Process

Due to delays in funding and limited time on CTS, the satellite Admission sub-experiment was discontinued as of February, 1978. Final evaluation was based on past experience on ATS-6 and the eight broadcasts on CTS. A cost analysis of travel vs. teleconferencing was also completed.

#### Faculty Sharing

Over the entire experiment, there were 75 broadcasts conducted, 50 broadcast teaching tapes prepared and approximately 3,400 student contact hours of teaching involving 70 faculty members.

All broadcasts were video taped for subsequent analysis regarding interpersonal interaction via satellite versus interpersonal interaction in person.

## GROUND SEGMENT

### Legislative Process

Participating sites: Rosario, WA  
(two-way video) Bethesda, MD - Exp. #7, Lister Hill  
Seattle, WA  
Boise, ID  
Fairbanks, AK  
Helena, MT  
Pullman, MT  
Moscow, MT  
Washington, D.C. - Goddard Space  
Flight Center,  
NASA Headquarters

### Minority Recruitment

Participating sites: Seattle, WA  
(two-way video) Fairbanks, AK  
Bozeman, MT  
Browning, MT

### Admissions Process

Participating sites: Bozeman, MT  
Fairbanks, AK

### Faculty Sharing

Participating sites: Fairbanks, AK  
(two-way video) Bozeman, MT

Consultation Process

Participating sites:

- Bozeman, MT
- Fairbanks, AK
- Seattle, WA
- Pocatello, ID
- Missoula, MT
- Great Falls, MT
- Browning, MT
- Spokane, WA
- Rosario, WA
- Billings, MT
- Kalispell, MT
- Pullman, MT
- Moscow, MT

RESULTS

Legislative Process

In general, participants felt that the technology was applicable to the public decision making process, that information could be exchanged in this way, and that the issues discussed were relevant, useful, clear and helpful. Participants also judged the audio quality, volume, picture quality, and color to be excellent. However, occasional technical problems such as the intensity of the lights and the heat in the studio, along with the audio switching, were of some concern. Participants at each site found satellite communication to be easy to use and, in general, felt it could replace a significant proportion of intrastate as well as interstate travel. In general, the medium was considered to be slightly

less effective than in-person communication, was definitely more effective than mail and telephone, and 87.5% felt they would be willing to conduct further hearings in this way since this was the only way input from the group of people could be obtained.

One especially meaningful, unsolicited comment from a participant in a broadcast between health planners and the Administrator of HRS was, "It (satellite broadcast) is probably the closest to personal contact that the majority of us will ever have."

The cost-effectiveness study showed significant savings in using satellite communications.

#### Minority Recruiting

A summation of the available data would suggest that participants were generally favorable to both the content and the technical features of the telecasts. Of significance is that 62% of the participants stated that had the broadcasts not occurred, there would have been no way of having achieved an equivalent interaction.

In addition, a growing number of requests for the use of videotapes made for this experiment have been received from the various minority groups in the WAMI territory.

#### Admissions

Through these broadcasts, the general consensus was that the "satellite-mediated interviews could satisfactorily be substituted for a significant portion of person-to-person interviews." The cost study added that not only can satellite communication be a substitute, but it may well be a very cost-effective means of conducting these career and professionally critical interviews.

#### Faculty Sharing

Based on the cognitive examination of the nutrition course, both years revealed equivalency in learning by satellite compared to the traditional

lecture format. Based on Flander's event analysis, no difference between satellite and traditional small group teaching could be found for student/faculty interaction. Numerical analysis of attitude questionnaires indicated that both students and faculty had a positive attitude toward satellite mediated education.

During the second year, both sending and receiving faculty acceptance of the media was such that more satellite time was requested than could be supplied. Satellite teaching can substitute for traveling faculty and the expertise and number of faculty made available to the receiving sites via satellite during the last two years would not have been possible through any other mechanism.

#### Consultation Process

The technology implemented through the Canadian Communication Technology Satellite and NASA Lewis Research Center is acceptable for teleconsultation purposes. Further: (1) the video capabilities of the hardware are adequate for a great variety of ancillary patient data to include: radiographs, sonograms, electrocardiograms, histology and pathology slides; (2) practicing physicians in remote communities indicated satisfaction for the services rendered by the university based consultations; (3) continued physician participation suggests "operational" capabilities of the system as opposed to "experimental" protocols; (4) routine teleconsultation as practiced in Consultation Process reduces the need for either patient or physician travel; and, finally (5) the routine utilization of the Communications Technology Satellite reduces the sense of isolation felt by specialists in rural communities.

The cost-effectiveness study showed that satellite communications is less costly than traveling for in-person conferencing.



## CONCLUSIONS

### Legislative Process

Interactive Satellite Communication can play a role in the public decision-making process, although a number of technical and format issues must be resolved for it to be used on a routine basis.

### Minority Recruitment

Interactive communication can influence not only the decision-making process of minorities pursuing health careers, but the consolidation and unification of efforts to identify, recruit, and retain minorities in health science programs.

### Admissions

Interviews via satellite can be a substitute for a significant portion of student interviews and from a cost-effective standpoint, it is clear that satellites can, and presumably will, be more effective than moving committee members and students.

### Faculty Sharing

Satellite teaching can substitute for traveling faculty, and the expertise and number of faculty made available to the receiving sites via satellite is greater than has been possible through any other mechanism.

### Consultation Process

The technology is adequate for operational consultation services and is perceived as a viable and acceptable means of patient-related consultation by participants. Comparative data collected during in-person consultations suggests time-efficiency exclusive of travel time necessitated by in-person consults.

In addition, it was demonstrated that teleconsultation as practiced in Consultation Process enables medical faculty to develop a teaching

presentation based on patient problems confronting and presented by physicians in a non-university setting. As many as 30 physicians and other health care professionals can and will participate on a recurring basis if such a teaching program is made available at a convenient time and location.

EXPERIMENT 15

TITLE:                    Communications in Lieu of Transportation

DISCIPLINE:             Community Services

ORGANIZATION:         Westinghouse Electric Corporation

OBJECTIVE:             Assess the applicability of video and audio  
                            communication (i.e., teleconferencing) as an  
                            economic alternative to travel in a large,  
                            geographically-dispersed, industrial  
                            organization.

PRINCIPAL INVESTIGATOR: Mr. J. Herb Nunnally

ACTUAL START:           5/76

COMPLETION:             6/78



**NASA**

# **CTS/VIDEO TELECONFERENCING**



**BALTIMORE, MD.**

**1975**

**MAJOR EXPERIMENT ACTIVITIES**

- PHASE I CONFERENCE ROOMS EVALUATION
- DEVELOP EVALUATION PLAN
- EVALUATION METHODOLOGY
- EVALUATION CRITERIA
- DEVELOP AUDIO/VIDEO SCRAMBLER
- GROUND HARDWARE INTEGRATION/TEST
- DOCUMENT PHASE I RESULTS

**LIMA, OHIO**

**1976-77**

- PHASE II TELECONFERENCING ACTIVITIES
- EXERCISE EVALUATION METHODOLOGY
- EVALUATE HARDWARE PERFORMANCE
- USER FEEDBACK
- EXPERIMENT MODIFICATIONS
- REPORTING RESULTS
- PUBLISHING OF RESULTS

## CONCEPT/RATIONALE

The Westinghouse Electric Corporation and other similar organizations are continually seeking new methods to reduce the cost of information and data exchange.

Specifically, in an attempt to lessen the need for costly air travel while still attempting to bring participants to an equivalent face-to-face setting, Westinghouse developed an experiment which utilized satellite teleconferencing in lieu of transportation.

## OBJECTIVE

The prime objective of the Westinghouse experiment was to test the hypothesis that a large geographically-dispersed industrial organization can economically use a communications satellite coupled with low-cost earth terminals effectively to exchange information necessary to conduct business by video, audio and hardcopy media as an alternative to personal travel.

## EXPERIMENTAL PROCEDURE

The Westinghouse CTS experiment was conducted in two phases. Phase I (pre-launch) began in mid-1975 and lasted for six months. During this phase, all support equipment and facilities were configured and utilized to simulate actual satellite teleconferencing. Phase II (post-launch) continued the experimentation via the Communications Technology Satellite (CTS), using teleconference rooms designed from data acquired in Phase I experimentation.

The Westinghouse earth terminals and CTS linked the Defense and Electronic Systems Center in Baltimore, Maryland to the Aerospace Electrical Division in Lima, Ohio. Each location was equipped with a small earth terminal to send and receive conference video/audio signals. The ground systems each consisted of full-duplex FM analog television transmitting and receiving facilities located in Baltimore, Maryland, and Lima, Ohio. The facilities employed a ten-foot parabolic antenna at Lima and a fifteen-foot antenna at Baltimore.

## EVALUATION PROCEDURE

The Westinghouse experiment posed two general areas of evaluation:

1. Effectiveness in terms of potential cost savings to the Westinghouse organization for information exchange at various managerial-professional levels and various functional groups.
2. Performance/reliability of Westinghouse-developed-and-integrated low-cost ground equipment for communications satellites.

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Questionnaires were used to measure the user's assessment of each teleconference. These questionnaires were primarily based on the concept of semantic differential by employing various words/phrases which solicit an analog response on various aspects of the media and teleconference room environment. This data was compiled and reduced by computer programs to test the statistical significance of the results.

SUMMARY AND CONCLUSIONS

The results of Phase 1 data collection indicated that different room configurations and combinations of function, environment, and time had little impact on the rating of selected aspects of the teleconferencing experience. The ratings reflected a satisfactory or excellent opinion of the system. Only in expressing their opinion of whether the system was equivalent to face-to-face did the users feel that the environment was something less than an actual person-to-person exchange.

The results of Phase 2 data came from several sources. Evaluation of post-teleconference questionnaires found the collective opinion of participants towards facility components and environment to be very positive. Evaluation of a questionnaire designed to determine causes of non-use found lack of pertinent business between counterparts in Baltimore and Lima was the most frequently-cited reason. Further, all respondents of the "non-use" questionnaire felt that the facility components or environment did not affect the outcome of meetings. A small percentage of respondents preferred face-to-face meetings. The final questionnaire sent to the managers of two Westinghouse divisions

received a modest but representative response. Middle-ranked management expressed the most interest in the system, while upper and lower segments exhibited less enthusiasm. In general, comments made by all participants were extremely positive.

All questionnaires used in Phase 2 were conceived and refined on the basis of previous teleconference research and questionnaire experiments conducted by Westinghouse personnel. Therefore, assuming that measurement methodology did not in some way skew the results, a paradox of sorts seems to exist within the Westinghouse organizational settings. Results from participants were extremely positive and yet participation dwindled as time passed. Efforts to increase visibility of the service had little discernable effect. Phase 1 data portrayed near independence in choice of configurations for the Phase 2 facility, and Phase 2 data indicated abundant acceptance of the chosen configuration. Nonetheless, participation diminished and remained low despite efforts by investigators to stimulate greater use. Perhaps limited access to the satellite was a contributing cause to the diminishing use of the facilities.

It appears, then, that the Westinghouse teleconferencing experiment was a design high in channel characteristics, that is audio and video fidelity, and basic environment, but low in system characteristics, that is poor facility access (in terms of available satellite time) in the experimental mode. A full service mode, and a network of teleconferencing terminals could very well offset this poor access, possibly making teleconferencing a widely accepted alternate to travel.



EXPERIMENT 16

TITLE: Project Interchange

DISCIPLINE: Education

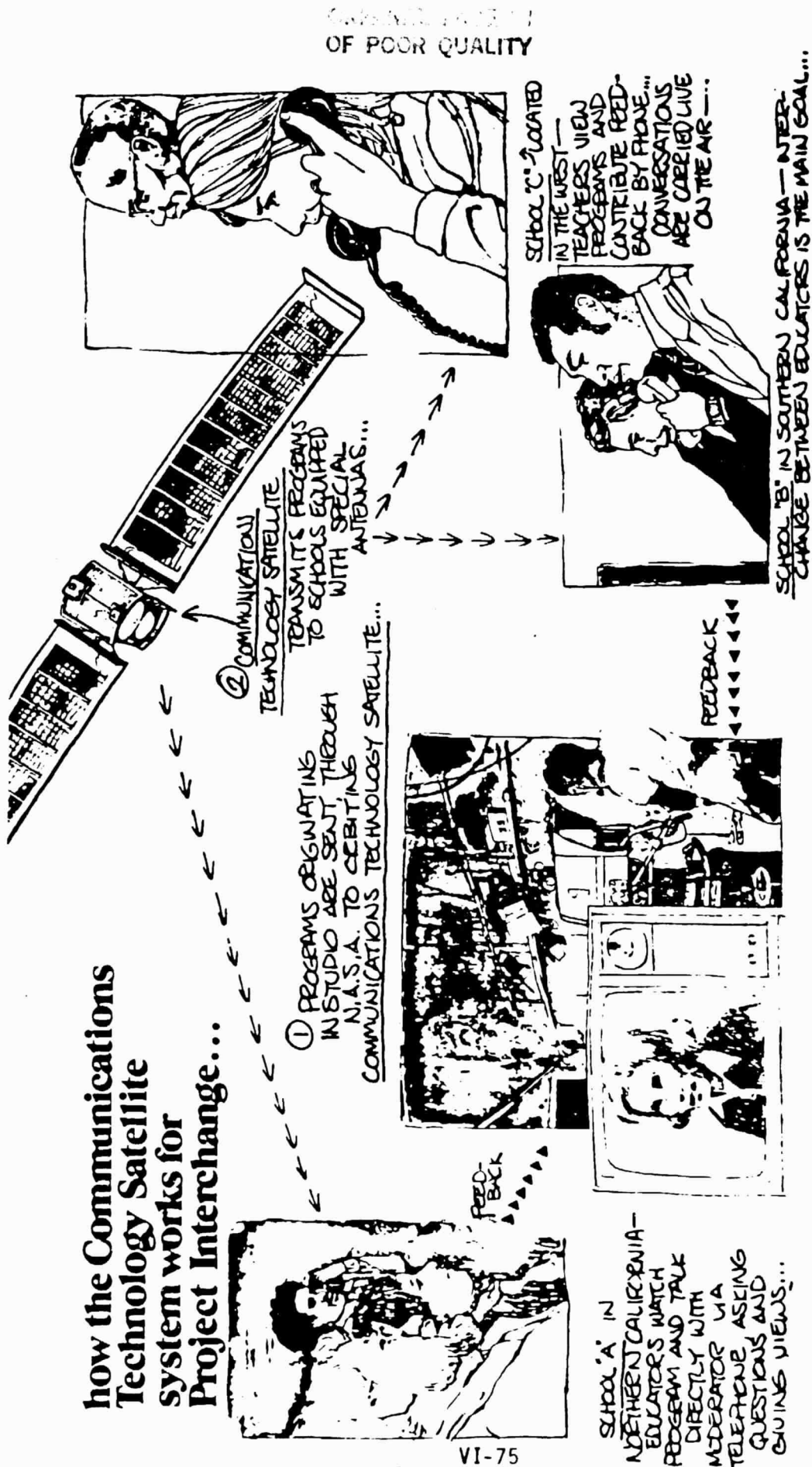
ORGANIZATION: Archdiocese of San Francisco

OBJECTIVE: Demonstrate continuing exchange of materials  
and teaching techniques related to personalized  
instruction and special education among class-  
room teachers in diverse areas of the country.

PRINCIPAL INVESTIGATOR: Mr. David Green

ACTUAL START: 3/76

# how the Communications Technology Satellite System works for Project Interchange....



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## CONCEPT

The primary focus of Project Interchange was to serve as facilitator in the dissemination and diffusion of validated innovative programs supported by the U. S. Office of Education under Title III of the Elementary and Secondary Education Act (ESEA). The programs chosen were those particularly oriented toward meeting clearly established needs of California schools. A key element in the achievement of this goal was the use of the Communications Technology Satellite to provide teachers in Northern and Southern California with opportunities for real-time observation and, via telephone interconnection, interactive participation in addressing persistent problems in individualized instruction.

## OBJECTIVES

With the use of teleconferencing, Project Interchange was designed to:

1. Stimulate teacher initiative and creativity in overcoming problems of implementing individualized instruction in their classrooms and schools.
2. Present expertise on solving educational problems from a wide range of disciplines and geographical areas.

3. Provide concrete and immediate means for initiating or expanding innovative instructional programs without significant additional cost.
4. Facilitate inservice education among teachers, principals, and others seeking to provide alternative approaches to personalized instruction.
5. Build positive teacher attitudes toward the use of technology in educational practice.

During its pre-satellite phase, Project Interchange effectively introduced electronic technologies to the participating teachers. Project Interchange demonstrated that it could accelerate the development of positive teacher attitudes and teacher competencies that are prerequisite to the proper design and development of appropriate electronic support systems.

#### EXPERIMENTAL PROCEDURES

Programs originated from the Archdiocese of San Francisco Educational Television Center in Menlo Park. They were sent by microwave to NASA's Ames Research Center at Moffett Field, about five miles away, where they were transmitted to the CTS satellite.

The CTS satellite relayed the programs to special receivers in San Francisco, Los Angeles, and Chico, which televised them over existing television stations and cable systems to schools where teachers were assembled for the presentations.

An important feature was the feedback capability which enabled teachers 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 hundred of miles apart was accomplished through use of private telephone lines and facsimile machines.

Teachers' comments were channeled via the private telephone line through the Archdiocese of San Francisco Educational Television Center to NASA's Ames Research Center from whence they were beamed by satellite to all participants in the network's conference. Teachers did not convene in a central place in their school system for the programs; they remained at their schools and participated through existing television distribution systems.

## RESULTS

### Objectives One and Two

The program model and technical model for live teacher-to-teacher interchange via the Communications Technology Satellite and landline systems were developed and proved very successful. The teachers did communicate among themselves and with the project staff in the studio and, by the end of the CTS broadcasts, were directing the project staff in what content they needed and how they wanted it presented during the satellite broadcasts. They were doing this from Torrance (Los Angeles County, California), to Chico (Butte County, California), and to the key teachers and project staff in the San Francisco Bay Area and back again. Their attitudes toward the project staff and the use of CTS achieved and stayed at a high positive level. They preferred teacher-to-teacher dialogue and

formal presentations by an expert or experts on a given topic. By the end of the third interchange, teachers felt comfortable and in control of the system.

### Objective Three

The technical support system of Project Interchange worked very well. There were a few, initial, minor problems (television sets not working, two or more teachers talking at once) but these were smoothly ironed out by the final broadcasts. The teachers are interested in adding to the telecommunications system the capacity for their participating in telephone and/or computer conferences between the satellite broadcasts. Telephone conferences were held on a regional basis and can be conducted on a statewide basis at the necessary high grade level by using a simple system design change developed by one of the project engineers. Computer conferences were also possible as Project Interchange was a participant in the NASA PLANET computer teleconferencing network and by the locating of additional terminals in the schools, the key teacher could expand to this mode of teacher-to-teacher interchange.

### Objective Four

A management plan was designed and carried out for the project. This plan included selection, by competitive, affirmative action bidding, of two external evaluators for the project. Their formative evaluations played a significant role in the direction and outcomes of the project.

The project was operated with minimum staff size and facilities. There were very limited funds for staff, none of whom were full time, and the participating agencies donated use of their facilities. Of the \$145,000 total budget received, approximately \$45,000 went for CTS receivers, related equipment, telephone service costs, and overhead to the Legal

Education Agency. At the beginning of the project search for funds, one agency director in Washington, D.C., knowledgeable about satellites, said the project couldn't be done for less than \$1,000,000. It was done and, because of staff and teacher dedication, done rather well.

### SUMMARY AND CONCLUSIONS

Project Interchange was a venture into largely uncharted terrain. The design of the system with one-way video and omni-directional audio; the exotic interface of one satellite, two ITFS systems and the phone company; the teachers harnessing high technology to aid themselves in professional development--all of these elements taken together made for a new, even a pioneering undertaking. While description of the system design and the teleconference content are worthwhile and interesting in themselves, a look at the group process and teleconference production provides additional valuable insights.

In its brief two-year life, Project Interchange saw many changes, particularly changes in format and locus of conference control. The focus of the Spring '76 conferences moved steadily away from a presentation by one or more resource people with "questions from the field," towards a true conference among peers with periodic requests for information from specialists in the studio or on the phone. This was certainly a healthy move in which teachers took upon themselves more responsibility for both the content and the process of the electronic meetings. In a word, the locus of control had moved from a centralized studio to a remote network, or from specialists to practitioners.

That the teachers were able to make such a move is attributable to two key factors: (1) participants' sophistication and determination to make the medium serve their needs, and (2) a very supportive teacher-oriented Project staff. This relocation of control is all the more remarkable when one realizes that the nature of the medium--one way pictures from the studio with all controls, both video and audio in the studio--might lend itself to a highly centralized type of discussion.

Two special learnings emerged from the project that are worthy of being included as a part of the summary.

1. Use the visual channel to greater advantage.

The teleconference is at least in part a visual medium. Recognizing this, the Project staff made several changes in visualization not so much to upgrade the production values of the Interchanges as to take fuller advantage of the wide band video channel. In Interchange/Spring '76, one of the most successful segments was one in which a teacher from Torrance narrated a series of slides illustrating how he used color coding to facilitate Peer and Cross-Age Tutoring. In Spring, 1977, the Project staff selected segments of the excellent Public Broadcasting System program, "The Puzzle Children," to illustrate key concepts in the recognition and understanding of specific learning disabilities.

The photographs of participating teachers were reshot in color, putting the teachers in more informal and comfortable settings.

Notwithstanding the improved visualization of the Spring, 1977, teleconference, there remained considerably more room for improvement. Using portable gear to videotape in classrooms added an important element of life and realism to discussions. Moreover, more careful coordination



between educational staff and production staff made the meetings considerably smoother and more enjoyable to watch.

2. Balance comfortable interaction with stronger task-oriented directions.

The group dynamics of a teleconference is its most fascinating element. As noted above, in Spring '76, locus of control rested with the teachers. In organizational teleconferences or staff meetings leading up to the longer content-centered meeting, participating teachers reiterated their desire to maintain a teacher-centered dialogue.

The problem that began to develop in the final Interchange was that teachers did not call upon resource people as much as they might have; and the resource people, most of whom were new to the process, were not as prepared as they might have been. The in-studio staff, being very sensitive to the teachers' reaction against being talked at or having their meeting manipulated, hesitated to adhere tightly to an agenda. While all participants, key teachers, staff, resource people and observers were pleased with the Interchange, the consensus seemed to be that more could have been accomplished if the discussion had been more directed.

In summation, then, Interchanges should attempt to use more visuals more effectively, and to strike a delicate balance between openness and direction so critical to any successful meeting.

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EXPERIMENT 18

TITLE: Interactive Techniques for Intra-NASA  
Applications

DISCIPLINE: Special Services

ORGANIZATION: NASA/Goddard Space Flight Center

OBJECTIVE: Develop and demonstrate interactive communications  
techniques between NASA centers and headquarters  
in support of agency management and administrative  
functions.

