

# NASA News

National Aeronautics and  
Space Administration

Washington, D.C. 20546  
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For Release Sunday,  
January 11, 1976

## Press Kit

Project Communications  
Technology Satellite

RELEASE NO: 75-316



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Sunday,  
January 11, 1976

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RELEASE NO: 75-316

## MOST POWERFUL COMMUNICATIONS SATELLITE TO BE LAUNCHED

The world's most powerful communications satellite will be launched from Cape Canaveral, Fla., about Jan. 13. The event culminates a five-year effort of international cooperation between NASA and Canada's Department of Communications.

The Communications Technology Satellite (CTS) will be used in an experimental program to pioneer new methods of providing communication services.

-more-

Such satellite systems provide the capacity for satisfying many human needs throughout the world, and their continued development can result in substantial benefits to mankind.

The CTS will extend present ability to meet those needs by incorporating new technology that will make possible television reception and two-way voice communication with the use of small, user-operated ground terminals.

The CTS is the second satellite designed to transmit high-quality color television to small, simple ground stations. The other is the Applications Technology Satellite-6 (ATS-6), launched in May 1974 and now being used by the government of India to relay educational programs to thousands of isolated villages before resuming broadcasts to the United States. ATS-6 achieves its high power by use of a 9-meter (30-foot) reflector antenna; CTS, by means of a very high-power (200 watts) transmitter. ATS-6's effective radiated power is 53 DBW (decibel watt); CTS's, 59 DBW.

When launched into a synchronous orbit CTS will be stationed over the equator at an altitude of about 36,000 kilometers (22,300 miles) at 116 degrees west longitude, just west of South America.

This position will permit a wide variety of unique experiments to be performed, both in the United States and Canada, that will demonstrate and encourage new satellite applications.

The United States and Canada will share equally in experiment time during the satellite's expected two-year life.

The CTS will operate in a new frequency band allocated for broadcast satellites. The transmitting power levels are 10 to 20 times higher than those of today's commercial communications satellites. High satellite power will allow experimenters to conduct a multitude of communication service demonstrations with a modest investment in ground receiving equipment. This communications capability is particularly attractive in remote areas of the United States and Canada where terrestrial communications are not highly developed. Such techniques also have considerable potential for most developing countries.

The satellite will probe the impact -- social, cultural and economic -- of its own new technology and attempt to show planners of future systems new ways of using modern communications tools.

Communications experiments, to be carried out by a variety of groups in both United States and Canada, include tele-education, tele-medicine, community interaction, data communications and broadcasting.

The combined United States and Canadian technology and communications experiment activities are planned and coordinated through a Canadian Department of Communications (DOC)-NASA Joint Working Group.

In Canada, DOC will provide ground terminals to experimenters. In the United States, each experimenter is responsible for providing the necessary ground terminals. An overall communication experiments schedule reflecting 50-50 time sharing between NASA and DOC on an alternate day basis has been jointly developed by the two agencies. For the Canadian experiments, DOC will maintain, and in some cases operate, the remote terminals for the experimenters. In the United States, except during preliminary checkout of the satellite's 200-watt traveling wave tube transmitter, experimenters will operate and maintain their ground terminal equipment.

The CTS program began April 20, 1971, when NASA and DOC signed a memorandum of understanding in which they agreed to undertake, on a joint basis, the development and launching of an experimental satellite to extend communications technology to much higher power levels of transmission than had been previously used. This would permit the use of small, low-cost ground terminals that would make communications services practical in areas not now served.

Under this agreement, DOC designed and built the spacecraft at the Communications Research Centre near Ottawa. NASA provided the spacecraft's high efficiency 200-watt traveling wave tube for the transmitter, together with its power supply. These units were built to the Lewis Research Center's specifications for operation in the 12 GHz frequency band. Environmental test facilities used for testing the spacecraft are located at Lewis Center, Cleveland, Ohio, and at the Goddard Space Flight Center, Greenbelt, Md. A NASA furnished Delta model 2914 launch vehicle will place the satellite in geostationary orbit.

The European Space Agency (ESA) is also participating by providing DOC a 1-kilowatt solar array, a 20-watt traveling wave tube and parametric amplifiers.

The objective of the CTS program is to advance the technology of both spacecraft-mounted and related ground-based components and systems applicable to high-radiated-radiofrequency-power satellites. To achieve this objective, the spacecraft will demonstrate new technology applications and conduct experiments on components and systems that will be applicable to future commercial communications satellites. The program will also include communications experiments with user agencies, universities and industrial groups in the United States and Canada.

In remote areas of the United States and Canada, the population density is not sufficient to support investment in the large ground receiving stations required for today's commercial communications satellites. CTS transmits at a high power level (200 watts) and thus permits the reception of color television with a simple, low-cost ground receiver.

Community services such as education, health care, news, cultural events and business information can be provided to segments of the population that cannot be reached by either terrestrial or existing satellite communications systems. Health care agencies can also be linked via CTS. Educational institutions can participate in teacher training and shared curricula. Intracompany business communication in widely separated locations and data transmission will also be demonstrated.

The policy of both NASA and DOC encourages wide participation from a variety of organizations such as state and local governments, universities, industry and the scientific community. As a result, many sociological and technical experiments will be performed that are expected ultimately to create markets for commercial services and space technology both in the United States and abroad.

In the launch configuration the overall height of the spacecraft is 188 centimeters (74 inches) and the outside diameter 183 cm (72 in.) The weight at launch is 675 kilograms (1,485 pounds). Two curved side panels carry most of the body-mounted solar cells that provide spacecraft power until the main solar arrays are deployed. The forward platform carries the super-high-frequency antennas and Earth sensors. Since these must be very accurately aligned, considerable care has been taken to isolate the platform thermally from the rest of the spacecraft.

An extendable solar array is mounted in the stowed configuration on two flat side panels. Jettisonable stowage containers are provided for the solar blankets. The release mechanism will be actuated on command.



Each array will be extended in a concertina-like fashion by means of a single extendable boom. When the solar array is extended, the total span of the satellite is 15.8 m (52 ft., 9 in.).

Why a more powerful satellite?

A number of restrictions inhibit development of present satellite communications systems to meet the needs of tomorrow. They operate in a 4 to 6 GHz frequency band shared with other types of systems on the ground. Limitations on satellite power levels are required to prevent interference. This has been a major factor in dictating the use of large and expensive ground antennas.

Better ways to expand television, voice and data transmission to even the most remote locations are needed, and there is keen interest in systems that permit transmission of live color television programs to all areas not served by terrestrial microwave links. A possible solution lies in the use of new, more powerful satellites operating at much higher frequencies, with smaller, less expensive, even portable ground stations.

But how does one build a more powerful satellite and still stay within the weight limitations imposed by the capabilities of available launch vehicles? That challenge led to development of a concept for a radically different kind of satellite. The design of the CTS centers around three major advanced technology subsystems:

- A pair of lightweight, extendable arrays carrying enough solar cells to provide an initial power output greater than 1 kilowatt.
- A traveling-wave-tube (TWT) amplifier of novel design, having an efficiency of 50 per cent, at a power output of 200 watts.
- A three-axis stabilization system, employing a fixed momentum wheel and hydrazine gas thrusters, to maintain antenna boresight pointing accuracy to within plus or minus .2 degrees in pitch and roll and plus or minus 1 degree in yaw.

Conventional communications satellites are stabilized by spinning. Because solar power cells are mounted on their outer circumferences, roughly two-thirds of the cells are in darkness at any one instant. CTS could not afford the luxury of a one-third-efficiency power source.

To provide the necessary power, a pair of arrays, each roughly three times as long as the diameter of the spacecraft body, are provided. They will be packed inside the satellite, accordin-style, until it is on station. A sensor mounted on each extended sail will control a drive mechanism to enable the sail to track the Sun.

The primary function of the CTS three-axis stabilization system, the first in a communications satellite with flexible arrays, is to keep the satellite antennas pointing accurately toward the center of selected target areas (about a time zone wide) on the surface of Earth, while the solar sails always face the Sun.

The CTS mission is divided into the following phases: launch, transfer orbit, apogee injection (motor firing), spacecraft drift to station, three-axis attitude acquisition and in-orbit operation. The first four phases are the responsibility of NASA, while the Canadian Communications Research Centre (CRC) is responsible for the three-axis attitude acquisition and in-orbit operation.

The launch phase terminates with injection of the spacecraft, spinning at 60 rpm, into an elliptical transfer orbit.

Injection into synchronous orbit could occur as early as the second apogee and as late as the tenth. The transfer orbit is circularized and the spacecraft put in the required position by the firing of the apogee motor.

