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CTS (HERMES) - UNITED STATES EXPERIMENTS AND OPERATIONS SUMMARY

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ABSTRACT

The Communications Technology Satellite (CTS) or Hermes, launched in January 1976, embodies the highest power transmitter in a communications satellite. The frequencies of 14/12 GHz are used for two-way television and voice communications. This joint program between the United States and Canada has helped to cement relations between the two countries. In the United States, the experiments are managed and controlled in real time by the NASA-Lewis Research Center. This control necessitates close coordination and contact with Canada as well as each of the accepted experiments in the United States.

Criteria were used by NASA for acceptance of United States experiments. These criteria are noted; acceptance procedures are discussed. The category for each accepted experiment is given.

The modus operandi employed for the U.S. experiments in the areas of management, coordination, liaison, and real time operation are described. Some of the highlights associated with Hermes utilization are given.

INTRODUCTION

The Communications Technology Satellite (CTS) or Hermes provides the capability for communications experimentation at 14/12 GHz frequency. Some of the experiments are on spacecraft components. Others employ the high-power communications capability of the spacecraft in conjunction with earth-bound equipment. The United States and Canada cooperate in the CTS program. NASA has responsibility for the United States; the Department of Communications (DOC) has the responsibility for Canada.

Acceptance, planning, and hardware procurement for satellite communications experiments must precede, of course, the launch of the spacecraft. NASA, following review of proposals, accepted some experiments prior to the January 1976 launch of CTS. U.S. experiments accepted by NASA are in the societal areas of Health Care, Community Services, Education, and Special Services and in the technical area of Technology. Experiment planning and implementation for some of the experiments was well underway in 1975 as evidenced by references 1 to 4.

Since launch, information pertinent to CTS experiments has appeared in the open literature. The catalytic influence of CTS on communications is discussed in reference 5. CTS flight characteristics, including results from spacecraft components, are presented in reference 6. Flight data from the key component of the spacecraft communications system - the 200W transmitter - were reviewed (ref. 7). In 1976, a review of U.S. societal experiments was given (ref. 8) and the status was reported in reference 9. In the Special Services area, two-way television experiments have produced interesting results (refs. 10 and 11).

In the U. S., each experimenter is responsible for providing the resources necessary to conduct the experiment. For in-orbit operations, the spacecraft is controlled by DOC from a telemetry, tracking and command station located at the Communications Research Centre (CRC) near Ottawa, Ontario. Control and coordination of U. S. experiments are handled by the NASA-Lewis Research Center (LeRC) in Cleveland, Ohio. Experiment success includes the requirements of coordinated efforts and compatibility of ground terminal equipment and operations with spacecraft equipment and operations. To insure success, insofar as possible, NASA employed the program-project management concept. In this concept, the programmatic aspects are the responsibility of NASA Headquarters (Washington, D. C.); the project responsibility is at the NASA-LeRC (Cleveland, Ohio).

In this paper, U.S. experiment acceptance procedures are discussed. Categories and geographic locations are noted for the accepted experiments. Modus operandi used in areas of management, liaison and real-time operation are reviewed. CTS utilization by U.S. experiments is synopsized.

UNITED STATES EXPERIMENTS

Acceptance Procedures

The acceptance procedures for United States utilization of CTS (christened Hermes) depend on whether the request is for an experiment or for a demonstration. An experiment includes data collection and publishing and may have a year's duration; a demonstration uses the spacecraft for a few days to a couple of weeks.

Experiments. - An Announcement of Flight Opportunity for experiments was issued by NASA in August 1972 for prospective United States users of CTS. At a pre-proposal briefing held in Washington, D.C. in October 1972, further guidance was given. Proposals submitted by prospective experimenters, are reviewed by the NASA CTS User Proposal Evaluation Committee. This committee is comprised of personnel from NASA Headquarters, Lewis Research Center (LeRC), Goddard Space Flight Center (GSFC), and appropriate NASA consultants.

The Proposal Evaluation Committee reviews proposals based on: technical content, compatibility with spacecraft, validity of the experiment, social worth of the experiment, experimenter's evaluation plan, experimenter's spacecraft utilization plan, integrity of the financial plan for performance of the experiment, subsequent evaluation and publication of the results. The proposer is formally notified of the acceptance of non-acceptance of their proposal. The Director of Communications Programs at NASA Headquarters is the approval authority for experiments.

Accepted proposers for experiments utilizing CTS are referred to as Users. (The terms User and Experimenter are employed interchangeably.) NASA provides time on the satellite for U.S. Users based on the 50-50 time sharing with Canada. In the U.S., the User's organization is responsible for providing the resources to implement the experiment (e.g., ground equipment, and operations) and to report the results. NASA, in turn, serves a management function, provides consultation to the Experimenter and allocates spacecraft time at no charge to the User.

Table I summarizes the status of U.S. experiments. There have been 35 proposals received by NASA. Of these 35 proposals, 28 have been accepted and are at different stages. Experiments are placed in pending status when it is decided that sufficient progress is not being made. The main reason for withdrawal was the User not being able to secure adequate funding.