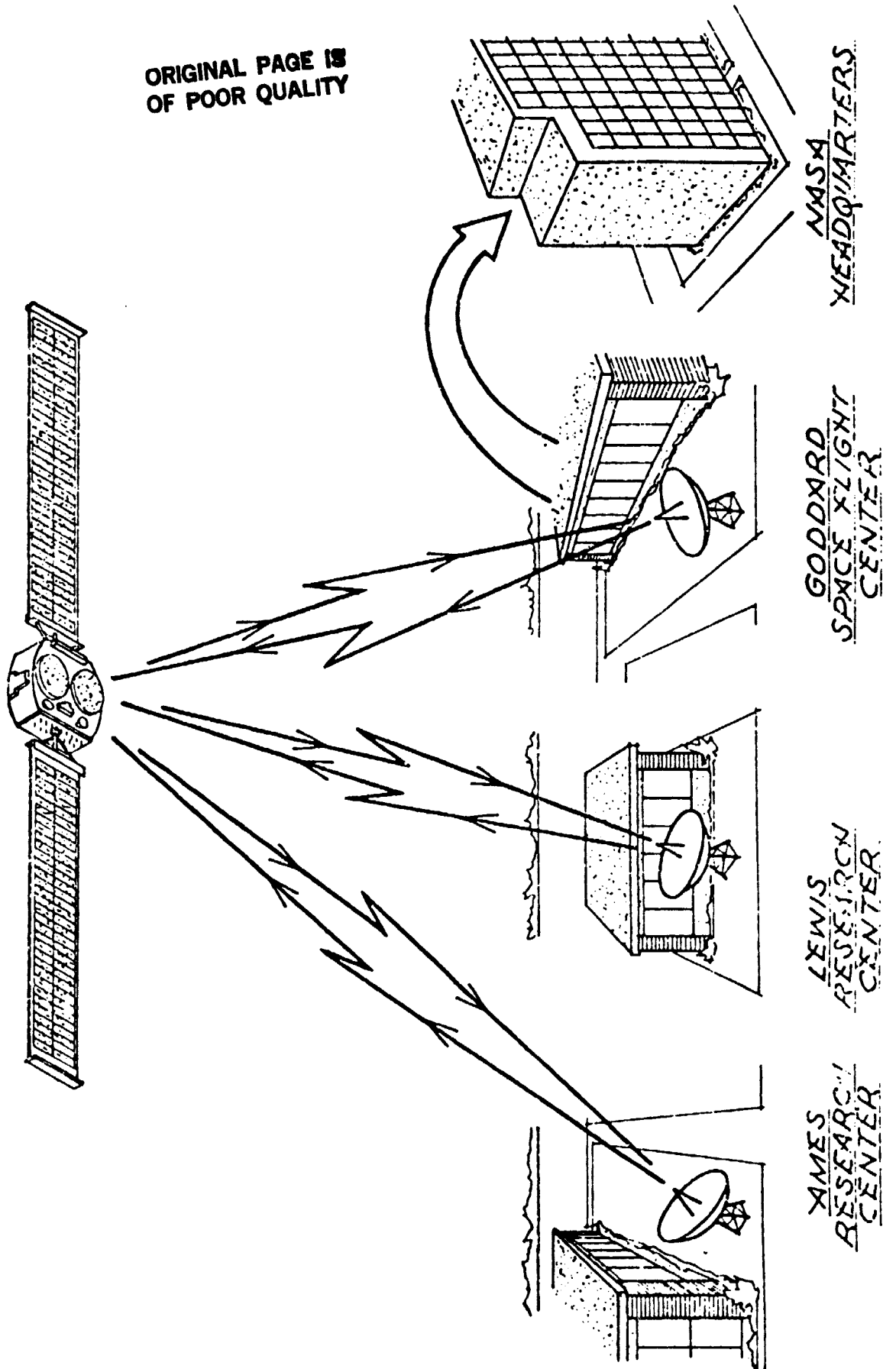
PRINCIPAL INVESTIGATOR: Mr. John Chitwood

ACTUAL START: 4/76

COMPLETION: 6/79

INTERACTIVE TECHNIQUES FOR INTRA-NASA APPLICATIONS

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## RATIONALE

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NASA has shown interest in determining the effectiveness of teleconferencing as a supplement to and a replacement for travel. This experiment linked together three NASA centers through the Communications Technology Satellite (CTS) by two-way video and audio. The three NASA centers involved were the Ames Research Center in California, the Goddard Space Flight Center in Maryland, and the Lewis Research Center in Ohio. In addition, the close proximity between NASA Headquarters in Washington, D.C., and Goddard enabled Headquarters personnel to enter into a teleconference with Ames or Lewis by using the ground station at Goddard. This was done by interconnecting the Headquarters teleconferencing facility with the Goddard station by video and audio lines. This experiment tested the hypothesis that NASA can effectively use teleconferencing through a high power communications satellite to manage its widespread activities effectively in spite of smaller travel budgets, increased travel costs, and a need for energy conservation.

## OBJECTIVES

The objective of the experiment on the CTS was to test the hypothesis that NASA can effectively use teleconferencing, in the form of video and

audio through a high power communications satellite, as a supplement to and a replacement for travel.

This hypothesis was tested for various types of earth stations and different types of operation (e.g., half-duplex video vs. full-duplex video).

Some of the specific problems that were addressed throughout this experiment included:

1. The effects of rain at 12 and 14 GHz, and to what degree the quality of the teleconference was affected.
2. The implementation of low-cost, effective security apparatus on the video and audio circuits.
3. The size and sophistication of ground transmitting and receiving stations necessary to provide adequate teleconferencing capability.

#### SUPPORTING EXPERIMENTS

In order for Experiment #18 to properly address the problems delineated above, the results of the Communications Link Characterization Experiment (CLCE), Advanced Ground Receiving Equipment Experiment (AGREE), and the Westinghouse Communications In Lieu of Transportation Experiment were required. Each was also a CTS experiment and are discussed briefly in following paragraphs.

##### CLCE

The objective of CLCE was to measure and characterize the radio frequency links of CTS with respect to natural and man-made components of the electromagnetic spectrum. The basic propagation phenomena of

importance in the CTS frequency bands are attenuation and signal degradation due primarily to absorption and scattering induced by precipitation. In particular the following were considered:

- Measures of the signal attenuation and fading statistics for specific user terminals as requested.
- Measures of the depolarization effects of precipitation on linear and circularly polarized transmissions, and sky noise and multipath effects for small user terminals at low elevation angles.
- Evaluation of site diversity techniques for improving system performance.
- Providing performance data on the CTS communications links under various meteorological conditions experienced at specific user experiment locations. This area included measurement of carrier-to-noise ratios, delay distortions, and linearity for analog modulation schemes and bit error rate, channel capacity, and information rate for digital transmissions.
- Establishing a model for the CTS communications links to allow for the precipitation of adverse propagation effects from measurable meteorological parameters to be used by specific CTS users.

#### AGREE

This experiment measured and evaluated the performance of relatively low cost ground terminals operating with CTS, simulating an operational broadcasting satellite system environment. Thirteen sets of ground receiving equipment were used. These consisted of two 2.4 meter, ten 1.6 meter, and one 1.0 meter paraboloid antennas and associated receivers.

A wideband frequency modulated carrier containing the picture and one audio channel were transmitted to CTS in the 14 GHz band from an earth station. CTS in turn transmitted this carrier to the ground receiving equipment or ground terminals in the 12 GHz band.

The performance and reliability of the ground receiving equipment was measured using techniques which are accepted as standard practice by the television broadcasting industry.

#### Communications In Lieu of Transportation

The Westinghouse Electric Corporation, in an attempt to lessen the need for costly air travel by utilizing satellite teleconferencing in lieu of transportation, established the need for video scrambling to protect company confidential material transmitted between various plants. As a result, Westinghouse developed a low-cost transmit-receive terminal for satellite television distribution which included a technique for scrambling of the TV signal prior to transmission and subsequent de-scrambling at the intended receiver so that the signal was available in intelligible form only to the proper individuals.

Westinghouse successfully demonstrated this technique which provided the following performance and technical advantages for teleconference applications:

- The scrambled signal had the same format, the same bandwidth, and the same amplitude range as an unscrambled signal. Consequently, no special requirements were placed on the satellite terminal and low-cost terminals could be used.
- Both black and white and color television signals could be scrambled.

- Because the signal was in standard format, any standard television equipment could be used at the transmitter and receiver.
- The operation was completely automatic for remote applications.

## RESULTS AND COMMENTS

Comments written in by respondents covered a broad range of subjects. Evaluative comments were generally favorable, with a few exceptions.

Occasional responses indicated that respondents were disappointed not to have had personal contact with the speakers. Others missed the capability for a complex interchange of ideas, which would be enabled by communication with all speakers concurrently rather than serially.

It was suggested that teleconferencing at regional centers might enable individuals to attend more conferences at less cost and less travel time.

Some comments were critical of technical details (mostly audio quality). Others expressed confidence that technique and effectiveness would improve with experience. Several mentioned enjoyment of the closeups of the speakers made possible by the large screen. A large number of comments were broadly approving.



EXPERIMENT 19

**TITLE:** Satellite Distribution Experiment

**DISCIPLINE:** Community Services

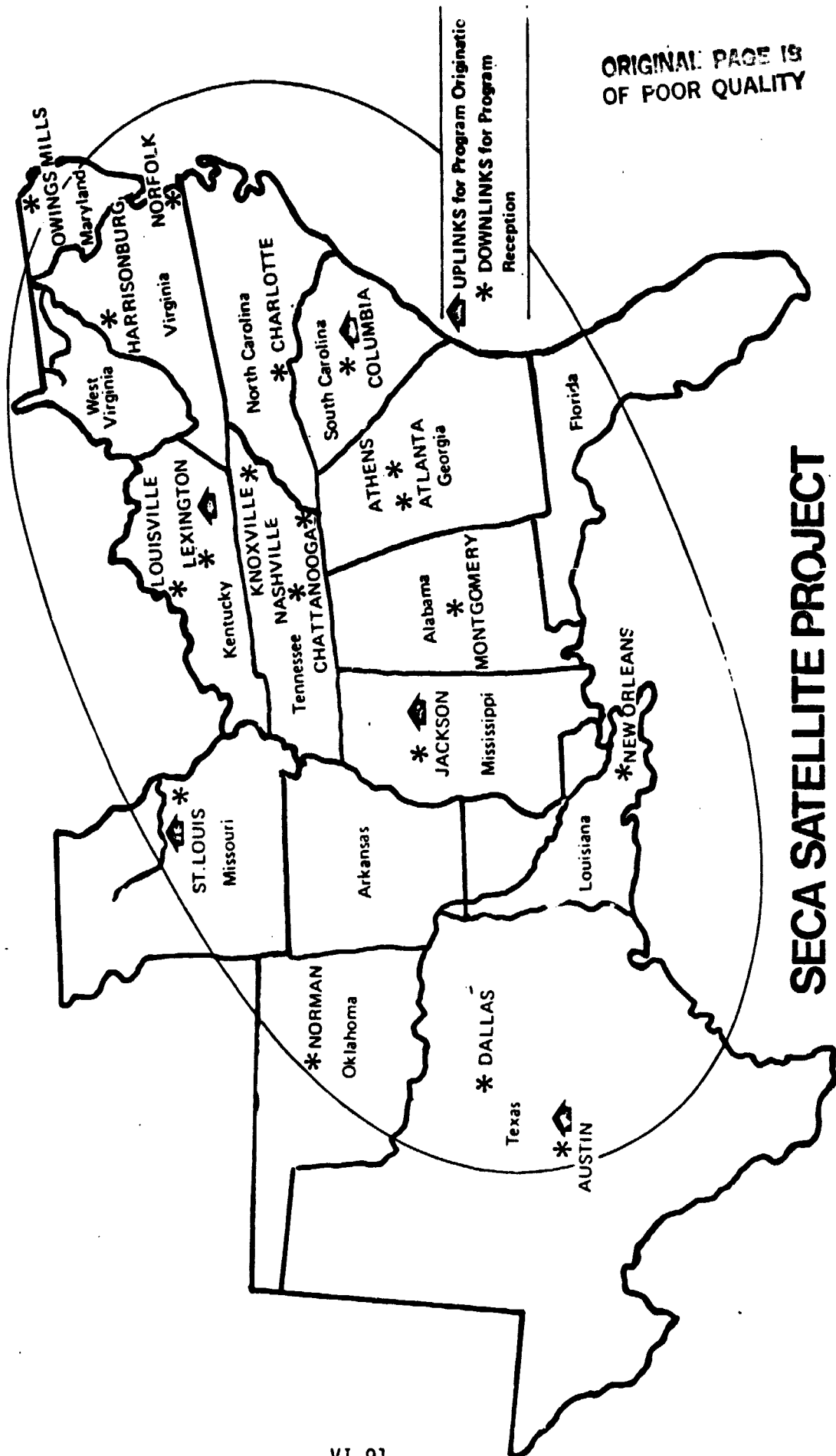
**ORGANIZATION:** Southern Educational Communications Association

**OBJECTIVE:** Demonstrate distribution of educational television materials originating at a central location to non-commercial T.V. stations for broadcast use.

**PRINCIPAL INVESTIGATOR:** Mr. Robert Glazier

**ACTUAL START:** 12/76

**COMPLETION:** 6/79



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**SECA SATELLITE PROJECT**

## CONCEPT

The SECA experiment was designed to determine the feasibility of satellite distribution of program material to television broadcast stations for rebroadcast purposes. The program material to be distributed in the course of the experiment was principally oriented for instructional use in elementary and secondary schools, or for evening viewing by an adult audience. Secondary experiments were proposed in exchange of program material over widely scattered regions of the United States and in the distribution of high-quality and multi-channel audio and video material.

## OBJECTIVES

Objectives of the experiment were to determine the feasibility of using high power satellites such as CTS, coupled with relatively inexpensive ground terminals, for distribution of program material to television stations; to gain experience with this means of communications by actual distribution of programs on a scheduled basis; and to assess the results obtained and cost of service as compared to terrestrial distribution means.

## EXPERIMENTAL PROCEDURE

Each of the participating noncommercial television broadcast stations provided at its own expense a receiving terminal for use during the course of the experiment. The nominal receive terminal consisted of a 3.0 meter (10 foot) fiberglass antenna with electronics similar to (and modified from) standard terrestrial microwave hardware. The cost of the terminal was considerably less than receivers used with typical domestic satellite installations.

Program origination was from the South Carolina Educational Television Commission studios in Columbia, South Carolina, with transmission via privately-owned terrestrial microwave to Rosman, North Carolina. The NASA facility in Rosman provided the uplink for the experiment.

### EDITOR'S NOTE

The following final report is printed as received. It was felt that much of the color and meaning would be lost in abstracting.

## FINAL REPORT

This is the final report from the Southern Educational Communications Association upon an experimental CTS project partially funded by the Corporation for Public Broadcasting in 1976 and additionally supported in 1977-78. An interim report was submitted August 5, 1977.

It is important to begin by distinguishing between SECA participation in the CTS experiment as a major subcomponent and certain specific efforts to undertake short-range activities partially funded by the grant from CPB.

By any scientific, political, or humanistic value judgment system, the CTS experiment, and SECA participation with its member stations, was a smashing success. The simple fact that the uplinking and downlinking worked, on these frequencies, with this equipment to the extent that program delivery could be assumed on a regular basis through a satellite out in space for a considerable period of time, is noteworthy. The scientific and technological documentation has been done by authorities far more competent, and we do point up the technological implications of the achievement. For SECA, it meant that their service became operationally reliable, which predisposed us to accept, endorse, and use WESTAR for programmatic experiments before some of our contemporaries. This is not to pass over the early technological problems. The service did not become operationally reliable until the Board of Directors of SECA invested \$50,000 of their own money in the purchase and installation of SECA's own uplink, operated for SECA by the South Carolina ETV Network. As time went on, the problem of drift began to plague some of our station users. It would have been interesting to have been able to try the brilliant technical solution to the problem proposed by one of the engineers involved in the project.

Just as it would have been interesting to convert the uplink into a portable uplink to see what would happen to program development if we had access to a reasonable moveable platform from which to get programs up to the satellite. Perhaps subsequent experiments will follow-up on these experimental hypotheses which SECA did not have the money, the people, nor the time to pursue.

SECA became the largest user of the CTS satellite quantitatively. SECA became a bold experimenter with the CTS satellite, both in its role as a deliverer of programs, and a partner and integral part of very complicated uplinking and delivery systems.

SECA came reasonably close to experimenting with the political implications of the satellite with a proposed experiment involving the Foreign Policy Association, the SALT talks, and President Carter and some of his critics. Had we been able to find the money to bring off this experiment, we just might have been able to bring the world of technology one step closer to becoming a meaningful part of the communication process in almost McLuhan terms.

Having established the fact of achievement for the CTS experiment and SECA participation with it, let us turn to some of the problems of the adventure as a way of getting an understanding of why SECA, its staff, and participating member stations were able to realize certain thrusts of our experiment and were not able to achieve others.

1. A major problem was the alternating of service on a daily and quarterly basis with Canada. This meant several things. The service could not be used for consecutive daily feeds, it could not be used for weekend feeds of children's pro-

grams (one of the principal original hypotheses). Consequently, no weekly series of more than twelve or thirteen programs could be assayed without arrangements to change feed days in midstream; always a risky process.

2. Another major problem was the potential utilization of the programmatic materials fed. Some of the program experiments were designed for instantaneous broadcast; some were not designed for open circuit utilization at all; some were intended for both. A further problem was introduced at times by the time dimension. Some programs were fed live and were meant to be reacted to at that time, either by telephone, actual video responses, or a combination.

Because our members are all television broadcasting entities, there were times when the demand upon their facilities, space, and personnel were almost impossible to meet. That they arranged to bring people to their studios, arranged for them to view programs never meant for broadcast, made tapes of almost one to one communication for use by other groups outside the studio, made substantial number of telephones available and sometimes staffed them, is indeed indicative of their genuine desire to cooperate with the major thrusts of the total experiment even when there were flaws in communication or hasty, last minute arrangements and changes. Unfortunately, the extent to which their involvement in this kind of activity diluted or lessened their enthusiasm for other aspects of the experiment may never be measured.

3. Closely associated with the problem of utilization is another problem which should be identified. Much of the experiment was carried out with the wrong generation of equipment. With one or two outstanding exceptions, most of the experimenting was accomplished with equipment designed, and for the most part utilized, in conjunction with open circuit television broadcasting entities. The fact that in many parts of the country people had to assemble at the television studio, or a great deal of money had to be spent to establish temporary participation places must play havoc with any research schema. The considerable success of the South Carolina Medical University series (reported elsewhere) which was able to capitalize upon the presence of a network of telephone line interconnections throughout the state for small group viewing and inter-participation is an interesting exception. (To make the point that the right equipment was not available is not, in this situation, special pleading. The right equipment, by definition, is almost never available for an experiment, or it shouldn't be an experiment, and we are aware of that. Furthermore, the presence or absence of the right equipment, some of which had not been designed yet, did not mitigate against the operational function of whatever equipment the innovative engineers and program people chose to bring to bear - including on one occasion a whole television station summoned to provide a studio for a prominent politician who was unable to be



anywhere near the appointed place of his participation.

Our point is only that there were substantive, quantitative, and humanistic as well as communication aspects to these experiments which were adversely affected by available technological services.)

4. There was a conspicuous lack of money. There is always a lack of money during an experimental process. We wish only to point out that the lack of money kept us from hiring people to do specific kinds of short-term record keeping, evaluation and research; it prevented us from underwriting interconnection costs and sometimes uplink costs for very interesting and significant proposals, and it kept us from assisting our station members to underwrite the R and D pre-production costs necessary for the kind of independently organized participation originally hypothesized. We did our best to acquire more money to support the total experiment and some of the specific sub-components. Our applications for matching funds to help more member stations install downlinks, were not favorably considered. Our application to NIE for a substantial amount of money to work out and carry through a comprehensive assessment of the fiscal implications and the programmatic implication of the situation were not favorably considered. We were left to use our own resources to cope with completely altered plans which had been made as few as two years ago.
5. Arnold Toynbee writes about the spiral of history and he views the spiral as being somewhat like a corkscrew, with smaller

and more frequent sweeps through time as time itself passes. The time is too short to understand whether that process will affect the development of communication technology and communication itself in our world; but it is very safe to say that we have already met ourselves coming and going along the time line of development.

First there was WESTAR. The installation of downlink dishes at public television station facilities and the limited access to WESTAR granted to regional networks, including SECA, had an amazing impact. No one will ever know what the operation presence of CTS experiments within SECA had to do with the readiness factor, but the immediate results were to turn the attention of SECA and its member stations to the inviting possibilities of WESTAR for national distribution, and for regional distribution to the membership, and to the cooperative use of both CTS and WESTAR for both. From this approach came a whole sequence of proposed and actual experiments, none of them foreseen, none of them researchable, all of them to the considerable detriment of the orderly pursuit of CTS experiments, research thereupon, and comparisons to other modes of delivery.

Second was the announced demise of CTS. Whatever research had been planned, whatever schedules had been made, whatever efforts to develop an enlarged base of participation, utilization and research had been hypothesized, all were laid to rest when the end of CTS was announced. It is regrettable, but understandable, because whatever money put to use on a dying CTS is better spent on a thriving WESTAR. Besides, there are more stations to work with. That is the American way.

Third was the political and potential structural upheaval within PBS, within CPB, and within and among the regional networks. No one currently

knows what the role of the regionals will be programmatically vis-a-vis PBS. No one currently knows what the membership and interest and drives of the regional networks will lead to. Henry Loomis once described the regional networks as "more than local and less than national." The chances are he was at least half right.

Fourth is the speed of events on the timeline itself. All of these confusions have developed within the last six months. What SECA is coping with is the necessity of using WESTAR as a practical delivery system to its members because telephone lines have already been released and CTS never became capable of delivering to more than a reliable 25 percent of the membership; At the same time, SECA is coping with the implications of service with some programs at some times to the open market of public television stations all over the United States, because in some fashion or other this service will become a meaningful responsibility of SECA to its own members. Nobody knows how, but it will. Therefore, CTS is redundant; research into CTS is redundant; therefore certain aspects of the experiments hypothesized under the grant to SECA from CPB became redundant.

We do not wish to end this final report on a negative note. We think the contribution towards a basic service and experimental demonstration within this experiment funding were absolutely outstanding. We regret we are unable to document that feeling of satisfaction because we do not have the field studies to support utilization, impact, or system learning from our major experiments. We have little progress towards objective evaluation, because the ground rules, the name of the game, and the size of the field, changed drastically, quantitatively, and qualitatively. However, we made notes on our major activities in which we became engaged. Our comments are to some extent anecdotal, but we think the logical inferences support the thrust of our conclusions.

7/10/76

Highland Games: Sixty minute program originating from Grand Father Mountain, annually the scene of sports and games of Scottish origin. Fed to CTS stations for live broadcast.

10/9/77

Monsour Medical Foundation.

1/7/78

Mass to St. Cecilia: Uplinked via CTS from Columbia, South Carolina.

2/7/78

Discussion of new copyright legislation: Panel in Washington speaking and answering questions from librarians gathered at CTS downlink sites. Although not designed for television broadcasting, material was so important that some stations aired tapes later.

3/16/78

Discussion with Congressman Dan Rostenkowski: Greater Cleveland Hospital Association/SECA. This one had elements of high drama. Congressman Rostenkowski, unable to get to Cleveland where the original plan had been to distribute his live appearance before the annual meeting of the hospital group via satellite to CTS users, ended up in Bethesda, Maryland where an ad hoc arrangement uplinked him to Cleveland by another satellite and thence onto CTS. There were questions from the audiences around the CTS circuit.

This presentation, and the copyright demonstration experiment, were exciting examples of what will eventually be commonplace, because the information was being distributed now and the reactions and questions

were coming now. Everyone in the business was extremely worried about the implications of the new copyright legislation, and the impact upon the audiences from Oklahoma City to Austin was profound.

Similarly, Congressman Rostenkowski was talking about a very controversial bill, as far as the health community was concerned, and his presentation, and the questions and answers were not of interest or concern to the general public at that time. This was a closed circuit situation at the downlink stations.

#### 5/10/78 and Following

Project Reach: Eight educational and informational programs from the National Institutes of Health and the Medical University of South Carolina. This was a CTS experiment, well underwritten, and was a most conspicuously successful example of what could be accomplished in the way of spreading expert opinion, advice, and comment to audiences of professionals and para-professionals. The programs were distributed by cable throughout the hospital system of South Carolina which was both a provider and a user of the service, were linked up and re-distributed to several states from the CTS feed, and on at least one occasion were distributed nationally through WESTAR from the South Carolina facility. These programs were designed for non-broadcast use, but later in the experiment at least one experiment with tailoring the programs partially for general use by separating the first hour from the second hour substantively and stylistically was attempted.

#### 6/29/78

First International Conference on Exceptional Children: Technologically almost miraculous. Relayed from Paris via SYMPHONIE, TV Ontario and CTS with no rehearsal, the two-hour program was carried live by at least two state networks.

9/12/78

Proceedings of American Hospital Association California Annual Meeting: Here was an impressive early example of the use of CTS for point-to-point communication. Its purpose was to get the signal from California to Columbus, South Carolina, so that it could be uplinked on WESTAR from the CTS downlink adjacent.

9/21/78

Space Shuttle Safety Conference: An early experiment with multiple uplink origination, originally Washington, Denver, Seattle.

12/15/78

Conference involving uplinks from Lewis Research Center and Goddard about frequent discoveries on the moon and Mars for the benefit of a teacher's convention in New York. Some of our stations copied the program for reference.

2/27/79

Two-hour preview of the THINKABOUT series upcoming from AIT: Fed simultaneously to CTS and WESTAR, the opportunity was provided for stations which had severely limited receiving facilities for WESTAR downlinking to receive the program. More than one hundred groups of interested people gathered in public television studios to watch the program and interact with phone calls. An interesting feature of the project was the feeding of a short videotape within the live program to all stations for subsequent air use.

3/27/79

Program involving representatives of the American College of Physicians relayed from San Francisco on CTS to be uplinked from Columbia on WESTAR.

We should note the most exciting day in the history of the project. On September 12, 1300/1500 SECA picked up the Medical University of South Carolina from Charleston via landlines, mixed the signal with a feed from Bethesda on CTS band 2, uplinking to stations on CTS band I and WESTAR I. At 1535 SECA picked up CTS signal from Anaheim and relayed it into WESTAR I with ten proceedings of the annual meeting of the American Hospital Association. At 2000 the regularly scheduled feed of programs to all CTS stations began, and 2100 live studio preview of THE OTHER SCHOOL SYSTEM to CTS and WESTAR.

