ATS

THE APPLICATIONS TECHNOLOGY SATELLITE

PROGRAM SUMMARY

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

TABLE OF CONTENTS

Section	Page
INTRODUCTION	1
SPACECRAFT	5
Description of System	5
Power System	5
Command System	6
Telemetry System	6
Microwave Communication System	6
Thermal Control System	6
Reaction Control System	6
EXPERIMENTS	7
ATS GROUND SYSTEM	15
GROUND STATIONS	15
ATS Operations Control Center (ATSOCC)	18
ATS OPERATIONAL HISTORIES	19
ATS-B	19
ATS-A	23
ATS-C	23

ATS SUMMARY - FIGURE LIST

Figure	Description	Page
1a	ATS-B (ATS-I after launch)	2
1b	ATS-C (ATS-III after launch)	2
2	ATS-A (ATS-II after launch)	3
3	ATS-D&E	3
4	Launch of ATS-I	5
5	Rosman Ground Station	16
6	Mojave Ground Station	17
7	Toowoomba Ground Station	18
8	First Photograph from Synchronous Orbit	20
9	Dawn-to-Dusk Series of Spin Scan Cloud Cover Photographs	21
10	Typhoon Sarah	22
11	AVCS Picture of Earth	23

LIST OF TABLES

TABLE		Page
1	ATS Launch Sequence	4
2	Applications Technology Satellite Experiments	14

ATS PROGRAM SUMMARY

FORWORD

There has long been a need for a short, yet comprehensive document describing the Applications Technology Satellite program. It is the intent of this summary to fill that need.

Ultimately five satellites will be launched which aggregately will contain in the order of forty experiments. The ground system to operate with the satellites consists of three NASA stations, and, at present, two participating foreign ground stations -- one in Japan and one in India. Obviously, in these few pages there can be no development in depth of such a complex laboratory.

INTRODUCTION

During the slightly more than two year period starting in 1966 and ending early in 1969, a unique series of five satellites will be launched into space to conduct some twenty major experiments and a number of related data gathering studies. These five spacecraft, called Applications Technology Satellites, will be expected to operate in orbit a minimum of three years. Each will continuously send back valuable information both on space and the unknown effects this far-away cold void may have on satellites (and soon our first "space travelers") and on the earth and its influence in space.

The Applications Technology Satellite (ATS) Program evolved directly from the Advanced Syncom study program. Its inception was necessitated by rapidly increasing requirements and technological advancements of space systems and concepts in various disciplinary areas. These include spacecraft design, propulsion and stabilization methods and systems; meteorological concepts, applications and techniques; space environmental studies and measurement systems; and communications concepts, techniques and applications.

The ATS program began with the termination of the Advanced Syncom program. The Advanced Syncom engineering design studies provides much of the base for the ATS. Syncom program techniques, especially for Synchronous Altitude, Spin-Stabilized configurations and complex synchronous orbit maneuvers, were adopted for the Synchronous Altitude Spin Stabilized flights.

There were several factors that led to the demise of Advanced Syncom. One factor, the newly formed Communication Satellite Corporation, was planning research projects identical to the Advanced Syncom program. Further, there were several individual NASA spacecraft programs which were being planned specifically for single or dual purpose experiments. These experiments include navigation, radiation detection, meteorology and communications, and a medium altitude gravity-oriented technological satellite designed solely to evaluate gravity-gradient stabilization.

The huge cost reduction and efficiency in consolidation of these multiple experiments into a single program became readily apparent. The Applications Technology Satellite program utilizing the Advanced Syncom as a base was born.

The uniqueness of this program can be seen in the words "Applications" and "Technology". The ATS, one of the largest groups of a single class of satellites to be spaceborne at the same time, are intended to collect and confirm data for various "technologies" having wide "applications" in space and space flight and in the daily lives of we earth bound creatures.

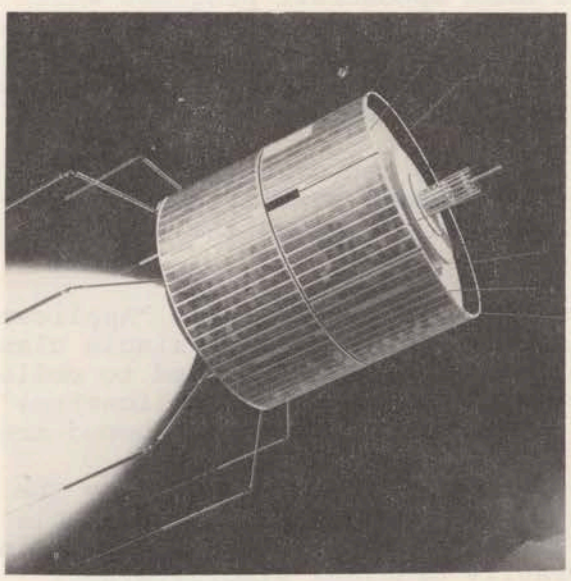
The underlying design philosophy of the ATS program has been the development of a multi-mission satellite having a large and adaptable volume for mounting the various experiment payloads, while still satisfying the requirements for either spin or gravity gradient stabilization.

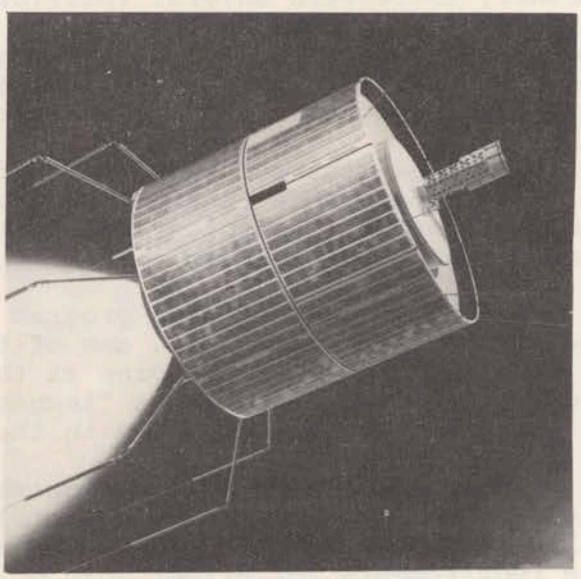
Of prime importance among the major experiments to be conducted are those concerned with the stabilization of the satellites by gravity