Demonstrations. - The approval for a demonstration is dependent on the scope of public interest and availability of spacecraft time and equipment. A demonstration (mini-experiment) requires the sponsorship of a User in the U.S. CTS Experiments Program. Sponsorship assures that the necessary technical support and ground terminals are available for planning and executing the demonstration. Sponsorship approval is secured from the experiment's Principal Investigator. The NASA Manager, CTS Operations and Experimentation, is the approval authority for demonstrations.

Demonstrations are reviewed and evaluated based on the submittal of a brief Demonstration Request that contains: concept and plans, scope of public interest, satellite time and boresight request, operational configuration, and the Demonstrator's commitment to submit a post factum report or letter. The Sponsoring Experiment makes the necessary arrangements to implement the mini-experiment. There have been 48 demonstrations conducted (table I).

Categories

To explore the uses of communications satellites at 14/12 GHz, U.S. Users are involved in a variety of experiments using both the 20W and 200 W transmitters on CTS. The experiment categories include Health Care, Community Services, Education, Technology and Special Services.

Government, education, and industry are all represented. The five categories and the associated experiments are given in Figure 1. The number following each item is the U.S. experiment number of experiment. For each of the experiments that are numbered in figure 1, there is a particular organization and a Principal Investigator (table II).

Referring to figure 1, there are three experiments in Health Care; these experiments are discussed further in references 12 to 14. Industry, academia, and the federal government are conducting diverse experiments in the Community Services and the Special Services areas. Experiments in these areas include video-conferencing as noted in figure 1. There are three experiments in the Community Services area and 6 experiments in the Special Services area. Additional information on some of these experiments is included in references 15 to 17 and, for Special Services, in references 18 to 21. In the Education area, there are 3 experiments that are in various stages of completion. These experiments are investigating and determining the feasibility of a range of educational requirements from counseling to curriculum sharing (refs. 17, 22, and 23).

As befits the utilization of a new frequency band, there are a considerable number of experiments in the Technology area (fig. 1). Technology experiments involve the demonstration and assessment of advanced technology components and subsystems, their use in the operation of the spacecraft and in the performance of communications experiments. In addition to spacecraft operational aspects, there are also technology experiments associated with the ground terminals that include link characterization, digital communications, etc. Up-to-date information on these experiments is contained in references 22, and 24 to 26.

Geographic Locations

The locations for the United States experiments range from the Atlantic to the Pacific seaboard and include Alaska as well. The experiment locations are depicted in figure 2. As noted on the figure, there are 24 uplinks which include 9 portable terminals. And there are 56 receive only terminals that include 4 beacon receivers. Thus, there are 80 ground terminals in the United States associated with CTS. These experiments use both wideband and narrowband signals. The wideband signals are utilized for television whereas, narrowband can be used for voice, data, and facsimile. Some experiments permit two-way television while others only permit one-way TV. Additional information on the signals, locations, and frequency plan is given in reference 8.

Management

The NASA-User relationship is one of mutual obligation. The User is responsible for providing the resources necessary to implement and report on the experiment. The resources include ground terminals for transmission and reception of the 14 and 12 GHz signals, any interface equipment, the personnel to operate and maintain the equipment, program material for transmission, data collection and publishing. The User organization includes a Principal Investigator (overall responsibility for the experiment), Technical Manager and Evaluation Coordinator. NASA provides: Experiments Program management, spacecraft information, and technical consultation to the User. NASA also allocates the spacecraft 14/12 GHz communications system at no charge to the User. And NASA serves as the single point-of-contact between the User and Canada for planning and real-time operations.

(Allocation, planning and operations are discussed in the EXPERIMENT OPERATIONS CONTROL section.)

For the management of the international Hermes program, NASA employs the program-project concept. NASA Headquarters in Washington, D.C. has the responsibility for the programmatic aspects which includes looking after NASA's broad interests. The NASA Lewis Research Center in Cleveland, Ohio has project responsibility which includes day-to-day activities.

As management tools, NASA employs User Experiment Bulletins, the submission by Users of periodic reports to NASA, a Technical Working Group and an Evaluation Working Group. In addition, periodic User Meetings are held by NASA; day-to-day communications are enhanced via a computer system. These tools are briefly discussed.

In August of 1973, the issurance of User Experiment Bulletins (UEB's) commenced. The purpose of the UEB is to provide written directives, information and requirements to experimenters about a variety of topics necessary to the successful fulfillment of CTS experimentation.

Since January, 1974, Users were required to submit a monthly report to NASA. The format is the Management Information and Control System (MICS). The primary objectives of the MICS include keeping NASA informed of the status of experiments, isolating problems in terms of schedule and technical performance, providing early warning of potential problems, and establishing a basis for developing and implementing work around plans. The MICS report includes a Narrative Analysis as well as a Schedule.

