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ABSTRACT

This document presents complete descriptions of Health, Education, and Welfare (HEW)-funded education experiments with the Applications Technology Satellite (ATS) program. Special note is made of the ATS-F program which is considered as the most complex, versatile, and powerful communications spacecraft ever developed. This spacecraft will serve an international community as a special broadcasting station in space. A history of the ATS program is presented. ATS-F is the sixth step in the program. A description of the ATS-F spacecraft is given, including schematic diagrams of the craft, geographical maps, and data. A list of program officials, contractor officials and the contractors is included in the report. Communication experiments, technology experiments, and other special investigations are presented. (EB)

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POWERFUL TV SATELLITE PREPARED FOR LAUNCH

The most complex, versatile, and powerful communications spacecraft ever developed is scheduled to be launched from Cape Canaveral, Florida, May 30 on a Titan III-C rocket.

In its geosynchronous orbit some 35,680 kilometers (22,300 statute miles) above the equator, NASA's Applications Technology Satellite-F will match Earth's 24-hour rotational period and thus remain over a fixed point on the globe. Operating from several selected stations over the next several years, the spacecraft will serve an international community as a special broadcasting station in space.

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April 29, 1974

The new spacecraft, to be renamed ATS-6 in orbit, will be used to test a variety of new space communications concepts requiring the use of a geosynchronous-orbit spacecraft. These include broadcast of health and education television programs to small, low-cost ground receiving units in remote regions; aeronautical and maritime communications, position-location, and traffic-control techniques; and spacecraft tracking and data relay.

All totalled, ATS-F carries more than 20 technological and scientific experiments, many of them international in scope.

The 1,402-kilogram (3090-pound) spacecraft consists essentially of an Earth Viewing Module (EVM) connected to a deployable reflector antenna that measures nine meters (30 feet) in diameter when deployed. Spacecraft control, communications, and experiment systems are located in the EVM. Electrical power is supplied by two semi-cylindrical solar panels on arms that extend over and beyond the antenna.

The spacecraft's most critical elements are the deployable antenna and the communications transponder. Through these two systems, ground controllers can relay high-quality communications signals on multiple frequencies at high transmitter power levels and high effective radiated power levels to simple land, sea, and air receivers located over a large geographical area.

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For the first year of operation, ATS-F will be located at 94 degrees west longitude over the equator. At this location, a point over the Galapagos Islands, the spacecraft will be in communications view of all the continental U.S.

Shortly after the spacecraft is on this station and checked out, it will be used, along with NASA's ATS-1 and ATS-3 now in orbit, to conduct the Health-Education Telecommunications (HET) experiment, which encompasses both educational TV and two-way medical teleconferencing demonstrations. The new capabilities pioneered in these experiments are expected to be fed into operational satellite systems established by the private sector in the future.

The HET experiments are planned in three geographic areas: the Rocky Mountain region, the Appalachian states, and the states of Washington and Alaska. HET will pioneer delivery of high-quality educational and health services to millions of Americans in remote parts of these areas, whose mountainous nature makes TV reception from ground-based transmitters difficult.

Principal Investigator for the HET experiment is the Department of Health, Education, and Welfare (HEW).

The Federation of Rocky Mountain States (FORMS) is coordinating the installation of ground terminals for the HET experiment, not only in the Rocky Mountain States but also in Alaska and Appalachia.

- more -

This equipment, consisting of an inexpensive TV set, a special converter, and a simple antenna, will either directly service a single community-type receiver or will be tied in with Public Broadcasting microwave or cable systems already operating in the cooperating states. Equipment for each of approximately 300 sites will cost less than $4,000.

For Appalachia, the main broadcast point to the spacecraft is the NASA ATS site at Rosman, N.C. For the Rockies, the broadcast point is Denver, Colorado, and for Alaska it is Fairbanks.

For the HET experiments, ATS-F will be able to relay two separate color TV signals, each accompanied by four voice channels. Thus, programs can be broadcast in several languages simultaneously, with the viewer being able to select among English, Spanish, or one of several American Indian dialects. The ATS-1 and ATS-3 spacecraft will be used for two-way voice and data transmissions in support of ATS-F during both educational and health-medical experiments.

The Federation of Rocky Mountain States will coordinate the educational part of the experiment in the eight-state Rocky Mountain area. Professionals and volunteers -- counselors, teachers, and others -- will work in these areas to evaluate the effectiveness of the program. The Appalachian Regional Commission will coordinate the programming to teachers at 15 sites throughout the Appalachian Region, while the Alaska Telecommunications Project will coordinate educational programming for Alaska.

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Also involved in the HET experiment are the Veterans Administration, the Health Sciences Administration of the University of Washington, and the Alaska Health Department. The many facets of the health and medical programming involve stimulating and improving medical education and understanding of medical problems, telediagnosis and teleconsultation to and from remote medical facilities, and the capability for immediate transmission of a patient's complete medical record to a hospital center far away for needed emergency diagnosis and medical assistance.

Each of the Federal agencies involved in the HET experiment will bear the cost of its particular activities. HEW is providing the money for the ground terminals required by the schools, community centers, and Public Broadcast System stations to receive the spacecraft's educational programs and for the development of the programs and the coordination of the organizations involved in Appalachia, the Rocky Mountains, and Alaska.

NASA is providing the necessary time on the ATS satellites.

Approximately one year after launch, ATS-F will be moved eastward to a station over the eastern edge of Lake Victoria in Kenya, East Africa. From this position the spacecraft will be "visible" to the subcontinent of India. It will then be used by the Indian Government about four hours a day for one year to conduct the Satellite Instructional Television Experiment (SITE).

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In this experiment ATS-F will be used to broadcast daily television programs to 5,000 villages and cities in seven states throughout India. Some 2,400 of the villages will be equipped with TV sets augmented by converters and small antennas to receive the signal directly from the spacecraft. Another 2,600 or more villages will use augmented TV sets to receive the signal rebroadcast from a ground terminal in the area. Programs will stress improved agricultural techniques, family planning and hygiene, school instruction and teacher education, and occupational skills. The single video channel will be accompanied by two audio channels in different languages.

The ground receiving terminals, the direct reception areas, are simple units, each costing about $600. They consist of a three-meter (10-foot) diameter antenna made of chicken-wire mesh, a converter, and a TV receiver.

NASA responsibilities for this experiment are to provide operating time on ATS-F's communications transpoder and to position and point of the spacecraft from the ATS mobile ground station to be located near Madrid,Spain. All other aspects of the experiment, including the design, development, manufacture of the ground trasmitting and receiving stations and all programming, are the responsibility of the Government of India. The Space Research Organization (ISRO) is procuring the hardware while All India Radio (AIR), an agency of the government, has prime responsibility for developing the programming in collaboration with ISRO.

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During its initial year of operation while at 94 degrees west longitude and transmitting to the United States, ATS-F will be used to conduct another major series of tests, called the L-Band Experiment. These tests will evaluate several communications and position-location techniques using ATS-F as a relay between ground terminals and airborne planes and ships at sea. ATS-5 also will be used in these tests.

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The U.S. Coast Guard and the Federal Aviation Agency of the Department of Transportation and the Department of Commerce's Maritime Administration will be active participants in the experiment. The L-Band experiment also is international in scope, with participation also by Canada's Department of Communications and Ministry of Transport and the European Space Research Organization.

Investigators expect to gain valuable experience and data that can be applied to future operational systems later in the decade. Such system would be used for day-to-day aeronautical and maritime communications, traffic control, and search and rescue operations.

Several tracking and data relay experiments (T&DRE) also are included in the first year's operation of ATS-F. NASA's Nimbus-F meteorological research spacecraft and its GEOS-C geodetic spacecraft, both planned for 1974 launches, will be tracked by ATS-F, which also will relay two-way data between these spacecraft and Earth.

The information collected during this experiment will be useful for the future transition from a totally ground-based network to the Tracking and Data Relay Satellite System planned for the late 1970s. This system would employ two geosynchronous spacecraft operated in conjunction with strategically located ground stations for tracking and data relay operations with low-orbit spacecraft. Such a system would not only be less expensive to instrument and maintain than the present network of ground stations but would provide more extensive coverage for the orbiting spacecraft.

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From a scientific standpoint, the information collected from GEOS-C will contribute significantly to continuing studies of Earth's gravitational field. It also will help improve man's concept and models of the geoid -- the true shape of Earth.

In mid-July of 1975, after ATS-F has been moved to 35 degrees east longitude for use by India, it will be used to track and relay TV and other data from the Apollo-Soyuz spacecraft as they orbit Earth in a 10-day joint U.S. - U.S.S.R. space-docking experiment to advance international cooperation in manned flight.

Because of the location of the U.S.S.R. launch site for the Soyuz, the orbits of both the Russian and U.S. spacecraft will be inclined to about 52 degrees north and south of the equator. This orbital path will swing them beyond the scope of many U.S. ground-based stations.

Use of ATS-F for tracking and data relay for the Apollo-Soyuz spacecraft will provide continuous coverage during 50 percent of their orbit. Thus it will permit larger amounts of biomedical and spacecraft data to be relayed to Earth in one transmission and increase the amount of live TV from the flight.

In addition to the HET, SITE, L-Band, and T&DRE experiments, ATS-F carries more than 20 others. These include radio-frequency interference, propagation at the millimeter-wave frequencies, cloud mapping, spacecraft thermal and attitude control, and radiation measurements at the synchronous orbit altitude.

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The ATS program is directed by NASA's Office of Applications. Project management is under NASA's Goddard Space Flight Center, Greenbelt, Md.

All operations of ATS-F are coordinated and controlled from the ATS Operations Control Center at Goddard. ATS ground stations are located at the Rosman, N.C., and Mojave, California, sites of NASA's Space Tracking Data Network (STDN), a global network maintained by Goddard for tracking and acquiring data from manned and unmanned spacecraft. A mobile ATS ground station will be located at the Madrid, Spain, STDN site during the spacecraft's second year of operation.

Fairchild Industries, Germantown, Md., is the prime contractor for development, integration, and test of the ATS-F spacecraft.

The AST-F launch agency for NASA is the Space and Missile Systems Organization (SAMSO) of the Air Force Systems Command, El Segundo, California. Assembly, check-out, and launch will be performed for NASA by SAMSO's 6555th Aerospace Test Group at the Eastern Test Range, Fla. Prime contractor to the Air Force for the Titan III-C is Martin Marietta Aerospace, Denver, Colorado, Division.

The cost of the mission to NASA is about $180 million for the spacecraft, including development and test and backup hardware, and about $25 million for the launch vehicle and services.

(END OF GENERAL RELEASE. BACKGROUND INFORMATION FOLLOWS.)

HISTORY OF THE ATS PROGRAM

Prior to development of the Applications Technology Satellite (ATS) program, NASA conducted extensive research with communications satellites at low, intermediate, and synchronous orbital altitudes. These spacecraft include passive reflectors such as the 33-meter (100-foot) diameter Echo balloons and active repeaters such as the Relay and Syncom spacecraft.

Upon the completion of these programs, an Advanced Syncom study was conducted to determine the next step to be taken in communications spacecraft. The ATS program was based on the results of this study and incorporated a number of Syncom techniques. These included spin-stabilized configurations and complex synchronous orbit maneuvers.

The first phase of the ATS program included the development, launch, and utilization of five spin- and gravity gradient-stabilized spacecraft, four of which were placed at the synchronous altitude. Communications satellites operating from this altitude view about 45 percent of the globe as compared to a 320-kilometer (200-mile) orbit spacecraft which views only about three percent of the globe at one time.

ATS-F is the next logical step in the program and continues and extends the scope of the experiments conducted by ATS-1 through 5.

ATS-1 (ATS-B before launch)

This spin-stabilized, synchronous-altitude satellite was the first ATS to be launched. Soon after its lift-off on December 7, 1966, from Cape Kennedy, Fla., the satellite was maneuvered into its permanent position over the Pacific Ocean and all its systems checked out as fully operational. Since then, all the experiments have been pouring a steady stream of data back to the ground stations. A wide variety of services have been performed by ATS-1 in addition to the large number of technological and scientific experiments.

A number of special TV events were relayed to the peoples of the world by this spacecraft during technological demonstrations of its capabilities. In June of 1967 viewers in Australia saw 10 hours of Canada's EXPO '67, and on October 12 of that year the Japanese people saw their Prime Minister's visit to Australia. Other transmissions included news clips of the death of Australia's Prime Minister Holt and President Johnson's resulting visit there in December of 1967.

Emergency communications during an Alaskan flood were relayed from Alaska by ATS-1 from August 16 through 24, 1967, to Government agencies below the border, saving many lives and millions of dollars. ATS-1 served as a VHF communications backup to the Alaska tracking station site at Fairbanks during the flood.

Educational broadcasting to both Alaska and the Pacific Basin is currently being done through ATS-1. Included are college-level seminars and courses at both primary and secondary levels.

ATS-2 (ATS-A before launch)

The second satellite in the ATS series was launched from Cape Kennedy on April 6, 1967. It was intended that this gravity-gradient-stabilized spacecraft be placed in a medium altitude orbit inclined to Earth's equator, so that it would continously circle the Earth. A failure in the fuel supply system of the Agena rocket prevented the booster from reigniting at the crucial point in the satellite trajectory, and the satellite went into a highly elliptical orbit. Large forces, caused by the severe decelerations occurring in this very irregular orbit, proved more than the gravity-gradient stabilization system could overcome, and as a result ATS-2 slowly tumbled and rotated. All the systems and experiments onboard functioned as well as possible under these conditions. The spacecraft reentered Earth's atmosphere on September 2, 1969, and was destroyed.

ATS-3 (ATS-C before launch)

The third satellite in the series, a spin-stabilized spacecraft, was put into synchronous orbit on November 6, 1967, from Cape Kennedy. After a perfect launch, it took up its station over the Atlantic Ocean, and all systems have been operating as expected since then.

A significant achievement of this satellite was the first ground-to-spacecraft-to-aircraft communications link over the Atlantic. This historic event took place on November 21, 1967, during a Pan American flight from New York to London. The communications engineer aboard the plane was able to maintain conversations with both Pan American officials in New York and NASA officials at Goddard Space Flight Center. The Mojave ground station in California handled the experiment control, and transmissions to and from the aircraft via the satellite were monitored at different places around the world as far away as London, Hamburg, Frankfurt, and Buenos Aires.

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Probably the nost notable achievement of ATS-3 was its sending the first color photograph of Earth in space; obtained from the multicolor spin-scan cloud camera. Another camera on ATS-3, the image dissector camera (IDCS), also obtained many cloud photographs. The spacecraft continues to monitor severe storms.

ATS-3 performed many services in addition to the technological and scientific experiments. These included support of the Apollo missions and TV coverage of Pope Paul's visit to Bogota, Columbia, in 1968.

Through a series of maritime experiments, involving both ship position location and ship-to-shore communications through the spacecraft, ATS-3 has demonstrated that major improvements in the management of shipping fleets can be made by use of the capabilities of synchronous-orbit communications satellites.

ATS-4 (ATS-D before launch)

ATS-4 was a gravity-gradient spacecraft launched from Cape Kennedy on August 10, 1968. The Centaur second ignition was never accomplished. As a result, the spacecraft, with Centaur and apogee motor attached, was left in an approximately 100 by 400 nautical mile orbit. Turn-on of all systems and experiments was accomplished; however, little useful data were obtained because of the extreme anomalistic conditions. ATS-4 reentered Earth's atmosphere and was destroyed on October 17, 1968.

ATS-5 (ATS-E before launch)

ATS-5, another gravity-gradient spacecraft, was launched from Cape Kennedy on August 12, 1969, and has contributed much technical and scientific information.

The auroral particles experiments on ATS-5 have now been operating successfully since 1969 and are continuing to provide a large quantity of useful data.

The NASA/GSFC L-band ranging and position location experiments, being conducted from the Mojave ground station to the ATS-5 satellite, have demonstrated the ability to obtain meaningful range measurements using Phas Modulation tone modulation at L-band frequencies.

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A ranging test was conducted for the Maritime Administration using the tanker, USS Manhattan to determine line-of-position of the ship. L-band ranging signals were transmitted from the Mojave station and relayed through ATS-5 to the ship.

The MARAD (Maritime Administration) project was also conducted. This was a successful test of real-time high-speed (100-wpm) teletype transmission, using standard equipment and relayed through ATS-5, two-way (not simultaneous), between Mojave and the Manhattan. The teletype equipment aboard the ship was unattended and running continuously.

Among the other tests and experiments have been ionospheric propagation tests, an on-going experiment involving three ground stations that accepted fading and fading-rate data from ATS-5 on L-band and VHF simultaneously; the Federal Aviation Administration/Boeing Aircraft Company experiment in transmitting at L-Band from ATS-5 to an aircraft, involving measurements of multipath effects and tone ranging; and a millimeter-wave experiment conducted by Westinghouse for GSFC concerning the propagation correlation with rain, fading, and weather conditions at 31.65-GHz uplink and 15,3-GHz downlink.

ATS-F SPACECRAFT

The ATS-F spacecraft is the most complex and powerful communications system developed in the 15-year history of communications satellites. Its high-power receiver/transmitter system, coupled with a large directive antenna called a parabolic reflector, can relay color TV and other signals of high quality simultaneously to a large number of small inexpensive stations located over a large area on the ground, at sea, and in the air.

The spacecraft weighs approximately 1,402 kilograms (3,090 pounds) and measures eight meters (26 feet) high. It consists of an Earth Viewing Module (EVM), housing controls and Earth-oriented experiments, connected to a nine-meter (30-foot) diameter deployable reflector antenna by a tubular support truss. Two structural arms, each supporting a semicylindrical solar array, extend from a hub that supports the reflector. Mounted on top of the hyb is an Environmental Measurement Experiments (EME) package. Maximum width of the spacecraft at the solar array is about 16 meters (52 feet).