These mini experiments, as the CTS administrators would describe them, or participation in more significant major experiments, were all in addition to a major and continuous supply of programs on a scheduled basis. During the life of CTS, SECA uplinked approximately 750.5 hours of programs averaging about 26.5 hours per month.

## EXPERIMENT 20

**TITLE:** Advanced Ground Receiving Equipment  
Experiment (AGREE)

**DISCIPLINE:** Technology

**ORGANIZATION:** NASA/Goddard Space Flight Center and  
Nippon Hoso Kyokai (Broadcasting Corp. of Japan)

**OBJECTIVE:** Determine system performance under field  
conditions of Japanese-built small, low-cost,  
low-noise, 12 GHz receivers.

**PRINCIPAL INVESTIGATOR:** Mr. John Miller for the U. S.  
Dr. Yoshihiro Konishi for Japan

**ACTUAL START:** 6/76

**COMPLETION:** 1/73

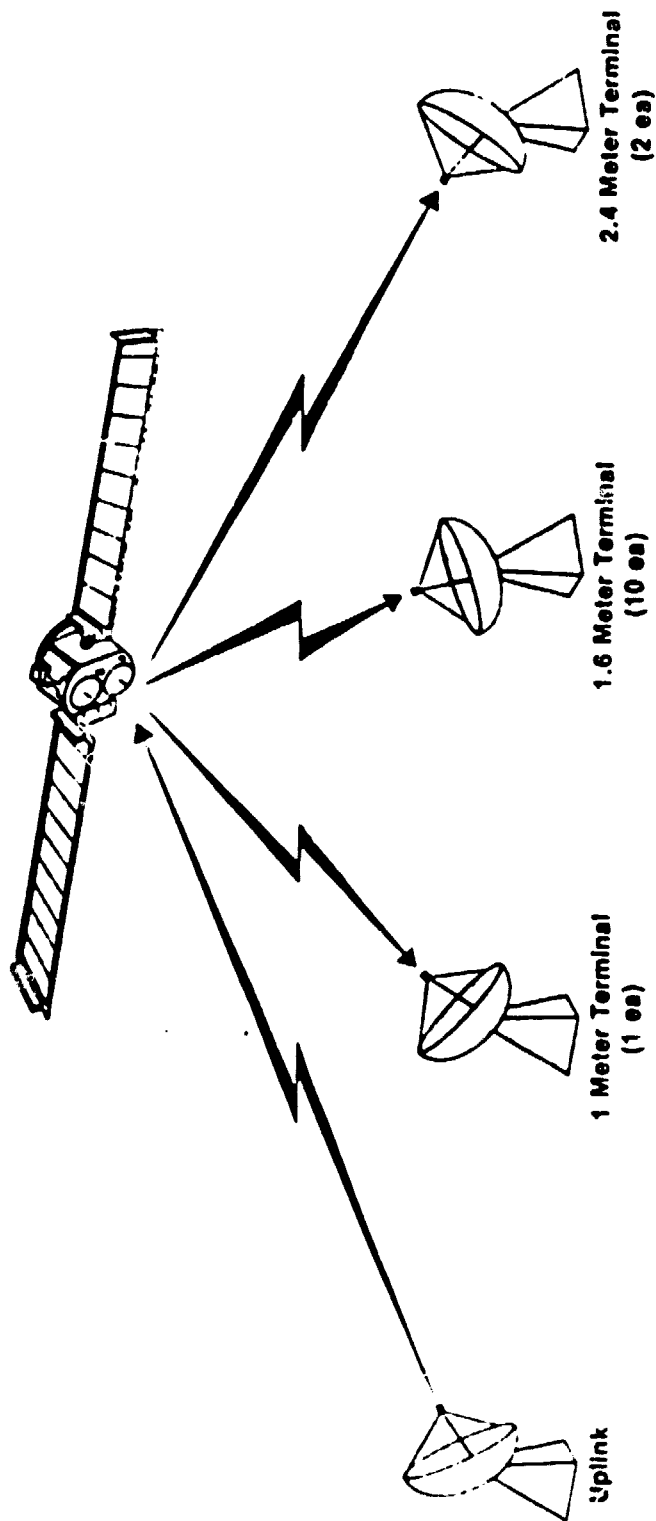




# AGREE ADVANCED GROUND RECEIVING EQUIPMENT EXPERIMENT

NASA

Principal Investigators: Dr. Yoshihiro Konishi, Nippon Hoso Kyokai, Tokyo, Japan  
John E. Miller, Goddard Space Flight Center, Greenbelt, Maryland



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## PHASE I

- Series of 18 Comprehensive Tests to be Performed
- Uplink at Goddard or Lewis
- All 13 Receiving Terminals at Goddard

## PHASE II

- Two Receiving Terminals at Goddard
- One Receiving Terminal at Lewis
- Ten Receiving Terminals to be Loaned to Approved CTS Experimenters
- Uplink Will be That Associated with Appropriate CTS User Experiment
- Limited Data Taken Over a One (1) Year Period

## CONCEPT

The Advanced Ground Receiving Equipment Experiment was designed to measure and evaluate the performance of relatively low cost ground terminals operating with the CTS under conditions simulating an operational broadcasting satellite system environment.

## OBJECTIVES

There is a world-wide interest in the application of communication satellite technology for broadcasting instructional, educational, and entertainment television. Studies have been conducted and several experimental projects have been undertaken to determine the feasibility and cost. Most notable of the experimental projects have been the Health, Education Telecommunications (HET) experiments conducted in this country and the Satellite Instructional Television Experiment (SITE) conducted in India.

The transition of these and similar experiments from the experimental to the operational stage could eventually require thousands or even millions of ground receiving equipment. Cost and reliability of this ground receiving equipment is a major factor in how fast operational systems will evolve.

Development of low-cost ground receiving equipment has been underway in this and other countries for some time. In particular, several manufacturers in Japan have developed low-cost ground receiving equipment under the guidance of the Technical Research Laboratories of Nippon Hoso Kyokai (NHK). This equipment was developed for use in the Japanese Broadcasting Satellite (JBS) experimental system which began in mid-1978. This CTS experiment provided an early opportunity to evaluate these earth stations under actual field conditions.

### EXPERIMENTAL PROCEDURES

Thirteen sets of ground receiving equipment were used. These consisted of two 2.4 meter; ten 1.6 meter; and one 1.0 meter paraboloid antennas and associated receivers. A wideband frequency modulated carrier containing the picture and one audio channel was transmitted to CTS in the 14 GHz band from an earth station. CTS in turn transmitted this signal to the receiving terminals in the 12 GHz band. The quality of the picture exceeded 43 db peak-to-peak picture to RMS weighted noise (TASO 1.5) and the audio channel exceeded 50 db test tone-to-noise ratio.

The experiment was conducted in two phases. The first phase was an intensive evaluation of the ground receiving equipment, and was performed over a period of two months. All measurements during phase one were performed at Goddard Space Flight Center.

For the second phase, ten 1.6 meter paraboloid antennas and associated receivers were loaned to approved CTS experimenters for their use for a period of one year. In return, CTS experimenters recorded limited data on the performance of the receiving equipment. One 2.4 meter ground terminal

was installed at the Lewis Research Center, and one 2.4 meter and 1.0 meter ground terminals were installed at the Goddard Space Flight Center.

#### EXPERIMENT SPONSOR

This was a joint experiment by NASA and the Technical Research Laboratories of Nippon Hoso Kyokai (NHK), Japan. The participation of NHK was sponsored by the Radio Research Laboratories of the Ministry of Posts of Telecommunications, Japan.

#### PHASE II EXPERIMENTS

Phase II experiments were conducted at NASA Goddard Space Flight Center, Lewis Research Center, Federal Communications, Public Service Satellite Consortium, (San Diego, Miami, Rockville) and Virginia Polytechnic Institute and State University. The results of the experiment at each station is summarized as follows:

##### NASA GSFC

The AGC voltages of the two receivers were recorded from February 1977 to December 1977 to estimate the receiver input power using a 1.0 or 2.4 parabolic antenna. The receiver input power was decreased due to the off-axis loss from beam center, as for most transmissions the ground station was off boresite. The fluctuations in received power are caused by the following factors:

1. Transmitting power of satellite,
2. Antenna pointing of satellite,
3. Atmospheric effects and rain attenuation,

4. Pointing error of receiving antenna, and
5. Fluctuation of receiver gain.

#### NASA LeRC

NASA's Lewis Research Center in Cleveland, Ohio, participated in Phase II of the experiment by maintaining a terminal consisting of a 2.4 meter antenna and the N-4 receiver. Using uplinks at both LeRC and GSFC, a series of quantitative measurements were made of the performance of this system.

#### FCC Report - (Extraction of the report from FCC to GSFC)

##### a. Measurements in Downtown Business Area

The terminals were obtained from GSFC on January 24, 1977. Both include respective 1.6 meter antenna units with SHF Converters and strip chart recorders.

Each of two terminals had been installed in turn for television reception via CTS in the office located on the corner of the seventh floor of the (nine story) office building, Washington, D. C. at approximately the heart of the downtown business district, where, despite window frames and glass, indoor antenna location, traffic, tall buildings in immediate vicinity, excellent video reception has been the general rule, with comparable assessment of sound reception somewhat hampered by the fact that most CTS transmissions use sound subcarrier(s) other than 4.5 MHz.

##### b. Measurements Near the Airport

The results of experimentation with CTS with regard to air traffic effects in the vicinity of a busy airport indicate brief (approximately 0.5 to 1.5 seconds) disruptions of television video

in the respective cases of six aircraft out of a total of 28 observed, apparently occurring when (and only when, as near misses seemed to produce no effects whatever) the aircraft were within the 1° beamwidth of the antenna. It is noted that the observed disruptions seemed to comprise the enhancement, then loss, of picture, followed by snow.

In the subjective opinion of the principal investigator, momentary disruptions of the type observed occurring only in the immediate vicinity of the airport in the case of no more than 1 plane out of 4 or 5, might be considered acceptable.

c. Measurements Near Washington, D.C., Metro Trains

As might have been expected from the previously outlined test results from observations with aircraft, the effects of a moving train overhead are limited in occurrence, duration, or loss of picture, and probable overall seriousness of any problem posed by locations near overhead trains in Japan.

d. Measurements of Reflection Beam by Building

Signals reflected from predominantly glass buildings (multi-window generally modern office-type construction) appear to undergo minimal loss of strength (with no degradation of picture quality when the antenna feed is polarized for maximum signal), but other types of building construction (such as the largely brick Shoreham Americana Hotel built well before World War II) seem to function markedly less efficiently as reflectors. Factors other than building construction may contribute to the end result.

## CONCLUSION

Most of the objectives of this experiment have been accomplished. Through the experiment qualitative data was obtained for rainfall attenuation, disturbance by airplanes near the airport, reflections from buildings, etc. These items must be further investigated in the future using an analytic approach.

EXPERIMENT 21

**TITLE:** Advancing U. S. Public Service Telecommunications  
Activities on CTS.

**DISCIPLINE:** Public Service

**ORGANIZATION:** Public Service Satellite Consortium (PSSC)

**OBJECTIVE:** Encourage and assist maximum public service usage  
of the CTS Communications Network; provide  
technical support to public service users who  
require such support; develop an information system  
which will collect, process, and make available  
data on organizational, technical, and financial  
effect; analyze the organizational, technical,  
and financial elements of CTS experimenters who  
choose to cooperate.

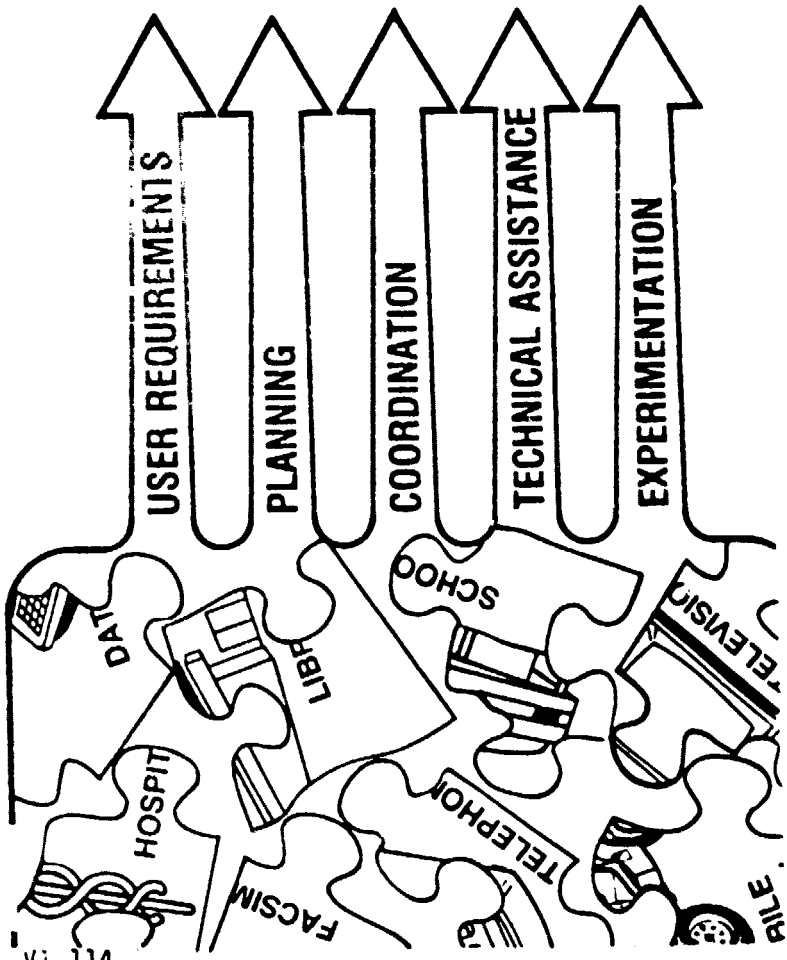
**PRINCIPAL INVESTIGATOR:** Mr. Robert Mott

**ACTUAL START:** 11/76

**COMPLETION:** 6/79

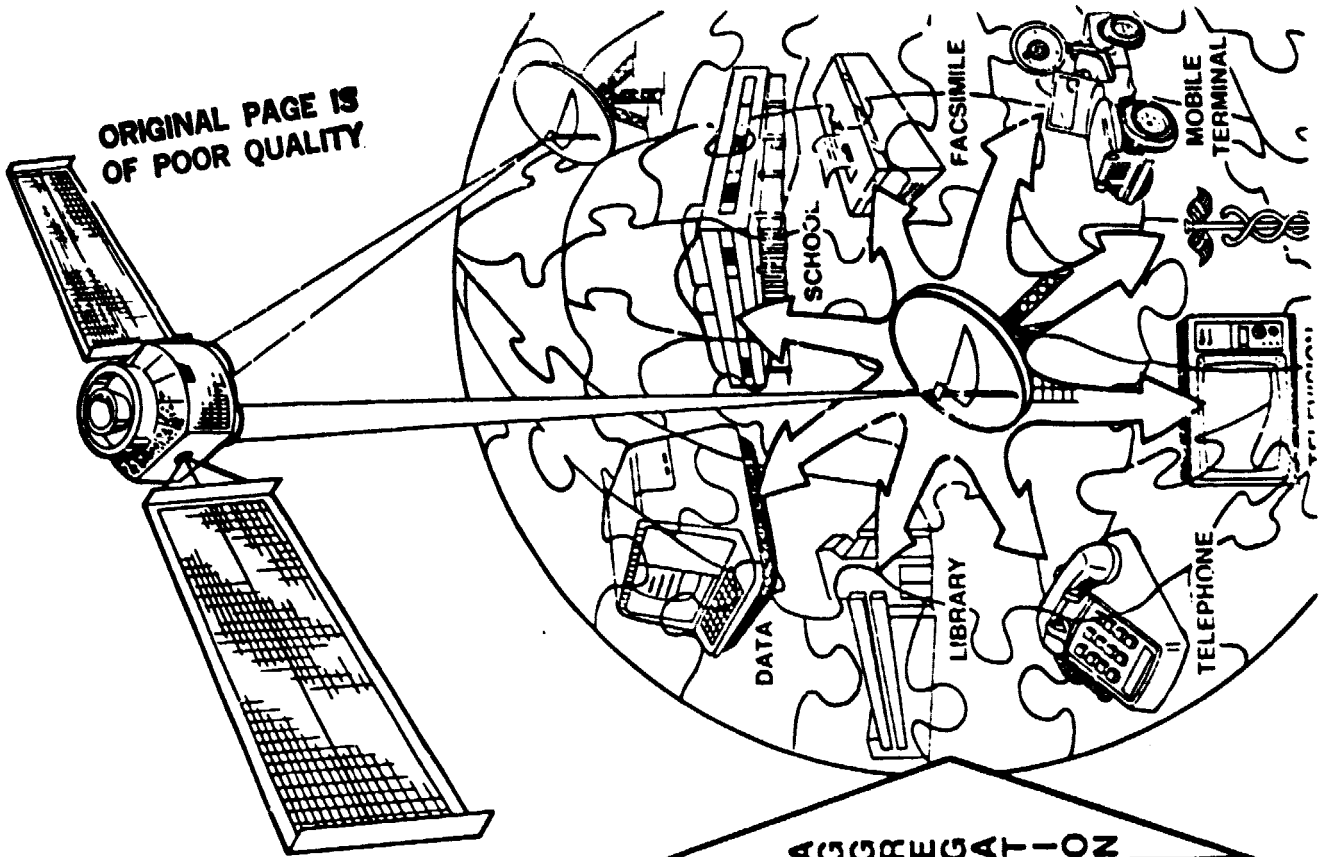


**EXPERIMENT 21:**  
 Advancing U.S. Public Service  
 Telecommunications Activities on the CTS



**Public**

AGGREGATION



## PURPOSE

To encourage and assist maximum public service usage of the CTS Communications Network

PSSC sought to assure that the public service community learn as much as possible from the CTS opportunity through both direct involvement and the opportunity to observe the manner in which satellite communications function by providing extensive support services to the public sector groups during experimentation on the NASA satellite.

## RATIONALE

The Consortium serves as a single-source service organization which provides a variety of consultation services, arranges networks for video and audio distribution of programming, performs objective studies of communications problems, and proposes workable, cost-effective solutions for member and non-member organizations.

Technical planning, coordination, and implementation support were major PSSC activities. These activities included securing satellite time, arranging facility linkages to portable earth terminals, determining compatibility of the transmit and receive sites with satellite footprints, coordinating frequencies for uplinks and downlinks, arranging full systems checkouts prior to scheduled events, and operating portable earth station equipment.

In August, 1977, PSSC assumed responsibility for management and operations of two transportable earth stations, designed and built at NASA's Goddard Space Flight Center (GSFC). These units, referred to as

the Class I and Class II, were made available to PSSC on a loan basis for the remainder of the CTS project to facilitate implementation of operational services of approved societal users. Additionally, in October, 1978, PSSC was awarded a contract to assist NASA in:

1. The day-to-day scheduling, coordination, and documentation of U. S. experimenter activities on CTS; and
2. The management, scheduling, and technical coordination of NASA's Portable Earth Terminal (PET) and Transportable Earth Terminal (TET).

PSSC also operated a satellite communications ground station complex in Denver, Colorado, in support of approved long-term experimenters on both CTS and ATS-6. The complex consists of an earth station near Morrison, Colorado, and a network coordination facility in Denver connected via microwave. The Morrison Earth Station is equipped with uplink and downlink systems at 4/6 GHz and 135.6/149.2 MHz, and a downlink at 2.5 GHz. The Denver Network Coordination Center (NCC) is the user-oriented facility which enables program origination (via its teleconferencing facility), signal relay, terrestrial network coordination, and interface with satellite operating centers.

With these responsibilities and the expertise in the field of satellite communications, PSSC assisted several experiments and demonstrations on CTS.

#### OBJECTIVES

The following objectives were created by PSSC to help assist users on CTS and to gain the knowledge and information necessary for future use of satellite technology:

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1. To enhance the experimental and demonstrative value of CTS by identifying additional potential users.
2. To identify compatible service factors of cooperating CTS users with a view toward long-range individual and shared system usage.
3. To derive data, and process it in a manner useful for planning and managing future satellite communications services. A particular interest will be the coordinated use of facilities by a diverse group of public service users. As in all aspects of PSSC operations, relationships between the Consortium and experimenters will be voluntary and based upon mutually advantageous ground rules.
4. To determine the nature of communities of public service users, identifying those factors which make services compatible and groups of services feasible for future operational development.
5. To investigate the practicality of an organized consortium of such users as an instrument to make their services feasible, effective, and economical.
6. To provide further evaluation of equipment, including the CTS ground terminals, the Denver Uplink, and the Network Control Center.
7. To determine short-range and long-range technical, organizational, and financial alternatives for making operational those groups of CTS projects which are identified by their respective evaluation processes as potentially valuable services.

TASKS, PROGRAMMATIC CONCEPT AND  
TARGET AUDIENCE, AND GROUND SEGMENT

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In order to accomplish the objectives, PSSC assisted the following long-term experiments and demonstrations:

EXPERIMENTS

Veterans Administration (VETSAT)

An experimental network designed to examine biomedical applications on CTS intended to determine future use of satellite communications for medical information exchange.

The network consisted of 32 receive only sites located at V.A. hospitals in the Western United States, and a mobile earth station for transmitting. PSSC was contracted to install and maintain the 32 receive only earth stations, one of which was placed at the PSSC Denver complex for all monitoring and troubleshooting of the VETSAT network.

Alaska/Veterans Administration (ALVA)

The Alaska Area Native Health Service (AAHS) at Anchorage was linked with the Veterans Administration CTS experiment via ATS-6. PSSC provided the interconnect capability between ATS-6 and CTS. Through the cooperative effort, Alaska was able to receive this valuable programming.

Telecommunications for Education to Rural Montana (TERM)

A cooperative long-term demonstration between the National Institute of Health (NIH), Veterans Administration (VA), Kalispell

Regional Hospital, and Montana State University was supported by PSSC. The 22 program demonstration used both CTS and ATS-6, and included programs regarding continuing education, extension, cultural outreach, and public service.

## DEMONSTRATIONS

Short-term demonstrations were the major activity PSSC assisted and supported during the CTS experiment. PSSC provided assistance to many public service organizations during this time.

Short-term CTS demonstrations were conducted by diverse organizations having one thing in common: a need to improve services and an interest in telecommunications as one alternative to meet their requirements. As the telecommunications requirements of the public service community vary, so it was that each demonstration had unique characteristics of its own. There were fundamental differences in the programmatic exchange, in the number and selection of participating sites, and in operational requirements, i.e., one-way video/audio versus full duplex operations. Additionally, in some cases, audio talkback had to be arranged, while in others supplemental linkage arrangements were required in order to reach the intended audiences. The PSSC had a major responsibility to coordinate the requirements of each user and provide the necessary technical support in order to assure the operational readiness, as well as maximum service and economy for each activity.

The following is a brief description of each demonstration and the purpose that was to be accomplished:

### The California Innovations Group

A three-hour two-way teleconference was held between The California Innovations Group at Menlo Park, California, and Mrs. Patricia Harris, Secretary of the United States Department of HUD, in Washington, D. C. The purpose of the teleconference was to demonstrate the feasibility of satellite technology and the utility of its applications.

### Council for Exceptional Children

The Council for Exceptional Children's 55th Annual International Convention in Atlanta, Georgia, was delivered to Harrisonburg, Virginia, Columbia, South Carolina, and Baltimore, Maryland via CTS.

Satellite delivery was used to explore the use of the technology as an informational and instructional delivery method.

### Indiana University School of Medicine/Maryland Center for Public Broadcasting

The Medical Educational Resources Program (MERP) of Indianapolis, Indiana, hosted the "19th Annual Meeting of the Health Science Communications Association" which included a three-way interactive teleconference via CTS between the conference in Indianapolis, Indiana, the Lister Hill National Center for Biomedical Communications, Bethesda, Maryland, and Johns Hopkins, Baltimore, Maryland. The purpose was to show the distance-insensitive attributes of satellites for people-to-people interaction, and to demonstrate medical education interaction through interchange between two medical institutions which was accomplished by a clinical patient exam using fiberoptic color television technology.

### University of Kentucky

The Special Education Satellite Project from the University of Kentucky held a three-hour satellite conference in conjunction with the "User's Conference for Special Educators." A one-way transmission involving teachers of the handicapped in Menlo Park, California, interacted with participants of the conference in Lexington, Kentucky.

The purpose was to gain insight into the value of satellite technology as an alternative to other methods.

### The Public Service Satellite Consortium

The PSSC held a workshop on "How to Become an Experimenter on a NASA Satellite" in Vail, Colorado, which included a teleconference where participants could exchange ideas and questions with NASA and NIE officials in Washington, D.C.

### University of Alabama in Birmingham

The University of Alabama's Telecommunication Center conducted two five-day continuing education courses via satellite to the rural area of Dotham, Alabama. One course was directed at physicians in the area, while the other course was directed at nurses.

The purpose was to successfully provide continuing education courses to rural areas without excessive travel.