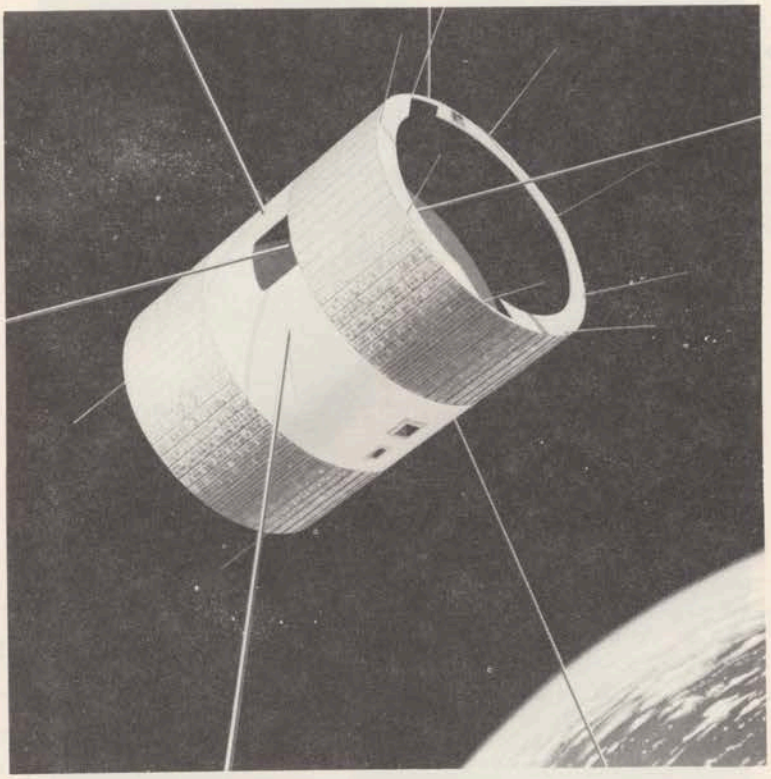
gradient techniques. The multiple-mission design concept allows for numerous different space and earth studies, plus experimentation with advanced satellite communication technologies.

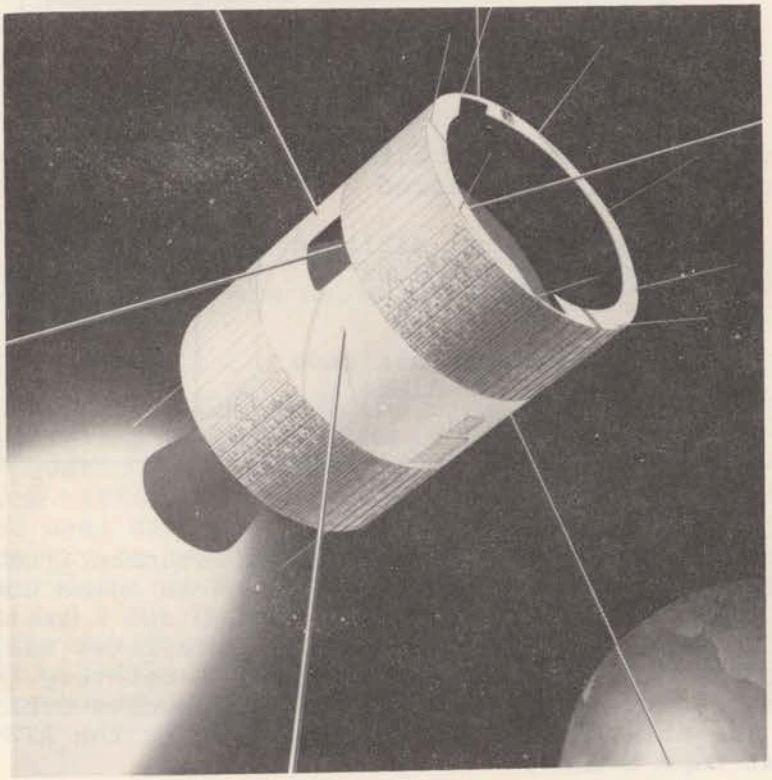
Participating with NASA at Goddard Space Flight Center in the design, development, fabrication, and testing of the five spacecraft that comprise the ATS family of satellites, have been many of the leaders and innovators in the space industry. Hughes Aircraft Company carries the prime responsibility for translating the designs into working hardware, with General Electric, Westinghouse, and the Jet Propulsion Laboratory assisting in special fields. Some of the individual experiments on board the spacecraft have been designed by, and are under the responsibility of, groups such as Westinghouse, the Geophysics Corporation of America, NASA Lewis Research Center, University of Wisconsin, the Meteorological Branch of the Goddard Space Flight Center, Sandia Corporation and Sylvania.

With performance, cost, and reliability in mind, the ATS spacecraft have been designed according to the two basic satellite configurations dictated by the two methods of stabilization to be utilized. The similarity between the two satellites stabilized by the gyroscopic effect of their spin, ATS-B and ATS-C, can be seen in Figure 1. The other three satellites, ATS-A, ATS-D and ATS-E, shown in Figures 2 and 3, follow the second design configuration and are stabilized by gravity gradient techniques. All five flight spacecraft are approximately 56 inches in diameter but vary in length from 53 to 72 inches and in weight from 650 to 775 pounds.









These five satellites will be launched separately into one of two planned orbits. Four of the five satellites will be boosted into an orbit in the plane of the earth's equator at an altitude of about 19,350 nautical miles. The speed of these satellites at that altitude will be synchronized to the rotational speed of the earth such that each will remain stationary above some point on earth. The other satellite (ATS-A) will be launched into an orbit inclined to the equator at an altitude of about 6000 miles. At this medium altitude, it will sweep around the earth about 4 times a day.

The ATS launch sequence is:

TABLE 1: ATS LAUNCH SEQUENCE

SPACECRAFT NAME	DESCRIPTION	LAUNCH DATE	LOCATION
ATS-B	Synchronous altitude (stationary) Spin Stabilized	Dec 7,1966	Over the Pacific
ATS-A	Medium altitude Gravity Gradient Stabilized	Apr 6,1967	N/A
ATS-C	Synchronous altitude Spin Stabilized	Nov 5,1967	Over the Atlantic
ATS-D	Synchronous altitude Gravity Gradient Stabilized	3rd Quarter 1968	Over the Atlantic
ATS-E	Synchronous altitude Gravity Gradient Stabilized	1969	Over the Pacific

All of the five ATS satellites will be launched from Cape Kennedy using the Atlas rocket as the first stage and an Agena booster for ATS-A, B and C and a Centaur booster for ATS-D and E as the second stage. All but ATS-A, the medium altitude satellite, will use the STARFINDER engine made by the Jet Propulsion Laboratory to get the extra boost necessary to put it into the synchronous orbit. Figure 4 shows one of the Atlas/Agena combinations lifting the ATS-I satellite off the pad at Cape Kennedy.