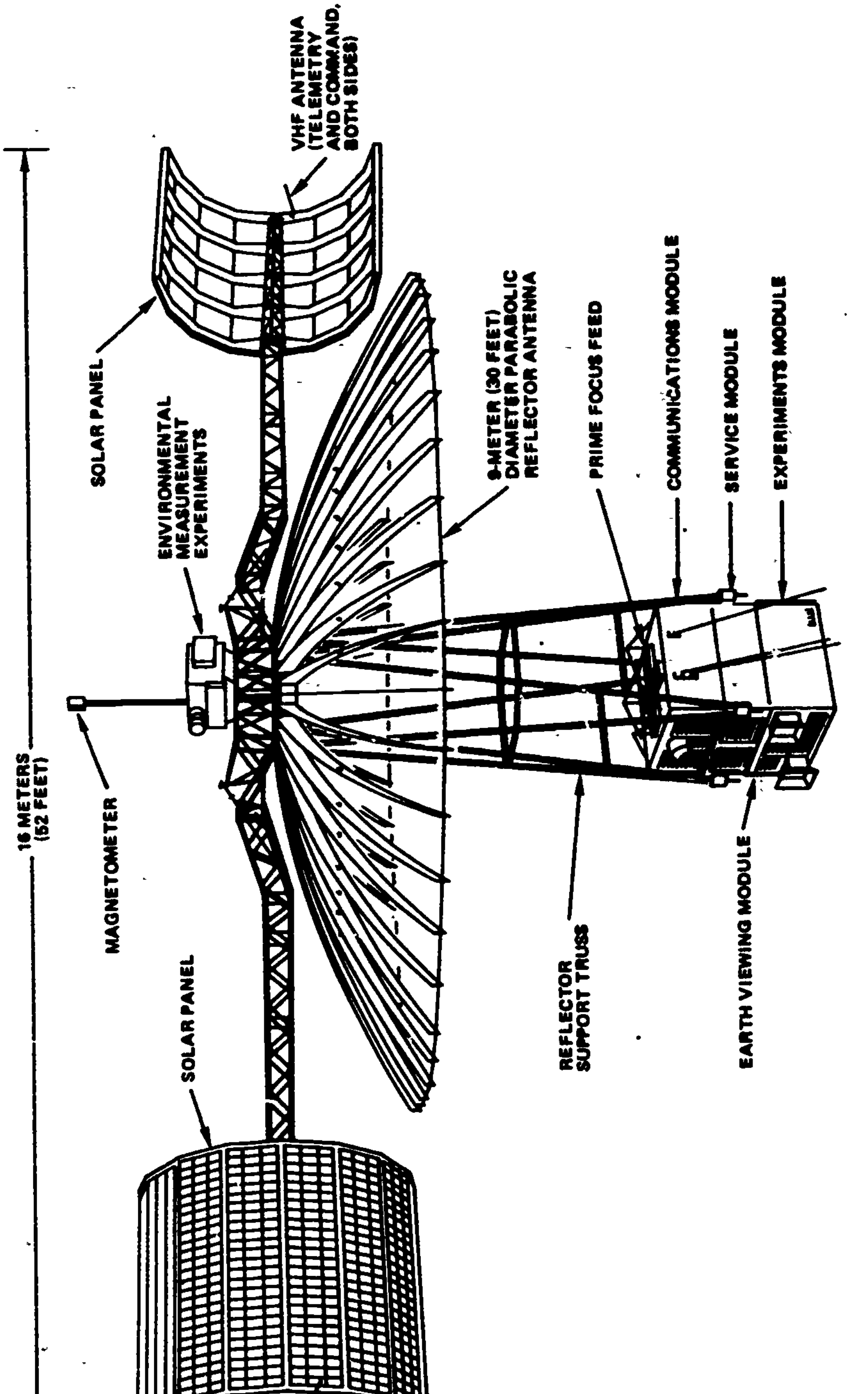
Earth Viewing Module

The Earth Viewing Module (EVM) is fabricated in three separate sections, each of which can be tested independently of the others. The bottom section is the Experiment Module, which houses a number of antennas and the experiments requiring an Earth-viewing location. The center section is the Service Module. It contains the spacecraft's attitude control, propulsion, telemetry and command, and parts of the power supply subsystems. The upper section, the Communications Module, houses the transponder (transmitter/receiver system) Antenna feeds that radiate energy from the transponder to the 9-meter reflector for relay to Earth are located on top of the communications Module.

Weighing approximately 907 kilograms (2000 pounds), the EVM measures 137 x 137 centimeters (54 x 54 inches) around the sides and is 160 centimeters (63 inches) high.

Due to the high power capability of the ATS-F and the variety of operating modes, the EVM requires a special design to control temperatures within plus or minus 15 degrees Centigrade (about 25°F) of normal room temperature. This is attained primarily with the use of heat pipes, superinsulation, and thermal louvers.

All but the north and south sides of the EVM are covered with a superinsultation blanket consisting of 30 layers of very thin aluminized mylar and an aluminized kapton coversheet. The north and south sides are honeycomb panels con-



ATS-F SPACECRAFT

taining thermal louvers that operate automatically to release or retain heat as the EVM temperature varies. Heat is distributed throughout the EVM by heat pipes fabricated of 13-millimeter (1/2-inch) square aluminum tubes containing ammonia, which has a high heat transfer capability. These pipes are bonded as an integral part of the north and south sides of the EVM as well as the transverse bulkheads connecting these sides.

Reflector Support Truss

The tubular truss connecting the EVM to the nine-meter reflector is fabricated of a tough, lightweight, graphite-fiber-reinforced plastic. This material, impervious to temperature changes in space, is designed to minimize twisting or bending of the spacecraft, because of the stringent pointing requirements of its high-frequency systems.

The truss measures about four meters (13 feet) high by about 137 by 137 centimeters (54 by 54 inches) square. Its height is dictated by the fact that the nine-meter reflector must focus signals on the prime focus feed located atop the EVM for relay to the spacecraft's communication system.

Deployable Reflector

The basic function of the nine-meter (30-foot) deployable reflector is to reflect signals from the spacecraft's transmitter/receiver system to land, sea, or air receiving units and to relay signals from such units to this system.

The reflector, when deployed, resembles a hugh open umbrella. Its support structure consists of a 1.5-meter (5-foot) aluminum hub from which protrude 48 aluminum ribs. The ribs, each containing a series of small sunlight holes for thermal control, are covered with a flexible mesh material made of copper-coated dacron. The reflectivity properties of the copper are protected by a coat of silicon to prevent flaking or tarnishing. Total weight of the hub, ribs, and mesh is 49 kilograms (180 pounds).

In the launch configuration, the aluminum ribs and the mesh are wrapped around the hub and held in place by 24 small doors connected to the hub and flipped down over the rib/mesh material. The 20 by 30 centimeter (8 by 12 inch) doors are held in place by a thin wire that is severed upon command by a pyrotechnical cable cutter. When the doors are released to flip up, the coiled energy in the ribs causes the reflector to deploy in less than two seconds.

Communications System

The communications system aboard ATS-F is the most complex ever developed for spacecraft application. It is capable of generating multiple frequencies, diverse beam paths, and high power levels needed for the varied communications experiments.

The heart of this system, contained in the Communications Module, is a multi-frequency transponder, a redundant transmitting/receiving device containing six receivers and nine transmitters capable of operating on about 20 frequencies ranging from 136 megahertz to six gigahertz.

All the transmitting and receiving units are cross-strapped, since the ATS-F experiments involve the conversion of signals from one frequency range (band) to another for transmission over different segments of the signal path. This capability makes the system analogous to a switchboard.

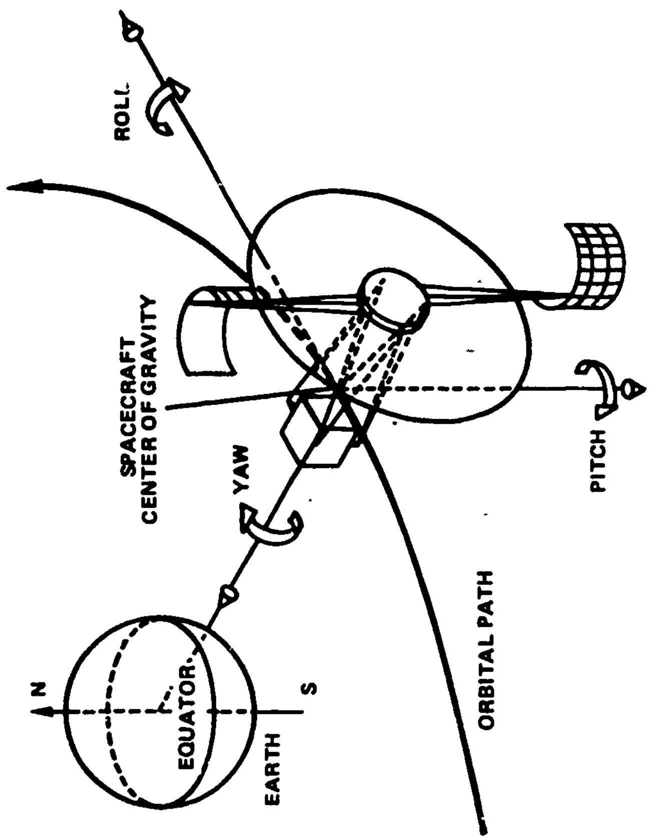
The antennas used in the communications system include: the prime focus feed, located on top of the EVM, which radiates to and receives energy from the nine-meter parabolic reflector, and two Earth-viewing horn antennas located on the bottom surface of the EVM for transmitting and receiving signals directly to and from Earth.

Attitude Control and Spacecraft Positioning

ATS-F must be maintained in a precisely controlled stable attitude in orbit for some of its experiments and be slewed in an accurately prescribed pattern for others. These stringent requirements are met with the use of an advanced Attitude Control System (ACS) and the Spacecraft Propulsion System (SPS).

The heart of the ACS is a pair of preprogrammed and reprogrammable PM digital computers (backed up by an analog computer) coupled with redundant Earth, sun, star, and gyroscopic attitude sensors. A Radio Frequency (RF) monopulse angular sensing system and an RF interferometer that derive information from ground stations are included in the attitude sensors. Based on information fed to it by the sensors, a computer will change the speed of one or all of three momentum wheels to speed up or slow down, and by the resultant reaction torgues roll, pitch, or yaw, the spacecraft.

The SPS consists of a series of one-tenth-pound hydrazine monopropellant thrusters located on the EVM and at the spacecraft's center of gravity on the reflector support truss about 61 centimeters (two feet) above the EVM. These thrusters back up the momentum wheels and will operate in tandem with them to provide spacecraft attitude movement when neces-



SPACECRAFT ORIENTATION

sary. The thrusters on the truss are also used to move the spacecraft east or west along the equator.

Spacecraft Power

ATS-F requires approximately 500 watts of power for spacecraft and experiment operation. This power is derived from solar energy by an array of solar cells and is stored by two 19-cell nickel-cadmium batteries for use during short periods when the solar array is not exposed to the sun or when peak power loads exceed the solar array capability.

The solar array consists of two semi-cylindrical panels supported by deployable booms. Together, the two panels contain 21,600 solar cells covering a total area of 20 square meters (218 square feet). A semi-cylindrical panel design was selected for weight balance and to equalize the effects of solar pressure on the spacecraft.

In orbit, the solar array booms extend north and south to give the solar cell panels an east-west exposure. One of the semi-cylindrical panels always faces the sun to insure constant power.

Telemetry and Command

The ATS-F telemetry and command system provides a closed radio command loop between ground controllers and the spacecraft for spacecradt control and monitoring. In addition, this system will be used as the command link between ground computers and the spacecraft's attitude control system during the Spacecraft Attitude Precision Pointing and Slewing Adaptive Control experiment.

Commands are received from an ATS ground station on one of two assigned VHF command frequencies by two command receivers. Information on the condition and performance of spacecraft systems is telemetered to the ground stations on the VHF band by one or both of two 2-watt transmitters.

Each receiver and transmitter unit has a backup unit. Further redundancy is provided for telemetry and command purposes by ATS-F's communications experiment transponder.

Once the nine-meter reflector is deployed and the spacecraft has attained the proper attitude, one telemetry receiver and transmitter unit will be commanded to operate via the nine-meter reflector at the prime telemetry and command frequency. The other receivers and transmitters will operate via omni-directional antennas located at the ends of the solar arrays.

Commands for ATS-F are initiated at the ATS Operations Control Center at Goddard and transmitted from the ATS ground stations at Rosman, N.C., or Mojave, California.

COMMUNICATIONS EXPERIMENTS

Health-Education Telecommunications Experiment

The information that follows on the Health-Education Telecommunications (HET) Experiment was provided by the National Institute of Education and the Lister Hill National Center for Biomedical Communications, National Library of Medicine, of the Department of Health, Education, and Welfare; and the Veterans Administration.

The National Institute of Education's Education Satellite Communications Demonstration

In 1971, the Department of Health, Education, and Welfare and the National Aeronautics and Space Administration agreed to use an Application Technology Satellite (ATS) to determine the practicability of satellites as an effective means of broadcasting educational and health information to people in remote areas of the United States. The theory was that satellites could get information to people who cannot be reached easily, quickly, or economically by other means and, given satellites' ability to perform many complex activities quickly, could convey special information needed by comparatively small, isolated groups.

The National Institute of Education (NIE) is one of the three agencies within HEW sponsoring projects scheduled for the ATS-F satellite. Taken together, these agencies' projects make up the Health-Education Telecommunications Experiment.

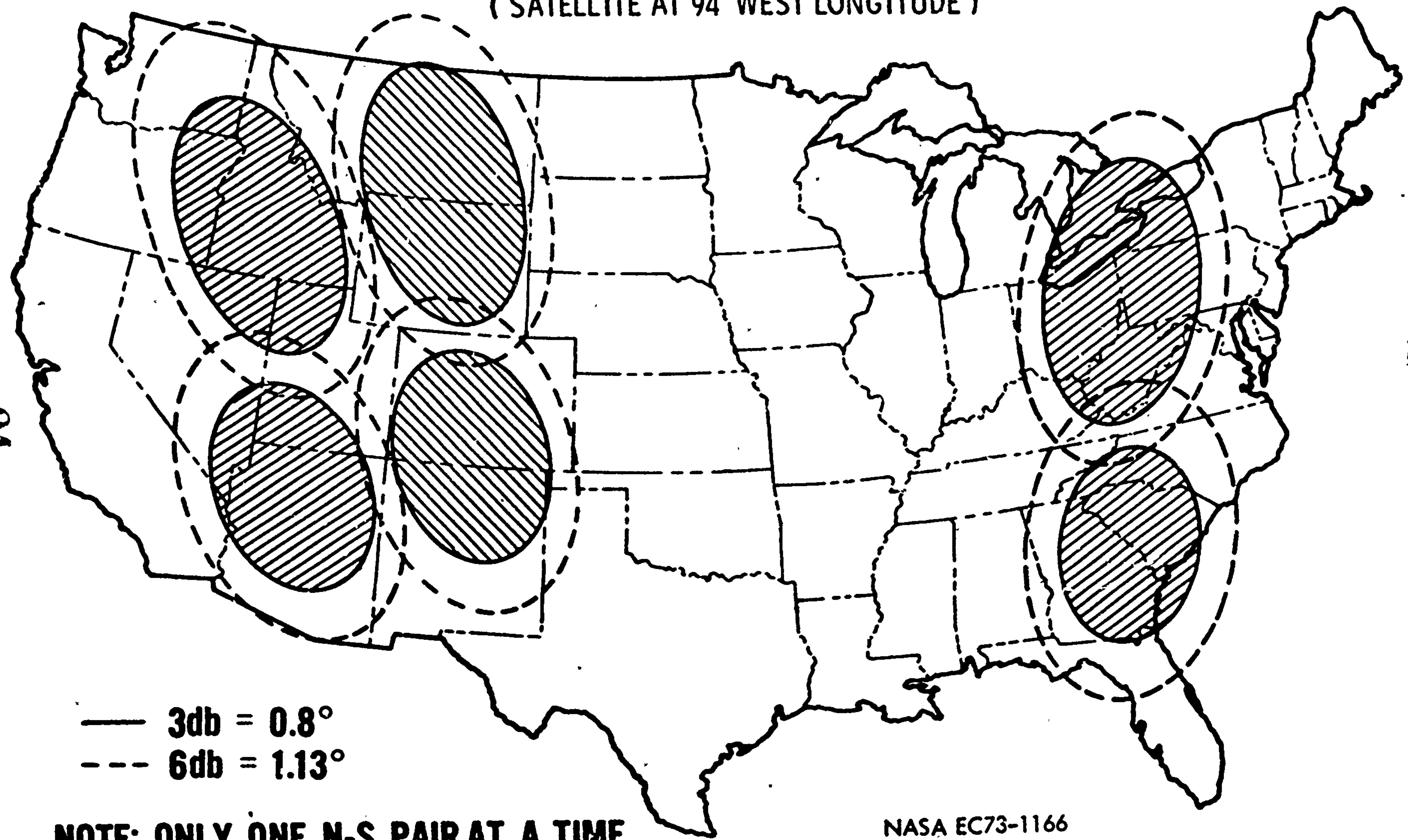
NIE's projects, which together are called the Education Satellite Communications Demonstration, are designed to determine if using a satellite is a feasible way to get educational information to and from people in isolated rural areas. Specifically, NIE wants to find out the actual costs involved, what the people in such areas think of information being received and sent via satellite, and what subjects and ways of presenting the information are most effective in this medium.

The areas involved in NIE's projects are Appalachia, the Rocky Mountain region, and Alaska. The people in these areas are comparatively isolated from one another and from people in other parts of the nation.