The second demonstration the University held was a continuing education course in Cardiology, and a workshop for dental practitioners. Again, Dotham, Alabama, was the receive site.



The purpose of the two-day activity was three-fold:

1. to provide CME programming for health care specialists in geographically rural areas;
2. to increase public awareness of satellites as a viable and cost-effective means for serving the CME needs and requirements; and
3. through program sharing, help to document a practical case for future expansion of the program.

#### The National Oceanic and Atmospheric Administration

NOAA, interested in improving the efficiency of their information dissemination process, conducted a full-duplex teleconference between the NOAA administrator and other high officials in Bethesda, Maryland, and participants in Denver, Colorado, and Seattle, Washington.

A second demonstration, full-duplex between the Lister Hill facilities in Bethesda, Maryland, and the NOAA offices in Boulder, Colorado, consisted of two business sessions. The purpose was for information exchange via satellite as opposed to costly travel. The Environmental Data Service of NOAA held a project review, and the Environmental Research Laboratories held an administration council meeting.

#### The American Hospital Association

The American Hospital Association's Annual Convention held in Atlanta, Georgia, was broadcast via CTS and ATS-6 to over 60 hospitals in the midwest and Alaska. One of the highlights of this demonstra-

was a live teleconference with the President of the American Hospital Association.

The purpose was to present the potential of reaching distant individual hospitals for educational purposes, and the viability of using satellite communications as an alternative to traditional conference participation.

The 1978 American Hospital Association Convention was broadcast via CTS and WESTAR I to over 250 medical institutions in 15 states. The program consisted of eight hours of educational programming directed at health care administrators on new and rapidly changing developments in the field.

#### The Send/Receive Satellite Network

A two-day teleconference was held between Ames Research Center in California and a New York City site, where the signals were further distributed to local cable T.V. systems for distribution. The program was designed to demonstrate the use of satellite communications and to inform the participants about the requirements necessary for its use.

The purpose was to obtain a better understanding of the manner in which satellite communications function.

#### Ontario Educational Communications Authority

The Ontario Educational Communications Authority conducted a full-duplex teleconference on CTS in conjunction with Project Interchange and the Public Service Satellite Consortium.

The program, entitled "Readalong," originated in Toronto, Ontario, Canada, and was viewed by reading experts in Menlo Park, California. The program was also distributed to educational television networks at both sites.

The purpose was to demonstrate the applications of satellite communications for educational purposes; specifically, to enhance the effective utilization of an innovative technique for teaching reading to primary grade students.

Medical University of South Carolina

One of the more extensive demonstrations sponsored by PSSC occurred in mid-January when a series of continuing medical education programs, coordinated by the Medical University of South Carolina, were transmitted via CTS. The live interactive medical seminar linked 160 universities and hospitals in 15 southeastern states and Ohio. Twenty-one hours of video-taped programming provided the opportunity for health care specialists to further their education and obtain AMA Category I continuing education credits. Each broadcast was followed by an information exchange between faculty and viewers via telephone and two-way television.

A second demonstration by the Medical University of South Carolina was part of an eight-month experiment funded by the National Institute of Health entitled "Reach." A full-duplex demonstration between the MUSC studio in Charleston, South Carolina, and the Lister Hill facilities in Bethesda, Maryland, enabled research experts from NIH and MUSC to discuss the latest findings in medical research and their implications to a variety of health problems. Health professionals and lay audiences were also able to view the program through the existing networks of NASA/LeRC, SECA, GTE Laboratories, HCN, and SCETV.

During the third month of the NIH experiment, MUSC attempted another REACH program which was cancelled due to extreme weather problems.

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The final REACH program, "Current Research on Epilepsy," was broadcast on CTS and WESTAR I. Seven public television stations and the Health Television Network in Cleveland, Ohio, were able to participate with the addition of the WESTAR I broadcast. Members of the National Foundation for Epilepsy were able to receive continuing education course credit for their participation.

The Medical University of South Carolina also conducted another continuing education course via CTS/WESTAR I to 32 V. A. hospitals and 53 public television stations across the country. The program, "Current Concepts on Epilepsy," was directed at physicians and nurses.

University of California, San Diego

The University of California, San Diego, in cooperation with San Diego County, the City of San Diego, and the San Diego Comprehensive Planning Organization sponsored a teleconference on offshore oil drilling. Local participants of San Diego were able to discuss national policy and local impacts of the OCS program with Ms. Heather Ross, Deputy Assistant Secretary, Policy Budget and Administration from the Department of Interior, speaking from the Lister Hill facilities in Bethesda, Maryland.

The purpose of this demonstration was to allow local planning and administrative entities to speak with a decision-maker at the national level.

Appalachian Regional Commission

The National Association of Social Workers brought information and research results to teachers, social workers, counselors, and psychologists via CTS/ATS-6 and ATS-3 (audio). The program originated in San Diego, California, and was viewed at 45 sites throughout the country.

Use of the technology for intercommunication with rural areas was found to be very useful.

DHEW/SAMOA

With the use of CTS, ATS-6 and ATS-3, the Department of Health, Education and Welfare, and NASA sponsored a teleconference between U. S. Government officials in Washington, D. C., and San Francisco, California, and local government officials of American Samoa.

The purpose was to demonstrate the application of communication satellites in the management, planning, and delivery of Department services to remote locations.

Indiana Higher Education Telecommunications System

Member institutions of IHETS conducted an instruction program for dental school faculties and for classroom teachers involved in the integration of handicapped children into the mainstream of our elementary and secondary education programs. The program was broadcast from Indianapolis, Indiana, and received at the Archdiocese of San Francisco in Menlo Park, California, the V. A. hospital in Long Beach, California, and several network locations at both the transmit and receive sites.

The purpose was "assessing" the potential of satellite communications in the field of professional continuing education.

The Indiana Higher Education Telecommunications system held another demonstration of CTS/WESTAR I in commemoration of the centennial anniversary of the Dental School at Indiana University. The program included a three-way teleconference between the Indianapolis School of Dentistry, the University of Mississippi School

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of Dentistry, and the University of Baltimore School of Dentistry. In addition, 20 public television stations provided audience viewing accommodations throughout the country.

#### Joint Council on Education Telecommunication

The Annual Meeting of the American Association for the Advancement of Science (AAAS) in Washington, D. C., was distributed via CTS in full-duplex to NASA Ames Research Center in Moffat Field, California, and the University of Washington, Seattle.

The purpose of the teleconference was to demonstrate and discuss the potential of satellite communications for meeting educational needs and consisted of presentations by five well-known leaders active in the field of societal satellite applications.

#### Forum for the Advancement of Students in Science and Technology

During the Annual Meeting of AAAS, a full-duplex demonstration between the NASA Ames Research Center in Moffat Field, California, and Washington, D. C. was conducted. The program entitled "The Search for Extraterrestrial Intelligence: Priority or Pandora's Box" was broadcast to teachers and students.

The purpose of this activity was to demonstrate and promote the applicability of satellite communications as one of the various "Tools of Science."

#### Greater Cleveland Hospital Association

During the 62nd Annual Meeting of the Greater Cleveland Hospital Association, a full-duplex teleconference was held via CTS. Officials of major health care associations and a member of Congress active in the formulation of national health care policy in Cleveland, Ohio,

and at the Lister Hill facilities in Bethesda, Maryland, discussed topics relating to health care. The program was also distributed to the SECA network and Indianapolis, Indiana.

The purpose was to demonstrate the effectiveness of satellite communications.

The second demonstration conducted by the Greater Cleveland Hospital Association was a program featuring "perinatal nursing grand rounds" at Case Western Reserve University. The program was broadcast to the Interact Hospital Network in Vermont and New Hampshire.

The purpose was to share some of the expertise within the "real-time" capabilities of satellite teleconferencing.

A third demonstration was held to deliver a medical continuing education program on "Down Syndrome" (mongolism) from Case Western Reserve University to the Interact Hospital Network in Vermont and New Hampshire.

#### North Alabama Educational Opportunity Center

A demonstration via CTS was held during the "Third Annual Career Fair and NASA Aerospace Symposium," at the Lewis Research Center in Cleveland, Ohio. High school and college students in Huntsville, Alabama, were able to interact with scientists at NASA Lewis.

This demonstration was designed to give high school and college students an opportunity to utilize satellite technology and to provide useful information about NASA engineers and scientists and the work they are doing at NASA's Lewis Research Center.

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### Lister Hill National Center for Biomedical Communications

A full-duplex demonstration between Denver, Colorado, and the Lister Hill facilities in Bethesda, Maryland, was held during the "Annual Rural Health Symposium." Rural Health planners and administrators at both locations were able to share and discuss the ideas put forth in the Symposium.

Lister Hill also completed a series of ten full-duplex programs enabling medical experts at Lister Hill facilities in Bethesda, Maryland, to discuss research in various areas of medicine with medical students and faculty members of the Tuskegee Institute in Tuskegee, Alabama.

### Radio and Television Commission of the Southern Baptist Convention

The Radio and Television Commission of the Southern Baptist Convention conducted a satellite demonstration on April 26, 1978, in conjunction with a three-day "Radio, Television, and Cable Consultation" held in Fort Worth, Texas. Proceedings from the Consultation were transmitted to a group of Southern Baptist Convention leaders assembled at the First Baptist Church of Nashville, Tennessee. With a program designed to create an economic and technical atmosphere in which decision makers could evaluate the operational efficiency of communications satellite networks versus current terrestrial systems, the decision makers in Nashville joined with participants in the Consultation agenda in exploring possible applications for RTVC operations.

### Family Symposium-Johnson & Johnson Company

The Institute for Pediatric Service of the Johnson & Johnson Baby Products Company conducted a two-day demonstration on CTS and



ATS-6. Selected portions of the "Family Symposium" held in Washington, D. C., were broadcast to various locations in the western U. S. and Alaska. The conference brought together a group of experts to reconsider the family with attention to the family as a system, and to the needs of the American family in the areas of health, communications, education, city planning and architecture, ethno-cultural tensions, social policy, and law.

Satellites were used to enable many people to participate in this popular symposium.

#### San Francisco State University

A full-duplex demonstration was held in conjunction with the "Third Asian and Pacific Television Conference" connecting the conference site of San Francisco and the Lister Hill facilities in Bethesda, Maryland. This conference enabled representatives from primarily the government, education and broadcast communities of the U. S., Canada, and numerous Pacific Basin countries to participate.

#### American Association of School Administrators

During the convention of the American Association of School Administrators held in Minneapolis, Minnesota, the address to the conference presented by the Secretary of the Department of Health, Education and Welfare, Joseph Califano, was broadcast via CTS from Washington, D. C.

This program allowed some 1,500 participants to experience satellite communications first hand.

#### UNICON

A video teleconference was held in conjunction with the UNICON IV annual science fiction conference in Silver Springs, Maryland.

Six prominent science fiction writers and motion picture specialists located at NASA/Ames Research Center in San Francisco were able to interact with conference attendees.

Corps of Engineers, Department of the Army

A teleconference involving Engineers at the Mississippi River Commission in Vicksburg, Mississippi, the Missouri River Division in Omaha, Nebraska, and the Corps of Engineers officials in Washington, D. C., was conducted. Briefings on flood control, navigation, and other water control objectives were presented.

Medical Care Development, Inc.

The Interactive Telecommunications System in central Maine was linked with the INTERACT Television Network in New Hampshire and Vermont via CTS. Physicians, social workers, psychologists, and rural health practitioners participated in two programs: "Ambulatory Data Collection" and "Psychiatric Problems of Alcoholics."

The purpose of this program was to assess the potential of satellites for interconnecting hospital television networks with a multi-state region for the purpose of continuing medical education and scarce resource sharing among areas with similar health care needs and requirements.

Library Information and Technology Association Institute

A full-duplex demonstration was held in conjunction with a three-day institute entitled "Management of Information for the 80's." The program originated in Washington, D. C., and was broadcast to information specialists and students at the University of Michigan in Ann Arbor, and Goddard Space Flight Center in Greenbelt, Maryland.

### Teachers Conference

The Project Office of Lewis Research Center (LeRC) sponsored a CTS demonstration designed to indoctrinate various groups of teachers to the recent findings of the Educational Programs Office at Goddard Space Flight Center (GSFC). The program included training sessions on the use of moon rock samples in classrooms.

The program originated primarily at GSFC in Greenbelt, Maryland, with secondary programming from LeRC in Cleveland. Receive locations included Purdue University in West Lafayette, Indiana, and the Abrahms Planetarium in East Lansing, Michigan, located on the Michigan State University campus.

### Joint NASA/GSFC-NASS/ERL-NCAR Satellite T.V. Colloquium

A special closed circuit satellite television colloquium was held jointly between the NASA Goddard Laboratory for Atmospheric Sciences, Goddard Space Flight Center, Greenbelt, Maryland; NOAA Environmental Research Laboratories (ERL); and the National Center for Atmospheric Research (NCAR), Boulder, Colorado. The colloquium, entitled "Is Climate Predictable," focused on the monthly and seasonal time scales. The primary purpose of the event was to demonstrate how satellite technology can stimulate research through improved links between geographical centers of atmospheric and hydrospheric science activity in the nation.

A series of three teleconferences were conducted. The first two were in regards to forecasting weather. The third teleconference focused on rainfall measurements via satellite and ranged from data analysis to discussion of the future of visual, IR, and microwave radiometric techniques.

### National Translator Association

A two-day demonstration was held utilizing CTS and WESTAR I to broadcast PBS programming from Denver, Colorado, to Round-Up, Montana.

This activity was designed to introduce a rural Montana audience to Public Broadcasting System programming.

### United States Catholic Conference

The second day of hearings on communication conducted at the Archdiocese of San Francisco Educational Television Center at Menlo Park, California, was broadcast via CTS/ATS-6 to twelve V. A. hospital networks in the western U. S. Panelists, including Bishop Pierre DuMaine and other church dignitaries, received testimony from experts in the field of communications.

### American College of Physicians

A dual satellite demonstration users CTS and WESTAR I was designed to broadcast two continuing education programs. The programs, selected from the "Meet the Professor" series hosted by ACP at its annual meeting in San Francisco, California, featured the topics "Coronary By-Pass Surgery" and "Pulmonary Disorders." This program was broadcast to over 160 medical facilities in 13 states.

### Gerontological Nursing

The American Journal of Nursing completed a series of programs in continuing education for professional nurses via CTS. All four programs were pre-taped regarding health care for the elderly patient and featured Rosalynn Carter. The programs originated from the Lister Hill facilities in Bethesda, Maryland, and were received at 30 V. A. hospital sites.

### Media Development Project for the Hearing Impaired

The University of Nebraska-Lincoln's Media Development Project for the Hearing Impaired conducted a two-day symposium with administrators and educators of the hearing impaired from Gallaudet College in Washington, D. C. This full-duplex teleconference featured Video Disc material, which promises to be a good educational tool for the hearing impaired.

### CTS User's Meeting Twenty-Two

The CTS Satellite was used to link Denver, Colorado, and Lewis Research Center in Cleveland, Ohio, for the twenty-second meeting of the CTS users. The Denver audience was able to view a series of panelists at LeRC. Cleveland panelists were able to listen to the presentations of CTS Experimenters, but were without video from Denver.

### Martin Marietta Teleconference

Martin Marietta Aerospace Division conducted a teleconference between Waterton, Colorado, and Vandenburg Air Force Base, California, via CTS. Tom Godwin at Waterton, and George Hewitt at Vandenberg, hosted three panels for a three-hour discussion with topics including a Critical Design Review, Data Link Usage, and Fuel Load Verification Equipment. The demonstration presented an alternative to travel between Colorado and California, and culminated a study in cost-effectiveness for satellite telecommunications at Martin Marietta.

### Asthma Workshop

Doctors from the National Asthma Center in Denver conversed with parents of asthmatic children in Trinidad, Colorado, and presented

a three-day Asthma Workshop via CTS. The University of Colorado Medical Center provided studio facilities for the team of medical instructors, while participants viewed the program at the county health building in Trinidad.

CTS DEMONSTRATIONS  
EXPERIMENT 21 INVOLVEMENT

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Supported	Sponsored	Demonstration	Date
X	X	California Innovations Group	3/1/77
X	X	Council for Exceptional Children	4/13/77
X	X	Indiana University School of Medicine/ Maryland Center for Public Broadcasting	5/23/77
X	X	University of Kentucky	7/1/77
X	X	PSSC Workshop	6/17/77
X	X	University of Alabama in Birmingham	7/7/-19/77
X		National Oceanic and Atmospheric Administration	7/21/77
X	X	American Hospital Association	7/30-8/1/77
X	X	Send/Receive Satellite Network	9/10-11/77
X	X	Rehabilitation Services Administration	9/27/77
X	X	American Dietetic Association	10/14/77
X	X	Bureau of Reclamation	10/28/77
X		Lister Hill National Center for Biomedical Communications	11/6-7/77
X	X	Appalachian Regional Commission	11/21/77
X		DHEW/Samoa	12/28/77
X		Ontario Educational Communications Authority	1/13/78
X	X	Medical University of South Carolina	1/10-22/78

CTS DEMONSTRATIONS

EXPERIMENT 21 INVOLVEMENT (CONTINUED)

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Supported	Sponsored	Demonstration	Date
X	X	University of Alabama at Birmingham	1/28-29/78
X	X	University of California, San Diego	2/11/78
X	X	Joint Council on Educational Telecommunications	2/14/78
X	X	Forum for the Advancement of Students in Science and Technology	2/14/78
X	X	Greater Cleveland Hospital Association	2/25,28/78
X	X	National Oceanic & Atmospheric Administration	3/28/78
X	X	North Alabama Educational Opportunity Center	3/30/78
X		NASA Headquarters/North Alabama Educational Opportunity Center	3/30/78
X		Lister Hill "Annual Rural Health Symposium"	4/7/78
X	X	Radio and T. V. Commission of the Southern Baptist Convention	4/26/78
X		MUSC	5/8-10/78
X		Lister Hill/Family Symposium/Johnson & Johnson	5/17-19/78
X		San Francisco State University	6/7/78
X	X	Council for Exceptional Children	6/29/78
X	X	American Association of School Administrators	7/8/78
X	X	Unicon	7/8/78

C-3



CTS DEMONSTRATIONS

EXPERIMENT 21 INVOLVEMENT (CONTINUED)

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Supported	Sponsored	Demonstration	Date
X		MUSC	7/11/78
X		Corps of Engineers, Department of the Army	8/10,15/78
X	X	American Hospital Association	9/12,14/78
X	X	Medical Care Development, Inc.	9/14/78
X	X	LITA (Library Information Technology Association)	9/28/78
X		Lister Hill	10/78
X		Medical University of South Carolina (MUSC)	12/13/78
X		Teachers Conference (Sponsored by NASA Lewis)	12/15/78
X	X	Greater Cleveland Hospital Association	2/6/78
X	X	Roundup National Translator Association Demonstration	2/10,11/79
X		Environmental Research Laboratories/ National Oceanic and Space Administration (ERL/NOAA)	2/8, 3/8, 4/13, 5/11/79
X	X	United States Catholic Conference	3/24/79
X		American College of Physicians (ACP)	3/27, 2/29/79
X	X	Greater Cleveland Hospital Association	4/4,6/79
X	X	American Journal of Nursing	4/16/79
X	X	University of Nebraska	4/18/79

CTS DEMONSTRATIONS  
 EXPERIMENT 21 INVOLVEMENT (CONTINUED)

Supported	Sponsored	Demonstration	Date
X		CTS Users Meeting	4/18/79
X	X	Martin Marietta Teleconference	5/9/79
X	X	Indiana Higher Education Telecommunications System	5/18/79
X	X	Medical University of South Carolina	5/30/79
X	X	National Asthma Center	6/18,20, 22/79

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## EVALUATION, RESULTS, CONCLUSIONS

Although short-term demonstrations did not necessarily solve any long-term problems, each was worth a thousand words in explanation as to how communications satellites can serve and benefit the public service community. These opportunities provided numerous public service groups a tangible experience from which to draw their own conclusions, based on individual needs and organizational requirements.

Although satellites are not the solution to all problems, certain questions have been answered without a doubt. Satellites are viable, technically and economically feasible when applied in an appropriate manner, and are an adaptive medium amazingly suited to meet many societal needs. On the other hand, some issues are not so easily determined. What technical configurations work best and what are the economic benefits to be derived and to what extent?

Here the solution depends heavily on the reasons and needs for communications services and the financial and organizational composition of a given group, and satellites may or may not be the answer.

In search of the practical solution, there is no substitute for actual experience, and short-term satellite demonstrations provided this experience to numerous societal groups and their constituencies. NASA programs over the past few years have collectively introduced more people to the capabilities of satellite communications than all the commercial satellite networks combined. Aside from economic support, many believe too, that NASA provided the necessary psychological support to many societal users perhaps reluctant to venture out on their own with new technologies. In any case, the short-term demonstrations allowed the

officials and decision-makers of these societal groups to set up, test, and appraise specific concepts on their minds without extensive monetary investments. It allowed them to gain experimental knowledge of the technical implementation process, while providing a practice opportunity for trying out various media techniques. Both are believed valuable in working toward the intelligent transfer of their experience to actual, operational satellite services. Decidedly, progress has occurred, as evidenced by the fact that fifty percent of the societal groups that conducted short-term demonstrations sponsored by PSSC during the course of CTS have already arranged, or are in the process of arranging, domestic satellite usage on either an occasional or continuing use basis.

Although the day of demonstrations has come to an end, the demand for communication via satellite has not. The trend toward effective use of satellite communication has now turned to the use of commercial satellites--specifically, the Western Union and RCA satellite series which are used in conjunction with the Public Television Satellite System and cable systems throughout the United States.

EXPERIMENT 22

TITLE: Arctic Ice Information

DISCIPLINE: Technology

ORGANIZATION: NASA/Lewis Research Center

OBJECTIVE: Demonstrate the capability and usefulness of relaying near real time ice information via CTS to a joint military-civilian vessel operations center located in Barrow, Alaska, in support of vessel-barge resupply operations along the Alaskan North Shore.

PRINCIPAL INVESTIGATOR: Dr. Richard Gedney

ACTUAL START: 8/77

COMPLETION: 9/78

CG/NWS/NASA ARCTIC ICE INFORMATION DEMONSTRATION

SMS/GOES  
SATELLITE

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UHF UPLINK

ALASKA

ARTIC  
CIRCLE

14 GHz

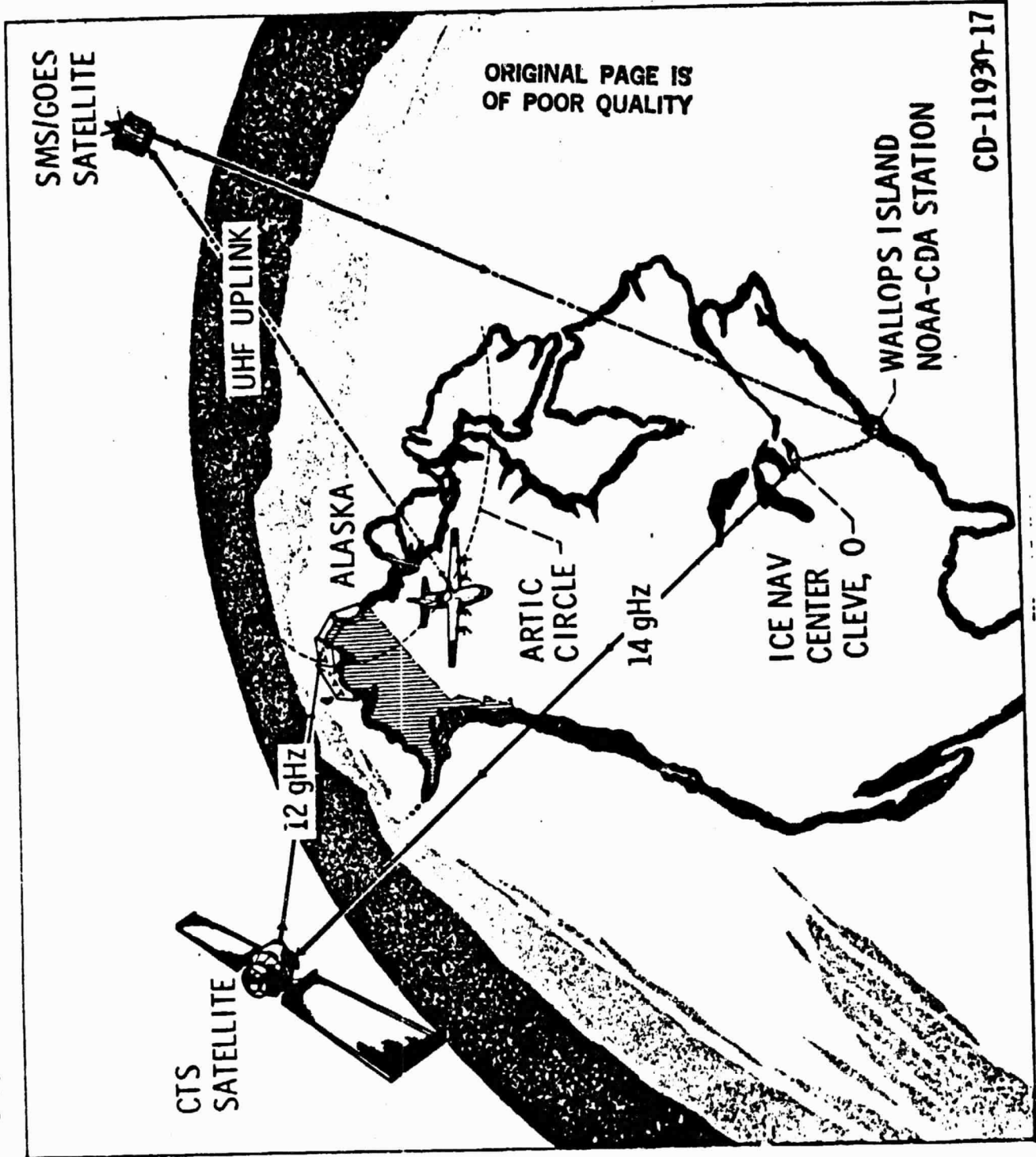
WALLOPS ISLAND  
NOAA-CDA STATION

ICE NAV  
CENTER  
CLEVE, O

12 GHz

CTS  
SATELLITE

CD-11930-17



## EXPERIMENT SPONSOR

The Arctic Ice Information experiment is a joint experiment of the NASA/Lewis Research Center, U. S. Coast Guard, and the National Oceanographic and Atmospheric Administration (NOAA), managed by the Aerospace Application Branch of the Lewis Research Center. Personnel from the CTS Project Office of the Lewis Research Center were responsible for transmitting and receiving the data via CTS. The U. S. Coast Guard deployed the C-130 SLAR aircraft to Alaska while NOAA made available the GOES satellite for data retransmission from the SLAR aircraft through Wallops Island, Virginia, data acquisition facility and on to Cleveland, Ohio, via telephone lines.