The Technical Working Group (TWG) was formed in September, 1974 and consisted of a chairman and a co-chairman from NASA and a Technical Manager for each of the U.S. Users. The purpose of the TWG was to provide technical support for the user experiments. The TWG determined the technical facilities required for accomplishment of experiment objective and attempted to insure, insofar as possible, their availability in a timely manner. Periodic meetings of the Technical Working Group were held prior to the launch of CTS in January, 1976.

In January of 1975, an Evaluation Working Group was formed consisting of a chairman and an Evaluation Coordinator from each experiment. This evaluation group continues to function. The purpose of the group is to conduct activities designed to develop synergism among CTS U.S. Users in regard to the formulation of their evaluation plan and the sharing of ideas and data.

Periodic meetings are held with CTS U.S. experimenters. The purposes of these meetings are: to provide information to Users, determine User status and problem areas, and provide for coordination among Users. As noted in table III, the U.S. Users Meetings commenced in October, 1973. Through October, 1977, there have been 19 meetings. Also noted in the table are the experiment number (see table II for experiment title, etc.) and the number of action items from each meeting. Action items are assigned to achieve desired results associated with the experiment program. The actions may be required of NASA, individual or all Users.

To provide for speedy hard-copy communication, utilization of a computer system (PLANET) - ref. 27) began prior to launch. This system allows NASA and Users, who are geographically separated, to engage in group planning and information exchange. The computer program is accessible through a network that may be reached conveniently within the continental U. S.

EXPERIMENT OPERATIONS CONTROL

Information pertinent to prelaunch, launch, transfer-orbit, drift, and attitude acquisition operations is discussed in reference 28 (page VI-1). In-orbit operations, specifically those associated with U. S. experiment control are discussed herein.

The concept for in-orbit control is depicted in figure 3. The spacecraft, including antenna pointing, is controlled by DOC from a telemetry, tracking and command station located at the Communications Research Centre (CRC), near Ottawa, Canada as mentioned previously. During in-orbit operations, the single U. S. point of contact with CRC is at LeRC in Cleveland, Ohio. LeRC, in turn, is the point of contact for each U. S. Experimenter (User). Control and coordination of U. S. experiments are handled by LeRC.

The experiment functional block diagram (fig. 4) depicts the various aspects required to support the User for planning and real-time activities. The three primary functional areas are the Canadian spacecraft operations, the NASA experiment control and coordination activities, and the User networks. The dashed lines depict planning activities and the solid lines real-time activities.

Planning

Downlink simulator. - Downlink simulators were designed and built by Lewis to permit checkout of U.S. receive equipment prior to CTS launch. The downlink simulator consists of a high quality FM transmitter and video test signal generator. A nominal 12 GHz carrier and standard test signal modulation simulate the signal normally received from the orbiting spacecraft transponder. External modulation capabilities allow the input of baseband programming material particular to User requirements. The modulator inputs accept TV, audio, FDM, PCM, or up to 10 megabit data. The downlink simulators were loaned to Users by NASA for their terminal checkout.

Lewis data processing. - To assist Users in locating the spacecraft with their ground antenna, Lewis processes and supplies data. Orbital parameters received from CRC after each stationkeeping maneuver are processed by Lewis to calculate orbital elements and spacecraft ephemeris, and, then, antenna azimuth-elevation (look) angles for each experiment site. Look angles are distributed to the 60 U.S. experiment sites.

Time allocation. - Time allocation is the scheduling of the spacecraft 14/12 GHz Super High Frequency (SHF) communication system for Users. The overall aim of the scheduling is to maximize time for the communications experiments, subject to spacecraft housekeeping and health. Procedures are applied to optimize the schedule for each experimenter and for an equitable distribution of time among the experiments. A summarization of the CTS mission is given in figure 5. Spacecraft time is divided 50-50 between the U.S. and Canada. The figure shows the U.S. experiment days as well as the dates for the changeovers. Eclipses by the earth and moon are noted. It also depicts the blackout (the lack of SHF system utilization) during the first and second eclipse seasons in 1976 due to a problem with the spacecraft (ref. 6). There has been SHF operation and utilization during E_3 and E_4.

Real Time

At CRC in Ottawa, the spacecraft control and health is maintained via command and telemetry links (fig. 4). The spacecraft is configured periodically for battery reconditioning, stationkeeping and momentum dumping. During the eclipse seasons, additional configuring is required.

Antenna boresight pointing is accomplished by the Ottawa ground control station according to the planned time and boresight allocation. The control of U.S. Users is conducted on a real-time basis at the LeRC Experimenters Coordination Center (ECC) (figs. 4 and 6). LeRC communicates via voice and data links with CRC. The ECC also receives Hermes telemetry which is processed and displayed to verify that the CTS spacecraft configuration is appropriate for the intended User. The U.S. User provides for coordination of his ground stations through a Network Control Center.

Spacecraft and natural constraints. - There are two major spacecraft housekeeping operations, momentum dumping and east-west stationkeeping. During these periods (approx. 1 hr), neither transponder switching nor antenna movement is permitted. But the User may transmit continuously. Momentum dumping has occurred about every three weeks. East-west stationkeeping occurs every 1 to 3 months. These housekeeping operations have not seriously hindered experimenters in their utilization of the communications system on board CTS.