Each of the projects explores how to convey educational information, but in different ways. In Appalachia, elementary and secondary-school teachers will receive in-service courses in career education and the teaching of elementary reading. They will also be able to request and receive specialized reference information via satellite. In the Rocky Mountains, junior-high students will have a course in career education, and adults will have some evening programs on topics of interest to them. Also, teachers in that area, instead of having to order videotaped materials for their classes months or weeks in advance, will be able to order those materials in a large number of subjects from a videotape collection in Denver and to receive those materials quickly via satellite. In Alaska, people who live in villages that can be reached only by airplane, and then only when the weather is good, will have a chance to learn about other people and

ATS-F HET FOOTPRINTS IN ROCKY MOUNTAIN AND APPALACHIAN REGIONS

(SATELLITE AT 94° WEST LONGITUDE)



—— 3db = 0.8°
- - - 6db = 1.13°

NOTE: ONLY ONE N-S PAIR AT A TIME

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cultures in their State. They also will have a chance to influence future programs in a series called the "Alaska Native Magazine." Alaska will also have several series of educational programs in village schools and a PBS link with the 48 States.

During the year scheduled for the projects, the people and organizations participating will be evaluating them. When the evaluation is complete, NIE will have information that will help to form future plans for using satellites as a means for educational activities.

Each of the Federal agencies involved in this endeavor will bear the cost of its particular activities. NASA is providing the time used by the NIE projects on the ATS satellites and supporting their operations. NIE is providing the money for the ground terminals needed by the schools, community centers, and PBS stations to receive the satellites' educational programs, the development of the programs themselves, and the coordination of the organizations involved in Appalachia, the Rocky Mountains, and Alaska.

The education projects will use the ATS-F's video and audio channels and the audio channels of ATS-1 and ATS-3. For Appalachia, the main broadcast point is NASA's ATS ground station at Rosman, North Carolina. For the Rockies, the broadcast point is Denver, Colorado. For Alaska, it is Fairbanks.

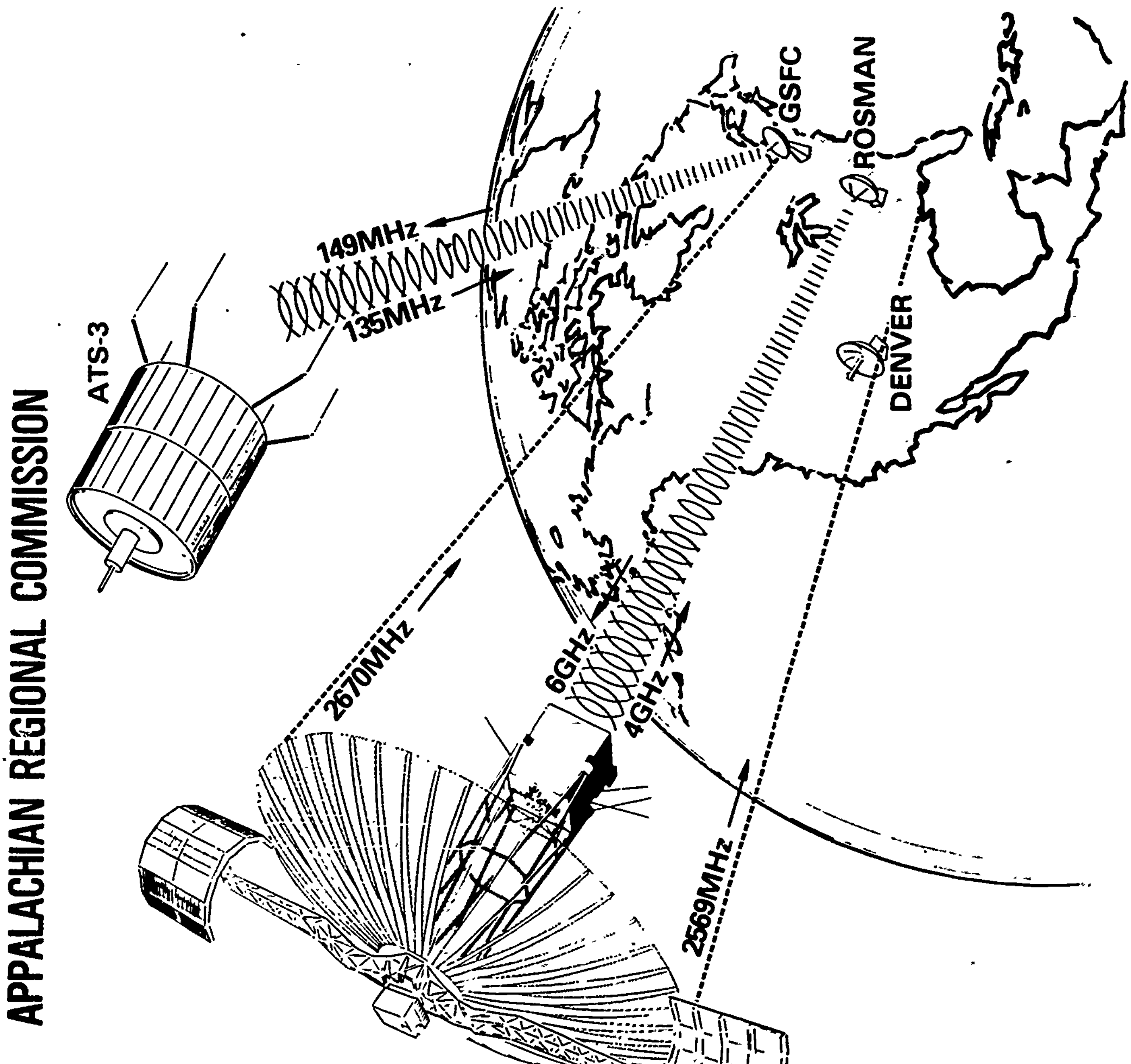
The Appalachian Educational Satellite Project

NIE's project in Appalachia has been developed by the Appalachian Regional Commission, a Federal-State agency created by the Appalachian Regional Development Act of 1965 to coordinate Federal, State, and local governments' attempts to improve the total economic development (roads, health service, education) of Appalachia. In 1971, the Commission surveyed 32,000 public-school teachers in Appalachia and learned that in-service training, particularly in the teaching of reading and career education, was needed. The Commission, with selected Regional Education Service Agencies (RESAs), and the University of Kentucky are participating in the satellite project.

This summer, the University of Kentucky will offer to elementary-school teachers, via satellite, two graduate-level three-credit courses through the 15 selected RESAs. One course will be in career education; the other, the teaching of elementary reading. Those who take the courses this summer will receive tuition-free scholarships, free textbooks, supplementary materials, and teaching materials.

The courses are being developed by a Resource Coordinating Center at the University of Kentucky. The career-education course will examine definitions of career education, its history, rationale, and function in elementary, junior, and senior-high schools. It will also help the teachers develop skills and materials for introducing career education to the schools in their communities. The course in the teaching of reading is designed to help elementary-school teachers diagnose their students' reading problems and use specific ways to assist those students. The teachers will learn to administer, score, and interpret several kinds of reading tests. They will then learn how to use several prescriptive methods to correct the problems revealed by those tests--how, for instance, to improve their students' vocabularies, word recognition, and comprehension.

In these courses, the teachers willview pretaped television lessons, complete programmed instruction based on those lessons, attend laboratory sessions, and participate in discussions during live seminars transmitted via satellite from the Resource Coordinating Center. The lessons, programmed instruction, and seminars are broadcast by ATS-F. After completing these courses, the teachers will be able to teach the same course to other teachers in the school districts they represent.


APPALACHIAN REGIONAL COMMISSION
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During the 1974-1975 school year, junior-high and senior-high teachers will be offered, again by satellite, in-service training courses in career education. The courses will consist of live seminars that will examine the relevance of career education, the introduction of career education into the total school curriculum, the role of guidance and counseling in career education, the use of career information systems, and other pertinent topics. These seminars will be transmitted from the RESAs after school hours.

Also during the school year, the teachers taking the courses will be able to get specialized information to help them address the problems of particular children and also to receive course-related research materials. A teacher will be able to provide information about a child -- the child's age, reading level, and reading habits, for example -- and receive helpful materials and suggestions that the teacher might use to further assist the student. This exchange is handled by the same system used for the satellite-transmitted courses.

The system will work as follows: The 15 RESAs have been divided into five groups of three each. In each group, the main RESA will have a terminal that receives and sends the material broadcast by satellite. The other two RESAs will have terminals that only receive broadcasts; they will be be connected to the main RESA by land lines, so the questions and comments of teachers who are taking the courses at the ancillary RESAs can be relayed to the other students and to the facilities in Kentucky.

The teachers who attend the classes at the RESAs are not necessarily the only ones who will benefit from the programs developed for this project. The programs have been requested by and will be made available to state-wide educational television stations, the other ARC RESAs, and 150 county school districts after the project ends. Thus, according to the ARC expectations, at least 10,000 to 15,000 other teachers will have access to the programs.

This project has established a regional system for the planning and dissemination of education programs and materials -- a system that will respond quickly and efficiently to the needs of Appalachia's teachers and most importantly the estimated 175,000 learners.

Sites and Types of Terminals for the Appalachian Educational Satellite Project

Location	Type of Terminal
Alabama	
Huntsville, RESA	Intensive
Guntersville	Receive-only
Rainsville	Receive-only
Maryland	
Cumberland, RESA	Intensive
McHenry	Receive-only
Keyser (W.Va.)	Receive-only
New York	
Fredonia, RESA	Intensive
Olean	Receive-only
Erie (Penn.)	Receive-only
Virginia	
Norton, RESA	Intensive
Stickleyville	Receive-only
Boone (N.C.)	Receive-only
Tennessee	
LaFollette	Intensive
Johnson City	Receive-only
Coalfield	Receive-only

<u>The Satellite Technology Demonstration of the Federation of Rocky Mountain States, Inc.</u>

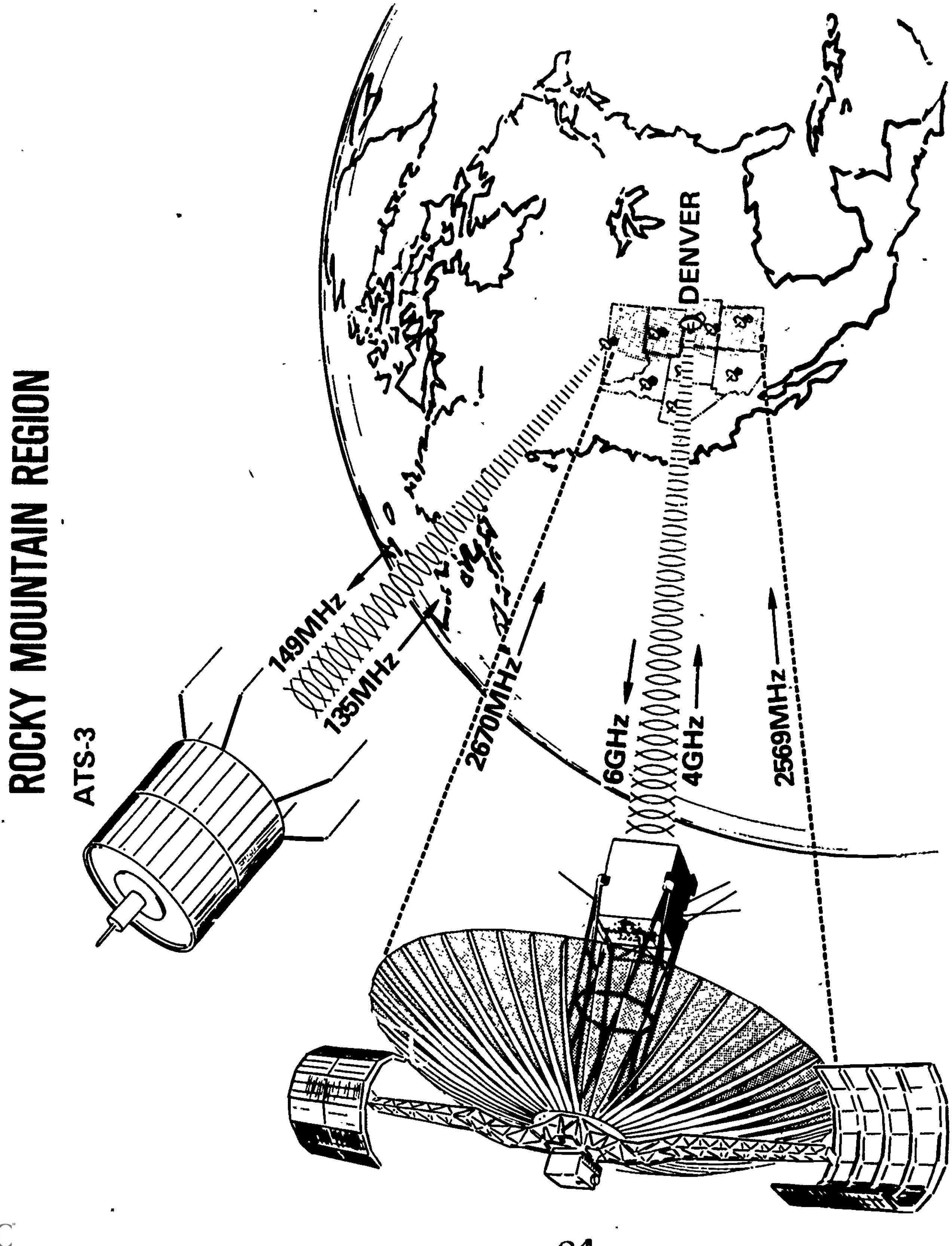
The Rocky Mountain project -- labeled the Satellite Technology Demonstration (STD) -- will focus on junior-high-school students as its primary audience. Starting in September 1974, about 4,900 students in 56 rural communities throughout Colorado, New Mexico, Arizona, Utah, Nevada, Idaho, Montana, and Wyoming will receive programs in career education directly by satellite. The programming will broadcast from Denver to the schools 35 minutes a day through the satellite. As many as 20,000 more students also will receive the programs through the region's public television stations.

The career education programming will emphasize three areas: (a) self-assessment, (b) dissemination of career information, and (c) instruction in specific skills necessary for making decisions. "Self-assessment" represents the groundwork of any career-related decisions, helping the student measure his or her needs, interests, aptitudes, and skills. "Career information" provides the spectrum of career options a young person can apply to his own defined needs and interests. "Specific decisions skills" will enable a student to implement the results of self-assessment and the exploration of options, whether it be in planning high-school courses or learning to prepare a job resume.

The Federation of Rocky Mountain States -- a Denver-based organization developing the project for NIE -- has been designing and implementing the hardware and software; and working with teachers, administrators, and others in the region to ensure that the subjects and format of the programs are relevant to the intended audiences.

STD terminals will be installed at 68 communities scattered through the eight participating States. Of these terminals, 56 will be at rural schools. The others will be located at the 12 Public Broadcasting Service (PBS) stations in the region, enabling these stations to carry the programs during the actual satellite broadcasts or to videotape and play them at some other time.

Twenty-four of the rural schools, three per State, have been selected as "Intensive Sites." During a segment of live broadcasting, these sites will have two-way audio communication capabilities through the use of the ATS-3 satellite, which has been in orbit since the late 1960s. This enables the programmers to respond instantaneously to and participate in the actual programming. Participants at one Intensive Site will be able to communicate simultaneously both with Denver and with participants at other Intensive Sites. One of the key features of the demonstration, this capability will be studied for its implications on future educational and telecommunica-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tions activities.

The other 32 rural schools, as well as the 12 PBS stations, are designated Receive-Only Terminals. They will receive the same radio and color TV signals as the Intensive Sites, but will not have two-way capability.

All the 56 rural schools also will receive supplementary aids, including teacher and student handbooks and personnel services. Supplementary print materials also will be made available at cost to schools choosing to participate in the programs relayed through public television stations.

Further, teachers at the 56 rural schools, as part of a unique Materials Distribution Service, will receive catalogues from which they can request some 300 videotaped programs on various subjects, such as history, social studies, or mathematics. For instance, a teacher of American history in a school in Arizona can request a program by catalogue number and relay that request to Denver. The videotaped material will then be transmitted from Denver through the ATS-F satellite to a videotape recorder at the school.

The STD also will originate adult, community-oriented programming to the 56 participating rural schools one evening every third week, focusing on subjects of concern discovered in surveys of the communities. Subjects already identified include aging, health care, and problems related to alcoholism and drugs.

In addition, there will be programming before the start of the 1974-1975 school year for teachers, counselors administrators, and any other school personnel involved in career education at the 56 sites. There also will be broadcasts during the school year devoted to continued training for participating teachers, as well as teachers who are not directly involved in the career education programming but who could benefit -- and help their students benefit -- by relating career education principles to their classes.

The Rocky Mountain STD project covers an area of 860,000 square miles -- about one-third of the land mass of the 48 contiguous States -- and reaches into rural communities ranging in population from 100 to 7,500. About 30 percent of the nation's Indian population lives in the area, most of them on more than 70 reservations, representing more than 30 tribes, and occupying 38,000,000 acres of land. The mountain States also contain more than 30 percent of all Mexican-Americans -- or Chicanos, as many prefer to be called -- in the United States. Blacks are the smallest in number of the major ethnic groups in the region, ranging from .03 percent of the population in Idaho to 6 percent in Nevada.

The STD experiment has a two-fold purpose: to demonstrate the feasibility of a satellite-based media distribution system for isolated rural populations; and to test and evaluate user acceptance, and the cost of various delivery modes using a variety of materials.

Sites and Types of Terminals for the Satellite Technology Demonstration of the Federation of Rocky Mountain States, Inc.