## CONCEPT

Resupply of the various military and commercial bases along the north shore of Alaska is generally accomplished by means of barges towed from Seattle, Washington. Barge resupply operations for these bases are scheduled for the months of July, August, and September, when the arctic pack ice traditionally recedes from the northern coastline. Weather systems moving through this area, however, made it extremely difficult to forecast with any degree of accuracy just when and where leads, openings, and melting will occur so as to permit vessels and barges to navigate these waters safely. Shifting winds accompanying such frontal passages impart a dynamic movement to the arctic ice pack. Leads and openings can be closed in a matter of hours. Information regarding the location, extent, and types of ice found in the Arctic has traditionally been gathered by means of observations from both aircraft and satellites in the visual light spectrum range. Clouds and especially fog so prevalent during the summer months severely hamper such visual observation.

In addition to the problem of obtaining ice information, there exists a problem in disseminating this information to support the various operational requirements of the user community, both civilian and military. This ice information is collected and analyzed by a number of different federal, state, and commercial agencies, including the Navy, the NOAA-



National Weather Service, the U. S. Coast Guard, the State of Alaska, the Arctic Institute, and the barge operations companies. This information is generally collected in a piece-meal fashion, and only recently have facilities been proposed to attempt to centralize such arctic ice information. The commercial development of the petroleum reserves of the Alaskan North Slope has accelerated the need not only for more comprehensive ice information, but also the near real-time distribution of such information to facilitate shipping operations; i.e., within a few hours after the information is collected. At the present time, comprehensive ice information distribution and dissemination to support such vessel-barge resupply operations is only minimal at best.

Two main problems were addressed during this experiment. The first involved the evaluation of the usefulness of Side-Looking-Airborne-Radar (SLAR) to survey and monitor the north shore arctic ice conditions. SLAR with its ability to penetrate all but the most severe weather along with a capability to map broad lateral distance from aircraft altitudes is ideally suited for such ice monitoring. The SLAR system to be used in this demonstration has been successfully used in the Great Lakes (Project Icewarn).

The second problem was to demonstrate the capability of facsimile transmitting a SLAR image and an accompanying interpretative ice chart from the NASA/Lewis Research Center in Cleveland, Ohio, via the Communications Technology Satellite (CTS) to a joint military-civilian vessel operations center at Barrow in a near real-time manner.

This information was subsequently relayed to the barges allowing them to navigate safely through the shifting leads and openings in the arctic pack ice.

## OBJECTIVES

The objective of this experiment was to demonstrate the capability and usefulness of providing photographic quality SLAR ice information to a joint military-civilian vessel operations center located at Barrow, Alaska. This ice information was then relayed to vessel-barge convoys attempting to resupply both military facilities and commercial oil drilling operations along the Alaskan North Shore.

## EXPERIMENTAL PROCEDURE

### SLAR System

As mentioned previously, the SLAR system proposed for this demonstration had already been successfully used in the Great Lakes to provide near real-time information in direct support of vessel navigation. A basic outline of this system is provided below; refer to NASA TMS-71815 for more details.

The SLAR used in this program was a Motorola An/APS-94C system and was mounted in a U. S. Coast Guard C-130B aircraft. Operating in the X-band at a frequency of 9.245 GHz (3.245 cm wavelength) using a real aperture antenna, this radar transmits and receives horizontally polarized radiation. For SLAR missions, this aircraft is flown at an altitude of 3.35 kilometers (11,000 feet) and at an average speed of 280 knots.

### Data Relay to Cleveland

The SLAR video was digitalized aboard the aircraft and transmitted to the NOAA-GOES satellite in geosynchronous orbit via a UHF uplink at 402 MHz center frequency in a real-time mode. The data was subsequently

relayed from the satellite via an S-Bank downlink at 1.6 GHz to the NOAA-NESS Command and Data Acquisition Station at Wallops Island, Virginia. The digital data was then synchronized, buffered, and sent via telephone lines to the NASA/Lewis Research Center in Cleveland, Ohio.

#### Data Processing and Analysis

At the Lewis Research Center the digital SLAR data transmitted from the aircraft was recorded on magnetic tape, decoded and converted to an analog signal for a CRT-fiber optics recorder that employs dry, heat-developed, photosensitive paper to generate a high-quality SLAR image at a scale of 1:500,000 or 1:1,000,000. The visual interpretation of these SLAR images was presented in a form of hand drawn ice charts. Such charts characterized the various areas of ice as to relative concentration, type of ice, and distribution of floe sizes using standard nomenclature. The combination of a SLAR image and an interpretative ice chart were referred to as a SLAR Image/Ice Chart Product or, more simply, as a SLAR Product.

#### CTS Relay

The combined SLAR Image/Ice Chart Products were transmitted using facsimile receiver and were used to acquire and pictorially display the transmitted products.

EXPERIMENT 24

TITLE: Digitally Implemented Communications  
Experiment (DICE)

DISCIPLINE: Technology

ORGANIZATION: NASA/Lewis Research Center COMSAT  
Laboratories

OBJECTIVE: Develop and demonstrate a digital communica-  
tions capability accommodating a mixture of  
information systems using minimal channel  
requirements in order to demonstrate the  
practicality and feasibility of satellite  
link implementation by digital techniques  
for the distribution of T. V., voice, and  
data via small earth terminals.

PRINCIPAL INVESTIGATOR: Mr. Howard Jackson

ACTUAL START: 6/77

COMPLETION: 6/78

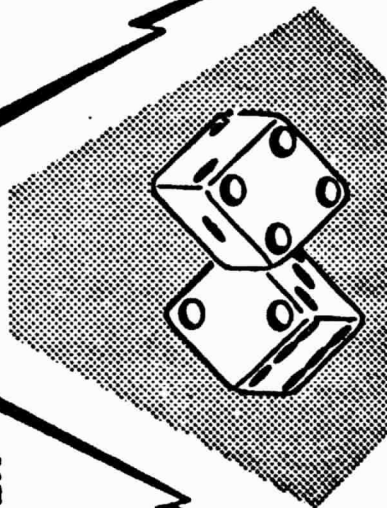
# DIGITALLY IMPLEMENTED COMMUNICATIONS EXPERIMENT



**LEWIS  
RESEARCH CENTER**

**COMSAT  
LABORATORIES**

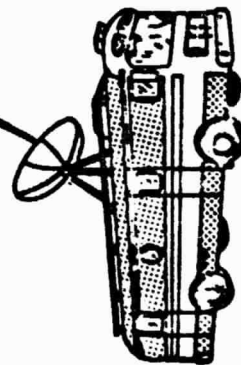
**COMMUNICATIONS  
TECHNOLOGY SATELLITE  
U.S. EXPT. 24**



# DICE

**SIMULTANEOUS TWO-WAY**

- COLOR TELEVISION
- 60 CHANNEL VOICE
- DATA



**PORTABLE EARTH TERMINAL**



**COMSAT**

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## CONCEPT

The demand for communications services is rapidly expanding. Satellite communications systems are currently playing a prominent role in fulfilling these growing demands. In conjunction with the expansion of satellite systems, there is a significant effort being directed toward new developments which will reduce the costs associated with the distribution of satellite services. In this light, advanced satellite transponder technology and small inexpensive earth terminals will be demonstrated as part of the Communications Technology Satellite Experiments Program. Another system element that holds promise for substantially reduced transmission costs is associated with the distribution of satellite services. In this light, advanced satellite transponder technology and small inexpensive earth terminals will be demonstrated as part of the Communications Technology Satellite Experiments Program. Another system element that holds promise for substantially reduced transmission costs is associated with methods for implementing the communications links. Digital implementation (when compared to analog transmission systems now in use) can offer substantial savings in both satellite power and RF bandwidth. Power and bandwidth savings, of course, can result in lower distribution costs.

## OBJECTIVES

The objectives of the demonstration and characterization of digital links can be divided into two categories: technical and operational/economic.

The technical objectives are as follows:

1. To design and fabricate a system which combines compressed digital transmission techniques for television, voice, and data.
2. To design and fabricate the necessary digital/RF interface equipment to operate the digital system at 11 and 14 GHz from portable terminals.
3. To package the digital and RF interfacing equipment for ruggedness, mobility, and ease of operation.
4. To determine the effects of rain attenuation and other perturbations of the proposed high data rate digital link at 11-14 GHz and to determine the feasibility of using this band for duplex T. V./voice transmission purposes.
5. To provide subjective ratings of picture quality using video compression techniques and error coding as a function of link parameters.

The operational/economic objectives are as follows:

1. To demonstrate a cost-effective digitally compressed video/voice system in conjunction with efficient channel coding.

2. To demonstrate the effectiveness and practicality of the digitally compressed video/voice system and portable terminals using low power to reduce satellite bandwidth and cost for users.
3. To keep detailed and accurate records of actual costs of demonstrations.

### EXPERIMENT PROCEDURE

Data was taken on carrier-to-noise and correlated with up- and down-link transmission variables such as weather conditions, antenna location, and deployment/configuration of system components. Transmission parameters were recorded at both stations through the test. Information on frequency, transmitter power, bit rate, and other pertinent channel parameters were gathered.

Compression effectiveness with and without error coding were conducted in a back-to-back mode with the RF link prior to field demonstrations in order to establish a performance baseline. A continuum was provided by utilizing the same program material (taped activities) for portions of both the back-to-back and field configurations under differing compression schemes and levels of activity (action).

### DEMONSTRATIONS AND TESTS

#### Demonstration Concept

The experimental demonstration concentrated on the evaluation of duplex television in the teleconferencing environment. The video tele-



conferencing environment has been chosen to provide feedback from a user's rather than critic's perspective of digital system quality and performance.

Two duplex television teleconferences were conducted with the DICE system. The first utilization was during a communications convention (IDD-77/Chicago) exhibit in June 1977. The exhibit was structured as a duplex video teleconference/open discussion between convention attendees and COMSAT video teleconference facilities in Clarksburg, Maryland. Concurrent with the videoconference open discussion, the SIDEL system was actively loaded with taped conversations on 59 of 60 channels. The remaining channel was used extensively by convention attendees. The second utilization was during a communications satellite conference (7th AIAA/San Diego) exhibit in April 1978. More detailed information of this activity is contained in the RESULTS AND DISCUSSION portion of this report. The SIDEL feature of DICE was not used during this exhibit.

#### Link Performance Tests

Link characterization concentrated on the DICE system operational bit rate of 42.95 Mbps. Bit-error-rate performance tests were conducted. Back-to-back operational performance of the modem and up/down converter were established during acceptance testing of the complete system to permit determination of link-only performance changes.

## RESULTS AND DISCUSSION

### Demonstration

The first utilization of the DICE Experimental System at the ICC-77/Chicago exhibit provided quality which was subjectively judged, for both CODIT and SIDEL, as excellent to better than network quality by approximately 250 communications media personnel in attendance.

The second utilization of the DICE experimental system in a demonstration format was for the full duplex transmission of selected sessions of the 7th AIAA Communication Satellite Systems Conference held in San Deigo, California, in April 1978.

The CTS duplex link was between the LeRC/PET in California, and the COMSAT terminal in Maryland. The following summary of teleconferenced session topics is provided to show that those who were involved and viewing the link quality were well acquainted with the typical large-terminal-through-satellite-to-large-terminal performance.

Duplex transmissions covered the following:

1. Session 2: "1980's Generation of Comm. Satellites and Key Issues in Technology" panel discussion.
2. Session 12: "Television Via Satellite," six papers addressing direct broadcast.
3. Session 16: "Defense System II," three papers addressing space laser communications, satellite-to-satellite data transfer, and a report on the LES 8/9 Program.
4. Informal System Display with hands-on interaction by conference attendees and COMSAT Labs attendees during exhibit periods.

Although no quantitative bit-error-rate (BER) measurements were made due to lack of spacecraft and program time, the subjective evaluation by those who have been working with the system was that the quality was equivalent to a  $10^8$  BER. The analog signal-to-noise quality of the video at both terminals is summarized below. Participants and viewers agreed that the video and audio quality were excellent, and that the translation to and from a digital format had no perceptible effect.

DICE Duplex Operational Mode/Result

TB2 (20W)	- 4-dB S/C atten. uplink EIRP 70 dBW S/C EIRP 46 dBS (10 W)/BER $10^{-8}$
TB2 (200 W)	- 5-dB S/C atten. uplink EIRP 71 dBS 4-dB S/C gain suppression S/C EIRP 58 dBS (160 W)/BER $10^{-8}$
BER $10^{-6}$	- 20 streaks/sec. - quite noticeable
BER $10^{-8}$	- .2 streaks/sec. - perceptible - not annoying
BER $10^{-9}$	- .02 streaks/sec. - barely perceptible

Link Characterization

Link characterization tests were conducted to define the performance relationship between the Hermes/CTS channel 1 EIRP and the DICE system. Using the LeRC fixed terminal, the plot of the channel 1 output stage tube (OST) versus bit error rate was developed.

The results showed that the combined link was uplink noise limited. Although the spacecraft does provide switchable attenuators, the largest

available attenuation (5dB) constrains the maximum uplink EIRP to 71 dBW, thereby limiting the uplink C/T to -130.0 dBW/K. The data shown is applicable to other receive terminals whose G/T does not significantly change the combined link C/T.

This data provides the means whereby simplex operating points may be chosen to provide predictable DICE receiver performance, i.e., BER operating point, with the COMSAT 3 meter (10 ft.) or LeRC 2.4 meter (8 ft.) terminals.

Hermes/CTS channel 1 EIRP requirement for these terminals is 57.5 dBW, or an output power level from the spacecraft transmitter of 140 watts (Sat. - 1.5 dB). This level produces a BER of approximately  $10^{-8}$  which subjectively is a good quality picture.

Another objective in the link characterization tests was to define the channel spacing criteria for acceptable performance of 2 carriers in a single Hermes/CTS channel. The tests were performed with digital and analog video signals using the spacecraft high power channel 1. Because the spacecraft 200 watt amplifier gain response across the band of channel 1 is not constant, carrier levels were set equal on the downlink before performance evaluation.

The results, although showing a TASO quality for a given set of conditions, require some additional explanation to better visualize the performance. In the FM/FM case, the interference was crosstalk; however, its perceptibility was a function of picture content. For active pictures, the crosstalk was negligible, and for static pictures it was there but not annoying. For the QPSK/FM cases, the interference presents itself as video noise rather than crosstalk.

For all carrier separations, the interference was more evident on the FM signal. For the 50+ and 50-MHz carrier separations, the digital signal showed no change in picture quality from operation in the simplex mode at the duplex link levels. Subjectively, the picture quality was very good to good for both channels. With a 30-MHz carrier separation, both pictures become unacceptably noisy; however, horizontal lock was maintained. Subjectively, the QPSK signal was fair to poor and the FM signal poor. It is, therefore, concluded that a spectrum separation of at least 10 MHz is required for reception of a good quality, single channel QPSK/FM video transmission.

#### CONCLUSIONS

The system design described will provide full duplex teleconference capability in addition to 60 channels of digital voice and 1-Mbps data. The CODIT and SIDEL compressions of approximately 2:1 and 4:1, respectively, provide excellent quality transmission equivalent to NTSC standards.

The CTS satellite link performance provided by small Earth terminals and using either the 200 watt or 20 watt channels at backed-off levels (140 and 10W, respectively) is sufficient to provide a system BER of  $10^{-8}$  or less without additional error excluding equipment.

EXPERIMENT 25

TITLE: Videoconferencing for Congress

DISCIPLINE: Community Services

ORGANIZATION: George Washington University

OBJECTIVE: Design and implement real-time demonstrations of Congressional videoconferencing using two-way audio-video (full duplex) communications between a member of Congress and/or Congressional staff and small groups of staff or constituents.

PRINCIPAL INVESTIGATOR: Dr. Fred Wood

ACTUAL START: 4/77

COMPLETION: 7/78

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This study was designed to help meet three distinct kinds of needs:

1. The needs of Congressmen for improved methods of communicating with constituents in carrying out their Congressional responsibilities.
2. The needs of policymakers for better data on the potential benefits and costs of using emergent telecommunications technology, such as the CTS satellite, for provision of public service.
3. The needs of NASA for unique experiments which will demonstrate new satellite applications and ultimately create markets for domestic civilian services using space technology.

#### OBJECTIVES

The objectives were as follows:

1. To design and implement a real-time demonstration of Congressional videoconferencing, using the Communications



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Technology Satellite (CTS) and related technologies, with the direct participation of selected members of Congress and their staffs and constituents.

2. To identify, analyze, and evaluate the results of the demonstration with regard to the advantages and disadvantages of Congressional videoconferencing as perceived by the participants.
3. To identify, analyze, and evaluate the results of the demonstration with respect to the direct and indirect effects or impacts, intended or unintended, of Congressional videoconference for the Congress and the general public as well as for the participants themselves.
4. To clarify public policy alternatives and options available to the Congress and other relevant policymakers in regard to the development and use of Congressional videoconferencing and related emergent telecommunication channels.

**EXPERIMENTAL PROCEDURE**

This experiment was the third phase of a long-term research on Congressional communication:

Phase 1

Concept Definition (1969-1970; based on political and technical analysis, literature survey, and discussion with Congressional staff).

Phase 2

Exploratory Assessment (1973-1974; based on interviews with a stratified judgment sample of U. S. Representatives and senior staff from the 93rd Congress).

Phase 3

Experimental Research (1976-1977; based on real-time demonstration of Congressional videoconferencing).

Phase 2 identified the potential and limitations of emergent telecommunication channels, as perceived by Congressmen and staff. The underlying purpose of the Phase 3 experiment was to test Phase 2 exploratory hypotheses and conclusions. In Phase 3, the number of demonstrations were very limited, with the applications selected on the basis of Congressional interest, research value, and technical feasibility. The five basic applications categories included:

Congressional subcommittee hearing,  
Congressional-constituent group meeting, constituent casework,  
Congressional-constituent individual dialogue, and  
Congressional information retrieval/legislative research.

PROGRAMMATIC CONCEPT AND TARGET AUDIENCE

The overall programmatic concept of the twelve experiments in this demonstration, stated simply, was "constituent communication" using satellite technology to help Congressmen and their staffs communicate more effectively with their sometimes-far-away constituents. In each

experiment, the programmatic concept involved some form of constituent communication; therefore, the target audience in each experiment was made up of constituents of some sort, ranging from high school students to psychologists. The following is a brief description of the programmatic concept and target audience of each experiment.

#### Experiment #1

Congressmen from rural districts where the population is distributed over a wide geographic area have a specific difficulty keeping in touch with their constituents. In this experiment, Congressman Charlie Rose of North Carolina met via satellite with high school students from his rural district.

#### Experiment #2

In addition to regular contact with the general public, Congressmen have to keep in frequent touch with local public officials and representatives of local business and government in the district. This presents a particularly severe problem for Congressmen who come from rural districts with many small towns and, thus, have many local public officials with whom to keep in touch. In order to test the potential of satellite videoconferencing to meet this need, Congressman Charlie Rose talked via satellite to several local public officials from his district.

#### Experiment #3

In Congress, committee and subcommittee hearings are at the heart of the legislative process. Tight scheduling of such hearings and the overwhelming workload of most Congressmen mean that people

must come to Washington to testify or depend on lobbyists to represent them. As a result, the large majority of Americans are effectively excluded from the hearing process. The purpose of this videoconference was to test the potential of satellite communications for use in a congressional hearing. This videoconference took place between Senator Adlai Stevenson and the Subcommittee on Science, Technology and Space, convened in Washington, D. C. with testimony via satellite from public witnesses in Springfield, Illinois.

#### Experiment #4

Urban (and suburban) Congressmen do not have a large geographic area to cover, but frequently their constituents place great demands on talking with them in person. Congressman Pete McCloskey of California has had difficulty trying to satisfy all the needs of his constituents to consult with him in person. Thus, a videoconference between Congressman McCloskey and a group of constituents--professional psychologists.

#### Experiment #5

Congressmen receive numerous invitations to speak at meetings of conferences sponsored by organizations with an interest in specific areas of legislative activity. More often than not, these invitations must be declined due to scheduling conflicts and competing priorities. In this experiment, Congressman Dan Rostenkowski (who serves as Chairman of the Subcommittee on Health of the House Ways and Means Committee) addressed the 62nd annual

meeting of the Greater Cleveland Hospital Association, via satellite, from the Lister Hill Center for Biomedical Communications in Bethesda, Maryland. In addition to the audience in Cleveland, health care professionals at many other locations viewed the activity.

#### Experiment #6

In recent years, American Indians have sought more direct access to the Congress on issues of concern to the Indian community. To test the potential of satellite communication for meeting these and other Indian needs, this experiment was intended to show how satellites can facilitate tribe-to-tribe, tribe-to-educational institutions, and tribe-to-federal agency communications. Intertribal Indian leaders and educators in Montana and New Mexico discussed via satellite the status of American Indian education programs with congressional participants in Washington, D. C.

#### Experiment #7

Two days after the discussion of Indian education, a second congressional videoconference was held to demonstrate the potential for Indian leaders to meet with their congressional delegations via satellite. The purpose of this experiment was to have an unstructured dialogue between Indians in Montana and New Mexico and the Senators and Congressmen who directly represent them in Washington.

Experiment #8

The 1978 annual conference of the American Institute of Aeronautics and Astronautics was held in San Diego, California. This experiment involved a panel discussion via satellite between conference attendees in San Diego and interested members of Congress in Washington, D. C.

Experiment #9

In May of 1978, the University of Florida's Institute of Food and Agricultural Sciences held a frost prevention conference. The conference focused on the use of satellite technology to predict more accurately weather conditions in fruit-growing areas. As Chairman of the Subcommittee on Space Science and Applications of the House Science and Technology Committee, and as a member of the Florida congressional delegation, Representative Don Fuqua was invited to attend. Congressman Fuqua was able to participate via satellite from Washington, D. C.

Experiment #10

In this experiment, Congressman Henry Reuss of Wisconsin and Milwaukee high school students participated in an historical event, the first ever live congressional videoconference which used the capabilities of both satellite and commercial television technology. The entire satellite videoconference between Washington, D. C., and Milwaukee was simultaneously broadcast live in the greater Milwaukee metropolitan area.

### Experiment #11

In many policy areas, congressional staff take the lead in developing an understanding of problems and available policy options prior to any formal action by a House or Senate committee. The staff will frequently identify individuals and organizations which have an interest in a given area and develop supportive relationships with those who share common goals. This experiment was devised to show that satellite videoconferencing can facilitate this process, bringing together via satellite senior congressional and White House staff in Washington, D. C. and participants at the annual meeting of the National Conference of State Legislatures in Denver, Colorado.

### Experiment #12

Many senior citizens have the time but not the money or physical strength to visit their congressmen in Washington, D.C. This videoconference demonstrated how satellite technology can make it possible for older Americans to meet regularly with their elected Representatives. Congressman James Hanley and an audience which included members of the staff of the National Council of Senior Citizens and the Council of State Governments in Washington, D. C., met via satellite with a panel and studio audience of senior citizens, all members of ACCORD (Action Coalition to Create Opportunities for Retirement with Dignity) in Liverpool, New York.

