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NEWS NASA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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FOR RELEASE: SUNDAY
August 10, 1969

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# PRESS KIT

# PROJECT: ATS-E

(To be launched no earlier than Aug. 12.)

## contents





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**NEWS**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546
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**FOR RELEASE:** SUNDAY
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# ATS-E LAUNCH

The National Aeronautics and Space Administration is scheduled to launch a football-field-size spacecraft (with booms fully extended) which will carry an experiment which may have great impact on air traffic control in the 1970s.

Called Applications Technology Satellite-E (ATS-E), the spacecraft will be launched into a synchronous, 22,300-mile-high orbit, from Cape Kennedy, Fla. aboard an Atlas-Centaur launch vehicle no earlier than August 12. The launch window is 6:53 to 7:53 a.m. EDT. Upon achieving orbit it will be positioned above the Equator at about 110° W. Longitude (600 miles west of Quito, Ecuador).

The primary experiment is a gravity-gradient stabilization system. This consists of four 124-foot-long booms (tip-to-tip totals 253 feet) forming an X with the satellite in the center. The booms keep the spacecraft pointed toward Earth, just as the Moon keeps one face toward Earth, so that experiments on the satellite are pointed in the proper direction at all times.

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Because such a stabilization system does not use power or fuel, such as is required by gas control systems, it is inherently long-lived and therefore is expected to extend the lifetimes of future operational satellites. For example, those used in communications, meteorology and a satellite series to be called Earth Resources to provide data on crops, forests, potential mineral areas, fishing, flood control, etc.

An important experiment carried by the ATS-E is the L-Band communications and air traffic control experiment. It appears to offer advantages over the Very High Frequency (VHF) spectrum tested on earlier satellites, ATS 1 and 3, for communications and position determination of aircraft. Because of the L-Band, frequency assignment has more capacity and is less crowded.

The L-Band experiment is being flown to compare results obtained with those from the earlier flights so that a decision can be made on which band to use for a future aeronautical communications and air traffic control system.

Earlier experiments showed that aircraft could be contacted, voice teletype and facsimile as well as positions of the aircraft located for navigation purposes. At the same time it was found possible to transmit photocopies of cloud covers taken by meteorological satellites so that the pilot would have an up-to-date picture of the weather ahead of him.

Conventional communications with aircraft over large ocean areas are not always of good quality and sometimes impossible. Satellite communications are expected to solve this problem.

Another experiment of great importance to communications industry is the millimeter wave experiment. It is designed to explore the possibility of using the less occupied, much higher part of the frequency spectrum for use by satellites.

This information is needed because of the continuing need for more and more communications channels throughout the world which has resulted in serious crowding of the available frequency bands now shared between ground and satellite communications systems.

If this experiment proves successful it could not only help in relieving the crowding problem but it could, with greater satellite power, also require less complex Earth stations.

Millimeter wave frequencies are from two to five times higher than frequencies now used. Information on quality as these signals travel through space is sparse, and is needed for the design of future operational communications satellite systems.

Two earlier ATS spacecraft carrying gravity gradient experiments, ATS 2 (launched April 6, 1967) and 4 (launched Aug. 10, 1968) because of problems with the launch vehicle, did not achieve the required orbits for gravity-gradient testing.

The long, thin booms on ATS-E will tend to bend away from the Sun as the result of solar heating. Earth control stations will observe the extent of this bending by the satellite's three-and-a-half pound commercially compatible television camera.

It is positioned at the center of the V formed by the X-shaped primary booms pointing toward Earth. Resolution will not be as good as previous ATS meterological cameras, (it has no meteorological function) but large surface features on Earth will be visible when the spacecraft is stabilized. This will be a few days to a week or more after launch.

Other ATS-E experiments include a microwave communications experiment, an ion (electrical) engine experiment, solar cell radiation experiment, and an Environmental Measurement Experiment (EME).

A C-band experiment (microwave), present on all ATS spacecraft to date, has been designed for transmission of voice, television (color and black and white), telegraph and digital data to several ground stations.

-more-

Results from previous microwave tests have shown that several hundred stations could simultaneously transmit and receive voice, television, telegraph and digital data.

The ion engine technological experiment on ATS-E is experimental but will also be used as a back-up east/west station keeping system. The 10.2-pound engine produces a controlled thrust from 5 to 20 micropounds (5-20 millionths of a pound).

A solar cell radiation damage experiment on ATS-E will investigate the effects of the radiation environment which exists in an Earth-synchronous orbit on the performance of solar cells of various design configurations and compare these effects with predicted behavior.

The Environmental Measurements Experiment (EME) consists of six separate packages designed to gain additional knowledge of the near-Earth environment.