Location	Type of Terminal
Arizona	
Gila Bend	Receive-only
Seligman	Receive-only
Tuba City	Intensive
Hayden	Intensive
McNary	Intensive
Fredonia	Receive-only
St. Johns	Receive-only
Tempe*	Receive-only
Tucson	Receive-only
Colorado	
Monte Vista	Intensive
Meeker	Intensive
Montrose	Intensive
Craig	Receive-only
Antonito	Receive-only
Naturita	Receive-only
Collbran	Receive-only
Denver*	Receive-only
Pueblo*	Receive-only
Idaho	
Challis	Intensive
McCall	Intensive
Lapwai	Intensive
Vallivue	Receive-only
Salmon	Receive-only
St. Maries	Receive-only
Osburn	Receive-only
Moscow*	Receive-only
Boise*	Receive-only
Pocatello*	Receive-only
Montana	
Colstrip	Intensive
Busby	Intensive
Ft. Benton	Intensive
Roundup	Receive-only
Whitehall	Receive0only

Location	Type of Terminal
Three Forks	Receive-only
West Yellowstone	Receive-only
Nevada	
Battle Mountain	Receive-only
Carlin	Intensive
Owyhee	Intensive
McDermitt	Intensive
Elko	Receive-only
Winnemucca	Receive-only
Ely	Receive-only
Las Vegas*	Receive-only
New Mexico	
Penasco	Intensive
Cuba	Intensive
Dulce	Intensive
Mora	Receive-only
Springer	Receive-only
Questa	Receive-only
Wagon Mound	Receive-only
Albuquerque*	Receive-only
Las Cruces*	Receive-only
Utah	
Blanding	Intensive
Enterprise	Intensive
Kanab	Receive-only
Panquitch	Receive-only
Heber	Intensive
Morgan	Receive-only
Hyrum	Receive-only
Provo*	Receive-only
Salt Lake City*	Receive-only
Wyoming	
Arapahoe	Receive-only
Lovell	Receive-only
Sundance	Receive-only
Dubois	Receive-only
Saratoga	Intensive
Pinedale	Intensive
Riverton	Intensive

*/ PBS Station

The Alaska ATS-F Education Telecommunications Experiment

The Alaskans' need for more and better ways to communicate with one another is enormous. Alaska has 265 communities scattered over 571,065 square miles. Two-thirds of those communities cannot be reached by railroads or highways, and 65,000 of Alaska's 325,000 people are Eskimos, Aleuts, and Indians. Isolation and many languages and dialects make communication and concerted action among the people extremely difficult. Yet, as members of the same State, they share problems they should be aware of and work to solve.

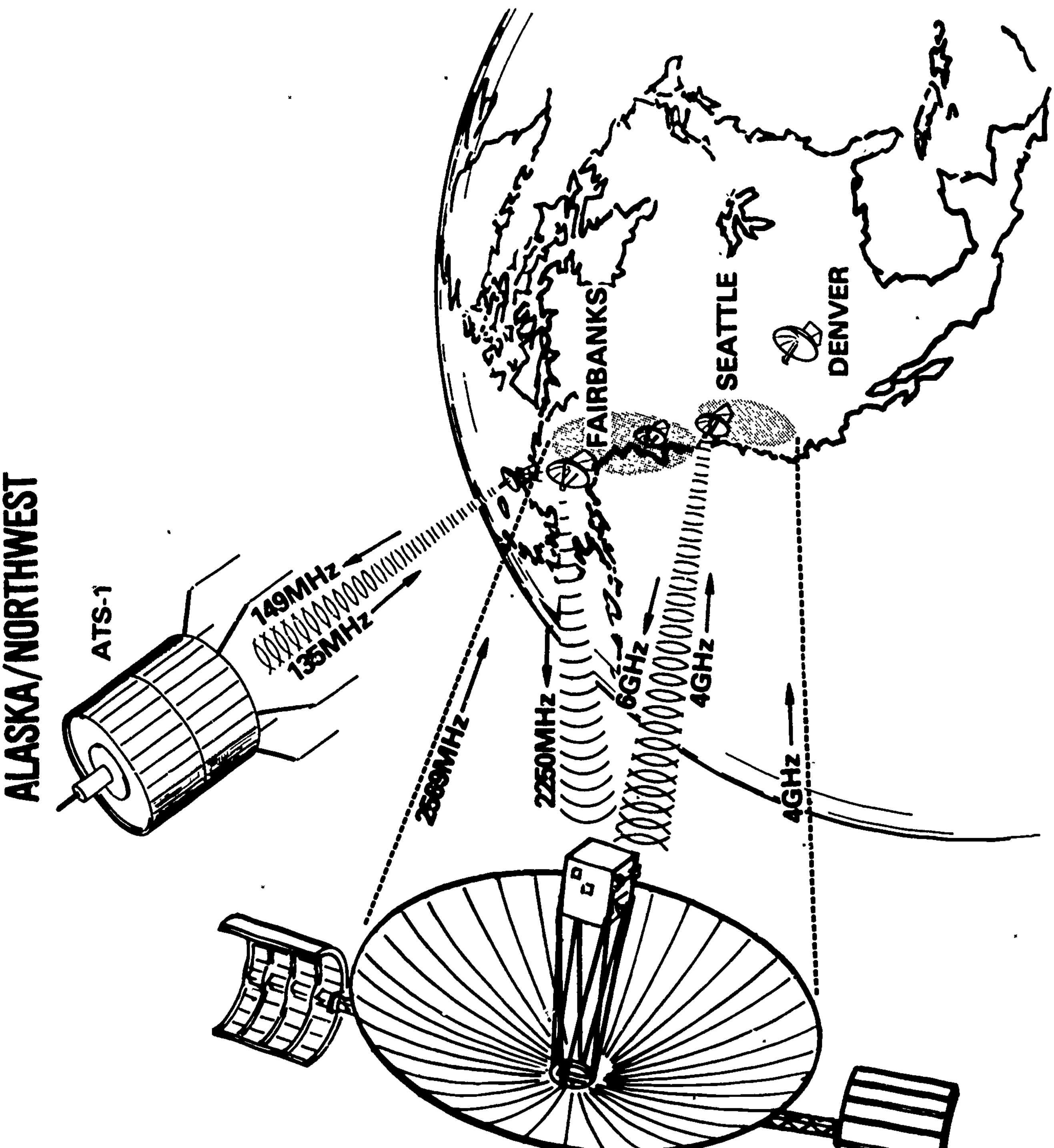
The Alaskan satellite project is designed to see if broadcasting several series of programs via satellite and combining the satellites' broadcasts with those of other media offer a possible way to meet the need for improved communication.

The programs in the education satellite project will be broadcast to 18 communities whose members are Caucasians, Indians, and Eskimos. Most of these communities now have no television service at all.

To explore as many different ways to use the satellites as possible, the Office of Telecommunications of the Office of the Governor of Alaska plans two major areas of activity -- instructional programming and public broadcasting. The area of instructional programming is divided into four parts.. They are basic oral language development, health education, early childhood education, and in-service teacher training.

Each of the Alaskan earth terminals will have a two-way audio connection through the ATS-1 satellite. This connection will be used in the training of teachers as well as the education of the students, especially in the basic oral language development programs. The television teacher conducting activities involving the children and conversing with them over the satellite radio will be setting a model for the teacher in the classroom, and both can communicate during classtime or during the teacher-training sessions.

The teachers will receive manuals containing program goals and objectives, descriptions of program content, lesson guides, and suggestions for teaching activities. The suggestions will address lesson preparations, viewing and interaction, follow-up activities, and evaluation. Teachers' manuals will be developed for each of the instructional program areas.


ALASKA/NORTHWEST
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FAIRBANKS
SEATTLE
DENVER

Consumer Committees composed of village representatives, native leaders, and representatives of State educational agencies will select specific topics for the program in each of the four parts.

The second major activity of the Alaska project is public broadcasting designed for the general population. There are two parts in the public broadcasting activity. The first is a program series called the "Alaska Native Magazine." Each week, the satellite will broadcast a half hour of prepared program material featuring such native concerns as land claims, pipeline impact, and native culture and arts. The programs will have built-in pauses for viewers to express opinions and ask questions. These programs will be followed by a half hour of panel discussions, conversation with village viewers, and suggestions for future programs. The audio part of the programs will be presented in several native languages and English simultaneously.

The other part of this activity will bring television and radio programs to Alaska at the time they are broadcast in the contiguous 48 States. Presently in Alaska, only radio news, major television sports events, and moon landings are broadcast live. Television network evening news programs are delayed from 4 to 30 hours after they are broadcast in the contiguous States. The satellite will provide the link between Alaska and the Public Broadcasting Service and the National Public Radio System in other States. As a result, Alaskans may become more interested in the programs if these programs are live, rather than time-delayed.

Sites and Types of Terminals for the Alaska ATS-F Education Telecommunications Experiment

Location	Type of Terminal
Little Russian Mission (Chuathbaluk)	Intensive
Petersburg	Intensive
Sleetmute	Intensive
Valdez	Intensive
McGrath	Intensive
Nikolai	Intensive
Allakaket	Intensive
Minto	Intensive
Aniak	Intensive
Nenana	Intensive
Yakutat	Intensive
Anchorage	Intensive
Fairbanks	Comprehensive
Juneau	Comprehensive
Angoon	Intensive
Craig	Intensive
Tanana	Comprehensive
Galena	Comprehensive

Health Experiments on the ATS-F Satellite

Background

Since 1971 the Department of Health, Education, and Welfare* has supported an experiment to improve the health care of native Alaskans by using a satellite for voice communication between Public Health Service physicians and health aides in remote villages. The Tanana Service Unit, an area in central Alaska about the size of Texas, was chosen as the site of the experiment. Satellite communication Earth stations were installed in 26 villages and NASA's ATS-1 communication satellite is now being used to relay voice consultation between health aides and physicians at Tanana. The native health aides, who actually treat the villagers, receive up to 16 weeks of training and are equipped with a basic drug kit and a first-aid manual. Because of the terrain and climate, the regular high-frequency radio they formerly relied on was irregular at best, and sometimes a week or more would pass before the health aide could establish radio contact with the physician.

At the end of the first year, despite the small number of villages involved, there was a statistically significant increase of 400 percent in the number of physician-health aide contacts in the villages equipped with satellite communication terminals. Both the health aides and the physicians are convinced that regular, daily consultations have improved the quality of health care and that, in fact, the satellite is responsible for several lives having been saved in emergency situations.

Although reliable voice consultation enhances the health aide's abilities, in many situations it is not possible through words alone to provide enough information to the physician about the patient's problem. Sometimes a medical decision must be delayed until the patient's condition changes, or until the patient can be flown to a medical center. Delays in diagnosis and unnecessary evacuation could in many cases be avoided if the physician had adequate information -- especially visual information. "Telemedicine," now possible in Alaska with the new ATS-F satellite, may provide the answer.

*Through its Lister Hill National Center for Biomedical Communications, National Library of Medicine, National Institutes of Health.

Expanded Health Communications via ATS-F

Several components of DHEW*, heartened by the success of the experiment with ATS-1, are cooperating in an attempt to utilize the new ATS-F satellite to broaden the amount and kind of medical information that can be transmitted. To coordinate the ATS-F health communications experiments with the education experiments sponsored by HEW's National Institute of Education (described elsewhere in this press kit), the Department established an ATS-F User Policy Committee chaired by the Director of HEW's Office of Telecommunication Policy, and made up of representatives from the participating agencies. A common factor agreed upon for all experiments was that the technology would support high priority objectives of the various agencies and that the professionals and paraprofessionals in the field would operate the systems.

The objective of the health communications experiments is to demonstrate whether health care in remote areas can be improved by (1) telemedicine -- i.e., enabling a physician to see and talk to a patient, listen to his heart, evaluate an EKG, and prescribe a course of therapy, all at a distance via satellite; and (2) health education to train physicians whose undergraduate experiences are rooted in rural America. While the telemedicine experiment will build on the work begun in Alaska with ATS-1, the second objective -- health education -- involves a consortium of four states: Washington, Alaska, Montana, and Idaho. Only Washington presently has a medical school.

Telemedicine

The experiement in telemedicine will be conducted at five sites in Alaska. The examining rooms in the small clinics at Fort Yukon (population 630) and Galena (population 425) will be equipped with "comprehensive" earth stations for sending and receiving video, voice, physiological information, and records data. The medics and health aides at these clinics will present patients to the viewing physicians at the Public Health Service Hospital in Tanana. This site is also equipped with a comprehensive terminal. Consultation with specialists will be available from Fairbanks (with a comprehensive terminal) and the Alaska Native Medical Center (ANMC) at Anchorage. The latter will have what is called an "intensive" terminal -- equipment similar to the others, but without the capability to transmit video. Medical record data can be transmitted and received via ATS-1 satellite from all sites.

* In addition to the Lister Hill National Center for Biomedical Communications: the Health Resources Administration and the Health Services Administration.

In actual operation, Tanana physicians will call the villages and clinics via ATS-1 to discuss medical problems with the health and medics as they have been doing for the past two years. Patients in the clinics who might benefit from visual consultation will be scheduled for ATS-F time. Prior to visual consultation, the patient's medical records will be retrieved via ATS-1 from the Indian Health Service Health Information ystem (HIS) computer in Tucson, A izona. The patient them will be "seen" by the Tanana physician and therapy prescribed. During presentation of the patient, physiological information such as EKG and heartbeat may be sent simultaneously via one or more of the four aural channels associated with the televised picture. Talk-back to the presenting clinics will be accomplished via ATS-1, since simultaneous two-way transmission through ATS-F is not possible in this mode. If needed, the Tanana physician will "call in" the specialists at Fairbanks and the ANMC to examine the patient. After the consultation, the physician prepares his report and transmits it via ATS-1 to the patient's medical record stored in Tucson. For the sake of privacy all video and audio associated with the consultation will be scrambled. Only the presenting clinic and consulting staffs will be able to unscramble the information.

It is hoped that the one-year experiment will yield data to help confirm or refute the following hypotheses concerning the improvement of patient care:

1. Telemedicine supported by a good medical record system, in this case the Indian Health Servic's Health Information System, will improve diagnosis so that only patients requiring first-hand physician services need be transported to hospitals and those retained in the villages can be adequately treated there;

2. Telemedicine plus HIS will permit treatment of problems to begin at a lesser degree of severity;

3. Telemedicine plus HIS will reduce the average time between a person becoming aware of a health problem and seeking treatment;

4. With the new technology, the percentage of patients lost to diagnostic, therapeutic, or follow-up programs will be reduced;

5. Visits by specialists to remote villages will be substantially reduced;

6. Educational programming supported by the new technology will give the native population a better understanding of health and the health care delivery system; and

7. The availability of expert consultation made possible by ATS-F will increase the sense of security of the native population.

Health Education

The health education experiment will test the feasibility of providing instruction to medical students via satellite, so that aspiring physicians in states without medical schools will have an opportunity to study medicine on an equal footing with students in other states. The medical education experiment is in two parts: basic science and clinical medicine.

Basic Science. Instruction in the basic sciences will involve the faculty at the University of Washington in Seattle and students and faculty at the University of Alaska in Fairbanks. There will be full two-way voice and video interaction for classes in basic sciences (chemistry, biology, etc.), administrative conferencing, counseling, and computer-aided instruction and evaluation of student performance. Lectures, demonstrations, and classroom experiments will originate from both sites, and a lively interchange between students and faculties at both ends is expected.

The computer-aided instruction courses will be of particular interest because they will expand the available curriculum in Alaska and can allow standardized comparisons with other institutions using the same programs. There is an existing array of basic science courses in computer-aided format presently available at over 70 institutions in the "lower forty-eight" tied together in a network sponsored by the Lister Hill National Center for Biomedical Communications. It is believed that these courses are sufficiently reliable to permit students in Alaska to interact, via satellite, with instruction programs run on the computer at the University of Washington.

The experimenters hope to show that learning via the satellite is fully as effective as learning in a "normal" classroom environment. It will be important to learn if the new technology is acceptable to the remote students and to the faculty at both sites. Will it reduce the sense of isolation of students and faculty in Alaska? Will counseling and consultation via satellite help clarify educational objectives?

Clinical Medicine. The part of the health education experiment dealing with clinical medicine will involve third and fourth year medical students studying under clinicians at Omak, in central Washington. The students will present patients (by video and voice transmission) to the medical faculty at the University of Washington in Seattle. The faculty, although "seeing" the patient, will be able to respond to the student only by voice. Students will be required to give both formal and spontaneous presentations of patients. In the former, the student will study a particular case in detail over a period of time and then present the patient to the faculty in Seattle. The spontaneous presentation will involve the student's interviewing of a new patient and then reviewing for the faculty the information collected on the patient's history, physical and laboratory data, diagnostic impressions, and tentative treatment plans.

In addition to student presentations, the clinicians at Omak will choose patients under their regular care who have problems on which they wish consultation. They will present them to the specialists in Seattle along with the data from their preliminary work-up. The clinicians and students at Omak will attempt to make decisions on patient care based on the consultation with the specialists.

These experiments in clinical medicine, it is hoped, will train students in preparing case studies for analysis and critique and also permit a careful evaluation of the students' knowledge and ability in the actual care of patients seen in practice. Clinicians at Omak will receive a valuable experience in continuing medical education and, of course, the patients seen will benefit from the consultation witht the specialists in Seattle.

Communications Equipment

The ATS-F Earth stations are designed to meet the needs of both the health and education communities. After the HEW ATS-F User Policy Committee established the types and characteristics of terminals to be developed, the detailed specifications were written jointly by the Lister Hill National Center for Biomedical Communications, NASA, and the Federation of Rocky Mountain States. A "building block" philosophy was adopted which would permit "receive-only", "intensive," and "comprehensive" stations to be assembled from the basic development components. It was envisioned from the outset that these stations would be designed for operation solely by the health professionals and teachers. It was inconceivable that the system could be cost effective in remote areas if it were necessary to have on hand a full-time technician. The following are characteristics of the hardware:

1. Solid state throughout;

2. No high voltages in the equipment;

3. Relatively few circuit boards so that first level maintenance would consist of plugging in boards until the defective one is found;

4. Very few switches and adjustments;

5. Simple go/no-go indications for critical voltages, signal levels, etc.

6. Low cost.

The basic station is the receive-only terminal. It consists of an external antenna and amplifier, and an indoor unit which contains the video and four-channel audio output. The four audio channels may be used for voice, physiological information, and data for computer-aided instruction and evaluation. The intensive terminal is made up of a receive-only terminal plus the VHF transmit-receive equipment in use with the ATS-1 satellite network in Alaska. Thus the user of an intensive terminal can not only receive video and associated voice/data channels, but can reply by voice. The comprehensive terminal is an intensive terminal with added transmission equipment which gives the user the ability to receive and originate full video, audio, and data.