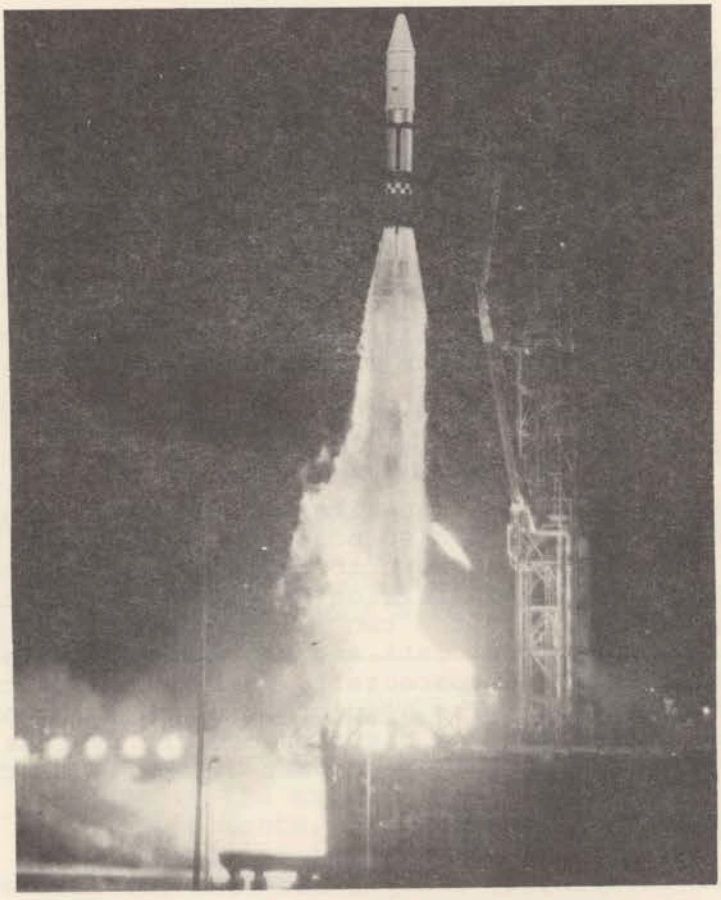


Figure 4. Launch of ATS-1

SPACECRAFT

Description of System

In addition to, and in support of, the payload of experiments, each spacecraft contains six basic support systems.

Power System

The electrical power necessary to operate and control all the other systems of the spacecraft comes from the arrays of silicon solar cells covering the outside of the satellite, and from the nickel-cadmium batteries within the spacecraft. The solar cell arrays can be used directly as the primary electrical energy source and/or indirectly to replenish the battery supply. The batteries provide a secondary source of power during occasional high power requirements and also during solar eclipse intervals when the solar cells are not receiving or producing any energy. The combination of solar cells, batteries, and the related power switching assemblies make up the power system.

Command System

The command system receives, decodes, and executes all the commands directed at the spacecraft by the various ATS ground terminal stations, thereby controlling all the various spacecraft systems and experiments. The actual system is made up of two command receivers and two command decoders. These decoders translate the command messages coming up to the satellite as combinations of signals of varying frequencies into pulses that can be used to control all the spacecraft functions. The command system also shares the use of the telemetry antennas and the spacecraft clock with the Telemetry System.

Telemetry System

This system encodes and transmits all the data being gathered by the operating experiments and also selected information about how the spacecraft is functioning down to the various ATS and STADAN (Space Tracking and Data Acquisition Network) ground stations on earth. This system includes the two telemetry encoders which take the spacecraft and experiment data and convert it into a form which can be transmitted from the spacecraft, four telemetry transmitters and the telemetry antenna. The spacecraft clock which provides timing reference pulses for the basic spacecraft systems and for the various experiments on board is also part of the telemetry system.

Microwave Communication System

This system, completely independent from the telemetry system, provides the ability to relay all types of wide band communications as well as to transmit any wide band experimental data originated on-board, such as the output of the meteorological television cameras. The system is made up of two transmitters, two receivers, a separate antenna system, and the necessary associated control subassemblies.

Thermal Control System

This system is provided to maintain the temperature of the equipment in the spacecraft within preset operational ranges. Two methods are used to control and vary these temperatures:

Passive Control: provided by proper insulation and thermal design and special coatings on the spacecraft exterior.

Active Control: provided by a temperature sensing system which automatically controls movable vanes covered with either high or low heat radiating coatings, exposing or covering them in variable increments.

Reaction Control System

To provide the various reactive forces necessary for spacecraft maneuvering and stationkeeping, five different types of reaction engines are used on board the spacecraft.

1) Cold nitrogen gas jet: used to give synchronous spacecraft the initial spin.

2) Hydrogen peroxide jets: the force of evaporating hydrogen peroxide is used for placing all synchronous spacecraft on station and for subsequent stationkeeping maneuvering of the spin-stabilized spacecraft.

3) Hydrazine: An advanced "state-of-the-art" system whose function is the same as the Hydrogen Peroxide System, which is flown for the first time on ATS-3.

4) Subliming solid jets: used to produce low pressure jet thrusting for long periods of time for inversion of the gravity-gradient spacecraft.

5) Resistojet engines: the force of vaporized ammonia through two opposed radial jets is used for east-west station-keeping maneuvers of gravity gradient stabilized space-craft at synchronous altitudes.

EXPERIMENTS

Each of the five satellites will carry as its payload a "package" of scientific instruments and experiments. In addition to the data received from these experiments, every piece of information concerning the operation of the satellite itself will be valuable engineering data, since the entire satellite and all its systems are really experiments in themselves. Such information on how the equipment on board is functioning is really engineering data which can be used to evaluate its design technology.

The actual experiments that are flown in the ATS have been carefully selected from a large number of proposals by a committee of space technology experts both from government agencies in NASA and from the space industries. This careful selection has provided NASA with the means of effecting some cost reduction and greatly improved efficiency in the execution of these experiments by eliminating individual and sometimes overlapping spacecraft programs.

These experiments can be classed into five groups according to experimental emphasis on what they are trying to investigate:

1) Meteorological experiments
2) Communications experiments
3) Spacecraft stabilization experiments
4) Other technological experiments
5) Environmental measurement experiments

The amount and worth of data and information expected to be obtained from the various experiments is immense and the ATS contribution to spaceflight technologies should prove invaluable due to the depth and breadth of the program.