During the first four phases of the mission, a central spacecraft control center at the Goddard Space Flight Center will be staffed by CRC and NASA personnel. They will continuously monitor the spacecraft status and provide orbital and attitude determination results. With the spacecraft at the target longitude and with the spin axis normal to the orbital plane, mission control will be transferred to the CRC ground station at Ottawa, where despin and attitude acquisition maneuvers will be accomplished by CRC. Goddard will continue to act as ground station backup through three-axis stabilization.

For the remainder of the mission the spacecraft is controlled in a three-axis mode with the antennas pointing toward Earth.

The Office of Applications, NASA Headquarters, has responsibility for the United States portion of the CTS program and has assigned project management to the Lewis Research Center.

The Office of Tracking and Data Acquisition has responsibility for providing tracking and data acquisition support. The Office of Space Flight will provide the launch vehicle.

The Delta launch vehicle project is managed by the Goddard Space Flight Center. Launch site operations are managed by the Unmanned Launch Operations Directorate at the Kennedy Space Center.

The Canadian Department of Communications, which has overall responsibility for the Canadian portion of the CTS Program, has assigned program responsibility to the Communications Research Centre.

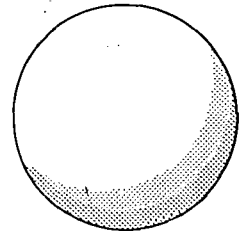
The program cost to NASA is about \$11.4 million plus about \$10.8 million for the launch vehicle.

(END OF GENERAL RELEASE. BACKGROUND INFORMATION FOLLOWS.)

## HISTORICAL SUMMARY OF COMMUNICATIONS SATELLITE DEVELOPMENT

### 1960 Echo

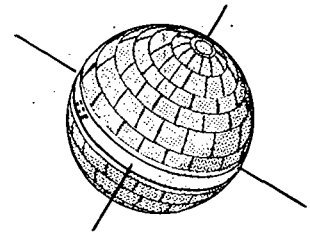
Echo, launched by NASA, Aug. 12, 1960, was inflated in space to form a 30-meter (100-foot) diameter sphere which reflected radio waves back to Earth receiving stations.



ECHO

### 1960 Courier

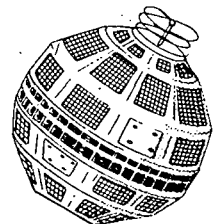
Courier, the first "repeater" satellite, launched by the Army Oct. 4, 1960, recorded signals sent from Earth stations and then played them back on command.



COURIER

### 1962 Telstar

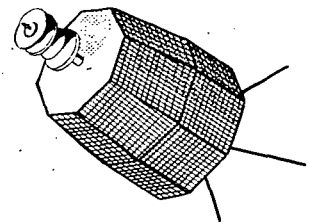
Telstar was the first non-government satellite. Launch by NASA for AT&T July 10, 1962, it transmitted the first live television broadcast from Europe to the United States.



TELSTAR

### 1962 Relay

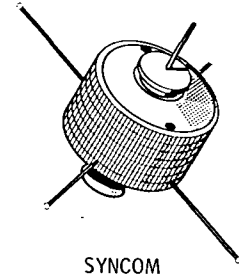
Relay, launched Dec. 13, 1962, was the NASA prototype for a working communications satellite. It successfully transmitted TV, telephone, facsimile and digital data.



RELAY

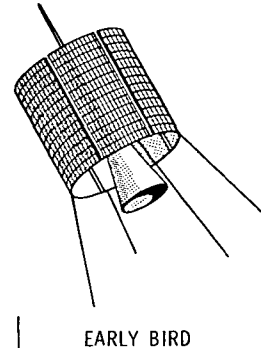
### 1963 Syncom

Syncom, launched July 26, 1963, was a major contribution to communications satellite technology as it demonstrated advantages of synchronous orbit spacecraft.



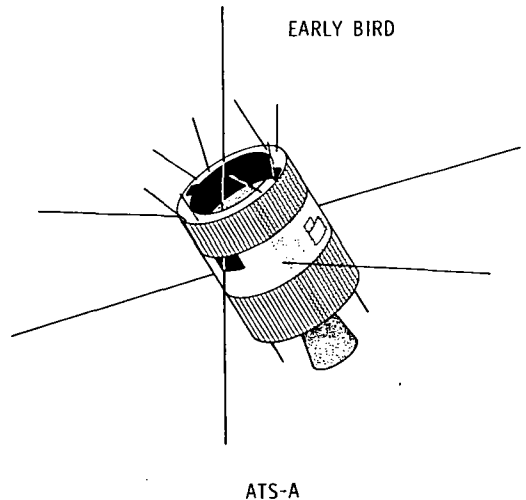
### 1965 Early Bird

Early Bird, the first international commercial communications satellite was launched April 6, 1965. It provided 240 telephone voice circuits and TV service.



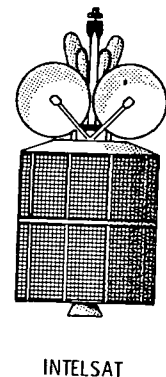
### 1966 ATS-1

ATS-1, launched Dec. 7, 1966, was the first of NASA's Applications Technology Satellites. Since then, four more of this series of satellites have been built to prove space communications techniques.



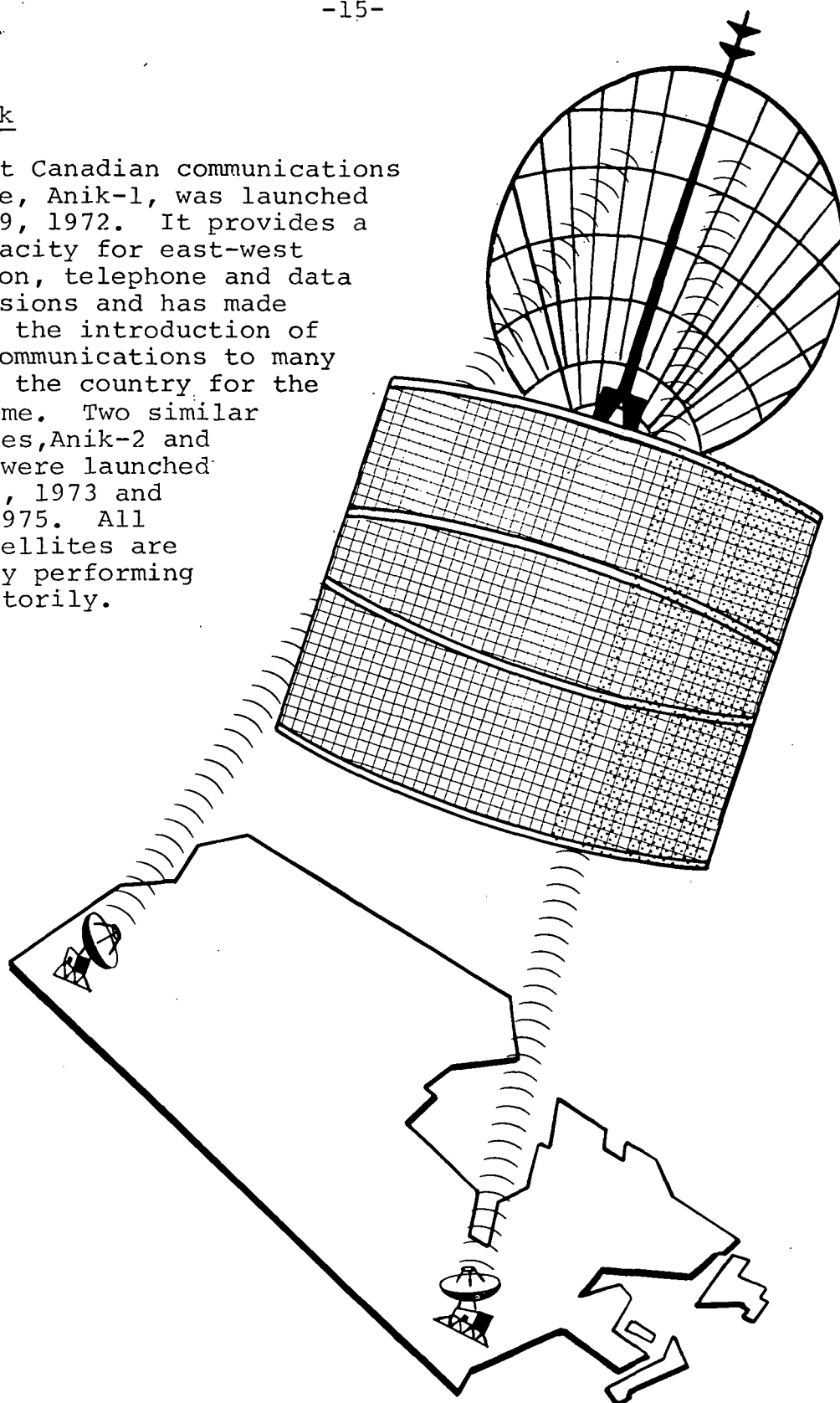
### 1968 Intelsat

Intelsat was the first truly global communications satellite system. First of the series of Intelsat satellites providing international service was launched Dec. 19, 1968.