Hewlett-Packard, Hughes Aircraft, Prodelin, and Westinghouse are all involved in developing equipment under contract for the ATS-F health and education experiments.

Veterans Administration Exchange of Medical Information Program

Ten Veterans Administration hospitals located within the footprint of the ATS-F spacecraft are participating in the VA exchange of medical information program as part of the Health-Education Telecommunications Experiment. The project is being coordinated by the Foundation for Applied Communications Technology.

The hospitals are located in Altoona and Wilkes-Barre, Pa.; Beckley and Clarksburg, W. Va.; Salem, Va.; Fayetteville, Oteen, and Salisbury, N.C.; Dublin, Ga.; and Mountain Home, Tenn.

"The Veterans Administration is constantly interested in exploring and developing new methods of exchange of medical information for educational and clinical purposes," said Donald E. Johnson, Administrator of Veterans Affairs. "Our aim is to bring these hospitals into direct communication with urban medical teaching centers."

The VA operates 171 hospitals. Some 160,000 veterans daily receive medical care in a VA hospital or clinic or in a nursing home or domiciliary. VA costs for veteran health care amount to nearly 9 per cent of the nation's total hospital bill.

Hospital staffs will participate in programs related to clinical problems experienced with hospital patients. VA telecasts are scheduled for approximately 2-1/2 hours weekly for about a year.

Topics will be presented in the following formats:

* Video seminars with groups at the VA hospitals asking questions and commenting over a return audio channel.

* Patient case presentations televised from one hospital to other participants, with TV return enabling viewers at all sites to participate.

* TV tele-consultation in which doctors at VA hospitals consult with specialists at teaching institutions. Patients and clinical material may be televised.

* Computer-assisted instruction in which physicians and staffers will participate in programmed instruction mediated by computer, including history-taking, diagnosis and management of various clinical problems.

* Slow-scan, using signals that do not require wide-band transmission. TV transmission will include such items as electrocardiograms, and X-rays. VA physicians will be able to obtain specialist consultation in making diagnoses.

Background on Applications of Satellites in Exchange of Medical Information Between VA Hospitals

As the nation's largest unitary health care delivery system, the Veterans Administration is interested in exploring and developing new methods of exchanging medical information for educational and clinical purposes. Such efforts materially assist the VA in providing, on a continuing basis, the most effective and up-to-date care to the patient in a VA hospital.

The Exchange of Medical Information Program of the Veterans Administration is the activity which enables the VA to harness technological advances in communications to the educational process. This supports innovative pilot projects which strengthen those Veterans Administration hospitals which are remote from urban medical teaching centers.

The enabling legislation (Public Law 89-785) also charges the Veterans Administration with fostering "... the widest cooperation and consultation among all members of the medical profession ..." whether within or outside the agency.

All VA hospitals are involved in the Exchange of Medical Information Program, either as "core" hospitals from which information flows to outlying institutions or as recipients of this information. To further carry out the intent of the legislation, Exchange of Medical Information activities are being made available to health professionals in 97 communities surrounding VA hospitals.

The Exchange of Medical Information projects are supported through grants provided to medical schools, hospitals, and research centers, as well as by direct funding of appropriate VA hospitals. These activities vary in concept, scope, and content and cover a wide spectrum of innovative activities and media usage with broad educational and clinical implications. Twenty major projects are being conducted or are in various stages of development.

One of these projects involves participation by the VA in a series of bio-medical communications experiments via ATS-F.

This satellite provides a unique opportunity to explore new modalities of information exchange involving 10 VA hospitals located in the Appalachian region of the United States.

ATS-F is an attempt to broaden through experimentation the scope of health services through long-distance low-cost, interactive transmission of consultations and perti clinical and educational materials.

The Appalachian region was selected as one of the areas for ATS-F experiments, since its mountainous terrain and the relative isolation of many of its communities often make communications difficult and expensive.

The VA broadcasts are scheduled for approximately 2 1/2 hours each week for about a year.

Major productions of films and videotapes which will be part of the broadcast programs are being developed in the studios of the National Medical Audiovisual Center, Atlanta, while live portions of the broadcasts will originate from Denver.

The location of an uplink transmitter in Denver makes it possible to reach the satellite directly from that location. Audio signals and slow-scan video images will be transmitted from the participating hospitals, thus bringing about live interactive participation from all involved sites.

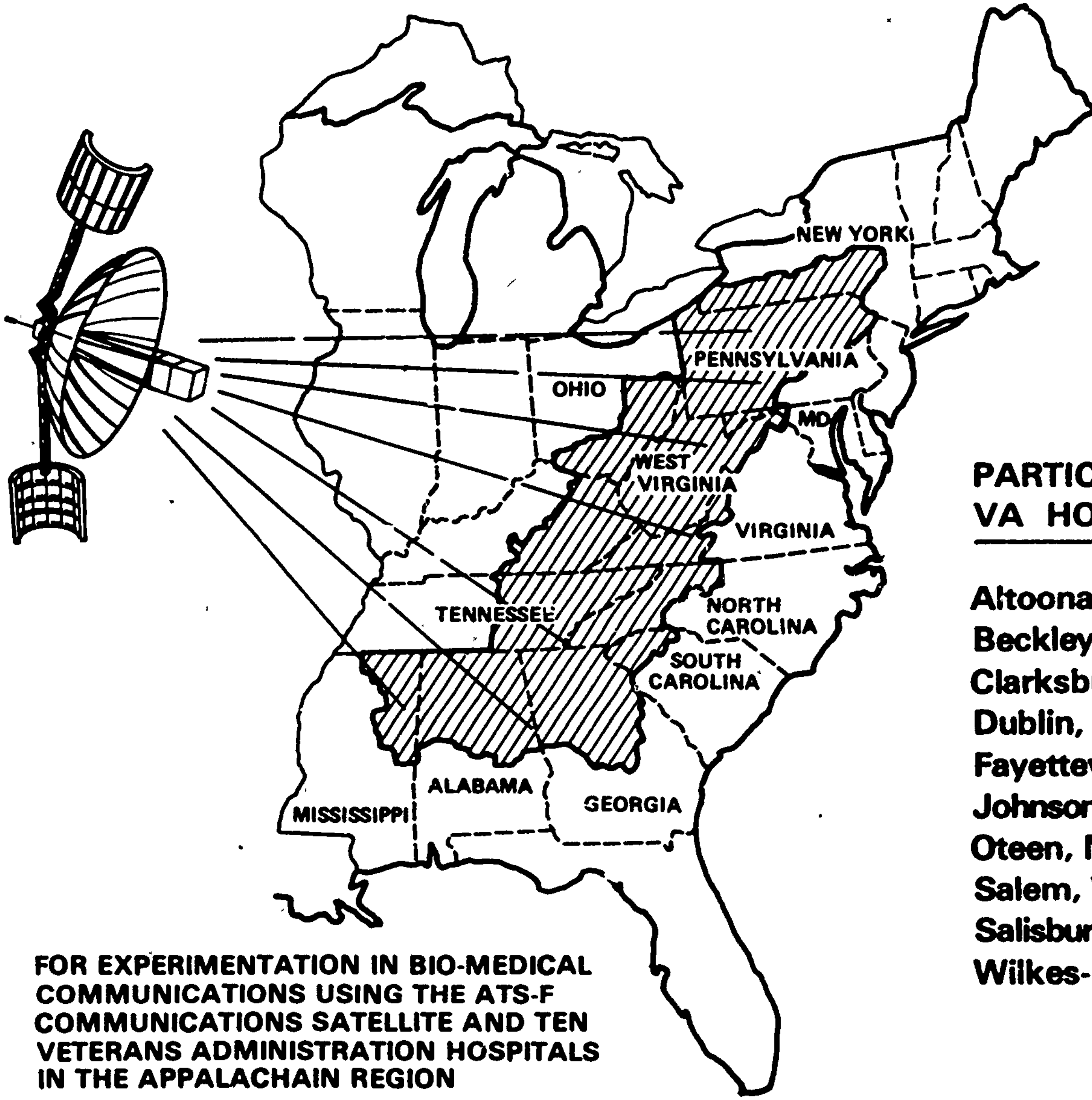
The Foundation for Applied Communications Technology, a non-profit California corporation of health planners, administrators, educators, and media and curricula specialists, is the VA's administrative/coordinative agent for the ATS-F project.

Careful planning of experiments has been the keynote in the development of the VA's participation in this project. In this connection and Experiment Coordination Committee, consisting of VA and non-VA health and education professionals from the Appalachian Region and nearby areas, began functioning more than a year prior to scheduled launch of the spacecraft.

The program topics were selected by the 10 participating hospitals based on their own areas of greatest need and interest. Following the selection of the topics, the hospitals were asked to name audiences and list objectives for each program.

Medical schools through the general region of Appalachia, and beyond in several instances, were advised of the project and asked to indicate their interest in participating by providing faculty for programming of specific topics.

HEALTH EDUCATION TELECOMMUNICATIONS EXPERIMENT VETERANS ADMINISTRATION'S EXCHANGE OF MEDICAL INFORMATION PROGRAM APPLICATIONS TECHNOLOGY SATELLITE - F



FOR EXPERIMENTATION IN BIO-MEDICAL COMMUNICATIONS USING THE ATS-F COMMUNICATIONS SATELLITE AND TEN VETERANS ADMINISTRATION HOSPITALS IN THE APPALACHAIN REGION

PARTICIPATING VA HOSPITALS

Altoona, Pa.
Beckley, W. Va.
Clarksburg, W. Va.
Dublin, Ga.
Fayetteville, N.C.
Johnson City, Tenn.
Oteen, N.C.
Salem, Va.
Salisbury, N.C.
Wilkes-Barre, Pa.

More than 50 topics covering broad areas of interest are scheduled for presentation. The target audiences include physicians, dentists, registered nurses, licensed practical nurses, nursing assistants, patients, and families of patients.

Five types of communications will present the selected subjects: grand rounds, video seminars, computer-assisted instruction, outpatient clinics for patients and families, and teleconsultations by glow-scan (compressed video).

Both black and white and color will be used for slow-scan or compressed video transmissions. Slow-scan television in color has never been adequately tested in this type of two-way teleconsultation setting. It will, therefore, be of particular interest to determine its effectiveness and potentiality as a comparatively low cost method of transmitting a video signal for these purposes.

Slow-scan television provides still pictures which are displayed on a television monitor after being sent as an electrical signal over telephone lines. Depending on the complexity of subject matter, a half-minute or more is required to transmit and display images via slow-scan.

To eliminate the need for audiences or consultants to wait in front of television screens, the slow-scan visuals will be transmitted prior to each of the teleconsultation broadcasts and stored on discs.

Hospitals will send X rays, diagnostic test results and other graphics via special equipment and telephone lines to the broadcast studio in Denver, where the images will be stored.

Consultants in the broadcast studio will appear along with any appropriate materials on the television screens of each of the participating hospitals. The hospitals will be able to communicate verbally with the consultant over a telephone circuit and visually using the slow-scan process.

A vital element of the VA's participation in the experiments via ATS-F will be the evaluation of these activities so as to provide a guide to the efficacy and cost effectiveness of using satellites in bio-medical communications. Paisley-Mick Associates of Stanford, Calif., has designed, and will conduct, the evaluation of this project for the Veterans Administration.

HET Experiment Officials

Dr. Albert L. Horley, Director, Office of Telecommunications, HEW

Dr. Lawrence P. Grayson, National Institute of Education, Project Officer of Education Experiments

Dr. Kevin F. Arundel, National Institute of Education, Alternate Project Officer of Education Experiments

Albert Feiner, Director of Lister Hill National Center for Biomedical Communications, National Library of Medicine, Project Officer of Health Experiments

Dr. Harold E. Morse, Appalachian Regional Commission, Project Director, Appalachian Educational Satellite Project

Dr. Gordon A. Law, Federation of Rocky Mountain States Inc., Project Director, Satellite Technology Demonstration of Federation of Rocky Mountain States

Dr. Kenneth A. Lokey, Federation of Rocky Mountain States Inc., Deputy Project Director, Satellite Technology Demonstration of Federation of Rocky Mountain States

Dr. Charles M. Northrip, Office of the Governor of Alaska, Office of Telecommunications, Project Director of Alaska ATS-F Health-Education Telecommunications Experiment

Dr. Martha Wilson, Indian Health Service, Project Director, Alaska Health Experiment

Roger Bennett, University of Washington, Health Sciences Administration, Project Director of Regionalized Medical School Experiment

Robert Shamaskin, Veterans Administration, Project Director, VA Exchange of Medical Information Experiment with ATS-F

Satellite Instructional Television Experiment

This is a joint experiment by NASA and the Indian Space Research Organization of India, by an agreement entered into September 18, 1969. Its central objective is to demonstrate the potential value of a direct broadcast TV system for education purposes, primarily in rural and remote areas, using a geosynchronous communications spacecraft in conjunction with low-cost ground terminals.

The expected information in this experiment will be disseminated especially to developing countries broadly and be available as one input for their consideration to employ mass-media spacecraft communications for educational purposes.

NASA responsibilities for this experiment include provision of adequate oper-ting time on ATS-F's communications transponder as well as positioning and pointing of the spacecraft from the ATS mobile ground station near Madrid, Spain. All other aspects of the experiment, including the design, development, and maintenance of the ground transmitting and receiving stations and all programming, are the responsibility of India. India's Space Research Organization (ISRO) is producing all the hardware, while All India Radio (AIR), of the India Ministry of Information and Broadcasting, has prime responsibility to develop the programming.

This experiment will begin approximately one year after launch, when NASA will move ATS-F to 35 degrees east longitude over the equator, a position over the eastern edge of Lake Victoria in Kenya, East Africa. Requiring about 40 to 60 days, this maneuver will place the spacecraft in a position where it will be "visible" to the Indian subcontinent, yet remain in communications view of Madrid for control purposes.

Programs will be transmitted four hours a day for one year from the primary Indian ground station in Ahmedabad or the secondary station in Delhi to ATS-F for relay to villages and cities throughout India.
Because of the large number of languages and dialects spoken in India, the video channel will be accompanied by two audio channels in different languages.

Daily programs will stress improved agricultural techniques, family planning and hygiene, school instruction and teacher education, and occupational skills. Children's proframs will be shown from 10:00 to 11:30 a.m. while general broadcast materials and adult education programs will be transmitted from 6:30 to 9:00 p.m., Indian local times.

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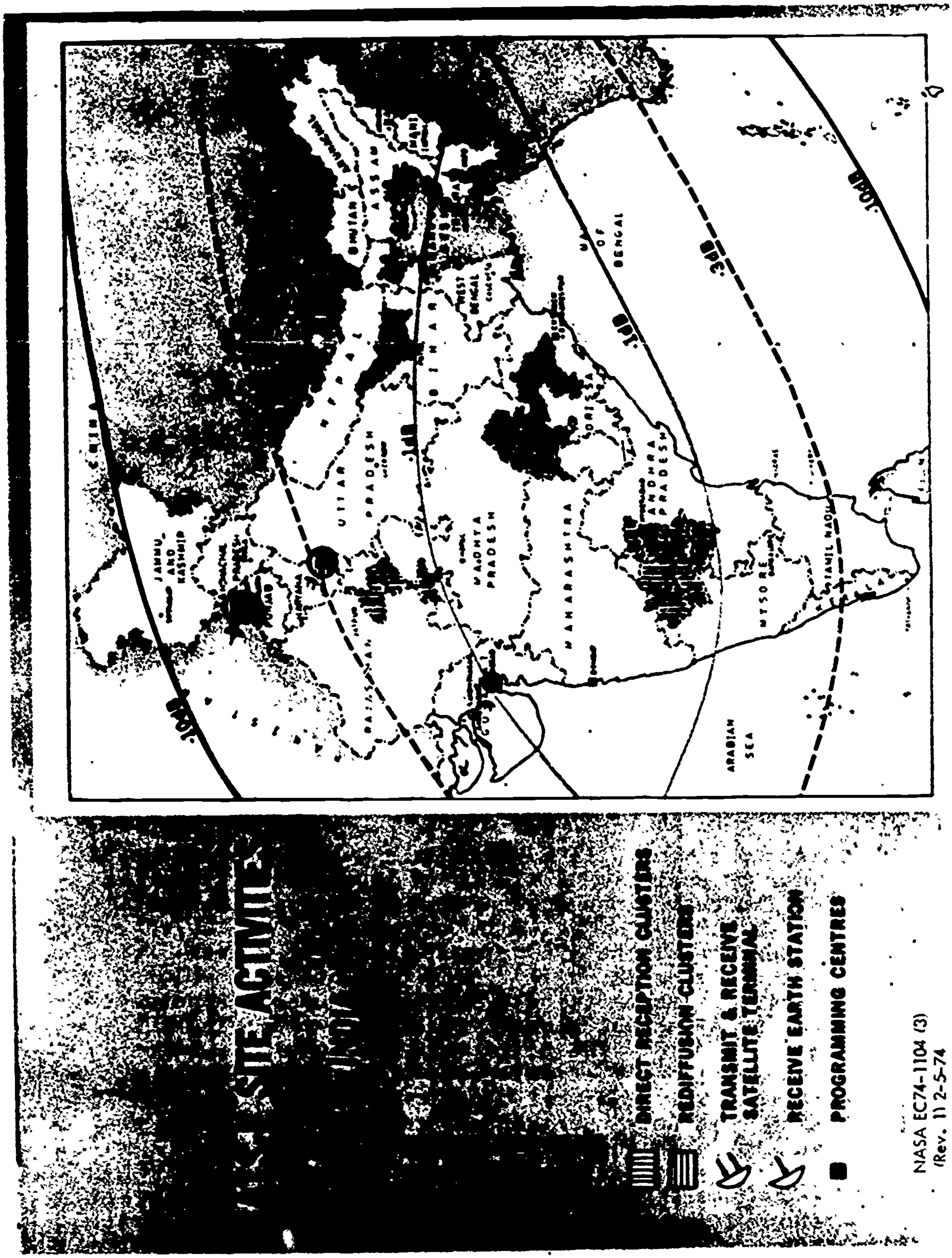


The basic ground terminal costs about $600 and consists of a three meter (10-foot) diameter antenna made of chicken-wire mesh, a converter, and a TV receiver. About 2,400 of these terminals will be located in six clusters of 400 in various parts of India for direct reception from the ATS-F.