From the data sent back to earth concerning the operation of the basic spacecraft themselves and their flights, valuable knowledge will be gained concerning:

- Performance and life to the spacecraft structures
- Performance and life of the power supply
- Technology and methods for placing large (700 lbs.) satellites in stationary orbits
- Performance and life of the spacecraft control subsystems
- Geodetic data (specifically with regard to improved knowledge of the location of the stationary orbit stable points)

From the stabilization experiments and especially from the gravity gradient satellites will come information for:

- Verification of the mathematical model of a gravity-gradient system at the 6000-mile altitude which will permit extrapolation of this technology to other altitudes
- Verification that the model and extrapolated results established by the medium altitude experiment are in fact valid at the 19,350 nautical mile altitude for stationary orbit

and also

- Precise data on the disturbing torques
- Effects of thermal bending of the booms
- Performance of the different damping systems
- Restoring ability and time constant of the system (obtainable from the spacecraft ability to produce predetermined disturbances)
- Precise data on the accuracy of such stabilization systems

From the communications experiments, information will be collected on:

- Performance and life of the communications transponder components
- Multiple access capabilities of Single-Sideband/PM systems
- Performance and life of two radically new high performance antennas for use on spinning satellites, the electronically controlled phased array antenna and the mechanically despun antenna

- Improved range and range rate measurements

From the meteorological experiments, data will be gathered on:

- The nature of short-lived meteorological phenomena since this experiment will provide continuous observation of the entire earth.

- Detailed observations of different parts of the earth's cloud coverage using the high resolution camera in an earth oriented synchronous satellite

- The movement, development, time variation and effects of clouds, and associated meteorological data

From the environmental measuring experiments, information will be returned from space on:

- Continuous radiation levels both at 6000-mile altitudes and at synchronous orbit altitude

- Radiation damage to various types of solar cells at both altitudes

- Evaluation of selected coating materials used for temperature control of the satellites

- Damage caused by the small "space dust" particles to reflective surfaces by erosion processes

- Measurement of the density, energy, and directivity of protons and electrons in space

- Measurement of the strength of the earth's magnetic field

Amoung the various experiments, those concerned with the stabilization of satellites by gravity gradient techniques both at medium and at synchronous altitudes, are of prime importance. In fact, one of the major purposes of ATS-A is to assess and analyze the operation of such a passive stabilization system at a medium altitude.

This concept is similar to the principle which causes the moon to rotate once during each orbit and thereby keep its "face" constantly toward the earth. Shortly after placement in orbit, the gravity-gradient satellite will extend four tip-weighted booms, each about 130 feet long. The weighted boom tips will interact with the earth's gravitational field to keep the spacecraft stable. Two television cameras will record bending of the booms and accurate sensors will detect spacecraft movements for evaluating the performance of this stabilizing system. If successful, such a system could keep a satellite continuously pointing toward the earth so that a TV camera or a communication antenna could be kept "fixed" on the earth without a gas jet control system with an inherently limited lifetime.

The meteorological experiments to be orbited as part of the ATS program are the outgrowth of carefully laid research and development planning aimed at continued expansion and improvement of weather satellite technology. Based and built on the proven global weather data collection and dissemination methods and equipment of the NIMBUS series satellites, the meteorological experiments include:

Advanced Vidicon Camera System -- AVCS utilizes two vidicon cameras and a tape recorder aboard the spacecraft to take both wide angle and high resolution pictures of the earth's cloud cover. These pictures can either be directly beamed down to earth as they are being taken, or stored on magnetic tape for later transmission.

Spin Scan Cloud Cover Experiment -- This experiment will demonstrate the feasibility and investigate the performance of a camera system using the satellite spin to scan the earth cloud cover picture. Instead of a vidicon tube, though, this camera has a simpler, more dependable photomultiplier tube as the light sensor, and the image is focused on its face by a high resolution telescope instead of a series of lenses. The first version will use one PM tube and take black-and-white pictures. The second version to be orbited will have PM tubes each with a primary color filter and will send back valuable pictures of the earth's cloud cover in natural color.

Image Dissector Camera Experiment -- This experiment utilizes a newly developed camera system to take cloud cover pictures from spin stabilized spacecraft. The camera scans one line of the television picture of the earth for each revolution of the satellite, producing a live-full-frame readout of a square area 6,040 nautical miles on a side in approximately 10 minutes.

Image Orthicon Camera Experiment -- This experiment uses a sensitive image orthicon tube and a set of lenses and movable mirrors to take pictures of various sections of the earth's cloud cover from a gravity gradient stabilized spacecraft. Combined with these "steerable" optics is a built-in light meter which controls a variable density filter mounted in front of the lens. This system allows for perfect camera exposure of earth scenes of varying brightness and is hence called the "day/night" camera.

Weather Facsimile Experiment -- WEFAX is an experiment utilizing the VHF equipment on board the satellite to relay weather maps and related information to and from the various weather stations around the world.

Omega Position Location Experiment -- the OPLE concept may be basically subdivided into two major areas of interest. The first being a position location system and the second an automatic information data transponder system. Both areas of interest use the same transponder and ground processing equipment. This experiment includes both areas of interest and employes a light weight automatic transponder with self-contained power source. Upon interrogation, the transponder transmits identification, physical location data and meteorological data, which is received and retransmitted by the spacecraft (ATS-C) VHF system to the ground receiving and data processing station. The meteorological data is provided to the transponder by sensor equipment

included with the transponder package. The location data consists of OMEGA navigational system signals, which are received and retransmitted by the transponder. The processed data provides: the transponder identification, its location, meteorological data and, through repeated interrogations and tracking, the rate of travel.

The communications experiments will investigate techniques and equipment for world-wide communication both in the VHF and in the microwave frequency bands. Based on information from, and subsequent refinements of, the communications systems of the Telstar, Relay, and Syncom satellites, the communications experiments include:

Microwave Communications Experiment -- This experiment will investigate the transmission of voice, television, telegraph, and digital data utilizing two unique systems. The first system utilizes a single-sideband transmitter (SSB) and phase modulator (PM) receiver in the "Multiple Access Mode" to simultaneously relay a large number of two-way telephone transmissions between any combination of participating ground stations. The second system is a high quality frequency-modulated (FM) system designed primarily for the relay of television or high speed digital data between two ground stations.

Antenna Evaluation Experiments -- The performance of two new antenna systems for SHF communications from spin-stabilized satellites will be investigated. The first antenna system is called a phased-array electronically despun antenna and makes it possible to concentrate the satellite's communication beam in the direction of earth, even though the satellite is spinning. The second antenna system to be tested accomplishes despinning of the antenna (to counteract the spacecraft spin) mechanically.