### 1972 Anik

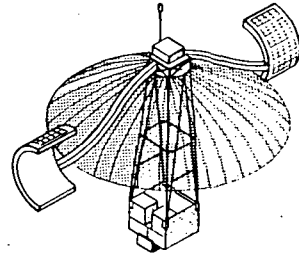
The first Canadian communications satellite, Anik-1, was launched on Nov. 9, 1972. It provides a high capacity for east-west television, telephone and data transmissions and has made possible the introduction of modern communications to many areas of the country for the first time. Two similar satellites, Anik-2 and Anik-3, were launched April 20, 1973 and May 7, 1975. All Anik satellites are currently performing satisfactorily.





### 1974 ATS-6

ATS-6 launched May 30, 1974, pioneered educational TV transmission by satellite. After a year of operation in this country the satellite was moved to provide India with educational programs to 5,000 villages. NASA plans to return the satellite to provide continuing experiments to the United States in the fall of 1976.



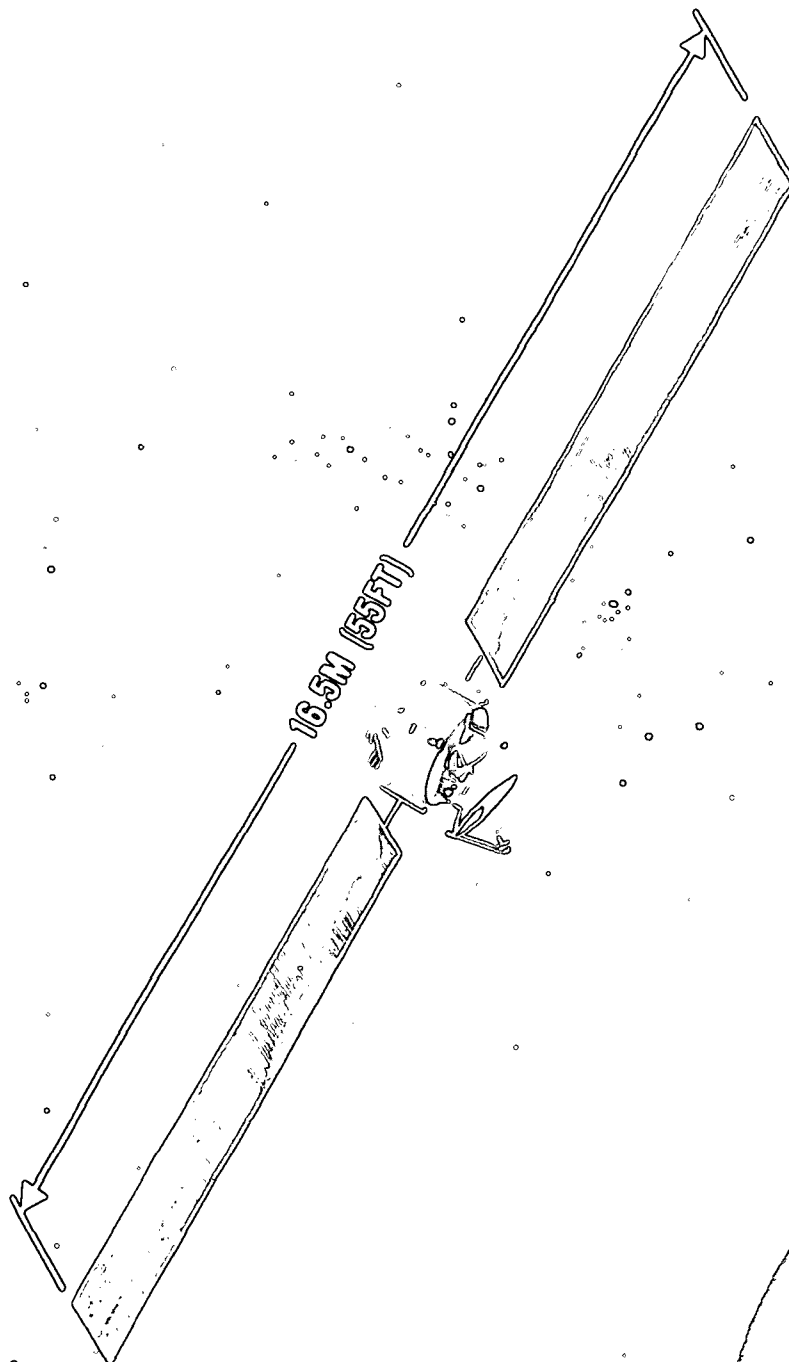
ATS-F

### 1976 CTS

Scheduled for launch on Jan. 13, 1976, the CTS will be the latest experimental satellite. The picture is an artist's concept of how it will appear when on station. The photograph is the actual spacecraft on test in the anechoic chamber at Communications Research Centre (Canada).

# COMMUNICATIONS TECHNOLOGY SATELLITE (CTS)

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### CTS PROGRAM OBJECTIVES

The overall objective of the CTS program is to advance the technology of both spacecraft-mounted and related ground-based components and systems applicable to high-radiated-RF-power satellites. In order to achieve this objective, the spacecraft will demonstrate new technology applications and conduct experiments on components and systems that will be applicable to future commercial communications satellites. The program will also include communications experiments with user agencies, universities and industrial groups in the United States and Canada.

Specific technology objectives include demonstrations of:

- a 12-GHz traveling-wave-tube (TWT) with about 50 per cent efficiency and with a nominal RF output power 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  $\pm 0.2$  degrees in pitch and roll and  $\pm 1$  degree 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 television and voice communication, wideband data transmission and data relay.

## UNITED STATES EXPERIMENTS

In order to explore the future uses of high-powered communications satellites, United States users have planned a variety of experiments. These include experiments in technology, health care, community services, education and special services. The ground station locations range from the Atlantic to the Pacific seaboard. Government, education and industry are represented.

### Education Experiments

Experiments are currently planned to investigate and determine the feasibility of a range of educational requirements from counseling to curriculum sharing. They include:

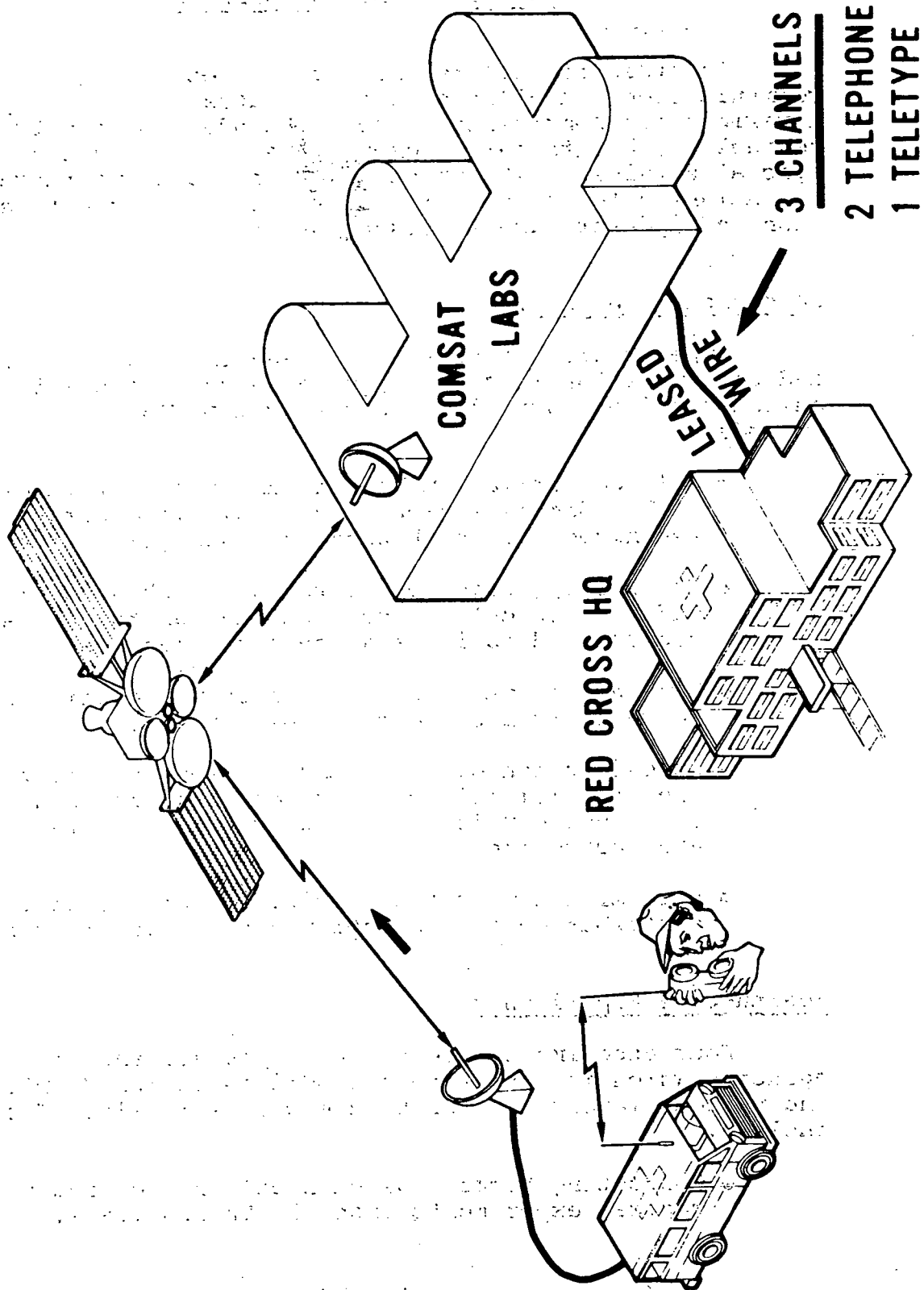
- College curriculum sharing among universities with a demonstration of digital video compression techniques for both bandwidth and power reduction.
- Teacher upgrading by improving teaching skills and development of instructional units and making graduate education available to teachers.
- Exchange of materials and teaching techniques 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.
- Determination of the feasibility of satellite distribution for education and public broadcasting.