The solar eclipse of the spacecraft occurs daily during spring and summer (fig. 5). It varies in duration, has a maximum duration of 74 minutes, and is centered about 07:50 GMT. Communications experiments are precluded during eclipse and for about one hour before and after.

The design life of the antenna steering mechanism is fixed in value about any axis. It has been found that this has not yet been a constraint on Users but it is calculated and monitored.

LeRC experiment evaluation. - The LeRC Experiments Coordination Center includes a facility to conduct the Transmitter Experiment Package (TEP) technology experiment. A description is given in reference 28 (page VII-16). This facility provides Lewis with performance measurements of spacecraft parameters such as transmitter power levels. These are needed by Users in setting uplink power levels.

Uplink transmit responsibilities. - Experimenters using the CTS transponder have two areas of responsibility regarding uplink transmission utilizing CTS. Firstly, Users are not to cause interference during another experimenter's satellite time. And second Users are responsible for controlling the uplink effective isotropic radiated power (EIRP) to safe levels which do not overdrive the spacecraft transponder.

SPACECRAFT UTILIZATION

An overall 50-50 time-sharing of CTS for communications experiments was developed by the U.S. and Canada following discussions between representatives of the two countries. The basic division is by alternate day usage (see fig. 5). Commencing in May 1976, the year was divided into four thirteen-week periods. For a given thirteen-week period, Canada has the spacecraft on Monday, Wednesday and Friday; the U.S. on Tuesday, Thursday and Saturday. The following thirteen-week period U.S. and Canada interchange days. Sundays alternate between the two countries.

Procedures were also developed for preemption of experiments. Preemption is predicated on Spacecraft Health and Safety, Medical Emergencies, Disaster Generated Emergencies, Unique Phenomena, and Higher Authority Request. Due to the close working relation and excellent cooperation between Canada and the U.S., there have not been any problems associated with the time-sharing between the two countries.

The start data for CTS utilization by the experiments listed in table II is given in table IV. The 200W traveling wave tube (part of TEP - ref. 28 - page III-9) on the spacecraft has operated over 7700 hours in-orbit through October 15, 1977. Table IV also lists SETS (Small Earth Terminal Station), TET (Transportable Earth Terminal) and PET (Portable Earth Terminal). The LeRC PET and TET facilities are discussed in reference 28. SETS is used to test and evaluate low cost hardware; the equipment includes parabolic reflector type antennas from 0.6 to 4.5 m in diameter.

There have been a wide variety of demonstrations or mini-experiments held in the U.S. using Hermes. These demonstrations commenced in May of 1976 and are listed in table V. As noted, they include the christening by the Canadian Minister of Communications (May 1976), ICC 76 (June 1976), Scottish games, etc. It is noteworthy that parts of several U.S. User Meetings have also been conducted utilizing CTS (Meetings 16, 17, 18, 19). During this part of the User Meeting, two-way television conferencing was held between the experimenters at a specific meeting location (tables III and V) and speakers at the NASA-Lewis Research Center in Cleveland, Ohio. For the television conference, the chariman and the Users were convened at the meeting location. Certain Lewis speakers were located in Cleveland, Ohio. Comments, questions, and answers were readily communicated between attendees at the participating locations via CTS during the duplex television conference mode.

These demonstrations have been successful due in no small part to painstaking efforts by the personnel associated with them. Additional information on some of these mini-experiments is contained in references 14, 15, 18, 19, 26, and 29.

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TABLE I. - CTS - U.S. EXPERIMENTS SUMMARY - OCT. 1977

Category	Item		Number
Experiments (~1 yr)			
	Proposals		35
	NASA accepted		
	Completed	1	
	Active	19	
	Pending	3	
	Withdrawn	5	
	Total		28
Demonstrations (mini-experiments - table V)			48

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

No.	Title	Origin	Principal investigator
*TEP	TEP/SHF TECHNOLOGY	NASA-Lewis	R. Alexovich
*1	COMMUNICATION LINK CHARAC.	NASA-Goddard	L. Ippolito
*4	COLLEGE CURRICULUM SHARING	NASA-Ames	D. Lumb
*6	TRANSPORTABLE EARTH TERMINAL	COMSAT	J. Kaiser
*7	BIOMEDICAL COMMUNICATIONS	Hew-ListerHill	E. Henderson
9	SAT. LIBRARY INFO. NETWORK	Salinet	M. Goggin
*11	HEALTH/COMMUNICATIONS	Vets. Admin.	R. Shamaskin
*13	COMMUNICATION SUPPORT FOR DECENTRALIZED EDUCATION	WAMI(a)	M. R. Schwarz
*15	COMM. IN LIEU OF TRANSPORTATION	Westinghouse	H. Nunnally
*16	PROJECT INTERCHANGE	ASF(b)	D. Green
*18	INTERACT. TECH. FOR INTRA NASA APPLICATIONS	NASA-Goddard	J. Chitwood
*19	SATELLITE DISTRIBUTION	SECA(c)	F. Morris
*20	ADV. GROUND REC. EQUIPMENT EXPT.	GSFC/NHK	J. Miller
*21	PUBLIC SERVICE SAT. EXPT.	PSSC(d)	R. Mott
**22	AK NORTH SHORE ICE INFO. DEMO.	NASA-Lewis	R. Gedney
*24	DIGITALLY IMPLEMENTED COMM. EXPT.	LeRC/COMSAT	H. Jackson
*25	CONGRESSIONAL VIDEOCONFERENCING	GWU(e)	F. Wood
*26	PROJECT ADJUNCT	SBS(f)	C. Rush
27	WOMEN'S SATELLITE SERVICES	NWA(g)	J. Zimmerman