VHF Communications Experiment -- This experiment uses a VHF radio repeater to provide voice and teletype communications at VHF. In addition to the relaying of weather analyses (WEFAX), techniques and equipment will be investigated toward the establishment of reliable communications links at VHF. The propagation of VHF waves through the ionosphere will be studied, leading to the development of a unique navigation system using satellites as fixed radio "beacons". This experiment will be of great interest to airlines and their agencies which will be able to use such systems for instant computerized communications from ground to satellite to airplane, expecially over the oceans where adequate navigation and communications do not presently exist. Various other uses of this VHF equipment will include evaluation of the ground station performance.

Each of the other technological experiments on board the ATS is designed to efficiently evaluate the performance of some piece of vital space hardware. Some of these technological experiments are:

Millimeter Wave Propagation Experiment -- The Millimeter Wave Propagation Experiment will be performed using the fifth Applications Technology Satellite (ATS-E). The objective of this experiment is to statistically determine the propagation parameters that are important in characterizing wideband earth-space communication or data links at K_u and K_a bands. This objective will be accomplished by transmitting signals (at 15.3 and 31.65 GHz) between a synchronous altitude satellite

and various earth-terminals over a one year period in order to include effects of seasonal changes. Correlating the measured propagation effects with weather conditions derived from radiometric, radar, refractometer and rainfall measurements will permit predicting the performance of future links under various weather conditions.

Ion Engine Experiment -- The performance of various designs of ion engines will be investigated. Such low thrust propulsion systems will have future stationkeeping applications in the synchronous, gravity gradient stabilized satellites.

Reflectometer Experiment -- The gradual degradation of various mirror coatings by space dust and other influences of space will be measured by this experiment. These light reflecting coatings have wide application in light concentrators and mirrors.

Self-Contained Navigation System Experiment -- The Self-Contained Navigation System (SCNS) Experiment has two objectives. The principal objective is to test a self-contained satellite navigation system which requires no sightings on the planetary body about which it rotates. Navigation is achieved by sighting an ejected particle intermittently over a period of two or more orbits. Aside from the ejection of the test body, the sensor requires no moving parts for a spin-stabilized satellite. Theoretically RMS accuracies on the order of 5 miles in position are achievable for a synchronous satellite. A second and equally important objective is to test a novel sensor for spacecraft attitude determination. The sensor can provide three-axis attitude data through a solution of the equations of motion of a spinning spacecraft to an accuracy of 10 seconds of arc for each axis.

Nutation Sensor Experiment -- This experiment will measure the nutation of the spinning spacecraft to determine their suitability as stable platforms for meteorological applications. Some small nutations even in the range of hundredths-of-a-degree if not damped out could cause constraints for some types of photographic equipment.

The Environmental Measuring Experiments ride somewhat "piggyback" on the ATS, since they are scientific experiments and not technological in nature. Nonetheless, they are designed to measure many of the important facets of the orbital environment of the ATS spacecraft. Information received from these experiments will be added to the pool of scientific knowledge of outer space used by scientists and engineers in the space field for design and application of space hardware.

Since the radiation damage to the solar power plant of a satellite and to other components will vary greatly depending upon the number and energies of the electrons and protons bombarding them, many of the EME have been designed to measure the strength and spectral distribution of such fluxes (Ion Detectors). Other experiments (Electric Fields Measurements and Magnetometers) will measure the electric and magnetic fields surrounding the spacecraft. Special radio receivers will detect and measure various signals from outer space, including VLF "whistlers" and cosmic radio noise.

Included in the EME, although it is more technological in nature than the above experiments, is a solar-cell radiation damage experiment to measure how the current/voltage characteristics of many different types of solar cells are affected by space exposure. Similarly, there is also an experiment to measure the variation of the absorptivity-to-emissivity ratios of a set of surface coatings used in satellite thermal control.

A more detailed list of which experiments will be orbited on the individual Applications Technology Satellites is included as Table 2.

Table 2. Applications Technology Satellite Experiments

EXPERIMENT	SPACECRAFT				
	A	B	C	D	E
Microwave Communications	X	X	X	X	X
VHF Communications		X	X		
WEFAX (see also meteorology experiments)					
Ground to Aircraft					
Propagational Effect of VHF					
Navigational Systems					
STADAN Calibration					
Millimeter Wave Communications					X
Meteorological Experiments					
Spin Scan Cloud Cover Experiment (SSCCE)					
Black and white		X			
Color			X		
Advanced Videcon Camera System (AVCS)	X				
WEFAX		X	X		
Image Dissector Camera System (IDCS)			X		
OMEGA Position Location Experiment (OPLE)			X		
Image Orthicon Day/Night Camera				X	
Gravity Gradient	X			X	X
Antenna					
Phased Array		X			
Mechanically Despun			X		
Nutation Sensor		X	X		
Resistojet		X		X	X
Ion Engine			X	X	X
Reflectometer			X		
Self Contained Navigation System			X		
Environmental Measurements Experiments					
Omnidirectional Particle Telescope (UCSD)	X				X
Omnidirectional Particle Telescope (Aerospace)		X			
Particle Detector (BTL)	X				
Proton/Electron Spectrometer (U. of Minn.)	X				
Solar Cell Damage (GSFC - Dr. Waddel)	X	X			
Thermal Coatings (GSFC - J. Triolo)	X	X			
Ion Detector (Rice Univ.)		X			
Magnetometer (UCLA)		X			
VLF Detector (BTL)	X				
Cosmic Radio Noise (Dr. Stone)	X				X
Electric Field Measurement (Dr. Aggson)	X				X
Trapped Radiation Detector (UCB)					X
Proton/Electron Detector (Lockheed)					X

ATS GROUND SYSTEM

The ATS program in space is supported by an extensive ground system which provides for command and control of the spacecraft; collection of range and range-rate data for determination of spacecraft orbit; performance of communications, gravity gradient, meteorological, and other experiments; scheduling experiments and maintaining data plots and distributing experimental data; tracking and data acquisition, providing computer services and information processing; and general communications and support. The major elements of this ground system are:

- Three ground stations for support in command and telemetry, collection of range and range-rate data for orbit determination and control; and performance of experiments.

  1. Rosman, North Carolina
  2. Barstow, California (Mojave)
  3. Cooby Creek, Queensland, Australia

- An Operations Control Center established as the Goddard Space Flight Center contact for all operational support (ATSOCC).