### Health-Care Experiments

Four experiments are planned by state and federal agencies which involve Veterans Administration Hospitals and various levels of health-care professionals. These include:

- Conducting biomedical clinical and continuing medical experiments among 27 VA hospitals.

TRANSPORTABLE EARTH TERMINAL



- Health education programs using live and video-taped techniques for use by hospitals and health-care facilities.
- 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

Industry, the academic community and NASA have planned four experiments which are as diverse as the organizations themselves and are structured to demonstrate or investigate the following:

- Feasibility of a satellite library information network to improve individual and organizational capabilities for assessing and disseminating information.
- Whether a large and geographically dispersed industrial organization can substitute video and audio communication for travel.
- Demonstration of the suitability of transportable Earth terminals to relay communications to and from a disaster area.
- Demonstration of interactive techniques for intra-NASA applications.
- Evaluation of low-cost receivers under field conditions.

#### Technology Experiments

Experiments are planned to investigate characterization of high-frequency communication links and transportable Earth terminals as extensions of existing technology. One of these is:

- 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.

UNITED STATES EXPERIMENTERS

Experiment

Organization and Principal Investigator

Communication Link  
Characterization

Goddard Space Flight Center  
L. J. Ippolito

College Curriculum Sharing

Ames Research Center;  
Carleton University, Ottawa,  
Canada; Stanford University,  
Stanford, Calif.  
D. R. Lumb, Ames

Transportable Earth Terminal

Communications Satellite  
Corp.  
J. Kaiser

Biomedical Communications

Lister Hill National Center  
for Biomedical Communications  
E. Henderson

Satellite Library Information  
Network (SALINET)

University of Denver  
M. K. Goggin

Health Communications

Veterans Administration  
R. B. Shamaskin

Communication Support for  
Decentralized Education

University of Washington  
WAMI Program  
M. R. Schwarz

Communications in Lieu of  
Transportation

Westinghouse Electric Corp.  
J. H. Nunnally

Project Interchange

Archdiocese of San Francisco  
G. Gibbs

Health Education Television

Association of Western  
Hospitals  
R. G. Allen

Interactive Techniques for  
Intra-NASA Applications

Goddard Space Flight Center  
J. S. Chitwood

Satellite Distribution  
Experiment

Southern Education  
Communication Association  
F. L. Morris

12 GHz Low-Cost Receivers

Goddard Space Flight Center  
Nippon Hoso Kyokai, Japan  
J. E. Miller, Goddard

## CANADIAN EXPERIMENTS

The following information was provided by Canada's Department of Communications:

The Canadian experiments encompass such varied fields as broadcasting (CTS is seen as a major forerunner of the direct broadcasting satellite), tele-medicine, tele-education, data communications, community interaction, government administration and operations, radio wave propagation and basic evaluation of small satellite Earth terminals.

The experiments are:

### Propagation Measurements

The Communications Research Centre of the Department of Communications and Bell-Northern Research are studying the effects of precipitation in weakening and affecting the polarization of radio signals transmitted to and from CTS. Such effects are much more marked at the higher frequencies used by this advanced satellite, and are an important factor in the design of Earth-space communications links.

Experiment Leaders: Dr. John Strickland  
Communications Research Centre,  
Ottawa  
Dr. Y. F. Lum  
Bell-Northern Research, Ottawa

### Time Division Multiple Access Synchronization Experiment

This experiment aims at investigating the feasibility of a novel TDMA synchronization scheme: measuring timing accuracies and guard times required for data bursts and the source and magnitude of natural phenomena that could disturb the system. It's hoped to obtain insights into practical problems encountered in transmitting high-speed data via satellite in the TDMA mode.

Experiment Leader: P. P. Nuspl  
Communications Research Centre,  
Ottawa



### FDMA Demand Assignment Experiment -- Two-Way Voice

Future domestic multipurpose satellite systems could benefit from this look at a new system for sharing telephony channels for services to remote locations by means of frequency division multiple access techniques.

Experiment Leader: R. J. Campbell  
Communications Research Center,  
Ottawa

### High-Rate Data Experiment

Subjective evaluations of digital TV transmission via a high-rate data link are an important part of this effort to test the performance of a newly-developed modem (modulator-demodulator) for such purposes.

Experiment Leader: P. P. Nuspl  
Communications Research Centre,  
Ottawa, Ontario

### Small Terminal Evaluation Experiment

The objective here is simply to evaluate the performance and operation of the small CTS ground stations in the user environment, contributing to a data base for the planning and design of future systems. Other CTS experimenters will cooperate in this effort to critically assess maintenance, installation and operation; transportability; survivability in the Canadian environment; radio interference and the feasibility of TV reception with a 30-inch dish antenna.

Experiment Leader: R. K. Tiedemann  
Communications Research Centre,  
Ottawa

### Technical Measurements and Demonstrations: Broadcast Signal Reception in a Metropolitan Environment

The Canadian Broadcasting Corp. (CBC) will evaluate reception of high-powered 12 GHz satellite TV signals, using a two-metre antenna and professional receiver in a metropolitan environment. Another aspect of the test will utilize a one-metre terminal to demonstrate direct-to-home satellite TV with simple, home appliance type equipment from laboratories in Japan and, perhaps, Europe.

As tests continue over the course of two four-week periods in the summer of 1976, it is expected important data on day-to-day variations in picture and sound quality and overall service reliability will be gathered. Results could have considerable impact on planning of TV distribution systems for the 1980s.

Experiment Leader: C. A. Siocos  
CBC Montreal

#### Radio Broadcasting Applications

Objectives are to demonstrate the technical feasibility of CTS for radio broadcasting, its relevance for the extension of radio services to and from and between small communities, and its possibilities for providing special interest programming direct to individual broadcasting stations.

Experiment Leader: Jim Landsberg  
CBC Ottawa

#### TV Special Demonstration

By transmitting coverage of the 1976 Olympics equestrian competitions from Bromont, Quebec, to Montreal during the period July 17 - Aug. 1, it's hoped to determine the suitability of a CTS type spacecraft for remote broadcast and control and assess transmission/reception from large, populated areas, while evaluating the flexibility and handling efficiency of portable ground stations under operational pressures.

Experiment Leader: Jim Landsberg  
CBC Ottawa

#### Staff Training by Satellite

Those unique characteristics of satellite technology which might enable use of cost-effective, high-speed learning environments for training federal employees in their home offices will be studied. Improved professional development methods will be sought through exploration of new directions for educational TV via satellite.

Experiment Leader: Dr. Mike Ryan  
Public Service Commission of  
Canada, Ottawa

### Telemedicine Experiments With CTS

The satellite will be used to provide continuing medical education to doctors and allied health professionals practicing in remote areas, by one-way video with two-way audio. Community health education programs and transmission of such medical data as electro-cardiograms and X-rays from remote areas will also be assessed.