*FINAL ACCEPTANCE BY NASA
**Complete
(a) Washington, Alaska, Montana, Idaho
(b) Archdiocese of San Francisco
(c) Southern Educ. Communications Assoc.
(d) Public Service Satellite Consortium
(e) George Washington University
(f) Satellite Business Systems
(g) National Women's Agenda

TABLE III. - CTS U.S. USERS MEETINGS

Mtg. No.		Date	Location(1)	Expt. no.	AI's(2) no.
1	1973	Oct. 30,31	LeRC, Oh	7	7
2	1974	Jan. 23,24	NASA Hq. DC	7	15
3		Mar. 27,28	LeRC, Oh	9	12
4		May 21,22	Ames, Ca	10	10
5		July 24,25	LeRC, Oh	10	9
6		Oct. 3	Denver, Co	15	10
7		Nov. 19,20	Ottawa	15	8*
8	1975	Jan. 28,29	GSFC, Md	17	11*
9		Apr. 8,9	Ames, Ca	17	14
10		June 10,11	LeRC, Oh	17	6
11		Aug. 19,20	LeRC, Oh	18	11
12		Oct. 29,30	COMSAT, Md	20	15
13	1976	Jan. 15,17	KSC, Fl.	20	2
14		Apr. 27,28	Ames, Ca	21	11*
15		Aug. 3,4	LeRC, Oh	22	
16		Nov. 17,18	Westing., Md	23	17
17	1977	Feb. 8,9	Ames, Ca	25	10
18		May 25,26	GSFC, Md	26	10*
19		Sept. 27,28	WAMI, Wa	27	8

*INCLUDES NEW UEB'S

(1) LeRC - Cleveland, Oh
Ames - MountainView, Ca.
GSFC - Greenbelt, Md
COMSAT - Clarksburg, Md
KSC - Cape Canaveral, Fl
Westing - Baltimore, Md
WAMI - Seattle, Wa.

(2) AI - Action Item

TABLE IV. - U.S. EXPERIMENTS' STARTING DATES

User	Initial Use
TEP	2/08/76
EXPT 1	2/19/76
EXPT 4	2/13/76
EXPT 6	2/19/76
EXPT 7	12/08/76
EXPT 11	6/12/77
EXPT 13	3/29/77
EXPT 15	2/18/76
EXPT 16	3/01/76
EXPT 18	5/10/76
EXPT 19	12/06/76
EXPT 20	4/23/76
EXPT 21	2/27/77
EXPT 22	8/14/76
EXPT 24	4/22/77
EXPT 25	4/15/77
SETS	4/24/76
TET	5/10/76
PET	1/08/77

TABLE V. - CTS DEMONSTRATIONS - U.S.

No	Date	Event	Expt. (a)	Location
1	5/6/76	IEEE Joint Meeting - Balt and Lima	15	Balt. Md, Lima, Oh.
2	5/10, 12, 14 17, 19, 21	Kalamazoo Bicentennial	LeRC and TET	Kalamazoo, Mi
3	5/20	CTS Inauguration and christening	CRC/LeRC	Ottawa, Cleve.
4	6/14	Inter. Comm. Conf., 1976	18/CRC	Phila. Pa
5	6/16	Conference on open learning	21, 18	Lincoln, Neb.
6	6/23	Paramp Review	15, L18	Balt. Md, Cleve. Oh
7	7/4	The Glorious Fourth	6, LeRC, NBC	Yellowstone Park, Wy.
8	7/10	Scottish Games	19, (6)	Columbia, SC
9	8/3, 5, 7, 10 12, 13, 14	Public Communication	Lewis/TET	Chicago Sci. Museum, Chi., Ill.
10	8/25	Public Communication	L18	Barrow, Ak.
11	10/29	Grade School	Lewis/TET	Pecatonica, Ill.
12	11/1, 3, 5, 8, 10, 12	Public Communication	Lewis/TET	Rockford, Ill.
13	11/17	U.S. User Mtg. 16	L18/15	Cleve. Oh, Balt. Md.
14	12/7/76	N.Y.C. Board of Education	G18	New York City
15	1/25/77	Moot Court	15	U. of Md., Ohio North
16	1/27/77	NASA Conference	G18	Mt. View, Greenbelt
17	1/29/77	Legal Continuing Education Seminar	A18	Hastings Coll., Ca.
18	2/8/77	U.S. User Mtg. 17	L18, A18, 4	Cleve., Mt. View, Ott.
19	3/1/77	Mayors Conference	21/PET	Wash., D.C., San Jose
20	3/3-10/77	Crisis Management	L18/PET	Syracuse, U., Canada
21	3/12/77	Symposium	A18	Mt. View, Ca. Greenbelt, Md.