Another 2,600 or more terminals equipped with standard TV receivers will be located near rediffusion transmitting stations where the signals relayed through the ATS-F will be retransmitted over conventional TV for the benefit of people in villages near the larger cities.

The entire experiment will be evaluated in accordance with a joint NASA/Indian plan during the broadcasting period and after it is completed to assess its technical and social impact. This information can then be used to aid other developing countries desiring to implement such a program.

Project Manager: Anthony H. Sabelhaus, Goddard Space Flight Center; Principal Investigator: John E. Miller, Goddard Space Flight Center; Program Manager: E.V. Chitnis, Indian Space Research Organization.

Television Relay Using Small Terminals

The purpose of this experiment is to test and evaluate the performance of small, low-cost ground terminals for the reception of quality color TV and television test signals in the Ultra High Frequency band (UHF) using ATS-F as a switchboard in space.

Developing nations interested in the use of such a system for national educational TV purposes will be given an opportunity to participate in the tests and demonstrations. Advice and consultation will be provided to each country in the design and implementation of suitable receivers for such a system.

This experiment will be conducted during the spacecraft's first year of operation while it is located at 94 degrees west longitude over the equator and in view of the U.S.

For the tests, the ATS ground station at Rosman, N.C., or Mojave, California, will transmit frequency modulated (FM) TV signals accompanied by multiple audio channels to ATS-F for relay as UHF signals to a pilot receiving unit located at Goddard. The pilot unit consists of a three-meter (10-foot) diameter parabolic antenna coupled to a low-cost receiver. Objective performance measurements will be made on this unit using internationally recognized and accepted standards for TV transmissions.

Principal Investigator: John E. Miller, Goddard Space Flight Center.

L-Band Experiment

This experiment will demonstrate and evaluate the application of a geosynchronous orbit spacecraft for aeronautical and maritime communications and traffic control using the L-Band frequencies (15 to 17 gigahertz). Certain frequencies in the L-Band range were allocated for aeronautical and maritime mobile-satellite communications by the United Nation's World Administrative Radio Conference in 1971.

The information and experience gained from this experiment will provide the basis for several future operational spacecraft systems intended for day-to-day aeronautical and maritime communications, traffic control, and search and rescue operations.

Organizations participating in this experiment include:

- NASA/Goddard Space Flight Center
- Dept. of Commerce/Maritime Administration (MarAd)
- Dept. of Transportation

  Federal Aviation Administration (FAA)

  U.S. Coast Guard (USCG)

  Transportation Systems Center (TSC)
- European Space Research Organization (ESRO)
- Canadian Dept. of Communications and Ministry of Transport

During this experiment, performance tests will be conducted on several communications and position-location techniques using the ATS-F and ATS-5 spacecraft with airborne planes and ships at sea. Other tests will include ground-based simulation and engineering excercises.

From its position at 94 degrees west longitude over the Galapagos Islands, ATS-F will provide two-way communications between mobile units and ground stations located in a 1,081-kilometer (672-mile) wide area extending from the east coast of the U.S. two thirds of the way across the mid-Atlantic Ocean.

Tests conducted between the ground stations and the aircraft and ships underway are designed to determine the effects of ionospheric, noise, and multipath disturbances as well as the geographic location of the tracked units on both L-Band communications and position-location techniques. Tests will encompass:

- Communications link performance;
- Multi-access performance;
- Power and frequency control techniques; and
- Quality and ranging precision for the various techniques under test.

Position location tests require altimeter readings from aircraft and accurate range measurements from each of the two ATS spacecraft and the aircraft or ship being tracked be known.

Precise spacecraft location is obtained by a trilateration technique in which accurate measurements of the distance from three ground stations to each spacecraft are used. ATS-F trilateration technique in which accurate measurements of the distance from three ground stations to each spacecraft are used. ATS-F trilateration measurements will be made from the three NASA tracking stations at Rosman, N.C.; Mojave, California; and Santiago, Chile. ATS-5 trilateration stations will be located in Schenectady, N.Y.; Hawaii, and Buenos Aires, Argentina.

The ATS ground station at the Rosman, N.C., site will serve as the primary L-Band experiment support facility for communicating with the ATS-F and the ATS-5 spacecraft. A terminal at the National Maritime Research Center, Kings Point, N.Y., also will serve to communicate with ATS-F.

Other ground facilities planned for monitoring ATS-F L-Band transmissions include the FAA's National Aviation Flight Experiments Center at Atlantic City, N.J.; the Transportation Systems Center's facility at Westford, Mass.; and the Canadian Communications Research Centre's facility in Ottawa, Canada.

Four jet aircraft and five ships will be provided for this experiment by the United States, ESRO, and Canada. All these units will be equipped with special L-Band communications and ranging equipment. An ESRO-provided ship also will be equipped to test an L-Band emergency buoy designed to provide search and rescue teams with a distressed ship's final position, information vital to locating survivors.

Principal Investigator: Dr. Ahmad Ghais, Goddard Space Flight Center.

Tracking and Data Relay Experiment (Nimbus-F)

Satellite-to-Satellite Experiment (GEOS-C)

ATS-F will be used to conduct tracking and data relay experiments with at least two other NASA spacecraft, both planned for launch in 1974. One is the Numbus-F meteorological research spacecraft to be placed into a polar orbit some 1,110 kilometers (690 statute miles) above Earth. The The other is the GEOS-C geodetic research spacecraft which will be launched into a highly inclined orbit (65 degrees from the equator) at an altitude of 843 kilometers (524 statute miles).

The information and experience provided by these experiments will have scientific as well as practical application. For example, the highly precise tracking information (range and range rate) will contribute to studies of Earth's gravitational field. This information will have further application to studies of the steady-state shape of Earth.

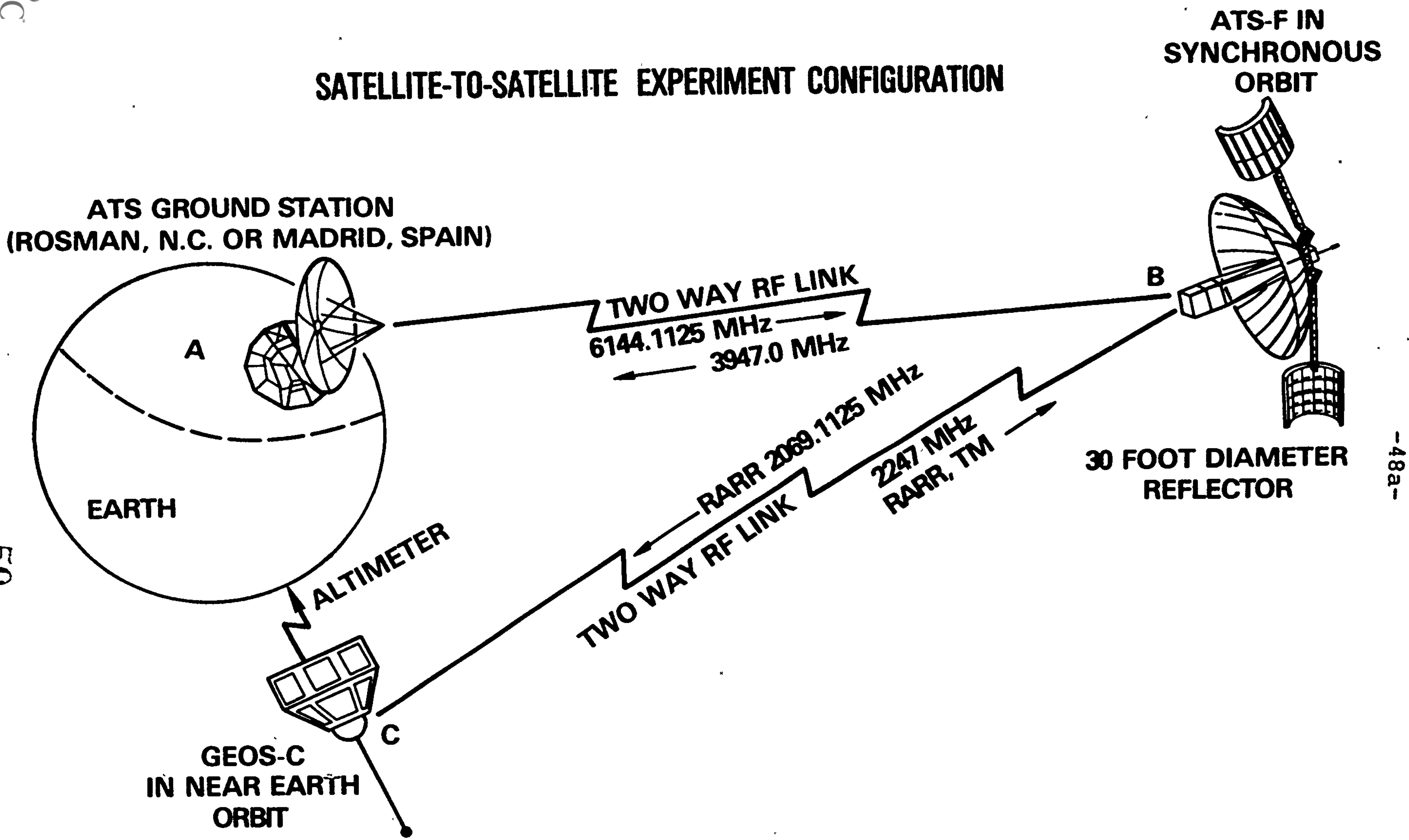
All the tracking and data relay information collected will be valuable for the future transition from a totally ground based tracking system to a Tracking and Data Relay Satellite System (T&DRSS) under investigation for the late 1970s. This system would employ two synchronous orbit spacecraft to relay command, tracking, and telemetry data between a few centrally located ground stations and multiple spacecraft in low Earth orbit.

Extensive networks of tracking stations have been established around the world in present tracking techniques to obtain relatively complete global tracking coverage for low-orbit spacecraft. Such networks are costly in terms of the instrumentation and the manpower involved in the operation. Also, because of the geographical location of the stations, these networks are unable to provide adequate coverage of spacecraft in some orbits.

The T&DRSS would help solve many of these problems. Such a system could perform many of the key functions of the ground-based tracking stations, thus reducing the instrumentation and manpower requirements. In addition, each synchronous-orbit spacecraft in the tracking system would be able to track a particular spacecraft for a much longer period of time than an Earth-based station. This would reduce the difficulties involved in sequential tracking by multiple ground stations.

For either the Nimbus-F or the GEOS-C experiment, ATS-F will be commanded first by the ATS ground station at Rosman, N.C., to point at and lock onto one or the spacecraft orbiting beneath it. Tracking signals will then be transmitted from Rosman to the ATS-F communications transponder for retrans-

SATELLITE-TO-SATELLITE EXPERIMENT CONFIGURATION



mission to the ATS-F communications transponder for retransmission to the target spacecraft and return over the same route. By comparing the transmitted and received signals at Rosman as a function of time, the range and range rate of the tracked spacecraft can be determined.

The GEOS-C will be equipped with a radar altimeter, cubed-corner reflectors used for LASER tracking, a Doppler transponder, and C-Band radar transponders. Consequently, the orbit of this spacecraft can be determined with high precision for geodetic purposes.

Principal Investigators: Dr. Friedrich F.O. VonBun, Goddard Space Flight Center, Nimbus-F experiment; H. Ray Stanley, NASA/Wallops Station, GEOS-C experiment.

TECHNOLOGY EXPERIMENTS

Very High Resolution Radiometer Experiment

This experiment is designed to evaluate (1) new concepts in meteorological and weather data collection and analysis by means of a synchronous weather satellite and (2) new camera systems aboard stabilized spacecraft. It also will provide information used for Earth albedo measurements and ocean temperature studies.

Located in the Experiments Module, the radiometer will provide both visible and infrared images of day and night cloud cover over about one-fifth of Earth. Information from these images will be used for the determination of cloud motions, storm life cycles, small scale phenomena such as thunderstorms, etc., and cloud climatology studies.

Operating through an eight-inch Cassegranian telescope, the radiometer generates an image in 20 minutes with resolutions of 5.5 kilometers (3.4 miles).

Data collected with this radiometer will be recorded on magnetic tape and selected frames will be supplied to the Principal Investigator in near real-time. Data reduction and analysis will be accomplished by means of a combination of digital computer and photo imaging techniques.

Principal Investigator: William E. Shenk, Goddard Space Flight Center.

Radio Frequency Interference Experiment

The major purpose of this experiment is to investigate the mutual Radio Frequency Interference (RFI) in the six-gigahertz common carrier frequency band shared between spacecraft and terrestrial telecommunications systems.

Information gained from this experiment will provide for more effective use and regulation of radio transmissions. It will thus aid the development and implementation of advanced spacecraft communications systems.

For this experiment, ATS-F's nine-meter parabolic antenna will be used to collect microwave RF signals in the 5925 to 6425 megahertz frequency bands that reach the synchronous-orbit altitude from Earth. These signals will be transmitted to a wide-band RFI transponder (500 megahertz) onboard the spacecraft, automatically converted to a four megahertz signal, and relayed to the ATS ground station at Rosman, N.C. At Rosman the signals will be fed to a computerized receiver analyzer for initial data processing and recording prior to delivery to Goddard for final analysis. All other communications systems on the spacecraft will be turned off during the RFI experiment to minimize local interference.

Initially, ATS-F will scan the entire U.S. to identify "hot spots" of RFI. Than a narrow-band analytical system will be used to determine the frequency, power level, and the geographic location of each area of interference. By positioning the nine-meter antenna such that its "shadow" c covers the hot spot from three different angles, triangulation techniques can be used to pinpoint locations within an area of 16 kilometers (10 miles) radius.

Principal Investigator: Varice Henry, Goddard Space Flight Center.

Millimeter Wave Propagation Experiment

The central objective of this international experiment is to evaluate the effects of Earth's atmosphere on space-to-Earth communications signals centered at the frequencies of 20 to 30 gigahertz, primarily during heavy precipitation such as rain, hail, or wet snow. Data collected from this experiment is expected to aid in the design of future space systems operating in the millimeter-wave bands -- 10 to 300 gigahertz.

Most present terrestrial and space communications are operated in the frequency bands below 10 gigahertz. These frequencies are rapidly becoming overcrowded, and the increasing communications demands of our expandind society require the systems designer to look toward higher frequencies. While the millimeter-wave bands offer a promising area to alleviate this crowding, these frequencies can be more severely effected by adverse atmospheric conditions than the lower frequencies.

During this experiment, signals will be generated by ATS-F's millimeter-wave experiment system and recorded on Earth by a number of special ground stations located in the U.S. and Canada. Weather conditions also will be monitored at each station.

ATS-F's millimeter-wave experiment package essentially consists of four traveling-wave-tube transmitters tuned to the 20 and 30 gigahertz frequencies and each developing two watts of power. Two antenna systems located on the EVM are used for this experiment. One of the antennas is a narrow-beam unit which will be used to direct wide band signals such as TV to specific locations. The other is a horn antenna designed to cover the U.S. and Canada for multi-station participation.

The primary ground station for this experiment is located at the ATS ground station near Rosman, N.C. It consists of a 4.6-meter (15-foot) diameter parabolic reflector coupled to lownoise receivers tuned to 20 and 30 gigahertz frequencies. Also included are weather radars, radiometers, rain gauges, and other meteorological equipment to monitor the weather conditions at the site.

Other ground stations are presently planned for the following locations:

Austin, Texas -- University of Texas

Blacksburg, Va. -- Virginia Polytechnic Institute and State University

Clarksburg, Md. -- Comsat Corp.

Columbus, Ohio -- Ohio State University

Ft. Monmouth, N.J. -- U.S. Army Satellite Communications Agency

Greenbelt, Md. -- Goddard Space Flight Center

Holmdel, N.J. -- Bell Telephone Laboratories

Ottawa, Canada -- Communications Research Centre

Richland, Wash. -- Battelle Northwest Laboratories

Waldorf, Md. -- Naval Research Laboratories

A number of European countries and India have expressed interest in participating in this experiment during the spacecraft's second year of operation while ATS-F is located over Africa at the equator.

Each ground station will record and process its own propagation data to develop detailed statistics on signal attenuation and amplitude and phase effects caused by adverse weather. Data collected by the Rosman station will be transferred to Goddard via wide-band data line for processing and evaluation.

Principal Investigator: Louis Ippolito, Goddard Space Flight Center.

COMSAT Propagation Experiment

This experiment will gather data on satellite signal attenuation, caused by atmospheric hydrometeors (mostly rain), at ground stations located in different climatological areas throughout the U.S. The data will be most useful in determining parameters needed for future spacecraft communications systems operating at frequencies in the millimeter-wave range.

Transmitting terminals, a spacecraft ransponder, a receiving terminal, and data reduction equipment comprise the principal elements of the experiment.

The 24 transmitting terminals will transmit a total of 39 randomly staggered carriers in the 13- and 18-GHz bands. The transponder will receive signals from the transmitting terminals, translate them to approximately 4 GHz, and then retransmit them. The receiving terminal and data reduction equipment will receive the 4-GHz signals, separate theindividual carriers, and record the carrier powers for future analysis.

There will be 24 transmitting terminals (15 dual-frequency and 9 diversity) located throughout the eastern half of the United States. The dual-frequency terminals will be spaced at least 160 km (100 miles) apart and will transmit signals around 18 GHz. These transmitting terminals are being installed now.

The transmitting terminals consist of a parabolic-reflector-type antenna (positioned manually), a power amplifier, a frequency generator, a power-monitoring system, a rain gauge, a strip-chart recorder, and an auxiliary power system.

The transponder is a single-frequency conversion repeater with separate inputs at 13 and 18 GHz. Its combined outputs will be amplified and retransmitted at 4.150 GHz. The transponder consists of redundant 13- and 18 GHz frequency translaters, two bandpass filters, a combiner hybrid, two 3-stage tunnel diode amplifiers, and two traveling-wave-tube amplifiers. The transponder has been delivered to NASA and is installed in the spacecraft.