Experiment Leaders: Dr. Max House  
W. C. McNamara  
Memorial University of Newfoundland

### Omnibus Network

To insure widest possible access to higher education in the province, the University of Quebec is decentralized -- operating out of regional centres, with a telephone network utilized for teaching, management and document exchange. The experiment will test the ability of CTS to improve this process, simulating educational satellite applications considered likely to be operational in the 1980s.

Experiment Leader: Pierre Dumas  
University of Quebec

### Radio Telephony With Remote Camps

One-metre terminals will be used to establish high-quality telephone links to and from remote sites in the James Bay area. The transportability of the terminal and any change in productivity due to better communications between the head office of the James Bay Development Corp. and survey parties will be assessed.

Experiment Leader: Michel Couillard  
James Bay Development Corp.

### Telephony Data Transmission and Synchronization Studies

The flexibility and reliability of the CTS system to aid in the precise control of remote power stations in Northern Quebec will be determined.

At present, HF radio links connect such generator sites with a regional dispatching centre in Quebec City. During the experiment period, clock synchronization as well as voice, facsimile and slow rate data by satellite will be assessed.

Experiment Leader: Pierre Girard  
Hydro Quebec Research Institute

#### Multi-Ministry Administrative and Operational Experiment

What are the capabilities of a satellite like CTS in meeting the needs of various ministries of a provincial government for communications links to and from areas? The spacecraft will be used by the Government of Ontario to transmit a variety of forms of information of an operational or administrative nature -- point-to-point and in "broadcast" mode, with several locations in Northwestern Ontario involved. The experiment aims at assessing the impact of a fully-developed, operational system such as that offered by CTS might have in improving delivery of government services in thinly populated regions.

Experiment Leader: D. I. Towers  
Government of Ontario

#### Government Teleprocessing Network

The Manitoba Government Computer Centre will investigate methods of interfacing CTS ground terminals in various locations with computer systems. The practical considerations involved in using satellite links in a teleprocessing network -- response times, error rates, interface requirements and costs, for example -- will be closely studied. High-speed digital transmissions between a three-metre terminal in Winnipeg and the nine-metre CTS master communications station in Ottawa will be investigated, as the Manitoba government participates in the time division multiple access experiments of the Communications Research Centre in the national capital.

Experiment Leader: R. O'Kane  
Manitoba Government Centre,  
Winnipeg, Manitoba

### CTS Digital Video University Curriculum Sharing Experiment

This bi-national experiment involves the development, demonstration and evaluation of curriculum-sharing via an all-digital satellite communications system. Carleton University in Ottawa and Stanford University in California will exchange courses, chosen from the respective lists, by means of a digital video compression technique developed by NASA's Ames Research Center. Human and administrative factors involved in such sharing will be closely studied.

Experiment Leaders: Dr. D. A. George  
Carleton University, Ottawa  
Dr. D. Lumb  
NASA Ames Research Center

### Satellite Link Radio Interferometry

Scientists are keenly interested in the location, distribution and structure of a number of intense sources of electromagnetic radiation deep in space. The purpose of this experiment is to permit the real time (live) comparison or correlation of signals from such sources as received by different radio telescopes hundreds of miles apart. Much information can be determined or inferred from such comparisons, helping to unravel mysteries surrounding extragalactic radio sources.

Experiment Leader: Y. L. Yen  
University of Toronto

### Performance Evaluation of a Digital Modem for High-Rate Data Transmission

This experiment will evaluate performance of a fast frequency-shift keying (FFSK) modem for the transmission of digital data at a high rate of speed. Interference and non-linearity effects will be closely studied. One element of the experiment is to test the suitability of the modem, designed by the Communications Research Laboratory of McMaster University, for transmission of digitized colour TV via the Communications Technology Satellite.

Experiment Leader: Dr. Simon Haykin  
McMaster University, Hamilton,  
Ontario

Exploration of A Satellite Computer Network to Supply  
Computerized Information to Native Peoples in Northern  
Canada

Satellites may have considerable potential for providing computer facilities to native peoples in Canada's isolated, far Northern regions. The experiment will provide technical data for the evaluation of that potential and assist in establishment of native centres making use of computer/communications networks. An information resource centre in the Northwest Territories will be linked via the spacecraft to a time-share computer in London, Ontario.

Experiment Leader: J. F. Hart  
University of Western Ontario,  
London, Ontario

Telemedicine Experiment Between A Remote Village and An  
Urban Health Science Centre

The satellite and variously sized and located ground terminals will be used to enable northern nurses to practice a level of medicine previously impossible or inappropriate. The experiment entails transmission and reception of audio-visual information for the purpose of practicing telemedicine to assist in clinical examinations, decision-making, supervision of a resident at a base hospital and consultation on, for example, ultrasonic images and radiographs.

Experiment Leader: Dr. Lewis Carey  
University of Western Ontario,  
London, Ontario

Studies and Evaluations of Signal Processing Techniques  
for Data Communication Via Satellite

Both coded and uncoded signals will be transmitted and received using a Codex 9600 data modem at rates in multiples of 2,400 Hz, up to 9,600 Hz. Signal coding and processing techniques will be studied with a view to their effectiveness in data communications over a satellite channel.

Experiment Leader: J. W. Mark  
University of Waterloo,  
Waterloo, Ontario

Upgrading Mathematical Competence of Elementary School  
Teachers in Remote Areas

Interactive programs on math and math education will be broadcast from a central location to a number of communities in Northwestern Ontario. Purpose of the experiment is to evaluate the feasibility of upgrading elementary school teachers by means of satellite communications. Each hour of programming will consist of an introductory 20-minute recorded lesson; 10-minute two-way audio exchange; another 20-minute recorded lesson and a final live discussion.

Experiment Leader: Dr. Gerry Vervoort  
Lakehead University,  
Thunder Bay, Ontario

Saskatchewan Education-Culture Exchange

Purpose of the experiment is to link two Francophone communities in different parts of Canada -- Zenon Park, in Northern Saskatchewan, and a community in Quebec -- for the interchange of cultural and educational programmes via two-way audio and two-way video links. Although far apart geographically, the two communities have much in common and will benefit from dialogue and better mutual understanding -- steps towards increased awareness of Canadian identity and national unity.

Experiment Leaders: Dr. B. Wilhelm  
University of Regina,  
Regina, Saskatchewan  
W. Cote  
Quebec Ministry of Education,  
Quebec City, P. Q.

Transportable Telecommunications System

Two of Canada's major telecommunications common carriers -- Telesat Canada (which operates our three domestic, geostationary communications satellites, ANIKs 1, 2 and 3) and Bell Canada will accumulate specific data on the use of an advanced technology satellite like CTS in such basic areas as transmission capabilities, ground station portability, reliability and maintainability.

The data will be useful in planning the evolution of our future domestic satellite communications system. Technical and user-oriented tests should provide good indications of overall system capability.

Experiment Leaders: R. M. Lester  
Telesat Canada, Ottawa  
H. P. Chamberlain  
Bell Canada

#### Health Care Delivery to Remote Areas

It's hoped this experiment will help determine optimum uses of two-way television in providing for operation and management of primary health care delivery in remote rural areas. Results will help develop a model for a national interactive urban-rural medical centre matrix. Specifically, the project will explore the extent to which the effective scope and effectiveness of a basic health team can be increased through audio-visual and data communications links to specialists in urban facilities.

Experiment Leader: Dr. Hugh MacGuire  
Rural Health Society, Victoria,  
British Columbia

#### Project Ironstar

Interactive communications will take place between the studios of the Alberta Native Communications Society in Edmonton and several native communities in the provinces north. Programming will be designed to reflect the freely expressed concerns and needs of all communities served, as the project determines and attempts to serve the overall communication needs of Alberta native communities.

Experiment Leader: L. Desmeules  
Alberta Native Communications Society,  
Edmonton, Alberta

For more details or assistance in contacting any of these experimenters, get in touch with:

J. M. Bryan, Information Officer  
Department of Communications - Ottawa  
Telephone (613) 995-8185



## SPACECRAFT DESCRIPTION

### General Equipment Configuration

The basic spacecraft structure consists of a central thrust tube, forward and aft equipment platforms and equipment panels on opposite sides of the body.

The apogee motor is mounted within the central thrust tube on the same structural member as the aft platform.