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TABLE V. - Continued. CTS DEMONSTRATIONS - U.S.

No	Date	Event	Dr	Expt. (a)	Location
22	3/15,17/77	EEO Spacemobile		L18/TET	Cleve., Chicago
23	3/24/77	Viking Presentation		L18/CRC	Cleve., Ottawa
24	3/31/77	Rural Health Conference		13/PET	Seattle, Wa, Bethesda Md.
25	4/13/77	Exceptional Children Conv.		21/PET	Atlanta, SE
26	4/19-21/77	Annual SECA Conference		19/TET	Gulf Shores, Ala.
27	5/23/77	Health Science Conference		21/TET	Indiana U., HEW, Balt.
28	5/25/77	U.S. User Mtg. 18		L18/G18	Cleve, Greenbelt
29	6/1/77	Special Education Conf.	34	21/TET	U. Kentucky
30	6/9,10/77	International Symposium	46	4	Mt. View Ca., /Montreal
31	6/10,15/77	Employment Conference	42	G18,1,II	Hot Sp., Albany
32	6/17/77	PSSC Workshop	36	21/II	Vail, Co.
33	7/7-19/77	Medical Workshop	39	21/PET/TET	U. Alabama
34	7/21/77	NOAA Conference	44	21	Md., Co, Seattle
35	7/25,26/77	Disaster Relief - Johnstown		6	Johnstown, Pa.
36	7/31-8/9-77	Boy Scout Jamboree	49	20	Moraine Pk, Pa
37	8/4/77	Co-op Conference	19	18	Greenbelt, Mt. View
38	8/23/77	Governors Conference	5	13/PET	Id/MT/WA/AK
39	8/23-9/6/77	Medical Clinics	6-11	13/PET	Idaho, Mont., Seattle
40	8/30/77	Am. Hospital Convention	32	21/TET	Atlanta, Ga.
41	9/11/77	SEND/RECEIVE Sat. Demo.	56	21/A18	NYC, ARC
42	9/27/77	U.S. User Mtg. 19		L18/13	Cleve., Seattle
43	9/27/77	Rehabilitation Conference	47	21/TET	WI, VA, SECA
44	10/9/77	Intelcom 77 - Medical Seminar	55	7/PET	Atlanta, Ga.
45	10/10/77	Intelcom 77 - Plenary Session	50	G18/PET	Atlanta, Ga.
46	10/10/77	Intelcom 77 - Educ. Session	51	G18/PET	Atlanta, Ga.
47	10/11/77	Intelcom 77 - Canad. Transm.	64	PROJ/PET	Atlanta, Ga.
48	10/14/77	American Dietetic Assoc.	61	21	Bethesda, Md.

(a) A18 - Ames 18
G18 - Goodard 18
L18 - Lewis 18

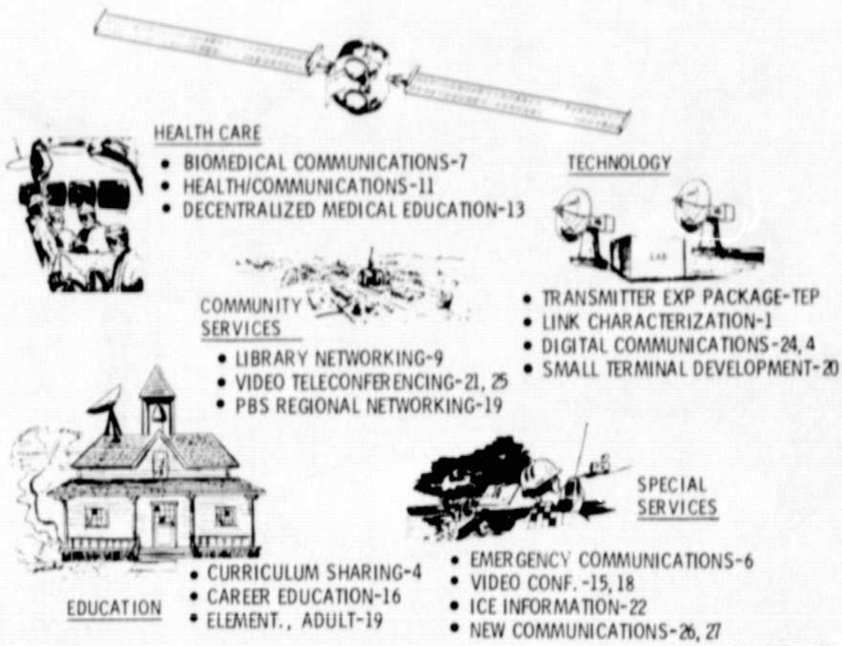

Figure 1. - Categories - U. S. CTS experiments.