ATS is directed by NASA's Office of Space Science and Applications. Project Management is under direction of NASA's Goddard Space Flight Center, Greenbelt, Md.

NASA's Lewis Research Center, Cleveland, is responsible for the Atlas/Centaur launch vehicle. Launch operations are directed by NASA's Unmanned Launch Operations, Kennedy Space Center, Fla.

Hughes Aircraft Co., Culver City, Calif., is responsible for the spacecraft and integration of spacecraft experiments for ATS-A through E. General Electric Co., Space Systems, Valley Forge, Pa., is responsible for the gravity gradient attitude and control system for ATS-A, D and E.

General Dynamics/Convair, San Diego, Calif., is the prime contractor for the Atlas/Centaur launch vehicle.

END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS

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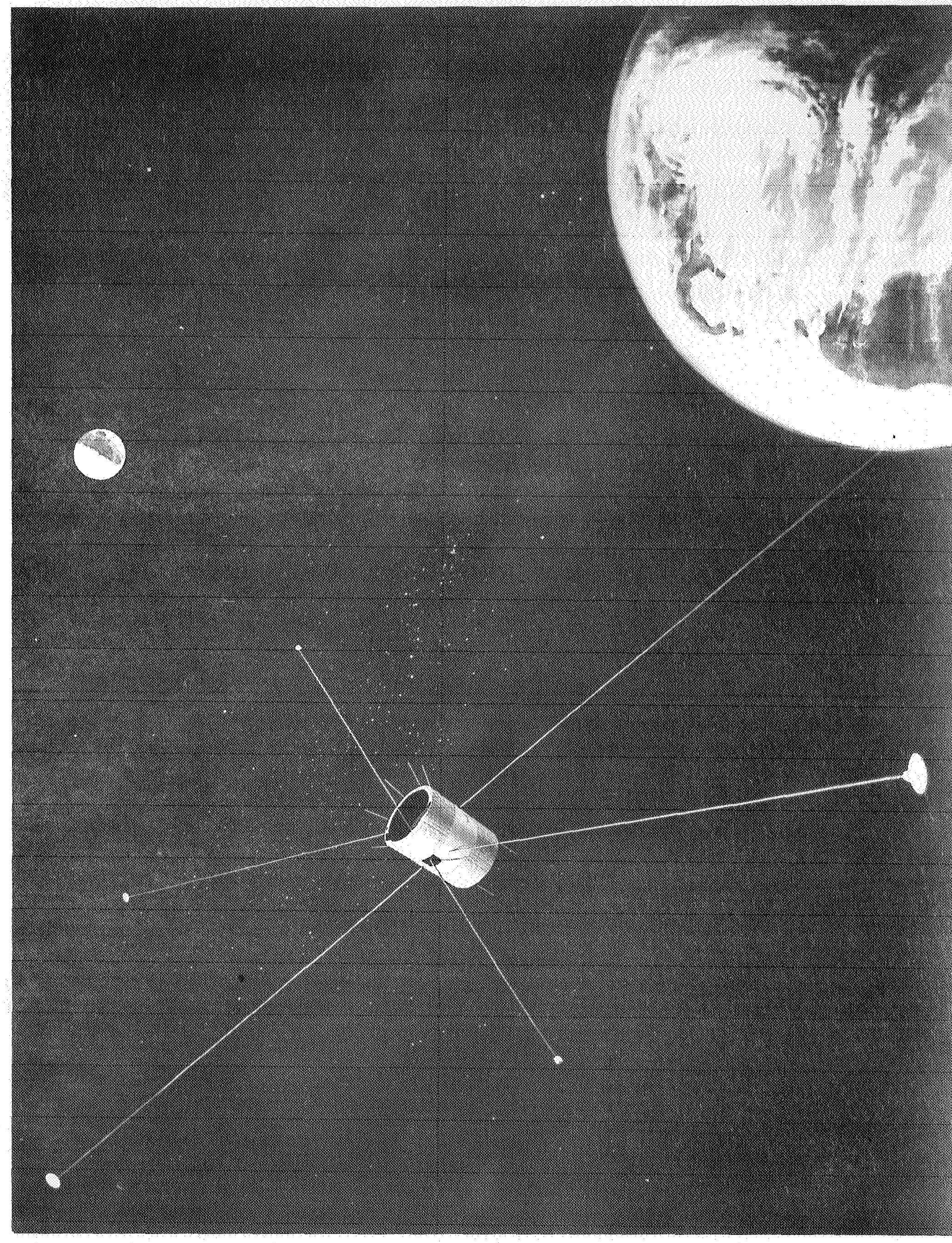