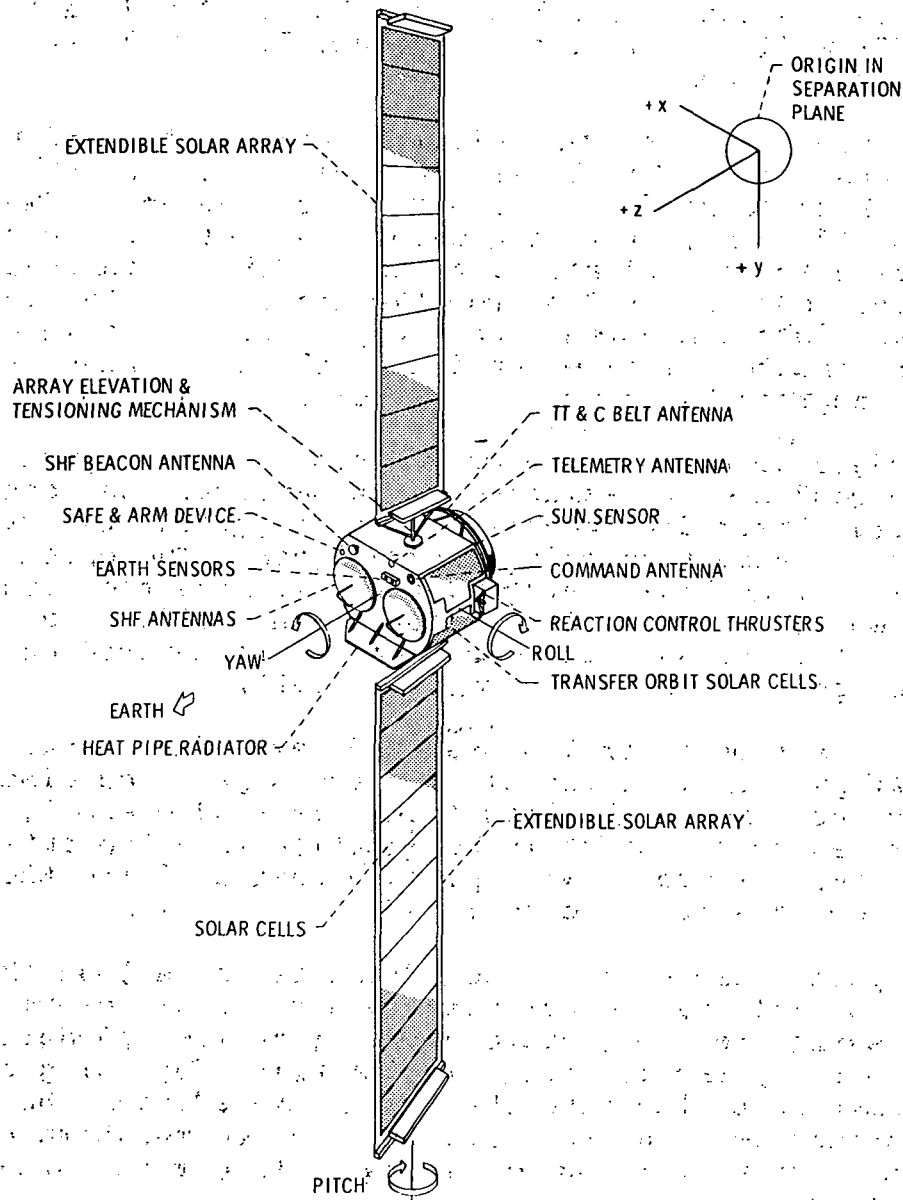
In the launch configuration the overall height and outside diameter are 188 and 183 cm (74 and 72 in.), respectively.

The outer diameter of the aft equipment platform is supported by struts that extend down to the base of the central thrust tube. The central thrust tube is made of aluminum alloy rings joined together by magnesium sheets rolled into tubular sections. The forward edges of the body panels are supported laterally by struts which extend to the forward equipment platform.

Curved panels on the other two sides of the spacecraft are used to carry the majority of body-mounted solar cells. Since the forward platform carries the super-high frequency (SHF) antennas and Earth sensors, which must be very accurately aligned, considerable care had to be taken to thermally isolate it from the rest of the spacecraft. This isolation is accomplished by supporting the center of the forward platform on the cylindrical section of the central thrust tube and supporting the outer edges of the forward platform by struts which are attached to the base of the central thrust tube.

The forward and aft equipment platforms and north and south equipment panels are 2.54 cm (1 in.) thick aluminum honeycomb panels.

The extendible solar array is mounted on one pair of panels. A flat-pack design is used for the stowed configuration. Each panel contains a single blanket and a single offset boom per sail. Jettisonable stowage containers are provided for the solar blankets. The enclosure release mechanism will be actuated on command and provides for disconnection of electrical leads to the solar panels on the enclosure lids.



CTS configuration on station in synchronous orbit.

Each sail will be extended in a concertina-like fashion by means of a single silver-plated stainless steel extendible boom. The booms are located on the shadowed side of the blankets. The boom is 0.18 mm (0.007 in.) thick, 3.9 cm (1.5 in.) in diameter and 7.37 m (24 ft.) long when fully deployed.

Mounted on the forward platform are the two SHF narrow-beam antennas, the conical beam and belt antennas, the static infrared Earth sensors and the SHF beacon antenna. The 12 GHz, high-efficiency traveling wave tube (TWT) is mounted at the intersection of the aft platform and the south panel. The TWT collector protrudes from the aft end of the spacecraft. Variable conductance heat pipes and the radiator subsystem are mounted as an extension to the south panel and are held in place by struts to the forward platform.

Projecting through the curved east and west panels of the spacecraft are the spinning Earth sensors, the spinning Sun sensors, the radial reaction control jet and the yaw and east/west low-thrust reaction control jets. The pitch, roll and roll/yaw low-thrust jets and the axial reaction control jet are mounted off the aft platform. The solar array deployment, tracking and drive mechanisms are mounted on the panels on opposite sides of the spacecraft.

The reaction control system hydrazine fuel tanks are on the aft platform. Integral with the separation ring around the aft end of the thrust tube is a 32-element, 2 GHz belt array antenna, which, in conjunction with the antennas on the forward platform, will provide near omnidirectional coverage for telemetry and command.

Components mounted on the aft platform include the reaction control system, batteries and the housekeeping components required to operate during transfer and drift orbits. Battery thermal control is achieved by using second-surface mirrors to increase the heat radiated from the battery mounting area. Heaters are provided to maintain critical components within their survival temperature range when these components are not in use.

The apogee motor is insulated to insure that propellant temperature remains above -7 degrees C (18 degrees F.) at the end of 10 transfer orbits. There is a thin stainless steel mesh shield attached to the aft end of the central thrust tube to protect the spacecraft from the apogee motor plume temperatures.

## Super-High Frequency Communications Systems

The SHF communications system will provide microwave signals in the 12 GHz region at power levels greater than heretofore available. It features a number of advanced technology units which will make possible low-cost ground terminals and permit communications with remote areas otherwise beyond economical limits. The communications system consists of the following elements: high-gain receiving and transmitting antennas; a receiver; an amplifier; filter circuits; a high-power, high-efficiency output stage; and a "spotting" beacon and its antenna.

The SHF antenna subsystem consists of two steerable parabolic reflectors with single feeds which incorporate linear, orthogonally polarized receive and transmit functions. The electrical axis of each antenna is steerable in any direction 8.5 degrees from a line parallel to the spacecraft yaw axis and passing through the vertex of the reflector. The transmit gain is 36.9 dB on axis; the receive gain, 37.9 dB on axis.

Six channels of telemetered data on the antenna subsystems are transmitted to the ground, and 11 antenna subsystem commands are received by the spacecraft.

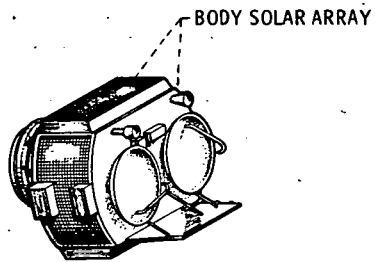
## Tracking, Telemetry and Command System

The tracking, telemetry and command system is basically a receiver/transmitter combination. Considerable redundancy is built in to enhance the reliability of the system. The transponder is designed to be compatible with the NASA worldwide Satellite Tracking and Data Network.

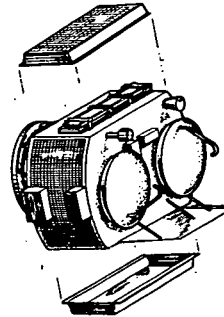
## Deployable Solar Array

The deployable solar array (DSA) provides power for all spacecraft loads after the spacecraft is despun and the solar array is deployed in synchronous orbit.