- A Communications Center at GSFC (NASCOM).

- A Computing Center at GSFC for furnishing ATS spacecraft orbital positions predictions in appropriate format to the ATS test stations and the STADAN stations.

- An Information Processing Division at GSFC for reduction and separation of ATS technological and scientific telemetry data.

GROUND STATIONS

The three ground stations all have essentially identical communications, and telemetry and command equipments. Rosman and Mojave are fixed stations, while the Cooby Creek station is transportable. All three stations have parabolic antennas; Single Side Band (SSB) and Frequency Modulated (FM) transmitters, and FM and PM (Phase Modulated) receivers which are integrated with other equipment to form Communications and Telemetry and Command (T&C) systems. A Master Control Console at each location provides a focal point for the ground station coordination.

Figure 5 shows the Rosman ground station facility located near Brevard, North Carolina. The 85-foot parabolic antenna, designated Rosman II, was erected primarily as a data acquisition facility for NASA scientific satellites requiring a high-gain, multifrequency antenna at a ground station in the eastern United States. Subsequent recognition of the possible future use of the antenna in an experimental communications systems configuration led to a modification of the antenna design. To this end, a Cassegranian feed system was added to the basic antenna structure, and a low-noise receiver system operating at microwave communication frequencies was installed. This advance planning has

made possible a relatively quick conversion of the antenna system from data acquisition to communications use, and vice versa; therefore, this antenna can be shared with other spacecraft projects.



The ATS operational emphasis was placed on the Rosman site because its capability is somewhat greater than that of the other two ground stations. The main emphasis is on the capacity of the communications systems. Rosman equipment can simulate, for example, 1200 separate voice communications channels simultaneously, as compared to only 240 for the other stations. Also, the Rosman station can transmit communication data in both the single-sideband (SSB) and in the frequency modulation (FM) modes at the same time, whereas the other stations can transmit in only one of these modes at a time.

The Mojave ATS Ground Station, shown in Figure 6, is quite similar to the Rosman station. The antenna consists of a 40-foot diameter hydraulically driven parabolic antenna with an X-Y mount and with a Cassegrainian type feed system.

The Mojave station is used as the base of operation for the WEFAX experiment. Housed in an Automatic Picture Transmission (APT) system van adjacent to the Instrumentation Building is the facsimile transmitter/receiver equipment necessary to handle the WEFAX data.

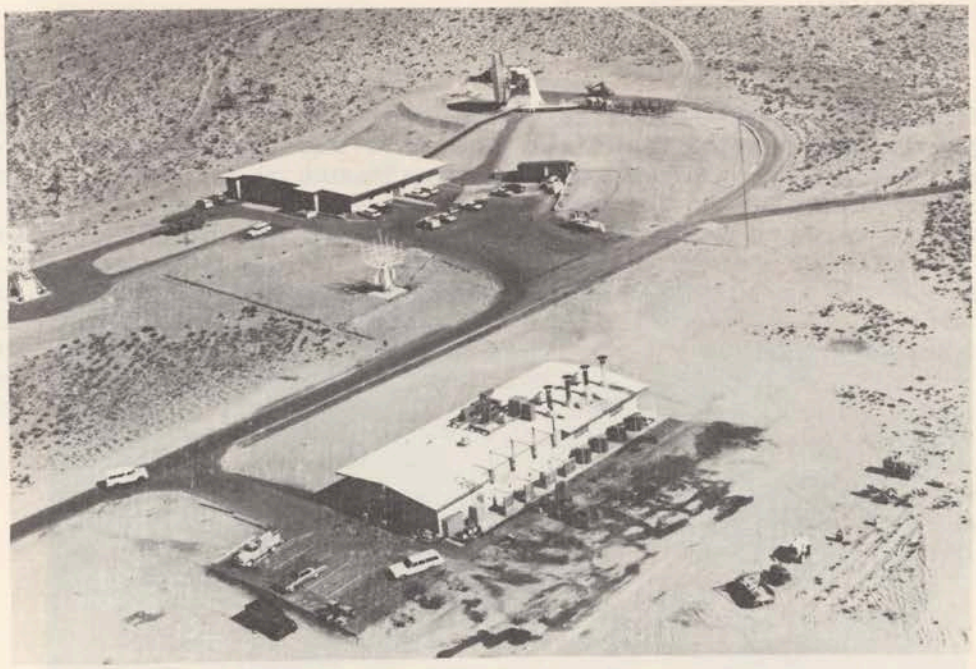


Figure 6. Mojave Ground Station

Figure 7 shows the ATS Ground Station, Cooby Creek, located near Toowoomba, Queensland, Australia. This station is operationally quite similar to Mojave. The antenna is a parabolic dish 40 feet in diameter and constructed in such a manner as to allow it to be dismantled, transported and re-erected in remote areas. The antenna feed system is of the Cassegrainian type, again to produce a high antenna-efficiency factor. The antenna tracking is mounted on an Azimuth-Elevation type mount, as opposed to the X-Y mounts of the other two ATS ground station antennas.

The station is composed of four 40-foot, air-conditioned trailers that house the electronics equipment. Three of these trailers have removable sides so that, when on site, they can be mated together side by side to form one complete Operation Control Complex (OCC) with access to all subsystems. The station Master Control Console, from which all monitoring and control functions are handled, is located in the center trailer. The fourth trailer contains the telemetry and command (T&C) system. This system, which is basically the same for all the ground stations, is integrated with the OCC so that overall control of the station can be maintained from one point. One advantage of this type of transportable ground station is that this T&C system can be physically separated from, and operated independently of, the other vans of the ground station as long as power is provided to it.

Within the area of the OCC complex is the supporting equipment, including three office vans, a maintenance van, two storage vans, a communications van and two power generating vans. Power and signal cables are routed through shallow covered trenches to interconnect the various elements of the station.



Figure 7. Cooby Creek Ground Station

ATS OPERATIONS CONTROL CENTER (ATSOCC)

Providing central control and coordination for all ATS operational support is the ATSOCC or ATS Operations Control Center located at Goddard Space Flight Center. This center is manned on a 24-hour per day, 7 day per week basis by personnel from the NASA Communications Division, Network Engineering and Operations Division, and the ATS Project Division.