# ATS-E FACT SHEET

| | |
|---|---|
| Spacecraft | Cylindrical, six feet long, five feet wide, weighs 1900 pounds at liftoff. Spacecraft measures 253 feet in orbit with gravity gradient rods fully extended. |
| Experiments | |
| Gravity Gradient: | Compare actual performance with a mathematical model and to establish the design parameters for gravity gradient stabilization systems for synchorous altitudes. |
| Communications: (Microwave) | Microwave communications experiment will be conducted at C-band and L-band frequencies. The C-band communications experiment will investigate techniques for transmitting voice, television, telegraph, and digital data simultaneously between multiple ground stations via the spacecraft C-band repeater.<br><br>The L-band communications experiment will investigate techniques for transmitting voice, data, and ranging tone between ground stations and aircraft via the spacecraft L-band repeater. |
| Scientific: | Solar Cell Radiation Damage Experiment will investigate the effects of the radiation environment of an Earth-synchronous orbit on the performance of solar cells of various design configuration and compare these effects with predicted behavior.<br><br>Environmental Measurements Package (EME), consisting of six scientific experiments designed to gain additional knowledge of the near-earth environment. |

<u>Launch Information</u>

| | |
|---|---|
| Vehicle: | Two-stage Atlas/Centaur |
| Complex: | Complex 36A, Cape Kennedy |
| Azimuth: | 97 degrees |
| Window: | 6:53 to 7:53 a.m. EDT |
| Date: | No earlier than August 12, 1969 |

<u>Orbital Elements</u>

| | |
|---|---|
| Orbit: | Synchronous, 22,300 miles |
| Period: | 24 Hours |
| Inclination: | About 1.42 degrees initially |
| Synchronous Station: | 108-112 degrees West Longitude, near 0 degrees Latitude (over the Pacific Ocean, 600 miles west of Quito, Ecuador and due south of Eagle, Colorado). |

<u>Power Supply</u> 22,000 negative on positive (n-On-p) radiation-resistant silicon solar cells.

<u>Tracking Stations</u>

| | |
|---|---|
| Orbit: | Seventeen stations in NASA's Space Tracking and Data Acquisition Network (STADAN). |
| Command: | Rosman, N.C. and Mojave, Calif. (Kagoshima, Japan; Cooty, Creek, Australia for transfer only). |

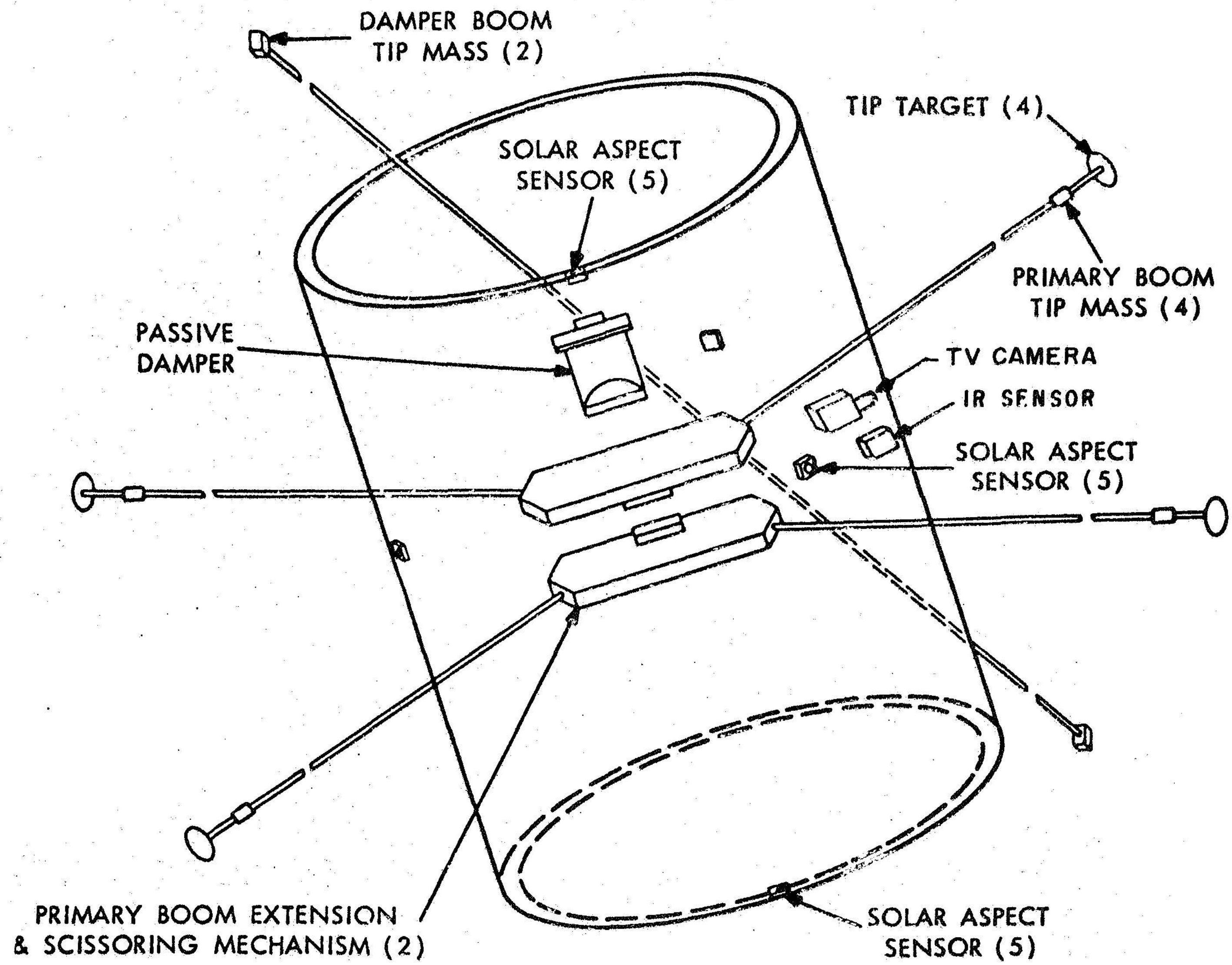
<u>Spacecraft Management</u> Goddard Space Flight Center Greenbelt, Md.