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# DEMONSTRATION PROFILE

# EXPERIMENT 25

## TITLE

Videoconferencing for Congress

## ORGANIZATION

The George Washington University

	DATE OF ACTIVITY	TYPE	LOCATION #1	EQUIPMENT	LOCATION #2	EQUIPMENT	PARTICIPANTS	
							PUBLIC	CONGRESS
1	4/15/77	2-way video	Washington, D.C.	Exp. 18 (HQ/Goddard)	Raeford, N.C.	PET	High school students	Rep. Rose
2	4/15/77	2-way video	Washington, D.C.	Exp. 18 (HQ/Goddard)	Raeford, N.C.	PET	Local officials	Rep. Rose
3	6/08/77	2-way video	Washington, D.C.	Exp. 18 (DSOB/Goddard)	Springfield, Ill.	PET	Public witnesses	Sens. Schmitt, Goldwater, Stevenson, Pearson
4	7/26/77	2-way video	Washington, D.C.	Exp. 18 (HQ/Goddard)	Moffett Field, Calif.	Exp. 18 (Ames)	Psychologists	Rep. McCloskey
5	3/16/78	2-way video	Bethesda, Md.	Exp. 7 (Lister Hill)	Cleveland, Oh.	PET (SECA distribution)	Hospital officials/GCHA	Rep. Rostenkowski
6	4/10/78	2-way video	Washington, D.C.	Exp. 18 (HQ/Goddard)	Crow Agency, Mont. Albuquerque, N.M.	PET TET	Indian leaders	Rep. Blouin Mr. Parker
7	4/12/78	2-way video	Washington, D.C.	Exp. 18 (HQ/Goddard)	Crow Agency, Mont. Albuquerque, N.M.	PET TET	Indian leaders	Sens. Schmitt, Domenici, Hatfield, Rep. Marlenee
8	4/26/78	2-way video	Washington, D.C.	Exp. 18 (HQ/Goddard)	San Diego, Calif.	PET	Satellite industry leaders/AIAA	Reps. Rose, Van Deerlin, Dr. Jackson
9	5/10/78	2-way video	Washington, D.C.	Exp. 18 (HQ/Goddard)	Orlando, Fla.	PET	Agricultural/energy leaders	Rep. Fuqua
10	6/28/78	2-way video	Washington, D.C.	Exp. 18 (HQ/Goddard)	Milwaukee, Wis.	PET/Commercial TV Studio	High school students	Rep. Reuss
11	7/6/78	2-way video	Washington, D.C.	Exp. 18 (HQ/Goddard)	Denver, Col.	Exp. 7 (U. Colorado)	National Conference of State Legislatures, PSSC, PBS, etc.	Messrs. Wood, Chaturand, Zimmerman, Gregory
12	7/27/78	2-way video	Washington, D.C.	Exp. 18 (HQ/Goddard)	Syracuse, N.Y.	PET/Public TV Studio	Senior citizens	Rep. Hanley

NOTES: Equipment and location varied with each videoconference. All demonstrations used the Communications Technology-Satellite (CTS) and a two-way audio video (full duplex) communications channel supplied by NASA, with support when needed from other CTS experimenters and commercial or public TV stations. See the "Technical Profile" for details.



**EVALUATION**

Data from the pre-test communications profile, the full demonstrations, and the post-test interviews was analyzed so as to satisfy the research objectives and provide a strong basis for evaluation of the experiment.

The analysis and evaluation were framed in terms of:

1. Advantages and disadvantages of Congressional videoconferencing;
2. Direct and indirect impacts of Congressional videoconferencing; and
3. Public policy alternative and options with respect to development and use of Congressional videoconferencing.

In each case, data was interpreted in terms of:

1. The participants themselves (Congressmen, staff, and constituents);
2. Congressmen and constituents in general (to the extent this level of generalization is possible);
3. Congress as an institution; and
4. The general public.

## RESULTS

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### 1. Reach More People More Effectively

In all twelve videoconferences, the Congressmen had an opportunity to meet with people and participate in activities which they would not otherwise have been able to fit into their congressional schedules.

### 2. More Effective than Letters or Telephone Calls

Demonstration participants found the videoconferencing to be clearly more effective than letters or telephone calls or not communicating at all.

### 3. Increase Citizen Participation and Feedback

The most significant finding is that videoconferences encourage meaningful dialogue between citizens and their elected representatives. The two-way interactive nature of the medium facilitates an open exchange of views and an honest, forthright approach to questions and answers--for both Congressmen and constituents. It can be fairly said that, in these twelve demonstrations, citizen participation was meaningful and not a put-on.

Perhaps most important, videoconferencing helps open up the legislative process to people who cannot afford the time or money to travel to Washington, D. C.

### 4. Save Time and Energy

Telecommunications is energy-conserving when compared to travel. The demonstrations provided evidence that videoconferenc-

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ing can save the time of the participants, both through the reduction or elimination of travel time and by the reduction of meeting time due to more focused and better prepared participation. Videoconferencing can also conserve the personal energy (fatigue factor) of participants and the physical energy that would have been expended in travel.

5. Citizen Interest and Understanding

The videoconferencing stimulated interest. Constituents were eager to meet with their elected Congressmen and had at least enough understanding of current affairs to hold their own.

6. Scheduling

A regular constituent meeting or town forum on the Congressman's next trip home is difficult enough to arrange, as is the scheduling of congressional hearings. The experimental videoconferencing system adds several more variables and complicates the entire process. Scheduling constraints were perhaps the major barrier to setting up the videoconferencing demonstrations, due to the shortage of CTS satellite time and limited availability of the mobile terminal (PET). Time should be more readily available in an operational mode.

7. Person-to-Person Contact

There are two concerns here: one that videoconferencing will somehow be artificial and devoid of human contact, and, two, that videoconferencing will induce Congressmen to reduce their trips back to the district and substitute media contact for personal

contact. The evidence from the 1977-78 demonstrations is that videoconferencing is very much a humanized use of communications technology.

Two-way, face-to-face, live interactive discussion over a videoconference is exactly what happens when people meet in person. The participants usually adjusted to the videoconference's format within minutes, and felt almost as if they were in the same room with each other.

With respect to the possible substitution of video conferencing for trips back home, none of the Congressional participants, however enthusiastic about the videoconference itself, expected to reduce his district visits as a result. Videoconferencing is viewed as a complement, not as a substitute, intended to meet their ever-increasing communications needs which can no longer be accommodated through traditional means alone. Videoconferencing is especially geared to helping Congressmen use their time and energy in Washington more effectively, while still being responsive to growing demands of citizens for discussion of a growing agenda of pressing public issues.

#### 8. Possible Abuse and Overuse

Some Congressmen and staff have expressed the concern that videoconferencing might be used by Congressmen to manipulate or stage-manage discussions with constituents or otherwise to abuse the notion of an honest, open dialogue. Based on the twelve demonstrations, this concern seems unfounded. In all cases, citizens with little or no media experience (especially the high school students, senior citizens, and psychologists) were able to adapt quickly to the video conference and participate in an even-handed dialogue with the Congressmen, several of whom are well-known for their media skills.

As to the use of videoconferencing contributing to an unfair political advantage for incumbents, Lou Harris and others have found that one of the most useful things that a Congressman can do is come home to the district and talk with his constituents. All twelve of the videoconferences were advantageous to the Congressional participants in terms of favorable exposure to their constituents and the good press coverage via newspaper and television. This possible advantage to incumbents would be expected to wear off as videoconferencing is used primarily for legislative activities (e.g., committee and subcommittee hearings), and if the Congress is only one of the many public users of a satellite videoconferencing system.

#### CONCLUSIONS

The first question Congressmen and staff generally ask about satellite videoconferencing is: "Will it work?" The answer is yes. If this series of demonstrations proved nothing else, it proved that satellite videoconferencing is technically feasible. The successful demonstrations described earlier are the basis for this conclusion. Overall, the results of the experiment confirm the potential of high power satellites like CTS to make satellite videoconferencing available to Congressmen and the public alike, through use of low-cost earth stations.

Many of the Congressmen participating in this (1977-1978) study and in the earlier (1973-1974) interview survey have expressed the need for videoconferencing and other emergent telecommunications channels to help them meet their public responsibilities. Faced with increased complexity in social problems and the volume and diversity of citizen demands,

videoconferencing can help the Congress do a better job representing the people and legislating on their behalf.

From the perspective of the public participants in the 1977-1978 experiment, videoconferencing can open up new possibilities for learning about the Congress, for acquiring more relevant information about (and participating in) the legislative process and specific issues, and for communicating views and opinions to Congress on a more timely and informed basis.

In summary, the results of this project suggest that satellite videoconferencing should be used by the Congress to facilitate broad public participation--experts and laypersons alike--in key aspects of the legislative process. Use of videoconferencing will help to open up the dialogue to people who do not have the time or money to travel to Washington, D. C., and will also help conserve the time and energy of the Congressmen themselves. Thus, new communication channels like videoconferencing are both democratic, by virtue of their two-way participative nature, and time, money, and energy conserving.

EXPERIMENT 26

TITLE: Project Prelude

DISCIPLINE: High Speed Digital Data Transmission  
via CTS

ORGANIZATION: Satellite Business Systems

OBJECTIVE: An experiment/demonstration to test and  
show the ability of state-of-the-art  
communications and terminal equipment  
to provide various high speed digital  
communications applications and evaluate  
usefulness.

PRINCIPAL INVESTIGATOR: Mr. C. Thomas Rush

ACTUAL START: 9/77

COMPLETION: 2/78



# SATELLITE BUSINESS SYSTEMS

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**CONCEPT**

New satellite communication technology has the potential for causing changes in the ways in which firms conduct business and even in the organizational structure of these businesses. Experiment 26 was set up to use state-of-the-art capabilities in order to learn more about the applications and the equipment capability requirements of tomorrow.

**OBJECTIVES**

The objectives of Project Prelude were to:

1. Demonstrate and evaluate the usefulness of high speed digital communications applications;
2. Increase user awareness of benefits of new communications technology; and
3. Stimulate potential suppliers to develop new high speed digital terminals by demonstrating user acceptance of applications presented.

## EXPERIMENTAL PROCEDURE

Project Prelude concentrated on three application areas: data processing, teleconferencing, and document distribution. For each area, the impact on operational procedures and business structure due to new communications technology was explored, the technology required to implement possible scenarios was examined, and the transitional period between current and future systems investigated.

Teleconferencing using full motion and freeze-frame video, high speed data transfer, remote high speed retrieval, data processing backup, load leveling-resource sharing, electronic mail (high speed digital facsimile and high speed communicating word processing) were demonstrated. Live teleconferences were set up for personnel of participating companies to use as a substitute for travel. Project Prelude worked with participating companies to enable them to test electronic mail and data processing capabilities.

Project Prelude was initially described as SBS's proposal and in NASA's approval as Project Adjunct. Project Prelude was chosen as the informal name in order to connote the forthcoming realization of advanced commercial satellite communications that the experiment was to explore.

### Project Prelude Participants

#### Host Companies:

Rockwell International Corporation

Texaco Inc.

Montgomery Ward and Co., Inc.

Aetna Life & Casualty

**Equipment Manufacturers:**

Advent Corporation (large-screen, color television  
projection equipment)

Arvin/Echo (television freeze-frame storage equipment)

Rapicorn (high-speed, high resolution facsimile terminal  
equipment)

Harris Corporation (high-speed data rate modems)

Hewlett-Packard Co. (computer systems data processing  
network)

Ikegami Electronics (USA), Inc. (color television cameras)

NEC America, Inc. (color freeze-picture transmission system)

COMSAT Laboratories (Experiment RF terminals)

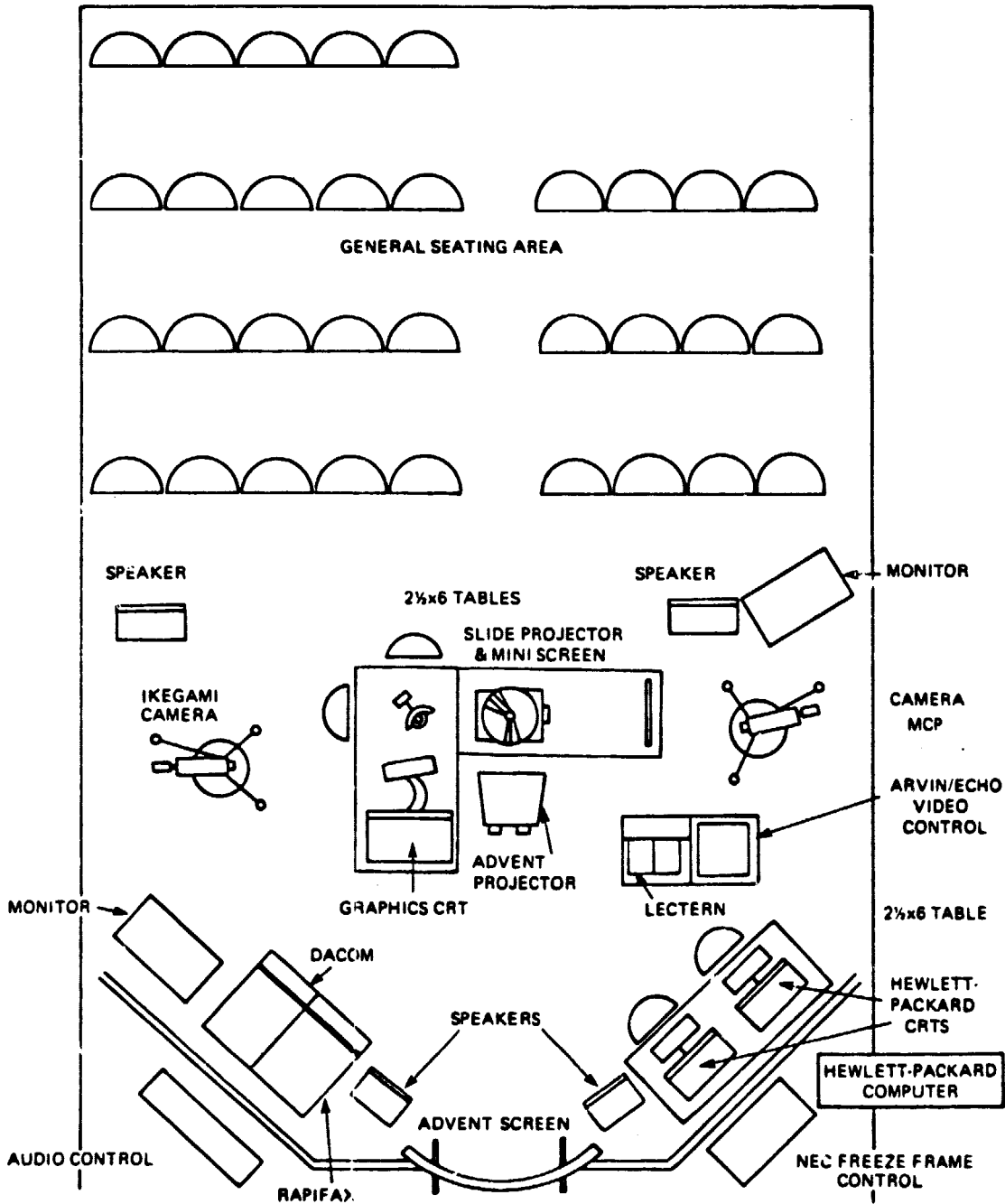
**Project Coordinators:**

Satellite Business Systems (SBS)

COMSAT Laboratories

Satellite Business Systems (SBS)

SBS is a partnership organized in December 1975 by wholly owned subsidiaries of Aetna Life & Casualty, IBM, and COMSAT General Corporation. It has been authorized by the Federal Communications Commission to proceed toward establishment of a domestic communications satellite system to serve business, government agencies, and other communications users.



TYPICAL PRELUDE EQUIPMENT CONFIGURATION

## PURPOSE OF EXPERIMENT-RATIONALE

Developments that are now taking place and that are proposed for the future, in terms of new communications satellite technology and facilities, hold the potential for bringing new and improved communications capabilities to both government and private users. However, the availability of the requisite satellite technology does not by itself result in improved communications being available to the end user. Also required are the availability of suitable earth terminal and ground communications equipment, as well as end-user terminal equipment that serves desired communications applications. The purpose of Project Prelude was to gain new information in these latter areas--to evaluate and demonstrate both the usefulness of certain applications of the new technology offered by CTS and the operation of equipment required in connection with those applications--with a view toward increasing user awareness of the communications improvements offered by the technology and stimulating the efforts of equipment manufacturers in the development and production of the required equipment.

In its proposal, SBS stated that Project Prelude was designed to bring together in a cooperative experiment the talents, resources, and perspectives of common carriers, suppliers of state-of-the-art terminal equipment and end users of communications equipment.

Project Prelude was designed to assess state-of-the-art technology and equipment in a realistic business environment and to stimulate advances in state-of-the-art where needed.

## OBJECTIVES

The objectives were specific. SBS and COMSAT Labs had a mutual interest in evaluating the application of small earth terminal design techniques to high-speed digital data transmissions and assessing the use of 12/14 GigaHertz (GHz) frequency bands on the earth terminal equipment and communications links required for such transmission.

In addition, the following objectives were stipulated:

1. To bring together for the first time in a realistic business environment satellite communications and manufacturers' state-of-the-art equipment for testing and evaluation.
2. To evaluate the state-of-the-art and stimulate new advances in high-speed, reliable, high-quality equipment for future satellite communications.
3. To identify user requirements across industries that could contribute to efforts by manufacturers to develop and produce equipment to meet those requirements.
4. To increase awareness among users and manufacturers of the services that can be offered by new communications technology.
5. To assess new applications, new opportunities for economy and new operating efficiencies that satellite technology promises for the user community.

## TASKS

To conduct Project Prelude, it was necessary to configure an end-to-end experimental satellite communications system. The resulting system was one for transmission of voice, high-speed data, facsimile and teleconferencing directly between pairs of user premises.

Specific tasks included:

1. selection and procurement of the equipment to be evaluated; and
2. selection of typical end-user companies willing to participate in the equipment.

SBS technical responsibilities included:

1. management of the equipment, digital modems, radio frequency terminals, audio systems, video equipment computers, facsimile equipment and master control unit;
2. inter-connect cabling of all equipment, and cabling connections between conference rooms and earth stations;
3. transportation arrangements;
4. logistical support arrangements;
5. technical coordination with host companies;
6. day-to-day operational coordination/liaison with NASA;
7. data collection;
8. data evaluation;
9. publication of experiment results; and
10. overall program management.

## PROGRAMMATIC CONCEPT AND TARGET AUDIENCE

Much attention has been focused in recent years on communications in the electronic office and on concepts such as "electronic mail," "teleconferencing," "a terminal on every desk," and other new applications. But these concepts hardly existed ten years ago, and little has been done to measure the acceptance of these ideas in the business environment until Project Prelude.

Project Prelude opened the doors in the following manner:

- Project Prelude did not ask abstract questions; rather it demonstrated concepts and asked "Would you use them?"
- Prelude was not a booth-in-a-trade-show demonstration; rather, it was conducted on-site at eight different business locations under the direction of the four companies involved.
- Prelude did not simulate electronic communications ideas; rather, it demonstrated real telecommunications in a real environment, utilizing the best equipment currently available.
- Prelude did not gather opinions only from those in telecommunications roles; rather, it covered a broad spectrum of management with a large enough sample of opinion to be statistically reliable 95% of the time and to be representative of American business and industry.
- Prelude utilized high-speed, high-quality transmit/receive portable earth terminals, sited on the users premises, to operate with the CTS satellite.



The user companies were selected to meet the criterion of having a significant intracompany communications requirement among geographically dispersed facilities. Additionally, they were chosen as representing a cross section of the user community, thereby ensuring that representative data would be collected.

SBS reached initial agreement with Rockwell International Corporation, Texaco, Inc., and Montgomery Ward & Co., Inc., respectively, to provide pairs of corporate facilities between which Project Prelude communications could be established. Subsequently, agreement was reached with Aetna Life & Casualty as the fourth user company.

After several tests and demonstrations for representatives of the participants, "hands-on" sessions were held to permit the companies to conduct actual or simulated business operations.

The greatest number of sessions were devoted to a general teleconferencing demonstration, and a hypothetical scenario was acted out by "players." In each teleconference session, whether a user hands-on session or a demonstration, all capabilities of the Prelude system were generally available. These capabilities included voice, full-motion television, freeze-frame, data transmittal and retrieval, and document distribution.

The 1,476 participants who responded to questionnaires represented a range of functional areas at the host companies--administrative (353), marketing (216), data processing (477). Thus, responders encompassed more than just corporate headquarters personnel. Most of them were second-line managers or higher.

While the participants were employees of the host companies, an audience of visitors from other companies, press, and guests of the equipment suppliers also attended.

## GROUND SEGMENT (CONFIGURATION)

The locations of the pairs of corporate facilities and the months during which Project Prelude sessions were held are as follows:

### November 1977

Rockwell headquarters in Pittsburgh and its facility at Seal Beach, California.

### December 1977

Texaco Executive Offices in Harrison, New York, and its Southwestern Regional Office in Bellaire, Texas.

### January 1978

Montgomery Ward Corporate Headquarters in Chicago and its Northeastern Regional Headquarters in Catonsville, Maryland.

### February 1978

Aetna Life & Casualty home office in Hartford, Connecticut, and a Montgomery Ward conference room facility in Chicago.

To conduct Project Prelude, it was necessary to configure an end-to-end experimental satellite communications system. The resulting system was one for transmission of voice, high-speed data, facsimile, and teleconferencing directly between pairs of user premises in a full duplex mode.

The equipment configuration at each Prelude site included two elements--the earth terminal on a trailer, and the business equipment in a conference room. At each pair of sites, in sequence, small trans-

portable earth stations, each consisting of a trailer with an 8-foot parabolic antenna and a control center were installed.

The trailers were fitted with the necessary radio frequency transmit/receive electronics and were towed from site to site.

In each case, they were set up in parking areas within 1,000 feet of the conference rooms.

The set-up within each of the eight conference rooms was different, but followed a similar pattern.

## RESULTS

The results of Project Prelude confirm that innovative satellite technology and equipment advances will bring productive new communications services during the 1980's. The results also provide strong support for judgments that the business community is ready to accept innovative new services.

Over the four months of Project Prelude sessions, 52 sessions were conducted, attended by 1,476 persons who filled out evaluation questionnaires. Approximately one-third (435) of these persons participated in "hands-on" teleconferencing where the full use of the equipment and facilities was at their direction.

The evaluation results, as detailed in this report, confirmed that new capabilities are needed for business communications and that this need is perceived broadly among users, though not in specific detail.

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A range of summary, speculative material has been written about the potential for business teleconferencing. But until Project Prelude, there had been no attempt to validate suppositions in a realistic business environment. Accordingly, the Project Prelude conclusions are of milestone significance.

Project Prelude audiences showed a high preference for saving time--reduced travel time and quicker decision making--as the most important benefit of teleconferencing. Together, these two benefits were noted 10 times more often than reduced direct costs of travel. Potential cost savings, though of a lower priority, were also regarded as important.

As a group, the responders, prior to attending Prelude sessions, knew little about the specific implications of satellite communications; they had not previously participated in a meeting conducted by teleconferencing; they had had little or no exposure to the use of facsimile communications; but they were familiar with data processing techniques.

After attending various Prelude presentations, the responders felt that teleconferencing was better than traveling as a way of conducting meetings (75% of responders); that they would use facsimile equipment five or more times a week if available (40%); that they would use an information retrieval capability five or more times a week (33%); and, given the authority, that they would move immediately toward the implementation of teleconferencing (15%). And 2% said they would not implement teleconferencing at all.

Another interesting finding pertained to personal operation of desk terminals. Responders were asked, "If you had a terminal and information

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storage and retrieval capability, would you want to personally operate the terminal?" Approximately one-fourth of the responders said they would operate it and use the terminal five or more times a week.

The one general aspect of Prelude that was not evaluated was the prospective cost to the user of a comparable commercial communications service. Although it was recognized that cost will usually enter into a decision to move ahead with an idea, the Project Prelude evaluation was centered on human factors, equipment capabilities, transmission speeds, and personal aspects of acceptance.

Only one detail of cost relationship was evaluated--the trade-off between full-motion video and freeze-frame video. In almost all sessions, freeze-frame transmission was used to some extent. This evaluation question was asked: "If only the freeze-frame method of transmission were available, would the proportion of meetings susceptible for teleconferencing stay the same, or decrease to zero?" Over 33% responded "stay the same;" 60% said it would have some impact (in other words, that some full-motion requirement was seen) and 7% responded "decrease to zero." Video is generally recognized as an essential ingredient in teleconferencing, but it does not always have to be full motion, as the "stay the same" answers indicate. Freeze-frame often may be sufficient, thereby reducing transmission requirements and, hence, user cost.