The functions of this control center include:

- Operations for maintenance of spacecraft control
- Monitoring telemetry data and maintenance of telemetry data plots
- Scheduling of experiments as well as stations for command and telemetry operations
- Assurance of distribution of experiment data to all stations and experimenters
- Maintenance of displays

ATSOCC maintains control over the utilization of the ATS spacecraft by directing the pre-launch and post-launch activities. In accomplishing this mission ATSOCC monitors and disseminates information on details of communications, tests and preflight checks, predictions, schedules, times for spacecraft and utilization; and for experiments, plots, logs and displays certain spacecraft telemetry items.

In addition to the above, ATSOCC has communications facilities available consisting of:

- Voice communications circuits to each of the three ATS ground stations, plus two additional call-up voice circuits for use during periods of heavy traffic
- Eight 100 word/minute full-duplex circuits consisting of two from each ATS ground station, one from the Radio Research Lab in Japan, and one, when required, from General Electric in Valley Forge, Pennsylvania.
- A facsimile terminal for monitoring the meteorological experiment
- A 5 Mc one-way video channel from Rosman to monitor the gravity gradient boom camera data and TV demonstrations.
- A 1 Mc wideband channel from Rosman for recording data on the meteorological experiment

ATSOCC also serves as an interface between the Project Office and the Tracking and Data Systems Directorate for the provision of that directorate's services to the project.

ATS OPERATIONAL HISTORIES

ATS-B

This spin stabilized, synchronous altitude satellite was the first ATS to be launched. Soon after its lift-off on December 7, 1966, this 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 on earth.

Figure 8 shows the first photograph of the earth from synchronous orbit. Figure 9 is a dawn-to-dusk series of the same system. Figure 10 shows one of the more noteworthy accomplishments of the meteorological experiments on board ATS-B. This series of pictures, taken by the spin scan cloud cover experiment, illustrates the value such satellite weather observations can be in the prediction of severe weather disturbances across the face of the earth.