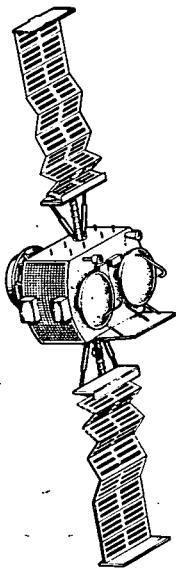
The DSA is stowed during launch, transfer orbit and synchronous drift orbit (spin-stabilized mode) in a flat, folded configuration between two honeycomb panels. Prior to deployment of the flexible array, the north and south jettisonable body solar arrays are jettisoned by pyrotechnic actuators, and a mechanical linkage releases the flexible arrays for deployment.



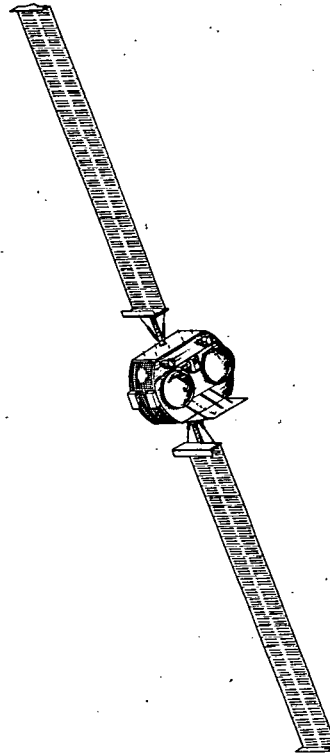
(a) Spin stabilized configuration.



(b) Storage containers and body arrays jettisoned.



(c) Array partially deployed.



(d) Array fully deployed.

Extendible solar array actuation sequence.

The deployment actuator is energized and deployment begins after the stowed array is elevated a distance of 76.2 cm (30 in.) by means of a boom. Array foldout continues at a nominal rate of 2.5 cm (1 in.) per second. The DSA has a total of 25,272 solar cells and is designed to produce 1,257 watts of useful power to the spacecraft.

#### Attitude Control System

During the spinning phase of the mission, attitude control of the cylindrical rigid body is provided by means of ground-computed commands sent to the spacecraft. During the in-orbit phase, when the satellite consists of a central body from which two large Sun-tracking solar arrays are deployed, stabilization and control are accomplished by means of a three-axis onboard autonomous system that uses the momentum wheel-offset thruster principal.

#### GROUND TERMINALS

Prior to 1971 the only frequency bands allocated for satellite communications were below 9 GHz. Bands at 4 and 6 GHz are being used extensively in international systems such as Intelsat and are also used by Telesat Canada for the Canadian domestic satellite system. These bands are subject to sharing constraints and power flux density limits by international agreement. In July 1971 the International Telecommunications Union World Administrative Radio Conference on Space Telecommunications allocated a number of new frequency bands to space services. The CTS band allocation (12 GHz) is one of these.

Communications experiments using CTS will be directed at investigating those applications that take particular advantage of the use of the 12 GHz band and the satellite's high effective isotropic radiated power. Ground station development within the CTS program will concentrate on terminals that have small diameter antennas, are modest in cost and can be located close to the user.

A unique feature of the spacecraft transponder is that one of the two communications channels is equipped with a high-power amplifier of 200 watts, compared with a 20-watt amplifier for the second channel. This permits the satellite to operate in a broadcast mode where one relatively large station can broadcast through this channel to any number of smaller stations within the coverage area of the high power beam.

The technical requirements of the ground terminals and consequently the cost are reduced considerably from the case of receiving the same quality signal from the low power channel.

In Canada, the ground terminals are provided by the government for user experiments and, in general, are installed and maintained by the government. In the United States the ground terminals are provided by the user and operated and maintained by the user.

Antenna diameters range from 0.8 to 9 m (32 in. to 30 ft.). Transmitter powers vary from 20 to 1,200 watts, and both tracking and non-tracking types are used.

#### DELTA LAUNCH VEHICLE AND LAUNCH SEQUENCE

CTS will be launched into a stationary orbit aboard a three-stage Delta launch vehicle managed for NASA by its Goddard Space Flight Center, Greenbelt, Md. Delta is 35 m (116 ft.) tall, 2.4 m (8 ft.) in diameter and weighs 132,949 kg (293,105 lb.).

As NASA's workhorse rocket, the Delta has launched 118 satellites during the past 15 years with a success record of over 90 per cent.

CTS will be launched from complex 17B at the Eastern Test Range, Fla. The launch window for January 13 is 6:20 to 7:20 p.m. EST.

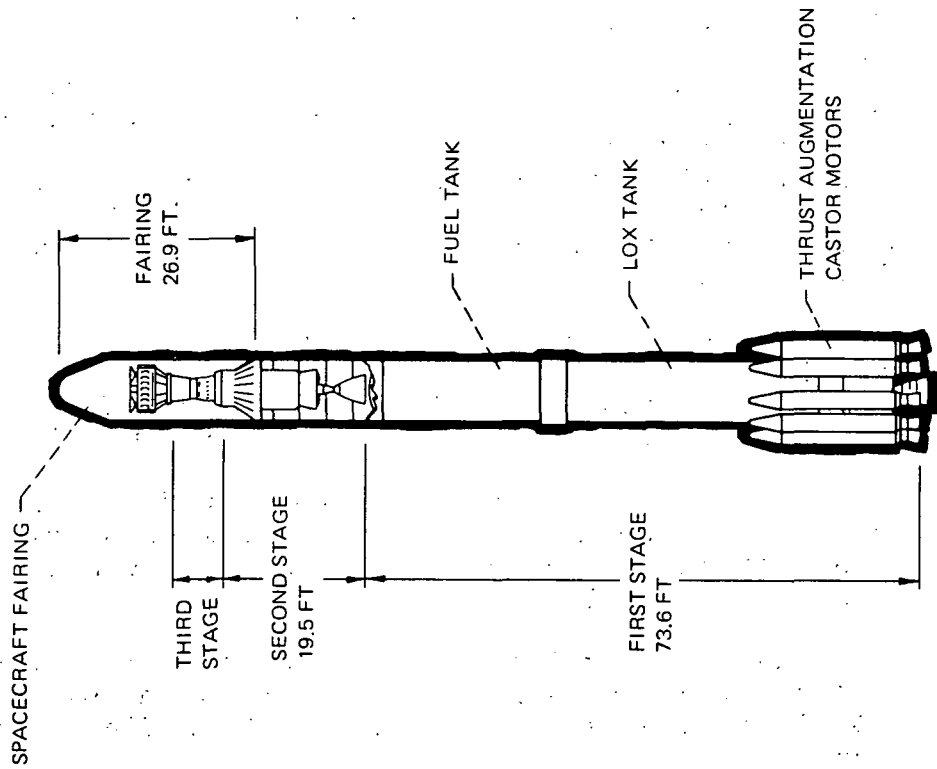
From liftoff until third-stage separation, Delta will be controlled by an onboard inertial guidance system. Sensors will provide vehicle attitude and acceleration information to the system's computer, which will generate steering commands for the vehicle's first and second stages. The third stage is spin-stabilized.

The Delta vehicle will place the spacecraft and its attached apogee boost motor (ABM) into a parking orbit ranging in altitude from 185 to 36,347 km (115 to 22,585 mi.). This orbit will be inclined about 27 degrees from the equator.

At the apogee of the fifth orbit around Earth, the ABM will be fired. This will simultaneously circularize the orbit at the near-synchronous altitude and place the CTS over the equator.

## THE LAUNCH VEHICLE

The launch vehicle that will put CTS into orbit is the three stage Thor Delta model 2914. It is 116 feet long and 8 feet in diameter weighing 202,600 lbs.





Injection into this orbit will occur at 169 degrees west longitude, a point over the Western Pacific. After drifting eastward at a rate of 5.2 degrees west CTS ultimately will be stopped at 116 degrees west longitude, due south of Baja California, for operational use.

At liftoff, six Thiokol strap-on solid motors will ignite to provide additional thrust for the McDonnell Douglas modified Thor booster. After burning 38 seconds they will shut down and three more strap-on solids will ignite just one second later at about 6 km (4 mi.) altitude. They will burn another 38 seconds and the first stage will shut down three minutes 43 seconds into the flight.