The receiving terminal will be located at Andover, Maine and will consist of the horn antenna, a low-noise amplifier, a calibration unit, and a down-converter unit, and will receive amplify, and convert the signals to the 70-MHz range. The converted signals will be processed and converted to DC voltages which are proportional to the input power of the received carrier signal. These signals will be scanned and applied to the data acquisition section which calculates the power of each carrier ignal and records it on ma netic tape. These magnetic tape recordings can be processed on any large computer and displayed on a teletypewriter to permit a statistical comparison between the measured attenuation at a site and general meterological parameters such as rainfall rate, number of thunderstorm days, and total precipitation. The data analysis will be performed at COMSAT Labs.

Principal Investigator: Goeffrey Hyde, COMSAT.

Cesium Bombardment Ion Engine Experiment

The primary objective of this experiment is to obtain and verify operational data on the use of an ion microthruster electric propulsion system aboard spacecraft for stationkeeping and attitude control maneuvers.

The experiment flight hardware consists of two identical cesium ion thrusters, each weighing about 16 kilograms (35 pounds) and requiring less than 150 watts of power. Each unit has a thrust capability of one one-thousandth of a pound.

The two systems are mounted in the EVM and aligned such that their undeflected thrust vectors pass through the spacecraft's center of mass, normal to the roll axis. This propulsion system will be used on ATS-F for north-south station keeping orbital maneuvers.

Principal Investigator: Dr. Robert E. Hunter, Goddard Space Flight Center.

Advanced Thermal Control Flight Experiment

This experiment will evaluate the performance of several new thermal control devices for stabilizing the temperature of spacecraft components. Simpler and more effective thermal control techniques for future space applications could result from the knowledge gained.

In essence, this experiment is designed to control the temperature of an equipment package subjected to heat dissipated from a simulated electrical component during a normal duty cycle. Solar energy will be used as the energy source in lieu of an electrical component.

Solar energy will be collected while the spacecraft is in sunlight by an absorber located on the east side of the EVM.

This energy will be transmitted through a one-way thermal diode (heat pipe) to the equipment package, which houses a heat reservior consisting of a container of paraffin. Once the paraffin melts at 28 degrees Centigrade (72°F), the excessive heat reaching it will be transmitted via a feedback-controlled, variable-conductance heat pipe to a space radiator located on the east side of the EVM.

The rate of heat removal is controlled electronically by the reservoir temperature, hence the term "feedback control."

When the spacecraft is in Earth's shadow, the heat contained in the reservoir will maintain the temperature of the simulated equipment package within the proper temperature range.

Principal Investigator: John P. Kirkpatrick, NASA/Ames Research Center.

Spacecraft Attitude Precision Pointing and Slewing Adaptive Control Experiment

The primary objective of this experiment is to evaluate the feasibility of a computer-controlled ground system for long term attitude control and determination as well as orbit determination of a geosynchronous spacecraft via radio command and telemetry.

For this experiment, a ground-based computer is programmed to put ATS-F through a series of attitude maneuvers utilizing the spacecraft's Radio Frequency Interferometer, the Attitude Control System, and the Spacecraft Propulsion System. These include precision pointing to fixed targets, slewing between targets, tracking of moving targets, and the generation of prescribed ground tracks.

This experiment is expected to lay the necessary foundation for the development of future ground-based spacecraft control systems which would perform many of the essential functions now performed onboard the spacecraft. As a result, reliability could be improved because the ground-based systems could be repaired or replaced in case of malfunction. Further, the weight and space savings resulting from smaller onboard control systems could be used for redundant or improved power and sensor systems.

Future ground-based control systems could provide more versatility in that new tasks could be programmed and performed as requirements or technology changed.

Principal Investigator: William C. Isley, Goddard Space Flight Center.

Radio Beacon Experiment

This international experiment is designed to provide data for studies of the effects of particles on radio signal propagation beyond the Earth's atmosphere. Such investigations not only increase man's scientific knowledge about the space environment, but provide designers with vital data necessary for the development of new communications systems.

The Radio Beacon experiment package, contained in the EVM consists of a low-power, three-frequency transmitter and an array of whip antennas. Each transmitter is amplitude modulated by one or two frequencies and is driven by a common oscillator. Signals will be generated at 40, 140, and 360 megahertz frequencies.

Research organization from a number of countries will conduct studies of the radio beacon using ground receivers based on a unit designed by the National Oceanic and Atmospheric Administration. Ground stations ranging from computer-controlled to simple manual units will be located at points in North and South America, Europe, the Middle East, India, and Africa. Many of the units are mobile and will be moved from continent to continent to keep the spacecraft in sight when its orbit is shifted along the equator.

Principal Investigator: K. Davies, NOAA, Environmental Research Laboratories, Boulder, Colo.

Environmental Measurements Experiments (EME)

The EME package consists of eight experiments carried on top of ATS-F to view deep space. This location separates the EME from Earth Viewing Module and the interference from power and communications signals generated there.

Primary purpose of the EME is to collect information on the spacecraft environment at the synchronous altitude as well as on electromagnetic-ionospheric interactions.

The EME experiments are:

1. Low Energy Proton-Electron

This experiment measures electrons and protons in the energy range from 2 Kev to 22 Kev. Among other things, this experiment will study intensity time fluctuations of low-energy electrons and protons when enhanced solar wind might push the subsolar magnetospheric boundary into the geostationary orbit.

Principal Investigator: Dr. Roger L. Arnoldy, Public
U. of New Hampshire, Durham, N.H.

2. Low Energy Protons

This experiment measure protons from 20 Kev to 201 Mev as well as alpha particles and various ion energies. It is designed to determine where in local time protons are injected into the magnetosphere and how closely in time such injections are associated with auroral substorms.

Principal Investigator: Dr. T. Fritz,
NOAA, Boulder, Colorado.

3. Solar Cosmic Ray

This experiment is designed to study solar cosmic rays, their entry and propagation within the magnetosphere, and to measure detailed parameters of trapped electrons, both as functions of local time in orbit.

Principal Investigator: A.J. Masley,
McDonnell-Douglas Aircraft Corp., Huntington Beach, California.

4. Auroral Particles

The primary objective of this experiment is to map the directional distribution and energy spectrum of low-energy (1 ev to 80 Kev) electrons and protons on a constant line of force so that correlation studies between these particle fluxes and the visible aurora can be conducted to determine the nature of the accelerating mechanism in the magnetosphere.

Principal Investigator: Dr. Carl E. McIlwain,
U. of California, San Diego, California.

5. Particle Acceleration Measurement

This experiment willinvestigate the origin of the Van Allen radiation belts encircling Earth. Protons from 20 to 500 Kev and electrons from 20 to 40 Kev will be studied. Measurements will be made of the intensity and time variations of these particles in the vicinity of the synchronous orbit. Detailed analysis of these variations in their relationship to polar and magnetic storms and other pertubations of the magnetosphere also will be made. Such analysis will advance existing knowledge of magnetospheric dynamics of acceleration and modulation processes.

Principal Investigator: Dr. John R. Winkler,
U. of Minnesota, Minneapolis, Minn.

6. Magnetometer

This experiment will provide data for a study of the properties of various magnetohydrodynamic phenomena in the magnetosphere and its tail and for use by the other experimenters.

Principal Investigator: Dr. Paul J. Coleman, Jr., U of California, Los Angeles.

7. Omnidirectional Spectrometer

The purpose of this experiment is to measure the omnidirectional fluxes and spectra of electrons and protons. Protons from 2 to 60 Mev will be counted as will electrons of energies greater than 150 Kev, 700 Kev, 1.4 Mev, and greater than 3 Mev.

Principal Investigator: G.A. Paulikas, Aerospace Corp., Los Angeles.

8. Solar Cell Radiation Damage

This experiment is a continuation of previous ATS engineering atudies into solar cell degradation mechanisms associated with current production solar cells. Eighty solar cells are mounted individually on the experiment. A solar aspect sensor on the EME insures that the sun is normal to the test cells at the time of measurement.

Principal Investigator: W. Dunkerly, Hughes Aircraft Co., El Segundo, California.

International Magnetospheric Relay

The primary objective of this international experiment is to collect simultaneous data on Earth's geomagnetic field from a synchronous world-wide network of Earth-based magnetometer stations operated concurrently with the EME magnetometer onboard ATS-F. Information collected with ATS-F during this experiment will be used for studies of the processes by which the solar wind interacts with Earth's magnetosphere (atmosphere and magnetic field).

This experiment will be conducted during the spacecraft's second year of operation while it is located at 35 degrees east longitude on the equator over the eastern edge of Lake Victoria in Kenya, East Africa. It will require the cooperation of a number of research organization in Africa, the Middle East countries, and Europe. The USSR's Institute of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation in Moscow is a major participant.

World-wide sets of geomagnetic measurements are difficult to collect using conventional techniques because of timing uncertainties, the multiciplicity of recording techniques, and the differences in the measuring instruments. The most serious difficulty results from the fact that many such measurements are recorded on film and charts that are difficult to convert into forms suitable for computerized methods of analysis and display.

The mobile ATS ground station near Madrid, Spain, will control the magnetometer stations by means of command signals relayed through ATS-F's EME telemetry frequency. Timing signals necessary for the synchronization of the magnetometer stations will be generated by the EME clock and included with the command signals on the telemetry frequency.

Synchronized geomagnetic measurements made at the magnetometer stations will be radioed to ATS-F on individual assigned frequencies for instantaneous relay to the Madrid station and ultimate delivery to Goddard. At Goddard, the measurements will be integrated on a single computer tape that will be sent to the participating investigators for analysis.

Principal Investigators: Dr. Paul J. Coleman, Jr., U. of California, Los Angeles.

SPECIAL INVESTIGATORS

Spacecraft Vibration Accelerometer

This experiment will provide data for use in updating the analytic model of the ATS-F spacecraft as well as for detecting and diagnosing anomalies during powered flight. It will be used further as an aid in the design of future spacecraft to be launched by the Titan III-C alunch vehicle.

For this experiment, three vibration accelerometers are mounted on the spacecraft in the area of the reflector hub on the top of ATS-F. Two of these will sense spacecraft m movement in a lateral direction and one willsense such movement in the vertical direction. An additional accelerometer is mounted on the Titan III-C third stage for sensing vertical movement.

All information from the accelerometers will be telemetered via the launch vehicle to ground stations and delivered to Goddard for analysis.

Quartz Crystal Microbalance Contamination Monitor

The primary objective of this experiment is to provide data on the existence of contaminants on ATS-F. This is done by the use of a wuartz crystal microbalance (QCM) that measures extremely small mass accretions. ATS-F, being stabilized, permits the QCM to be mounted on a face that views space, and it therefore is designed to run at temperatures around 200 degrees Kelvin (minus 100^{0}F). Sources of possible contaminants on the spacecraft, in addition to general outgassing, include the ejecta from the spacecraft propulsion subsystems and propulsion experiment.

The experiment flight hardware consists of a sensor assembly mounted externally on the north face of the EVM and an electronic unit mounted internally on the same face. The sensor assembly contains the sensing and reference oscillating quartz crystals, heaters, and the electronic driving circuitry for the crystals. The design goal temperature of 200 degrees K for the crystals is obtained by the use of optical solar reflectors for external thermal control and thermal insulators for mounting structures. The electronic unit contains the signal-processing, temperature-control, and command circuitry.

Television Camera

A subminiature television camera is mounted inside the EVM with the lens attached through a hole in the prime-focus feed plate to provide a view of the nine-meter (30-foot) parabolic reflector. Its primary purpose is to verify that the reflector is properly deployed and indicate possible anomalies such as tears, holes, folds, and other distortions. Its secondary purpose is to determine periodically any change in the status of the reflector. This information will be u used in operating and analyzing the communications system.

The TV camera is controlled by ground command and uses the communications subsystem wide-band data unit to transmit pictures to the ground. Deployment of the nine-meter parabolic antenna will not be viewed by this camera.

Interferometer High Data Rate Acquisition System

The purpose of this system is to provide the Spacecraft Attitude Precision Pointing and Slewing Adaptive Control (SAPPSAC) experiment with data for the long-term evaluation of spacecraft vibrations, flexible motions, and thermal distortions as well as for calibrating the spacecraft's interferometer in flight. This system also will provide spacecraft controllers with capability for a quick look at spacecraft vibration so that corrective action can be taken if necessary.

Spacecraft motion data generated by the interferometer is fed through a high-speed data link and transmitted at C-band downlink frequency to the Interferometer High Data Acquisition System located at the Rosman, N.C., ATS ground station. The raw data is recorded on a digital tape for quick-look and long-term analysis.

The high data rate capability of this system permits the determination of selected bias errors that influence the accuracy of attitude determination using an interferometer. Once bias errors are identified, this information is used to update the SAPPSAC interferometer mathematical model.

The detection and control of vibration is important to the ATS-F mission because such vibration could affect the performance of experiments that call for a highly stable and precisely oriented platform in space.

TITAN III-C LAUNCH VEHICLE

The ATS-F launch agency for NASA is the Space & Missile Systems Organization (SAMSO) of the Air Force Systems Command, El Segundo, Calif. Assembly, check-out, and launch will be performed for NASA by SAMSO's 6555th Aerospace Test Group at the Eastern Test Range. Prime contractor to the Air Force is Martin Marietta Aerospace, Denver, Division.

The Titan III-C consists of a three-stage liquid-propellant core vehicle supplemented by two solid rocket motor (SRM) strap-ons. The complete four-stage launch vehicle (less payload and fairing) has an overall length of approximately 34 meters (110 feet) and a liftoff weight of .6336 million newtons (1.4 million pounds).

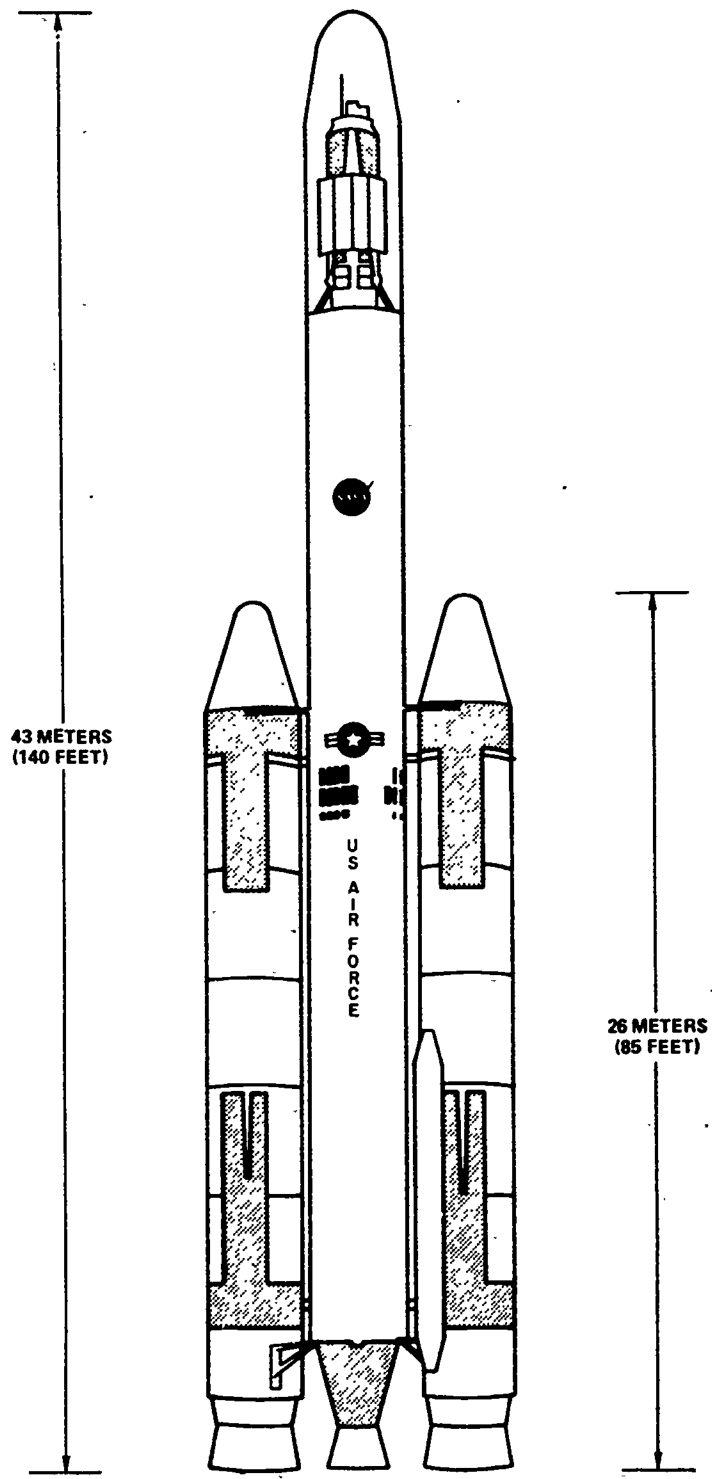
Stage 0 consists of two identical SRMs, mounted 180 degrees apart on the core vehicle. The SRMs lift the vehicle off the launch pad with a thrust of approximately 5.34 million newtons (1.2 million pounds) each.

First and second stages consist of the basic Titan III with structural modifications to provide for increased loads. The third stage (transtage) was a new development designed especially for use with Titan III Stage I and II.

The Stage I engines develop about 1,957,300 newtons (440,000 pounds) of thrust at sea level or 2,313,170 newtons (520,000 pounds) when ignited at altitude. The Stage II engine develops 494,840 newtons (100,000 pounds) of thrust at altitude.