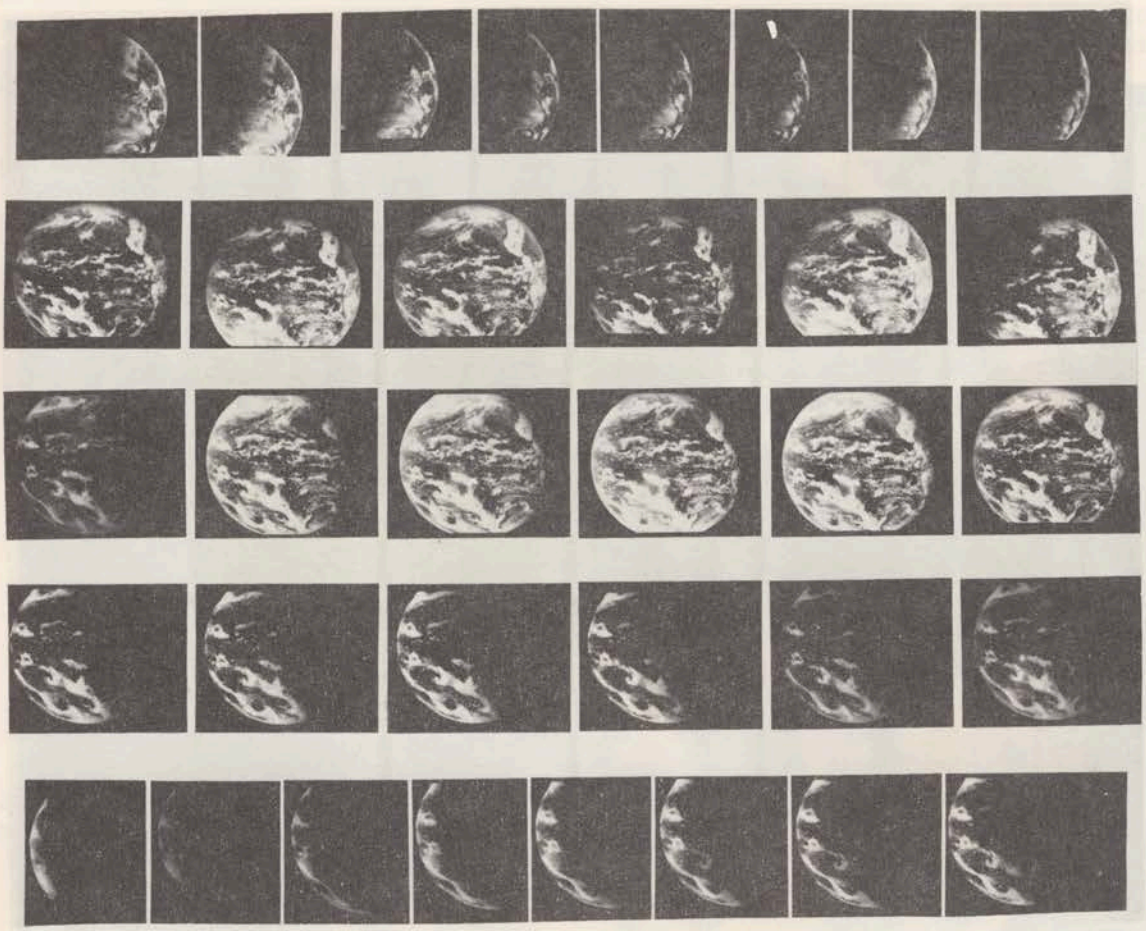


Figure 9. Dawn-to-Dust Series of Spin Scan Cloud Cover Photographs

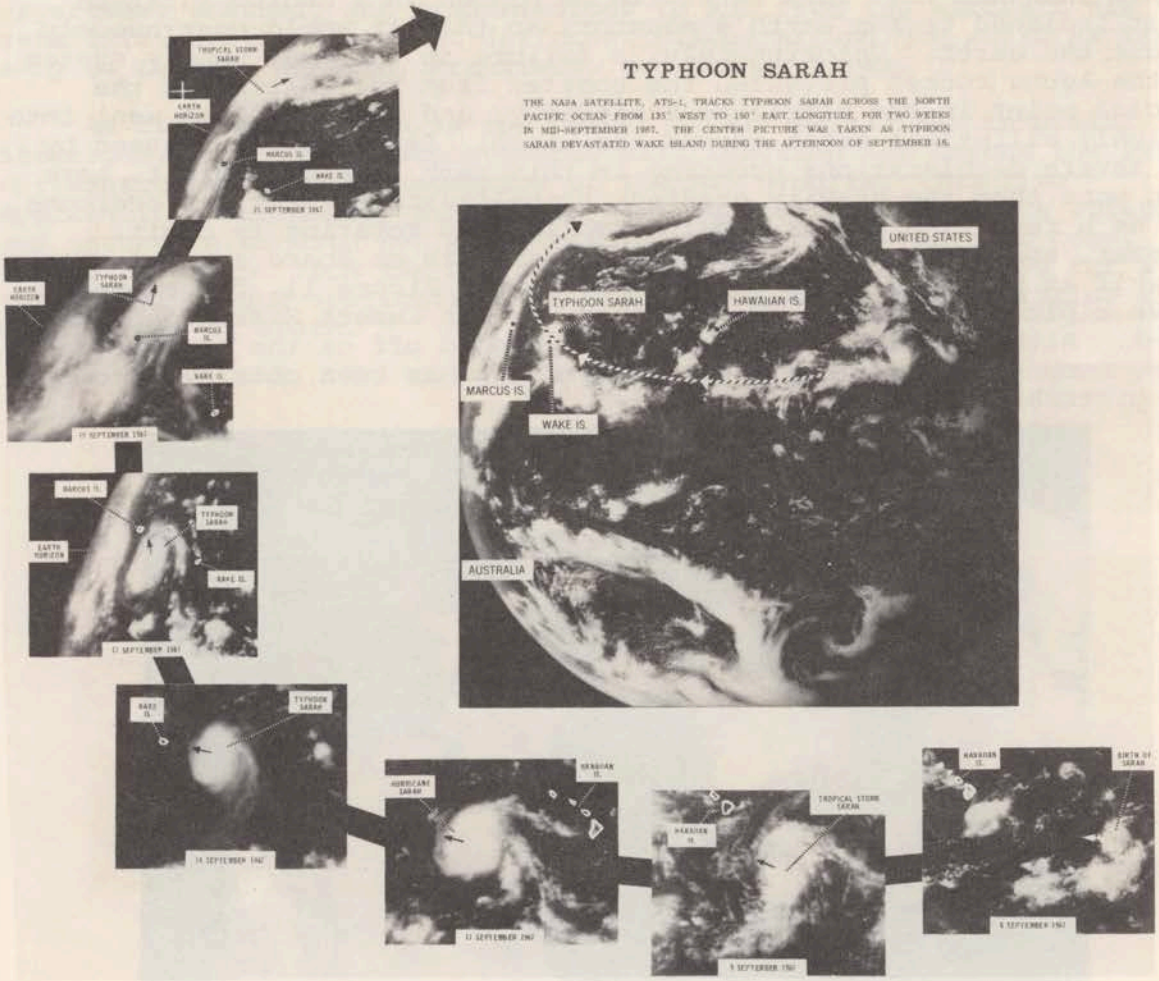


Figure 10. Typhoon Sarah

ATS-A

The second satellite in the ATS series was launched on April 6, 1967. It was intended that this satellite be placed in a medium altitude orbit inclined to the earth's equator, so that it would continuously circle the earth. Unfortunately, a failure in the fuel supply system of the Agena rocket prevented the booster from re-igniting at the crucial point in the satellite trajectory, and the satellite went into a highly elliptical orbit around the earth. Large forces, caused by the severe decelerations occuring in this very irregular orbit, have been more than the gravity gradient stabilization system can overcome, and as a result, ATS-A is slowly tumbling and rotating in orbit. However, again all the systems and experiments on board are functioning as well as possible under these conditions. Figure 11, for example, shows a picture taken by the Advanced Vidicon Camera System on board ATS-A. Although part of the earth is chopped off on the picture's edge, much valuable cloud cover information has been obtained from the pictures taken.

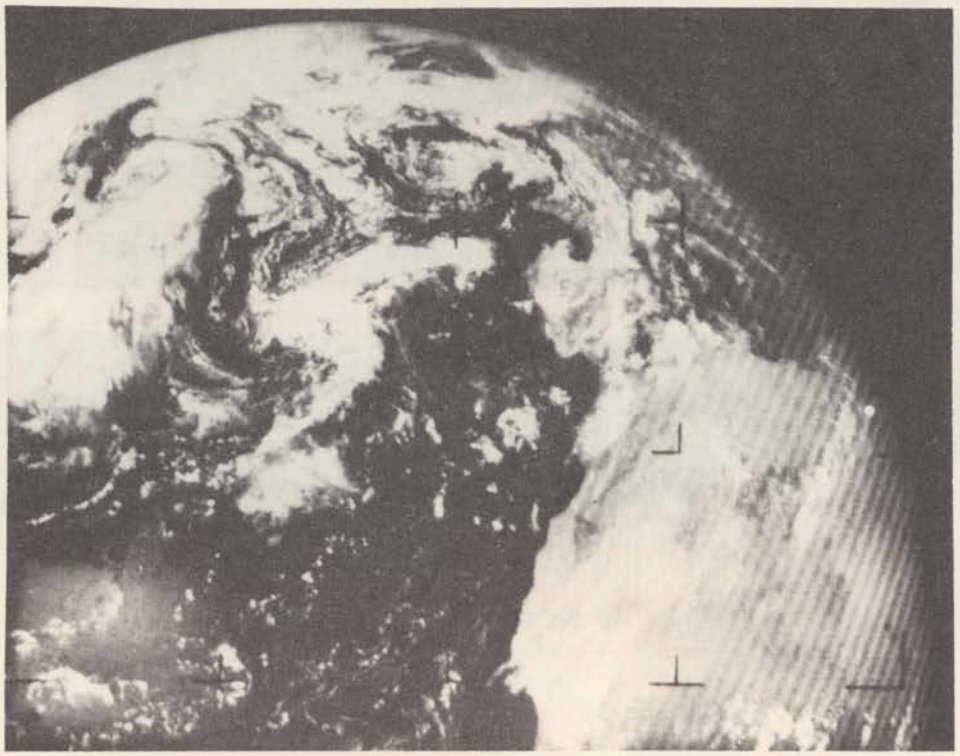


Figure 11. AVCS Picture of Earth

ATS-C

The third satellite in the series, a spin stabilized spacecraft, was put into its synchronous altitude orbit on November 5, 1967. After a perfect launch, it was placed on station over the Atlantic Ocean.

One of the most notable of the achievements of this satellite is the first ground-to-satellite-to-airplane communications link over the Atlantic Ocean. 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 with NASA officials at Goddard Space Flight Center. The Mojave ground station actually 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.

As time goes on and as the number of ATS satellites in orbit increases, the list of achievements will lengthen far beyond the initial optimistic hopes of the planners of the ATS program. The five Applications Technology Satellites will be providing numerous sciences and technologies with new and vital information for years to come. The data derived from the ATS should help provide solid bases for a variety of unique applications as man progresses from exploration to utilization of space.