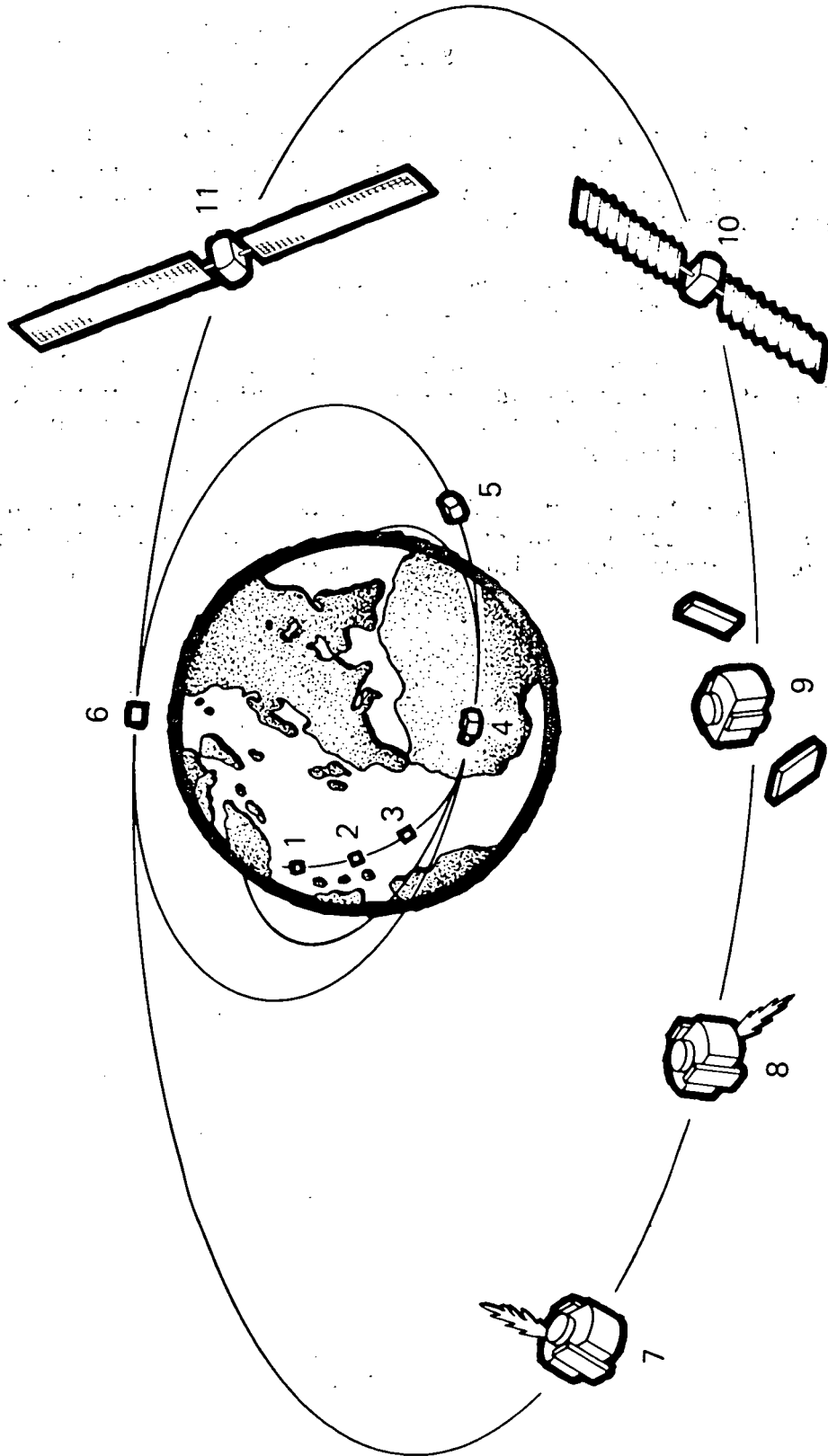
The TRW liquid-fuel, pressure-fed engine of the second stage will ignite 13 seconds later to boost the spacecraft to an altitude of some 166 km (103 mi.). The second stage burns for five minutes before it enters a 13-minute coast period. The second stage will restart at 21 minutes and 13 seconds into the mission and shut down 10 seconds later shortly before second-third stage separation.

The third-stage TE-364-4 spin-stabilized, solid-propellant Thiokol motor will ignite about 100 seconds later, and burn 43 seconds to place the spacecraft into its transfer orbit of 36,347 km (22,585 mi.) by 185 km (115 mi.).

At the fifth apogee the spacecraft's onboard apogee boost motor will be fired to put it into geosynchronous orbit at an altitude of about 36,000 km (22,350 mi.), where the solar arrays will be unfurled.

NASA's Spaceflight Tracking and Data Network (STDN) will provide necessary support for the mission. The global STDN is also managed for NASA by the Goddard Space Flight Center.

ORBIT SEQUENCE



LAUNCH OPERATIONS

The Kennedy Space Center's Unmanned Launch Operations Directorate plays a key role in the preparation and launch of the thrust-augmented Delta rocket carrying the Communications Technology Satellite.

Delta 119 will be launched from Pad B at Complex 17, Cape Canaveral Air Force Station.

In providing launch operations, KSC handles scheduling of test milestones and review of data to assure that the launch vehicle has met all its test requirements and is ready for launch.

All launch vehicle and pad operations during the launch countdown are conducted from the blockhouse at Complex 17 by a joint government-industry team.

DELTA/CTS FLIGHT EVENTS

EVENT	TIME	ALTITUDE		VELOCITY	
	Min/Sec	Km	Miles	Meters/Feet	Per. Sec
Liftoff	00:00	0	0	0	0
Six solid motor burnout	00:38	6	3.7	685	2,251
Three solid motor ignition	00:39	6.2	3.8	686	2,252
Three solid motor burnout	01:17	21	13	1,180	3,872
Nine solid motor jettison	01:27	26	16	1,274	4,180
Main engine cutoff (MECO)	03:43	92	57	5,360	17,586
First/second stage separation	03:51	98	61	5,367	17,611
Second stage ignition	03:56	101	63	5,362	17,591
Jettison spacecraft fairing	04:40	126	78	5,571	18,278
Second stage first cutoff (SECO-1)	08:51	167	103	7,836	25,708
Second stage restart	21:14	179	111	7,819	25,652
Second stage second cutoff (SECO-2)	21:24	180	112	7,940	26,051
Third stage spin up	22:23	182	113	7,938	26,043
Second/third stage separation	22:25	182	113	7,938	26,043
Third stage ignition	23:07	184	114	7,935	26,034
Third stage burnout	23:50	189	117	10,261	33,664
Third stage/spacecraft separation	25:03	224	139	10,229	33,560

-more-

CTS/DELTA TEAM

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for Applications

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Deputy Associate Administrator  
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Deputy Director

Robert N. Lindley

Director of Projects

Robert Baumann

Associate Director of  
Projects for Delta

Robert Goss

Chief, Mission Integration  
and Analysis

George D. Baker

Chief, Mission Integration

William R. Burrowbridge

Mission Integration Engineer

Tecwyn Roberts

Director for Networks

Albert Ferris

Director of Mission and  
Data Operations

Steve O'Dea

Network Support Manager

Robert Sanford

Mission Support Manager

Walt Frazier

Communications Engineer

Kennedy Space Center

Lee R. Scherer

Director

George F. Page

Director, Unmanned Launch  
Operations

Hugh A. Weston, Jr.

Manager, Delta Launch  
Operations

Wayne McCall

Chief Engineer, Delta  
Operations

Edward M. Chaffin

Spacecraft Coordinator

Canadian Department of Communications

Dr. John H. Chapman

Assistant Deputy Minister,  
Space Program

Communication's Research Centre

Dr. Irvine Paghis

CTS Program Manager

Dr. John N. Barry

CTS Project Manager

George N. Davies

CTS Experiments Manager

CONTRACTORS

NASA Contractors

Litton Industries  
Electron Tube Division  
Redwood City, Calif.

Prime contractor for development of 200-watt traveling wave tube (TWT)

TRW  
Redondo Beach, Calif.

Prime contractor for power processing unit for TWT

McDonnell Douglas Astronautics  
Huntington Beach, Calif.

Contractor for Delta launch vehicle

Contractor Officials

Litton Industries

Stanley E. Webber

President

Gerold Pokorny

Manager, Cross Field  
Department

James C. Munger

Manager, Linear Beam  
Department

Robert S. Cerko

Chief Engineer

C. L. Jones

Program Manager

TRW

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George A. Harter	General Manager Electronics Systems Division
Charles W. Stephens	Manager of Electronics Development Operation
Dr. A. E. Sabroff	Assistant Manager of Elec- tronics Development Operation
Will A. Finley	Manager of Control and Sensor Systems Laboratory
Daniel Goldin	Transmitter Experiment Package Program Manager

Canadian Contractors

SPAR Aerospace Products, Ltd. Toronto	Spacecraft/structure and mechanical subsystems
RCA, Ltd. Montreal	Electronics, antennas and 1- and 2-meter Earth terminals
SED Systems, Ltd. Saskatoon, Saskatchewan	Three-meter ground stations, ground-station electronics and computer software
Bristol Aerospace Winnepeg	Electrical units



December 23, 1975