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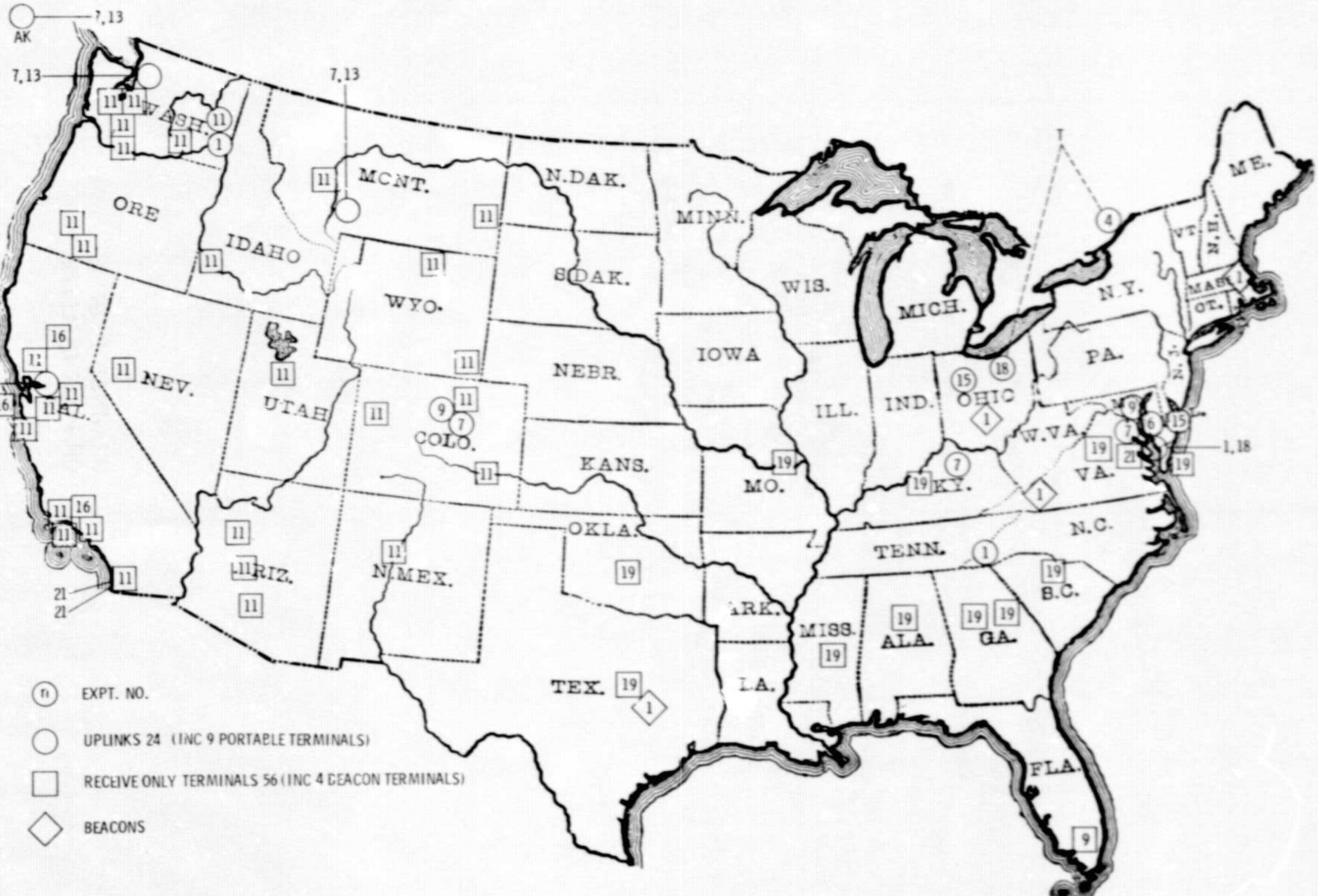


Figure 2. - CTS - U.S. expts. - Earth terminal locations.

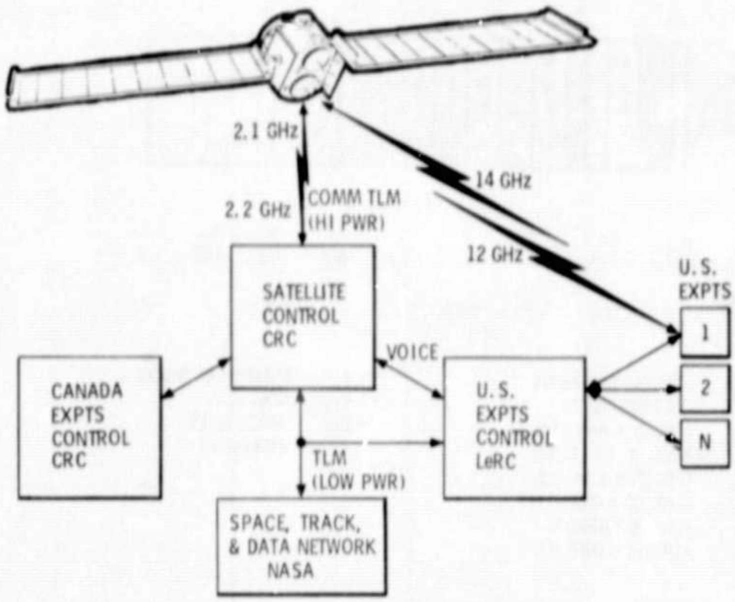


Figure 3. - CTS and experiments control concept.