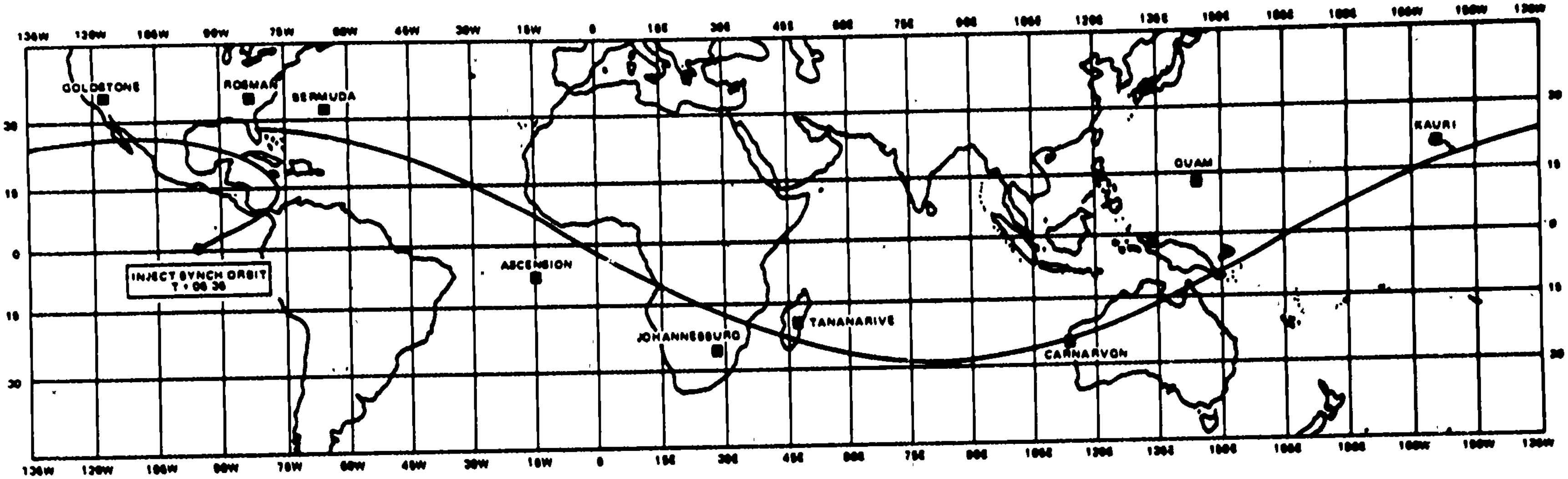
The Stage III engines develop a total thrust of 71,174 newtons (16,000 pounds) and have a total burning time capability of more than seven minutes.

A flight control system stabilizes the attitude of the Titan III-C in all phases of flight from launch through payload separation. This system established the flight path of the launch vehicle by implementing all steering commands issued by an Inertial Guidance System (GS). The IGS consists of a missile guidance computer and an inertial measurement unit which is a derivative of the Carousel IV, widely used on commercial aircraft.


43 METERS
(140 FEET)
US AIR FORCE
26 METERS
(85 FEET)

SEQUENCE OF EVENTS

Events	Time after Liftoff (Hours, Minutes, Seconds)
Liftoff with solid rocket motor ignition	00:00:00
Stage I ignition	00:01:49
Jettison solid rocket motors	00:02:01
Stage II ignition	00:04:16
Stage I jettison	00:04:17
Jettison payload fairing	00:05:05
Stage II shutdown	00:07:44
Jettison Stage II; injection into parking orbit	00:08:00
Orient for first burn of transtage (Stage III)	01:12:11
Transtage ignition	01:12:26
Transtage cutoff; injection into transfer orbit	01:17:37
Transtage second ignition	06:36:56
Transtage cutoff; injection into synchronous orbit	06:38:45
ATS-F separation from transtage	06:41:37
Begin solar array release	06:47:37
Complete solar array release	06:48:37
Begin nine-meter reflector deployment	07:03:07
Complete nine-meter reflector deployment	07:04:07
Begin transtage retro maneuver	07:08:44
Complete transtage retro maneuver	07:09:44
Begin final solar boom motion	07:10:07
Complete final solar boom motion	07:10:29
Sun acquisition in pitch and yaw axes	About one hour after full deployment
Earth acquisition in roll and pitch axes	About 12 hours after sun acquisition
Polaris acquisition in yaw axis	About 3 days after launch



TRACKING STATION	TRACKING TIME FROM LIFTOFF (HOURS:MINUTES:SECOND)		
BERMUDA	00:01:01	TO	00:02:00
ASCENSION ISLAND	00:21:01	TO	00:27:00
JOHANNESBURG, S.A.	00:31:01	TO	00:39:00
TANANARIVE, MALAGASY REPUBLIC	00:33:01	TO	00:44:00
CARNARVON, AUSTRALIA	00:50:01	TO	01:06:00
GUAM, MARIANAS ISLAND	01:07:01	TO	01:14:00
KAUAI ISLAND, HAWAII	01:18:01	TO	01:36:00
GOLDSTONE, CALIFORNIA	01:27:01	TO	06:35:00*
ROSMAN, N.C.	01:33:01	TO	06:35:00*

* INJECTION INTO SYNCHRONOUS ORBIT

ATS-F LAUNCH TRAJECTORY GROUND TRACK

SEQUENCE OF LAUNCH AND ORBIT EVENTS

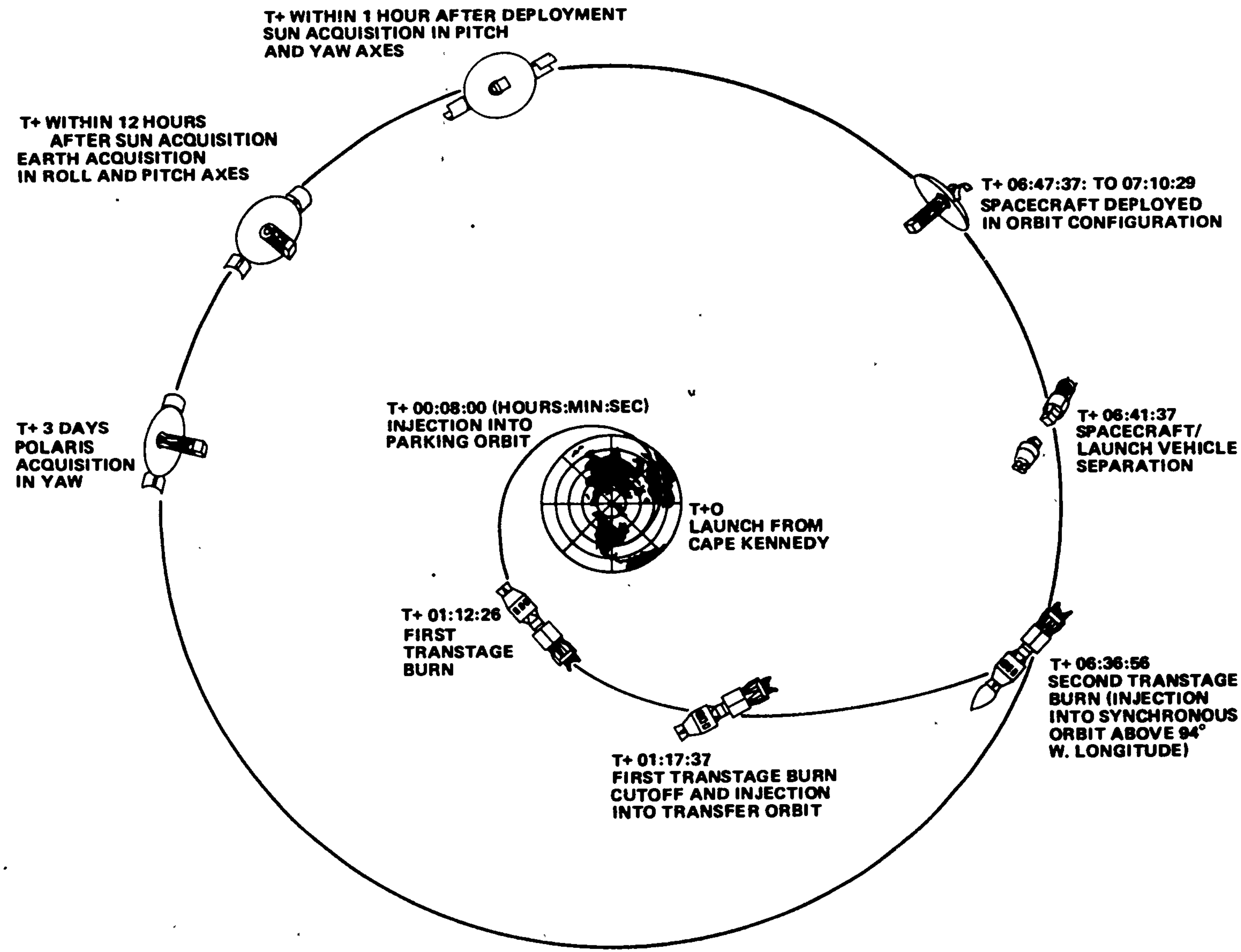
ATS-F will be launched from Launch Complex 40 of the Eastern Test Range at Cape Canaveral, FL, aboard a Titan III-C launch vehicle. The launch azimuth is 93 degrees (slightly south of east).

The initial operating station for the spacecraft is a geostationary orbit over the equator at 94 degrees west longitude, a point over the Galapagos Islands, about 965 kilometers (600 miles) off the coast of Ecuador. The geostationary orbital altitude is 35,680 kilometers (22,300 miles). In this orbit ATS-F will match the Earth's rotational period and remain over the same spot of the globe until moved.

About a year after launch, ATS-F will be repositioned to 35 degrees east longitude, over Lake Victoria in Kenya to support the Indian Government's educational TV broadcast to about 5,000 Indian villages.

From the launch pad, the spacecraft will be boosted initially into a parking orbit of approximately 152 by 871 kilometers (95 by 541 statute miles). At its first northerly crossing of the equator, about 75 minutes after launch while over the Pacific Ocean, a short burst from the Titan's third stage will place the spacecraft into a transfer orbit with an apogee (high point) equal to the geosynchronous orbit altitude of 35,680 kilometers (22,300 miles). When the spacecraft reaches apogee, about six and a half hours after launch, the third stage will be reignited for insertion into the synchronous orbit at a point above 93 to 98 degrees west longitude on the equator. Minutes later, the ATS-F spacecraft will be separated from the Titan III-C third stage by a spring mechanism, and the third stage will retro-fire to increase the distance between it and the valuable spacecraft ready to begin its deployment sequence.

First the solar arrays will be deployed, followed by the nine-meter deployable reflector. Then commands will be sent to the various sensors to acquire sequentially the sun, Earth, and the North Star (Polaris). While the sun sensor provides initial orientation for the spacecraft's attitude control system, the Earth sensor output provided this system with information for roll and pitch control and the Polaris sensor provides the yaw axis control input.

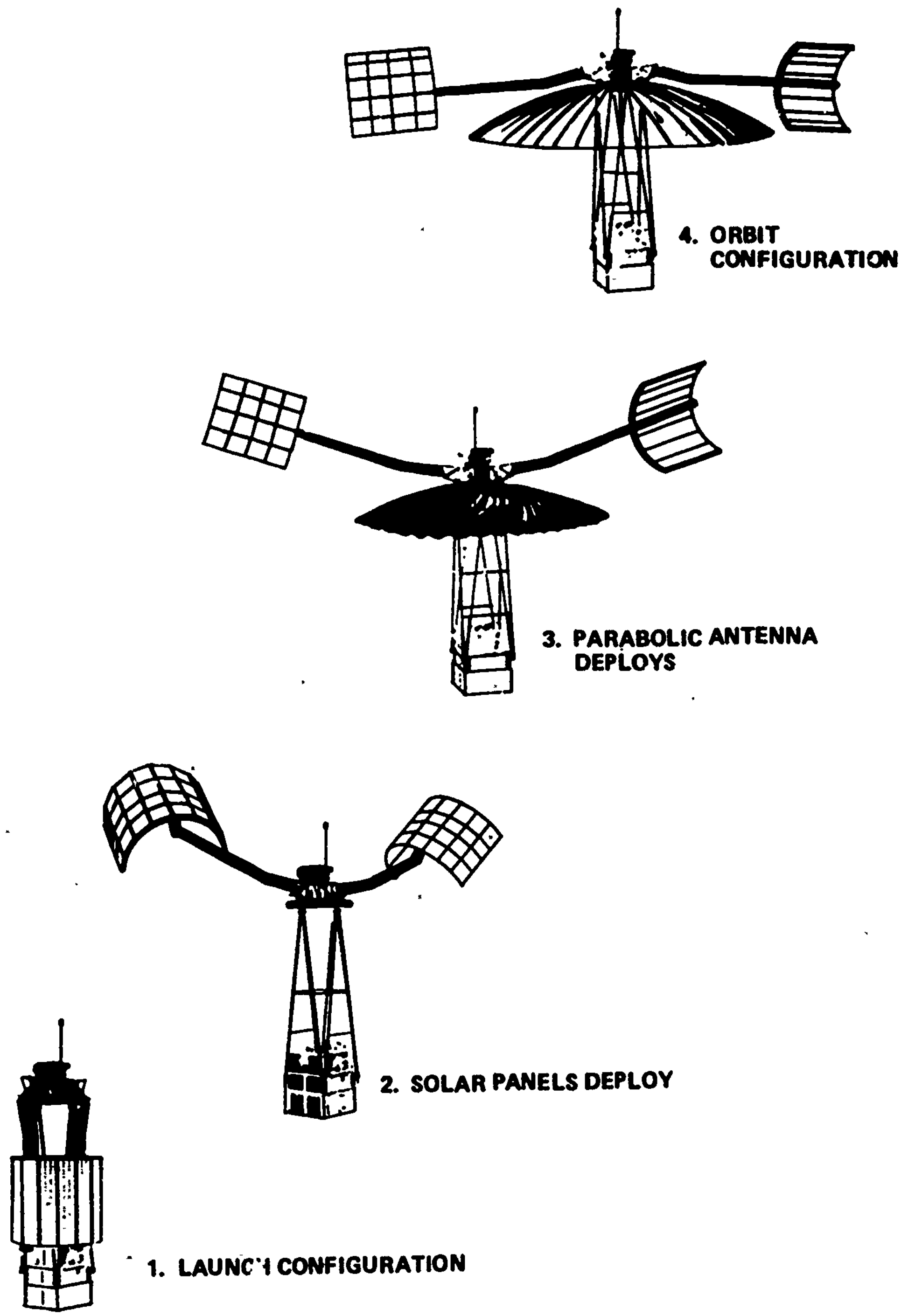


ATS-F LAUNCH AND ORBIT SEQUENCE

After stabilization, about four hours will be required for ground controllers to determine accurately the spacecraft's orbit. Based on this information, commands will be transmitted to the spacecraft to make the necessary orbit corrections. Due to the limited thrust avaialble from the spacecraft's propulsion system, it may take as much as one week to correct the orbital position to 94 degrees west longitude.

Once the orbit has been determined and corrected, as many as 30 days may be needed to check ATS-F's systems, even though some tests can be made during the orbit correction maneuvers.

The launch window on May 30 is 9:00 to 9:31 a.m. EDT.



ATS-F DEPLOYMENT SEQUENCE

ATS-F OPERATIONS CONTROL AND TRACKING

All spacecraft operations are controlled by the ATS Operations Control Center (ATSOCC) at the Goddard Space Flight Center, Greenbelt, Md. In addition to coordinating all experiment requirements, the ATSOCC schedules spacecraft operations and the activities of the participating ground stations.

Three ATS ground stations provide the main support for the ATS-F operations. All these stations are located at sites of NASA's Space Tracking Data Network (STDN), a global network maintained by Goddard for tracking and acquiring data from manned and unmanned spacecraft.

The primary ATS-F ground station is located at the Rosman, N.C., STDN site near Brevard, N.C. The two secondary ATS-F ground stations are located at the Mojave STDN site on Goldstone dry lake near Barstow, California. One is a fixed terminal like Rosman and the other is a transportable unit.

All three stations have the same basic performance and evaluation capabilities as well as identical communications, telemetry, and control functions.

The transportable unit will first be checked out at the Mojave location for several months after launch of ATS-F and then be moved to the Madrid, Spain, site of the STDN to support the Satellite Instructional Television Experiment, to be conducted in cooperation with India about a year after launch, and other experiments.

The world-wide STDN will be used to track ATS-F during launch and until the spacecraft reaches the synchronous altitude where the ATS ground stations will take over.

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ATS-F CONTRACTORS

Spacecraft Systems

Fairchild Industries, Germantown, MD -- Prime contractor for development, integration, and test of the ATS-F spacecraft.

Philco-Ford, Western Development Laboratories Division, Palo Alto, CA -- Development of the communications module.

IBM, Gaithersburg, MD -- Design and development of the telemetry and command system.

Honeywell Aerospace Division, St. Petersburg, FL -- Development of the attitude control system.

Lockheed Missile Space Center, Sunnyvale, CA -- Development of the nine-meter (30-foot) parabolic reflector.

Rocket Research Corp., Redmond, WA -- Development of the spacecraft propulsion system.

Hercules, Magna, VT -- Development of the parabolic reflector support truss.

Experiments

Bell Aerospace Co., Buffalo, NY -- Development of the L-Band Experiment.

Hughes Aircraft Co., Space and Communications Group, Los Angeles -- Development of the Radio Frequency Interference Experiment, the Solar Cell Radiation Damage Experiment of the EME package, and the spacecraft equipment for the Millimeter Wave Propagation Experiment.

ITT, Aerospace-Optical Division, Ft. Wayne, IN -- Development of the Very High Resolution Radiometer Experiment.

Martin-Marietta Corp., Orlando Division, Orlando, FL -- Development of the ground systems equipment for the Millimeter Wave Propagation Experiment.

Westinghouse Electric Corp., Defense and Electronic Systems Center, Baltimore-Washington International Airport, MD -- Integration of the Environmental Measurements Experiments package, integration of the ATS-F ground systems, and analysis of the Millimeter Wave Propagation Experiment data.

X rox Corporation, Electro-Optical Systems Division, Pasadena, CA -- Development of the Cesium Bombardment Ion Engine Experiment.

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