Project Prelude also contributed to the perceived value of on-premise communications facilities.

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Participants from the host companies and audiences of invited guests were explicitly reminded of one of the key advantages of satellite communications--the capability for establishing a link wherever the need exists by putting the appropriate transmit/receive capability on-site, without regard to terrestrial facilities.

### CONCLUSIONS

Conclusions of Project Prelude offer the business communications community (equipment suppliers, services suppliers, and users) significant planning information, for the first time, on the requirements and acceptance of many electronic communications concepts.

Some of the key conclusions of the Project Prelude experiment and evaluation are as follows:

1. Teleconferencing, as demonstrated, is often an acceptable, and in many cases a preferable, substitute for face-to-face conferences.
2. Motivation to use teleconferencing facilities flows from a need to increase responsiveness and save time, not just money.
3. Businessmen today have little understanding of new communications tools and techniques.
4. Businessmen have an ability to rapidly perceive the uses for new communications tools and techniques, once they have an understanding of what is involved.

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5. High-quality and high-speed equipment was used in all aspects of the experiment, and much interest was shown in the adaptability of the equipment to replicate the environment of face-to-face meetings.
6. Use of terminals for data inquiry would significantly increase if terminals were conveniently accessible to the users.
7. Use of high-speed, high-quality facsimile for message transmission would significantly increase if terminals were conveniently accessible to the users.
8. While freeze-frame video transmission is acceptable for a high percentage of teleconferences, full-motion is required for some sessions.
9. There is a mood among users to "get started now" in implementing improved business communications systems and services.

EXPERIMENT 30

TITLE: Terminals of Tomorrow

DISCIPLINE: Technology

ORGANIZATION: Federal Communications Commission

OBJECTIVE: To conduct an independent experiment  
with terminals from other sources.

PRINCIPAL INVESTIGATOR: Irma B. Galane

ACTUAL START: 3/78

COMPLETION: 1/79



## CONCEPT

The FCC as an independent experimenter expanded upon earlier results, most particularly by (1) studying a variety of environmental effects, and (2) comparing data acquired under conditions similar to those encountered previously but with reception via CTS by terminals which were not identical to the NHK terminals.

## EXPERIMENTAL PROCEDURE

During the months December, 1977, and January, 1978, monitoring observations were made of the joint U. S.-Canadian Communications Technology Satellite (CTS) to determine the existence of any spurious emissions and to make certain measurements of them if found.

Several types of spurious emissions were detected and photographed. The worst case of spurious signal, an unmodulated radiation, even with carrier modulation present, was measured at a level about 24.5 decibels below carrier radiation level, corresponding to 26.9 below full or saturated transponder output.

Six spurious emissions were found radiating from the CTS satellite. Two were interesting examples; one having a level of 24.5 decibels below satellite carrier radiation, and a second about 38 decibels below the carrier, but located 163 MHz lower in frequency than the carrier. Spurious emission band found comprised a total width of 216 MHz.

## REFLECTED 12 GHz T.V. SIGNALS

Determination of the effectiveness of receiving 12 GHz CTS signals reflected from two surfaces.

### Procedure

1. Direct Signal:

The DX earth terminal (.9m dish) was set up to receive a direct signal from the satellite. The AGC voltage, TASO picture grade, and feed angle were recorded.

2. Single Reflection:

Secondly, the dish was situated to receive signals reflected from each surface of the two adjacent buildings.

3. Double Reflection:

Finally, the dish was situated to receive a signal reflected from both surfaces.

4. The AGC voltage, TASO picture grade, and feed angle were noted for 2 and 3 above.

## EFFECTS OF FOLIAGE

Determination of the effects of foliage on receiving 12 GHz T.V. signals from the CTS satellite.

### Procedure

1. April 15, 1978 - Without Foliage
  - a. The DX earth terminal (.9m dish) was set up to receive a direct signal from the satellite. The AGC voltage, TASO picture grade, and feed angle were recorded.
  - b. The dish was then situated so that a tree was positioned in the signal path. Again, the AGC voltage, TASO grade, and feed angle were noted. Additionally, the type of tree and the exact location of the dish were recorded.
2. May 31, 1978 - With Foliage
  - a. Same as 1.(a).
  - b. Same as 1.(b) at the exact site of the original measurement.

### CONCLUSIONS

Significant degradation of signal strength and quality was observed as a result of reception through foliated trees.

EXPERIMENT 31

**TITLE:** Two-way Time Transfers Between NRC/NBS and  
NRC/USNO via the Hermes (CTS) Satellite.

**DISCIPLINE:** Technology

**ORGANIZATION:** U. S. Naval Observatory

**OBJECTIVE:** To test two-way time transfers between  
NRC/NBS and NRC/USNO via the Hermes (CTS)  
satellite.

**PRINCIPAL INVESTIGATOR:** William J. Klepczynski

**ACTUAL START:** 7/78

**COMPLETION:** 12/78

## PURPOSE

The purpose of this experiment was to enlarge on the Symphonie two-way time transfer conducted by the National Research Council and LPTF in France.

## EXPERIMENTAL DESIGN

Two-way time transfers via the Hermes (CTS) satellite between NRC, Ottawa, and NBS, Boulder, and between NRC and USNO, Washington, D. C., began once a week in July 1978. At each station, the differences were measured between the local UTC seconds pulse and the remote UTC pulse received by satellite.

All satellite terminals used a standard TV channel which required a 1 volt peak-to-peak video input. The 1 pps and the TV horizontal sync pulses simulated the TV video and maintained proper video levels. It was realized that using a 1 pps was not the most efficient way to use the 6 MHz bandwidth, but NRC had already committed to using this format with France. It was also an easy format to put into operation quickly since all had 1 pps clock pulses available.

Because the NRC used the master terminal at the Communications Research Center (CRC) with a 30-foot antenna, the 20 W beam was directed to Ottawa, and the 200 W to Denver or to Washington.

In Denver, NBS had the use of a terminal owned and operated by the Department of Health, Education and Welfare (HEW). It had an 8-foot antenna and 400 W transmitter power. This gave, at CRC in Ottawa, a received carrier of 40 dB S/N with a 300 kHz bandwidth in the television channel.

In Washington the story was more complicated. In late July, experiments started with USNO using a NASA terminal at Goddard, but unfortunately had no success. Initially the boresight was directed not to Ottawa, but halfway between Ottawa and Goddard. The signal to noise, down about 3 dB, seemed adequate, but caused some difficulties. Trials began again some seven weeks later, after NASA had been off the air to make changes at the site, but the experiments were not successful. An additional time allocation was used, but NRC and USNO computer failure and interface problems compounded to frustrate the experiment.

At the Hermes Users Meeting in Wingspread, Wisconsin, September 19-21, 1978, it was suggested that it might be possible to put a COMSAT Hermes terminal at the USNO. Since this had the enormous advantage of avoiding the requirement for a time transfer from the laboratory to the terminal, and saved so much time in travel and equipment displacement, this was followed up with some enthusiasm by the USNO, and the COMSAT terminal was placed at the USNO. Successful transfers were achieved.

The time transfer from NBS to the HEW Denver terminal was done by carrying two Cx standards to the terminal, using one as the station clock, and obtaining closure after the experiment at NBS. This has given 1-2 ns accuracy.

In Ottawa, the NRC relied on the TV Line-10 receivers. CRC is about 32 kilometers (20 miles) from NRC, and both sites had a clear line of sight to the TV transmitter. The path difference was indexed with portable clocks. Often, 1 ns standard deviation for 300 readings was obtained, but variations over 200 ns were seen. It was usually possible to tell when the readings were reliable, but there was no doubt that the NRC/CRC link gave the largest source of error in the transfer.

## RESULTS

NBS evaluated their NBS-6 primary cesium standard at the end of October 1978 and obtained a normalized frequency difference in UTC(NBS) - NBS-6 (sea level) of  $0.6 \times 10^{-13}$ . Over this period, the normalized frequency difference of the two time scales UTC(NRC) - UTC(NBS) was  $1 \times 10^{-13}$ . The frequency of UTC(NRC) is the frequency of CsV corrected to sea level, and therefore the normalized frequency difference for the primary standards CsV (sea level) and NBS-6 (sea level) was  $1.6 \times 10^{-13}$ . This is the same order as the differences that were observed over the past few years, which indicated that there was not a large change in the CsV frequency on September 15, 1978.

The experiment did not match the precision achieved by Chi (1975) and Saburi (1976) in experiments by NASA and the Radio Research Laboratory of Japan, but the main virtue of this experiment was the transfer over a long period between very stable time scales.

The difference between the readings, if station delays are assumed to be symmetrical, is two times the difference between the clocks at the two ground station sites. Over a 20-minute period, the precision over the satellite is better than 1 ns. The time transfer from NRC to the CRC satellite is better than 1 ns. The time transfer from NRC to the CRC satellite terminal near Ottawa and from NBS to the Denver HEW terminal were subject to larger uncertainties. The absolute measure of UTC differences was dependent upon the measurement of station delays.

EXPERIMENT 32

TITLE: Digital Testing Via CTS

DISCIPLINE: Technology

ORGANIZATION: NASA-Goddard Space Flight Center

OBJECTIVE: To characterize the performance of newly-developed digital communications equipment.

PRINCIPAL INVESTIGATOR: Douglas R. Kahle

ACTUAL START: 10/78

COMPLETION: 12/78



## PURPOSE

The purpose of the Digital Testing experiment was to characterize the performance of newly-developed digital communications equipment with simulated Gaussean noise and with the CTS.

## EXPERIMENTAL EQUIPMENT AND PROCEDURES

### The QPSK Modem

The QPSK modulator section accepts a synchronous, digital data stream and clock selectable from 1 to 60 Mbps and assigns pairs of information bits to occupy one of four phase states of a 60 MHz carrier frequency. The demodulator section performs matched filter detection to recover the data and associated clock. Salient features of the modem are:

- Variable data rate operation, continuously selectable from 1 Mbps to 60 Mbps
- Transversal filtering for spectral sidelobe reduction
- Operational flexibility
  - . Hard/soft decision outputs
  - . Differential encoding in/out
  - . Staggered QPSK in/out
  - . Serial/parallel data interface
  - . Scramble in/out
  - . Normal/test
- Automatic carrier acquisition, fast noncoherent sweep followed by coherent sweep

- AGC input, -50 dBm to 0 dBm.

In the simulated tests the  $E_b/N_0$  was varied by increasing the additive noise power, whereas during the spacecraft tests the signal power was altered by varying the ground station output power to the spacecraft. Data taken via CTS was compared with that taken under calibrated, simulated noise conditions. Measurement inaccuracies, bandlimiting effects, and amplitude non-linearities were believed to cause the differences in degradation results between the CTS and simulation tests. All the satellite tests were performed below saturation.

#### The Video Adaptive Delta Modulator

The video adaptive delta modulator acts as an adjunct to the QPSK modem. The delta modulator encoder accepted a 4 MHz, monochrome, composite television signal and encoded it into a digital format at rates between 8 and 22 Mbps.

The key features of the adaptive delta modulator were its low data rate, simplicity, immunity to outside noise effects, and equally good performance for either slow or rapid scene changes. Both the encoder and decoder were implemented in breadboard fashion and each fabricated on a single circuit board 15 cm by 20 cm consuming approximately 7 watts of power.

The performance of the delta modulator varied according to its sampling rate. At the lower rates (8 Mbps) the delta modulator's decoded video as displayed on a conventional television monitor exhibited an "edge busyness." This effect, noticeable along sharp, black and white, vertical transitions, diminished as the sampling rate was increased. Immunity-to-noise measurements taken via CTS and simulated noise showed good performance at error rates as low as  $10^{-4}$ . At this error rate

quickly decaying streaks were noticeable--on the order of a few picture elements long. The streaking became objectionable at error rates approaching  $10^{-3}$ . Tradeoffs in picture quality could be made by reducing the sampling rate to counteract noise effects. For example, during a late CTS test a fade was simulated by reducing power until an error rate of  $5 \times 10^{-3}$  resulted. The streaking in this test was quite noticeable. A 3 dB improvement in link quality was then accomplished by reducing the data rate from approximately 20 to 10 Mbps, thus increasing the  $E_b$  value or energy per bit. This improvement reduced the error rate to  $1 \times 10^{-4}$ , thereby lessening streaking effects, but at a cost of increased edge busyness.

#### SUMMARY AND CONCLUSIONS

Tests were conducted at Goddard to characterize the performance of newly-developed digital communications equipment with simulated Gaussian noise and with the Communications Technology Satellite (CTS).

Two hardware units were tested: a quadrature phase shift key (QPSK) modem built by Stanford Telecommunications, Inc., and a breadboarded, video adaptive delta modulator developed by The City College of the City University of New York.

The QPSK modem was developed to supplement existing facilities for simulating end-to-end satellite communications links, and for use in experimental digital satellite tests. Experimental results at 60 Mbps were within 1.4 dB of the theoretical limit with simulated Gaussian

noise and with 2.3 dB of the limit via CTS. Typical applications for the modem's transmission capability were digitized video, and high-speed, synchronous computer-to-computer links.

The adaptive delta modulator for real-time encoding and decoding of composite television signals was developed as a spectrally efficient, low-cost alternative to more complex, video digital processors. The primary application for the video delta modulator is for small ground station use where broadcast quality video is not required.

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EXPERIMENT 33

TITLE: CTS 11.7 GHz Propagation Measurements

DISCIPLINE: Technology

ORGANIZATION: GTE Laboratories

OBJECTIVE: To measure satellite-to-earth rain  
attenuation.

PRINCIPAL INVESTIGATOR: O. G. Nackoney

ACTUAL START: 2/78

COMPLETION: 1/79

## PURPOSE

To measure satellite-to-earth rain attenuation rates in order to establish reliability statistics for the 12/14 GHz frequency band and improve prediction techniques for other locations.

## EXPERIMENTAL PROCEDURE

### CTS Beacon Measurements

CTS beacon measurements at GTE Laboratories located in Waltham, Massachusetts (42.4°N, 71.3°W) were made at a mean elevation angle of 23.7° and azimuth of 23.58° TN. The beacon signal was received using a 3-meter dish antenna. Automatic antenna pointing was based on NASA ephemeris predictions and tracked satellite motion with less than 0.2 dB pointing error. A phase-locked loop receiver measured the beacon signal strength over an 18-dB dynamic range using a coherent detector with a one-second time constant. The beacon signal strength was sampled every ten seconds by a desk-top computer and recorded on magnetic tape. Rainfall was measured using a 0.254 mm tipping bucket rain gauge located at the terminal site, and one-minute samples were stored on magnetic tape.

## RAINFALL ATTENUATION EVENTS

A thunderstorm on September 11, 1978, had the deepest fade during the second year's data collection, and was the only event where the received beacon signal level fell below the phase-locked loop threshold

(gap in signal curve). Phase lock was lost for 1.5 minutes when the attenuation exceeded 18.5 dB. During loss of phase lock, computer control of the receiver frequency held the receiver exactly at the previously measured beacon frequency. This permitted acquisition of the beacon signal below -19 dB and gave accurate fade recovery data. For this event the attenuation exceeded 3 dB for 23 minutes and exceeded 6 dB for 14 minutes. This maximum local rain rate was 61 mm/hr and is noteworthy because it was the first time during a major fade where the peak in the rain rate preceded the peak in attenuation. The converse usually occurs because storm systems in the experiment area typically moved from west to east and thereby intersected the propagation path before heavy local rainfall arrived at the terminal site.

The second deepest fade occurred during a thunderstorm on August 6, 1978, where the maximum attenuation was 17 dB (based on continuous strip-chart recording). Outage time at the 3-dB level was 45 minutes which is the longest continuous 3-dB fade recorded in the two years of data collection. The 6-dB outage time was 27 minutes, the longest duration for the second year's data. Peak rain rate was 61 mm/hr which occurred 7 minutes after maximum attenuation.

A double fade event occurred during an intense thunderstorm June 19, 1978. Peak attenuation for the first fade was 13.5 dB and 12 dB for the second. Total time attenuation exceeded 3 dB and occurred 5 minutes after the deepest part of the first fade. This was the highest rain rate recorded for the second year's data.

## TERMINAL OPERATION

During the second year's data collection, rain attenuation data were collected for 91% of the year. For the 785 hours that data were not collected, 117 hours of data were lost because of satellite shutdowns during eclipse periods, and 668 hours of data were lost because of equipment failures.

Loss of data during eclipse shutdowns was kept to a minimum by automatically re-acquiring beacon signal phase-lock using the desktop computer. Eclipse shutdowns occur at night centered at 9744 UTC and last 1 to 1½ hours. After loss of signal, the desktop computer continuously updated the antenna pointing and swept the receiver frequency until the beacon signal was acquired. Acquisition occurred typically about 5 minutes after beacon transmitter turn-on. Fortunately, rainfall occurred for only 6 of the 94 days during eclipse shutdowns, and the maximum rain rate was less than 2.5 mm/hr.

## ATTENUATION

Attenuation distributions are based on signal strength samples taken every 10 seconds and the distributions are calculated for 1-dB changes in attenuation. The second year's distribution for Waltham Massachusetts, shows that the attenuations exceeded 8.5 dB for 0.01% of the time, or a total of 49 minutes. High attenuation greater than 18 dB occurred for 0.0003% of the time, or 1.5 minutes, while low attenuation less than 1 dB occurred 0.24% of the time, or 19 hours.



Attenuation data collected during the first year were dominated by a single thunderstorm occurring August 1, 1977. The 0.01% attenuation changed 4.4 dB from 10.4 to 6.0 dB when the data associated with the thunderstorm were excluded. No such single-storm dominance occurred during the second year. The three thunderstorms which were principally responsible for setting the 0.01 attenuation dropped from 8.5 dB in approximately 1 dB steps to 5.3 dB with all three thunderstorms excluded. Summer thunderstorm activity dominated the distributions with spring and fall attenuation occurring less frequently, and winter attenuation occurring rarely. The summer 0.01% attenuation was 12.5 dB; spring 9.0 dB; fall 5.4 dB; and winter 1.5 dB.

## RESULTS

The specified attenuation was continuously below 3, 6 and 10 dB levels. For attenuation below 3 dB there were 68 outages lasting longer than 1-2 minutes during the first year. This was over twice the number which occurred the second year, yet the tails of both year's distributions were similar. Three -dB outages lasting more than 20 minutes were infrequent, with only 1-2 occurring per year. One 3-dB fade outage lasted 45 minutes during the attenuation event on August 5, 1978. For attenuation below 10-dB, 8-10 outages lasting 1-2 minutes occurred each year.

## INCOMPLETE OR WITHDRAWN EXPERIMENTS

The following are approved experiments which were withdrawn. The most common reason for withdrawing an experiment was the inability of the sponsoring organization to secure adequate funding for program development and ground equipment.

### Experiment 2

Title: Document Delivery  
Organization: New York State Education Department

### Experiment 3

Title: An Educational Experiment via Alaska Utilizing  
the Communications Technology Satellite  
Organization: The Boeing Company, Aerospace Group

### Experiment 5

Title: The APACHE Project (Astral Program for  
Advancement of Continuing Health Education)  
Organization: University of Texas Medical School at  
San Antonio

### Experiment 8

Title: Presentation of First Aid Programs and  
Testing of a Model System for Disaster  
Communications  
Organization: The American National Red Cross

Experiment 9

Title: SALINET (Satellite Library Information Network)  
Organization: Graduate School of Librarianship  
University of Denver

Experiment 10

Title: Satellite Users Network  
Organization: The Federation of Rocky Mountain States

Experiment 12

Title: Appalachian Education Satellite Project II  
Organization: The Appalachian Regional Commission

Experiment 14

Title: American Forces Radio and Television  
Wideband Direct User Technology  
Organization: Office of Information for the Armed Forces,  
Department of Defense

Experiment 17

Title: Health Education Television  
Organization: Health Services Education Council

Experiment 23

Title: 12 GHz Hardware Review  
Organization: Committee for the Future-Protronics Corporation

Experiment 27

Title: Women's Satellite Services  
Organization: National Women's Agenda

Experiment 28

Title: Radio Interferometry  
Organization: Department of Astronomy  
University of Illinois at Urbana-Champaign

Experiment 29

Title: Investigation of New Equipment  
Organization: New Worlds Center

Experiment 34

Title: Time Sharing of Computerized Axial  
Tomography  
Organization: University of Colorado Health Sciences Center

Experiment 35

Title: University Graduate Level Studies Via Satellite  
Organization: Varion Corporation

## VII. CTS U. S. DEMONSTRATIONS

CTS demonstrations were mini-experiments lasting from a few days to several weeks. There were 146 approved demonstrations conducted between May 1976 and May 1979. Since the majority of the demonstrations were remote from fixed uplinks, there was great dependency on the utilization of the Portable Earth Terminal (PET) and the Transportable Earth Terminals (TET).

A sampling of the demonstrations will be reported. The demonstrations which are cited were not primarily selected for their importance, but rather to provide readers with an understanding of the many disciplines represented, geographic distribution of the users, the variety of sponsors, the uniqueness of the events, use of PET and TET, and the complexities of the broadcasts.

DEMONSTRATION NUMBER 21

TITLE: Opening General Session 55th Convention of  
"The Council for Exceptional Children"

DATE OF DEMONSTRATION: April 13, 1977

SPONSOR: The Council for Exceptional Children

TYPE OF EQUIPMENT: Portable Earth Terminal

DISTRIBUTION OF PROGRAM: From Atlanta, Georgia, to Baltimore,  
Maryland; Harrisonburg, Virginia;  
Columbia, South Carolina; and Anchorage,  
Alaska

DESCRIPTION OF PROGRAMMING: The four-hour opening session was broad-  
cast. There were thirty+, specifically  
programmed, segments which included  
speakers, panels, announcements, special  
presentations, and talk-back from Baltimore.  
The program included one-way video and  
two-way audio.

DEMONSTRATION NUMBER 23

TITLE: Colloquium on Viking-Mars

DATES OF DEMONSTRATION: March 23, 1977

SPONSOR: National Research Council - Canada

TYPE OF EQUIPMENT: Fixed Hermes-CTS Equipment at CRC,  
Ottawa, and LeRC, Cleveland

DISTRIBUTION OF PROGRAMMING: LeRC to Ottawa, Canada

DESCRIPTION OF PROGRAMMING: Two-way television conference by a  
Viking Project Scientist to the  
National Research Council Meeting  
in Ottawa, Canada.

DEMONSTRATION NUMBER 24

TITLE: Rural Health Conference

DATES OF DEMONSTRATION: March 30 - April 1, 1977

SPONSOR: American Medical Association

TYPE OF EQUIPMENT: Portable Earth Terminal

DISTRIBUTION OF PROGRAMMING: Seattle, Washington, and  
Bethesda, Maryland

DESCRIPTION OF PROGRAMMING: Presentations made via CTS from  
Bethesda, Maryland, to the attendees  
of the 30th National Conference on  
Rural Health.



DEMONSTRATION NUMBER 55

TITLE: Professional Continuing Education  
Conference

DATES OF DEMONSTRATION: February 25 and February 28, 1978

SPONSOR: Public Service Satellite Consortium  
on behalf of the Indiana Higher  
Education Telecommunications System

TYPE OF EQUIPMENT: Portable Earth Terminal in Indianapolis,  
the AMES Research Center equipment

DISTRIBUTION OF PROGRAMMING: Throughout the State of Indiana and  
the San Francisco Bay Area

DESCRIPTION OF PROGRAM: Educational materials were presented  
for Doctors, Dentists, and Medical  
Engineers.

DEMONSTRATION NUMBER 72

**TITLE:** American Indian Conference

**DATES OF DEMONSTRATION:** April 10, 12, and 14, 1978

**SPONSOR:** Bureau of Indian Affairs

**TYPE OF EQUIPMENT:** Portable Earth Terminal in Crow Agency, Montana; Transportable Earth Terminal in Albuquerque, New Mexico; and fixed terminals in Washington, D. C., and NASA Ames, California

**DISTRIBUTION OF PROGRAMMING:** Four locations in Montana, New Mexico, Washington, D. C., and California

**DESCRIPTION OF PROGRAMMING:** There were three types of programs:

1. Tribal to Federal Government agencies such as Department of the Interior, Congress, Bureau of Indian Affairs, Department of Agriculture.
2. Tribe to Tribe communications such as communications between the all-Indian Pueblo Council and the Crow Tribes.
3. Educational communications.

DEMONSTRATION NUMBER 79

TITLE: Bureau of Reclamation; Remote Dam  
Site Construction

DATE OF DEMONSTRATION: October 28, 1977

SPONSOR: Bureau of Reclamation

TYPE OF EQUIPMENT: Class I and Class II terminals

DISTRIBUTION OF PROGRAMMING: From the dam site at Edna, Texas, to  
the Bureau of Reclamation in Denver,  
Colorado

DESCRIPTION OF PROGRAMMING: Construction engineers at the Palmetto  
Bend Dam construction project described  
problems being encountered (via satellite)  
and conversed with Denver Bureau of  
Reclamation engineers about their  
problems.