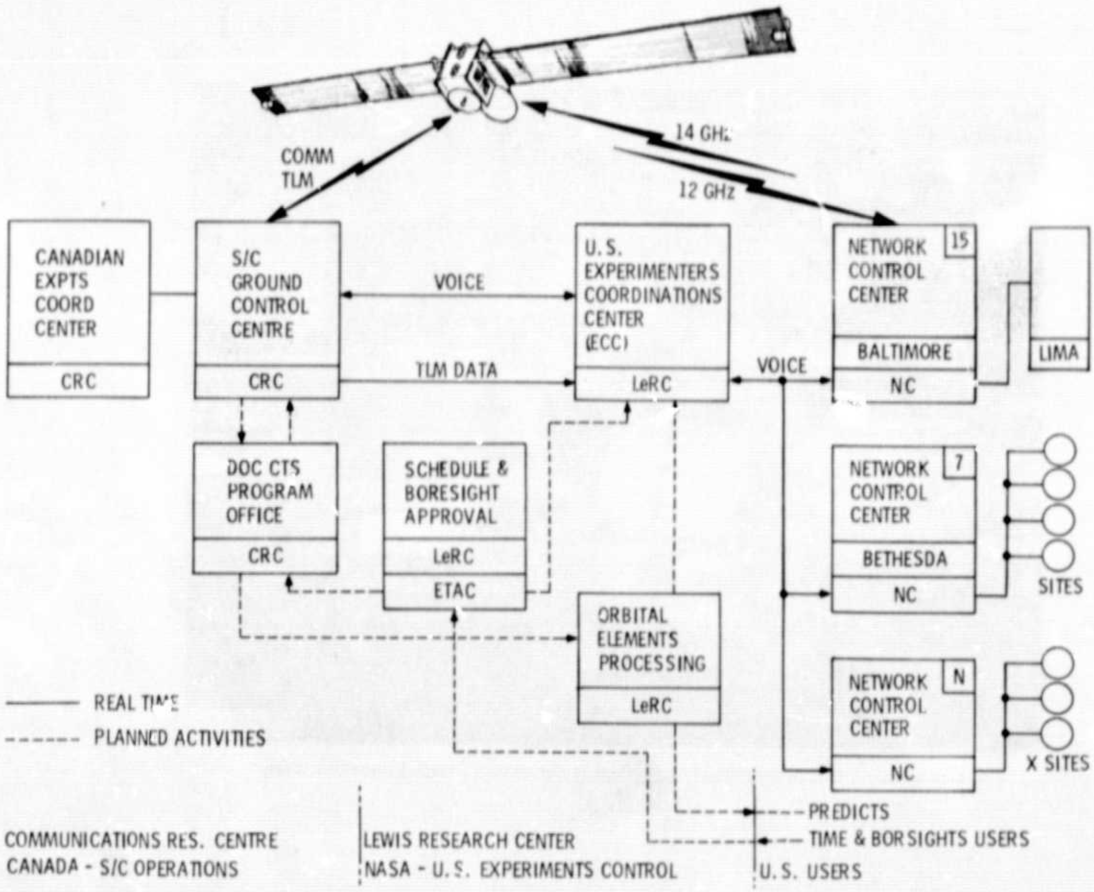
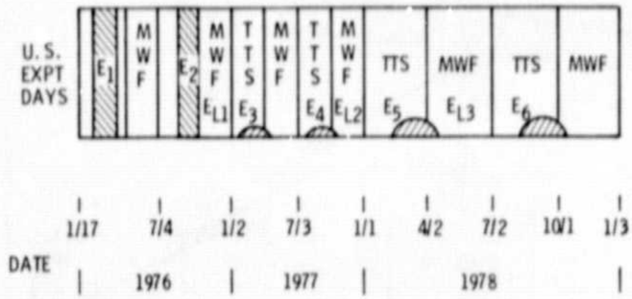


Figure 4. - U.S. experiments control.



E_N ECLIPSE BY EARTH
C AT 0750 GMT
E_1 FEB. 26 - APR. 14
E_2 AUG. 30 - OCT. 16
E_3 FEB. 27 - APR. 13
E_4 AUG. 30 - OCT. 14
E_5 FEB. 26 - APR. 8
E_6 AUG. 31 - OCT. 16

E_L ECLIPSE BY MOON
E_{L1} NOV. 21
E_{L2} OCT. 12, 13
E_{L3} APR. 8

Figure 5. - CTS mission summary.

Figure 6. - CTS experimenters coordination center at NASA Lewis Research Center.