DEMONSTRATION NUMBER 89

TITLE: Health Care Conference

DATE OF DEMONSTRATION: March 17, 1978

SPONSOR: Greater Cleveland Hospital Association

TYPE OF EQUIPMENT: Portable Earth Terminal, Transportable Earth Terminal Class II equipment and Southern Educational Communications Association terminal (SECA)

DISTRIBUTION OF PROGRAMMING: Cleveland, Indianapolis, Chicago, the SECA network, and the Indiana intra-city ITFS/CATV network

DESCRIPTION OF PROGRAMMING: Congressman Rostenkowski and representatives from major health organizations made presentations along with pre-taped material on legislation activity in the health field.

DEMONSTRATION NUMBER 96

TITLE: United Nations Conference; "Technical Cooperation Among Developing Countries"

DATES OF DEMONSTRATION: August 29-31 and September 2, 5, 7, and 9, 1978

SPONSOR: United Nations

TYPE OF EQUIPMENT: Portable Earth Terminal at the United Nations and COMSAT at Buenos Aires, Argentina. Full-duplex T. V.

DISTRIBUTION: New York and Buenos Aires

DESCRIPTION OF PROGRAMMING: Speakers from both the U.N. and from the "Conference on Technical Cooperation Among Developing Countries" were carried by live two-way video and audio to each site. There were simultaneous interpretations made in the five official languages used in the U. N.

DEMONSTRATION NUMBER 129

TITLE: United States Catholic Conference:  
Community Communications

DATES OF DEMONSTRATION: March 24, 1979

SPONSOR: United States Catholic Conference

TYPE OF EQUIPMENT: ITFS to NASA ARC receiver sites, twelve  
Veterans Administration terminals and  
Denver uplink to Alaska via the ATS-6

DISTRIBUTION OF PROGRAMMING: To twelve Veterans Administration sites  
and Alaska

DESCRIPTION OF PROGRAMMING: A panel was presented, followed by  
expert testimony and questions and  
comments from all sites in a live and  
interactive mode. The topic was  
communications in social services and  
the use of satellite communication  
technology.

TABLE VII-1

## C.T.S. U. S. DEMONSTRATIONS

<u>NO.</u>	<u>DATE</u>	<u>EVENT</u>	<u>EQUIPMENT</u>
1	5/6/76	IEEE Joint Meeting	
2	5/10,12,14, 17,19,21/76	Kalamazoo Bicentennial	TET
3	5/20/76	CTS Inaug. & Christening	CRC/LeRC
4	6/14/76	Inter. Comm. Conf., 1976	CRC
5	6/16/76	Conference on Open Learning	
6	6/23/76	Paramp Review	
7	7/4/76	The Glorious Fourth	LeRC, NBC
8	7/10/76	Scottish Games	
9	8/3,5,7,10, 12,13,14/76	Public Communication	TET
10	8/25/76	Public Communication	
11	10/29/76	Grade School	TET
12	11/1,3,5, 8,10,12/76	Public Communication	TET
13	11/17/76	U. S. User Mtg. 16	
14	12/7/76	N.Y.C. Board of Education	
15	1/25/77	Moot Court	
16	1/27/77	NASA Conference	
17	1/29/77	Legal Contin. Educ. Sem.	
18	2/8/77	U. S. User Meeting 17	
19	3/1/77	Mayors Conference	PET
20	3/3-10/77	Crisis Management	PET.
21	3/12/77	Symposium	

TABLE VII-1 - Continued

C.T.S. U. S. DEMONSTRATIONS

<u>NO.</u>	<u>DATE</u>	<u>EVENT</u>	<u>EQUIPMENT</u>
22	3/15,17/77	EEO Spacemobile	TET
23	3/24/77	Viking Presentation	CRC
24	3/31/77	Rural Health Conference	PET
25	4/13/77	Exceptional Children Conv.	PET
26	4/19-21/77	Annual SECA Conference	TET
27	5/23/77	Health Science Conference	TET
28	5/25/77	U. S. User Mtg. 18	
29	6/1/77	Special Education Conf.	TET
30	6/9, 10/77	International Symposium	
31	6/10,15/77	Employment Conference	
32	6/17/77	PSSC Workshop	
33	7/7-19/77	Medical Workshop	PET/TET
34	7/21/77	NOAA Conference	
35	7/25,26/77	Disaster Relief - Johnstown	
36	7/31-8/9-77	Boy Scout Jamboree	
37	8/4/77	Co-op Conference	
38	8/23/77	Governors Conference	PET
39	8/23-9/6/77	Medical Clinics	PET
40	8/30/77	Am. Hospital Convention	TET
41	9/11/77	SEND/RECEIVE Sat. Demo.	
42	9/27/77	U. S. User Mtg. 19	
43	9/27/77	Rehabilitation Conference	TET
44	10/9/77	Intelcom 77 - Medical Seminar	PET



TABLE VII-1 - Continued

C.T.S. U. S. DEMONSTRATIONS

<u>NO.</u>	<u>DATE</u>	<u>EVENT</u>	<u>EQUIPMENT</u>
45	10/10/77	Intelcom 77 - Plenary Session	PET
46	10/10/77	Intelcom 77 - Educ. Session	PET
47	10/11/77	Intelcom 77 - Canad. Transm.	PET
48	10/14/77	American Dietetic Assoc.	
49	10/28/77	Bureau of Reclamation	
50	11/7/77	Medical Center	
51	11/20-23/77	Satellite Arts Project	
52	11/21/77	Social Work Symposium	
53	12/12/77	AMA Sci. Meeting	PET
54	1/10-22/78	Health Education Program	PET
55	1/13/78	Teleconference Demo	
56	1/28,29/78	Continuing Medical Education	PET
57	1/7/78	Stereo Simulcast	PET
58	2/2/78	Explorer - 20 yr. Anniv.	TET
59	2/7-9/78	Ed. Curric. Sharing, Ind. & Univ. Research	PET
60	2/8/78	Am. Library Association	
61	2/11/78	Teleconf. - Offshore Oil Drilling	
62	2/14/78	Am. Assoc. for Adv. Sci. - Annual Meeting	PET
63	2/14/78	Adv. of Students in Science and Technology - Forum	PET
64	2/23/78	IEEE	
65	2/25,28/78	Continuing Ed. Conf.	PET

TABLE VII-1 - Continued

C.T.S. U. S. DEMONSTRATIONS

<u>NO.</u>	<u>DATE</u>	<u>EVENT</u>	<u>EQUIPMENT</u>
66	3/7/78	UM #20	
67	3/9-30/78	Shuttle - Remote Man. Syst.	
68	3/17/78	Health Care Conference	PET/TET
69	3/23/78	Interview with Calio	
70	3/28/78	NOAA Teleconf.	
71	3/30/78	MSFC Symposium	
72	4/10,14/78	American Indian Conf.	PET/TET
73	4/24,27/78	AIAA	PET
74	4/26/78	Teleconf. with AID	
75	4/26/78	So. Baptist Conven.	
76	4/26/78	Elementary Student Prog.	
77	4/27/78	Teleconf. with Congress	PET
78	4/28/78	Teleconf. with AID	
79	5/03/78	Cal. State Rehabilitation	
80	5/8,10/78	Frost Prevention Teleconf.	PET
81	5/10/78	Representative Fuqua	PET
82	5/12/78	Disaster Simulation-Balt. AP	TET
83	5/17,19/78	Family Symposium	
84	6/07/78	Asian-Pacific Conf.	
85	4/10,12/78	Joint American Indian Telecomms Project	PET/TET
86	4/17,19/78	Chicago State Univ: "Inner City Meets Space"	PET
87	5/12/78	Catastrophy Simulation for Medical Support Tests	TET

TABLE VII-1 - Continued

C.T.S. U. S. DEMONSTRATIONS

<u>NO.</u>	<u>DATE</u>	<u>EVENT</u>	<u>EQUIPMENT</u>
88	6/19,21/78	AMA Conv. Proceedings Broadcast	PET
89	3/17/78	Greater Cleveland Hospital Association Teleconference	PET/TET
90	3/30/78	NASA Symposium '78 Broadcast - Career Scenario for Students	
91	5/8/78	NASA Community Affairs: Aerospace Careers Symposium	PET
92	6/16/78	AMA Exchange of Medical Information	
93	5/8,10/78	CTS Video Communications Demonstration	PET
94	4/26/78	Education Broadcast for Cleveland Children	
95	3/28/78	Communications Between NOAA Offices	
96	8/26/78	UN Conference (2-way TV)	PET
97	7/8/78	Amer. Assoc. of School Administrators Conference	TET
98	8/17/78	NYS Science Supervisors Assoc. - demo of CTS	
100	7/8/78	UNICON, Inc. Conference	PET
101	7/7/78	Broadcast of NAACP Conference	PET
102	10/2-8/78	Chicago State Univ. "Inner City Meets Space"	PET/TET
103	10/9,11/78	Nat'l. Space Institute "Spacewatch" Broadcast	TET
104	11/15/78	Institute for Theological Encounter with Science & Technology	
105	9/28/78	Library & Information Technology Assoc. (ALA) Teleconference	PET
106	7/3/78	Government of Quebec	PET

TABLE VII-1 - Continued

C.T.S. U. S. DEMONSTRATIONS

<u>NO.</u>	<u>DATE</u>	<u>EVENT</u>	<u>EQUIPMENT</u>
107	8/10,15/78	LMVD/MRC: Briefings on Water Control Topics	PET/TET
108	9/12/78	AHA Annual Convention	TET
109	10/13/78	Medical Amateur Radio Council Mtg.	PET
110	12/15/78	Broadcast of Moon, Mars & Earth Findings for School Teachers	PET/TET
111	11/20/78	Teleconference Between Mayors of Maryland & Columbus, Ohio	PET
112	9/19,20/78	Second Joint Meeting of U.S. & Canadian Participants	PET
113	9/21/78	System Safety Society Meeting	
114	9/2,9/78	UN Conf. on Technical Cooperation	PET
115	11/15/78	Michigan Space Center: Seminar on State Opportunities in Space	PET
116	9/14/78	Medical Care Development Inc.: Medical Applications	TET
117	10/23/78	20th NASA Anniversary: Satellite Capabilities Highlighted	PET
118	4/4,6/6/79	Greater Cleveland Hospital Assoc.: Perinatal Nursing Topics	TET
119	4/2,4,6/79	Interaction Between Gifted Students	PET
120	3/29/79	No. Alabama Educational Opportunity Center: Symposium for Students	TET
121	12/9/78	NASA-Ames: Coverage of Pioneer- Venus Encounter	
122	1/6/79	Glassboro State College/Ames: Interactive Discussion of Views	TET
123	Cancelled	KLFN-TV: "Fiesta San Antonio"	PET

TABLE VII-1 - Continued

C.T.S. U.S. DEMONSTRATIONS

<u>NO.</u>	<u>DATE</u>	<u>EVENT</u>	<u>EQUIPMENT</u>
124	1/26/79	WMVS-TV Interactive Teleconference with Local Community	
125	1/19,20,26 & 2/2/79	WAMI Program	PET
126	2/8/79	Nat'l. Translator Association: PTV Distribution in Montana	PET
128	2/9/79	Amer. Journal of Nursing & American Nursing Assoc. Continuing Education	
129	4/23,30 & 5/7/79	U.S. Catholic Conference: Community Comms.	
130	3/27,29/79	Teleconferences Between Gifted Students from Michigan & Ohio	PET
131	3/1,22/79	Teleconferences Between Gifted Students from Michigan & Ohio	
132	4/18/79	NASA-Lewis: Conduct CTS Users Meeting #22	
133	4/18/79	Media Dev't. Program for Hearing Impaired: Potentials	
134	4/4, 6/6/79	Repeat of Demo #118	TET
135	3/7/79	Interactive Teleconference Between NASA Goddard & NOAA	
136	6/22/79	NASA-Lewis Education Opportunity Workshop	
137	5/11/79	Children's Interactive "Personalities" Broadcast to Children in Ohio	
138	5/30/79	Medical University of South Carolina: Epilepsy Topics	
139	4/13/79	Videconference Between N. Carolina State Legislature & Washington, D.C. Regarding Telecommunications Legislation	PET

TABLE VII-1 - Continued

C.T.S. U. S. DEMONSTRATIONS

<u>NO.</u>	<u>DATE</u>	<u>EVENT</u>	<u>EQUIPMENT</u>
140	6/13-28/79	WAMI Program: Continuing Ed. for Rural Medical Personnel	PET
141	6/1/79	United Methodist Communications: "New Light on the Bible" Teleconference	PET
142	5/10/79	Martin Marietta Teleconference	PET
143	5/18/79	Indiana University Dental School 100th Anniversary	PET
144	5/16/79	Videoconference Between GTE & NASA-Lewis	
145	6/18,20,22/79	National Asthma Center: Curriculum for Patients & Family	
146	6/13/79	Videoconference Between NASA-Goddard and NOAA	

VIII. NASA EVENTS

Over the duration of the CTS Experiments/Demonstrations/Events, there were 63 approved Events. Events were one-time happenings of very short duration and completed in one or two days. Like Demonstrations, the Events were widely distributed geographically and, when not conducted at a NASA or experimental site, were dependent on Transportable Earth Terminals and Portable Earth Terminals for transmission and reception.

While Events were short in duration, they provided much needed information and experimental data and broadened the geographical exposure of satellite communications.

The approved Events are as follows:

TABLE VIII-1 - APPROVED NASA EVENTS

<u>EVENT</u>	<u>DATE</u>	<u>ORGANIZATION</u>	<u>LOCATION</u>	<u>EQUIPMENT</u>
1	6/10,13,15/77	COMSAT	Chicago, IL	PET
2	9/26,27,28/77	COMSAT	Washington, D.C.	PET
3	10/9,15/77	COMSAT	Atlanta, GA	PET
4	4/15/77	Prgm. of Policy Studies	Raeford, N.C.	PET
5	4/27/77	Prgm. of Policy Studies	Corvallis, OR	PET
6	5/2/77	Prgm. of Policy Studies	Denver, CO	PET
7	5/4/77	Prgm. of Policy Studies	Iowa	PET
8	6/8/77	Prgm. of Policy Studies	Greenbelt, MD	PET
9	4/11/77	CTS Prgm. Office	NASA Hdqtrs.	LeRC
10	6/20/77	Prgm. of Policy Studies	Southland, IN	PET
11	5/22/77	Prgm. of Policy Studies	Ohio	PET
12	5/25/77	LeRC (CTS Office)	Goddard	LeRC
13	4/22/77	NASA/AMES	Moffet, CA	AMES
14	5/9/77	CTS Prgm. Office	NASA Hdqtrs.	LeRC/GSFC
15	5/16/77	CTS Prgm. Office	NASA Hdqtrs.	GSFC
16	6/22/77	Goddard Space Flight Center	Greenbelt, MD	GSFC
17	7/1/77	Ames Research Center	Ohio/CA	LeRC
18	7/26/77	Prgm. of Policy Studies	Wash., D.C./CA	AMES
19	8/2/77	CTS Prgm. Office	Wash., D.C.	GSFC/ARC
20	8/11/77	NASA	MD/CA	GSFC/AMES
21	12/7/77	CTS Prgm. Office	Utah	GSFC
22	12/15/77	CTS Prgm. Office	Nat'l. Space Test Lab	GSFC
23	9/27/77	LeRC (CTS Office)	Seattle, Wash.	LeRC
24	11/18/77	CTS Prgm. Office	MD/Ohio	GSFC/LeRC



<u>EVENT</u>	<u>DATE</u>	<u>ORGANIZATION</u>	<u>LOCATION</u>	<u>EQUIPMENT</u>
25	11/11/77	NASA/GSFC	MD/CA	GSFC/AMES
26	11/30/77	NASA/GSFC	MD/CA	GSFC/AMES
29	4/24-26/78	LeRC/COMSAT	MD, San Diego	PET
30	3/7/78	LeRC (CTS Office)	Cleveland/CA	LeRC/AMES
32	3/9-30/78	Johnson Space Center	Ottawa/KY	Ottawa
33	3/23/78	NASA/AMES	MD	PET
34	4/21/78	NASA/GSFC	CA/MD	GSFC/AMES
35	4/28/78	NASA/Lewis Research	Cleveland/ Washington, D.C.	LeRC
36	4/26/78	Prgm. of Policy Studies	San Diego, CA	PET
37	5/10/78	Prgm. of Policy Studies	Orlando, FL	PET
38	5/7/78	NASA/GSFC	Greenbelt, MD	GSFC
39	5/26/78	NASA-Lewis Research	Cleveland/D.C.	LeRC
40	6/21/78	Prgm. of Policy Studies	MN/MD	PET
41	6/7/78	NASA/GSFC	CA/MD	GSFC/AMES
42	6/12/78	NASA/GSFC	CA/MD	GSFC
43	6/12/78	NASA/GSFC	CA/MD	GSFC/AMES
44	6/26/78	NASA Lewis/GSFC	Ohio/MD	LeRC
45	6/28/78	Prgm. of Policy Studies	WI/MD	PET
46	7/6/78	Prgm. of Policy Studies	CO/MD	U. of Colo.
47	7/27/78	Prgm. of Policy Studies	Syracuse, NY	PET
48	7/29,30/78	Hughes Aircraft	Los Angeles/OH	LeRC
49	8/22/78	NASA/AMES	CA/D.C.	PET
50	12/12,14/78	Johnson Space Flight Center	Houston, TX	PET/TET
51	8/24/78	NASA/AMES	CA	AMES
52	8/15/78	NASA/AMES	CA/MD	PET
53	8/1/78	NASA/GSFC	CA/MD	GSFC

<u>EVENT</u>	<u>DATE</u>	<u>ORGANIZATION</u>	<u>LOCATION</u>	<u>EQUIPMENT</u>
54	10/18/78	NASA/LeRC	OH/MD	LeRC/GSFC
55	10/18/78	NASA/LeRC	OH	LeRC
56	10/25/78	NASA/LeRC	OH	PET
57	1/16/79	NASA/GSFC	CO/MD	PET
58	1/18/79	GSFC	CA/MD	AMES/GSFC
59	2/1/79	NASA/AMES	CA/MD	GSFC/AMES
60	3/22/79	NASA/AMES	CA/MD	GSFC/AMES
61	4/30/79	NASA/AMES	CA/OH	LeRC/AMES
62	5/25/79	NASA/LeRC	CA/OH	LeRC/AMES
63	6/25/79	NASA/LeRC	All CTS Sites	LeRC

## IX. TOTAL CTS USAGE

The following statistics show the number of CTS operating hours that U. S. experimenters utilized during two-week operating periods from February 12, 1976, through June 30, 1979. Experimenters utilized the CTS a total of 6,093.9 hours out of a total availability of 14,784.5 hours for a 41 percent usage.

TABLE IX-1 - U.S. USER TOTALS - EXPERIMENT OPERATING HOURS

Includes: TEP, SET, TET, PET

<u>PERIOD</u>	<u>OP. HOURS</u>	<u>PERIOD</u>	<u>OP. HOURS</u>
<u>1976</u>		<u>1977</u>	
2/12 - 5/10	356.9	1/1 - 1/15	62.5
5/11 - 5/31	191.6	1/16 - 1/31	98.8
6/1 - 6/15	138.3	2/1 - 2/15	103.5
6/15 - 6/30	129.6	3/1 - 3/15	67.4
7/1 - 7/15	83.8	3/16 - 3/31	78.8
7/16 - 7/31	45.5	4/1 - 4/15	71.7
8/1 - 8/15	81.8	4/16 - 4/30	73.0
8/16 - 8/31	96.6	5/1 - 5/15	57.25
9/1 - 10/15	ECLIPSE PERIOD	5/16 - 5/31	70.75
10/16 - 10/31	70.3	6/1 - 6/15	111.00
11/1 - 11/15	104.3	6/16 - 6/31	51.5
11/16 - 11/31	54.0	7/1 - 7/15	77.75
12/1 - 12/15	70.0	7/16 - 7/31	95.00
12/15 - 12/31	63.5	8/1 - 8/15	107.25
		8/16 - 8/31	75.75
		9/1 - 9/15	65.5
		9/16 - 9/30	59.75
		10/1 - 10/15	84.25
		10/16 - 10/31	78.1
		11/1 - 11/15	99.82
		11/16 - 11/30	93.2
		12/1 - 12/15	94.45
		12/16 - 12/31	95.6

U.S. USER TOTALS - EXPERIMENT OPERATING HOURS - Continued

Includes: TEP, SET, TET, PET

<u>PERIOD</u>	<u>OP. HOURS</u>	<u>PERIOD</u>	<u>OP. HOURS</u>
<u>1978</u>		<u>1979</u>	
1/1 - 1/15	79.9	1/1 - 1/15	46.1
1/16 - 1/31	87.4	1/16 - 1/31	57.0
2/1 - 2/15	93.5	2/1 - 2/15	70.9
2/16 - 2/28	64.4	2/16 - 2/28	41.4
3/1 - 3/15	50.2	3/1 - 3/15	59.0
3/16 - 3/31	64.8	3/16 - 3/31	68.5
4/1 - 4/15	94.05	4/1 - 4/15	69.9
4/16 - 4/30	90.05	4/16 - 4/30	68.4
5/1 - 5/15	97.9	5/1 - 5/15	84.1
5/16 - 5/31	97.05	5/16 - 5/31	93.1
6/1 - 6/15	71.7	6/1 - 6/15	100.0
6/16 - 6/30	64.1	6/16 - 6/30	95.5
7/1 - 7/15	53.95		
7/16 - 7/31	67.45		
8/1 - 8/15	68.15		
8/16 - 8/31	133.05		
9/1 - 9/15	85.8		
9/16 - 9/30	76.2		
10/1 - 10/15	79.8		
10/16 - 10/31	90.95		
11/1 - 11/15	66.15		
11/16 - 11/30	115.60		
12/1 - 12/15	98.4		
12/16 - 12/31	50.6		

TOTAL U. S. USAGE       $\frac{6,093.9}{14,784.5} = 41\%$

## DOWN TIMES

### Eclipses

During the first and second years of operation, the CTS was shut down during eclipse periods. In 1977, the satellite was shut down for 117 hours. In 1978 and 1979 as more experience was gained, the satellite was kept operational during the eclipse periods.

### Anomalies

As reported in Experiment 33, there was lost time of 668 hours due to equipment failure. There were also rain attenuation conditions in some locations as reported in this experiment that exceeded 8.5 dB for .01% of the time, or 49 minutes.

A total of all anomalies and eclipses accounted for only 9% down time. Thus, the CTS was 91% efficient during the experiments.

## X. SUMMARY

The Communications Technology Satellite project began on April 20, 1971. One of the service oriented objectives was to: conduct satellite communications systems experiments using the 12 and 14 GHz bands and low-cost transportable ground terminals.

As we look back on the CTS experiments, we must conclude that the CTS/Hermes project was a success. The CTS communications and ground terminal experiments provided a wealth of data relating to the management, operation, and programming of a communications spacecraft. The knowledge gained is being used daily and has created one of the country's newest and fastest growth industries--satellite communications.

The satellite industry would not be experiencing this growth were it not for the CTS users, and it is in this area, user development, that the CTS/Hermes project made its greatest contribution. There were 20 completed Experiments, 146 Demonstrations, and 63 Events. Each of these maxi or mini communications projects touched new user groups and demonstrated to the various publics the feasibility and cost effectiveness of satellite communications. Many of the CTS users moved directly from being a CTS Experimenter to being a commercial satellite user. Hundreds of persons involved in CTS experiments are now engineers, technicians, program developers, teleconference specialists in this new industry. New job descriptions are emerging and a whole new vocabulary has come into being as a result of the satellite industry.

The final report of Mr. Robert Glazier, Principal Investigator of the SECA Project (Experiment 19), pp. VI-70-84, eloquently summed up the

experiences of many of the CTS Experimenters. There were many successes and many frustrations. Each experiment and mini-event added to the body of knowledge, and created new constituencies. It is unfortunate that many well-planned experiments did not get their programs on the spacecraft. These experiments would have added substantially to the body of knowledge and would have created additional groups of users.

Another experimenter, the Public Service Satellite Consortium (Experiment 21), pp. VI-93, has continued to work with public service groups. It has continued to expand its membership and its work with public service organizations in the use of satellite communications. Over 50 percent of the public service groups that participated with PSSC in CTS Experiment 21, have arranged for domestic satellite usage on an occasional or continuing use basis.

NASA's CTS program provided the economic and psychological support for many organizations to become satellite users. Many of these organizations would not have ventured into satellite communications on their own. The CTS program has proven that satellites are viable and an economically cost effective means of addressing many of our societal needs. The CTS program in the United States, and the companion Hermes program in Canada, have already had a positive effect on the quality of life on the North American continent, and, as satellite technology continues to expand, the contributions made by the CTS/Hermes program will become even more significant.