<u>Launch Vehicle Management</u> Lewis Research Center, Cleveland

<u>Launch Operations</u> Kennedy Space Center, Fla.

Major Contractors

| | |
|---|---|
| General Dynamics Astronautics | Atlas/Centaur launch Vehicle |
| General Electric Co. | Gravity Gradient stablization |
| Hughes Aircraft Co. | ATS-E spacecraft |




ATS-E Gravity-gradient
Stabilization System

## ATS-E EXPERIMENTS

The ATS-E will carry three basic types of experiments: communications, technological and scientific. They include two communications experiments (microwave and millimeter wave); a gravity gradient stabilization experiment; an ion (electrical) engine experiment; a solar cell damage experiment; and an Environmental Measurement Experiment (EME) consisting of six individual scientific packages.

### Gravity Gradient Stabilization Experiment

#### General

Man has known for centuries that the Earth's gravitational field exerts erecting forces on objects such as the Moon, causing them to keep the same attitude toward the Earth. Only recently, however, have engineers and scientists been able to demonstrate practically this law of physics with man-made satellites.

The key to gravity gradient is that the gravitational field surrounding the Earth varies with distance. As the distance between an object and the Earth increases, the gravitational pull decreases.

Because of its long slender shape (253 feet from tip to tip with booms extended) one end of ATS-E will be closer to Earth than the other, and thus will be more affected by gravity. Although these gravity forces will be very samll -- about one-hundred-thousandth of a pound -- they will be sufficient to cause the satellite to maintain a fixed attitude with respect to the Earth.

The spacecraft was designed to stabilize in all three axes, within plus or minus six degrees in both pitch and roll and plus or minus 11 degrees in yaw. This pointing accuracy can only be achieved with an effective damper system. In orbit, ATS-E will have a tendency to swing away from the local vertical due to a combination of the Earth's magnetic field, solar pressure, and movement inside the spacecraft.

Therefore, in addition to the four primary booms that form an X-shape when extended, the satellite will carry two 45-foot long booms attached to a passive damper for eliminating undesirable motions.

Because gravity gradient stabilization systems are passive they have a high degree of reliability. They require no power, once deployed, and are lighter than active systems because they require no electronics, no stored gas and no sensors. However, active control systems which use gas jets to keep spacecraft pointed at Earth are better for highly elliptical orbits. It takes much longer for the motion in gravity gradient systems to be removed than with active systems.

The two ion engines, which produce a thrust less than 20 micropounds (equivalent to the weight of an office staple), were fired for a total of 23 hours during five separate tests.

Ion engines have controllable thrust level and direction (with no movable parts), and have higher fuel efficiency and longer life than chemical engines.

## Hardware

The ATS-E gravity gradient control system consists of the following subsystems:

Primary Boom Subsystem

Damper Boom Subsystem

Combination Passive Damper (CPD)

Television Camera

Attitude Sensor Subsystem

Power Control Unit (PCU)

## Primary Boom Subsystem

When fully extended, the four, 124-foot-long booms form a giant X configuration, with the basic spacecraft at the center of the X.

The booms are made of beryllium copper strips two inches wide.

The booms weigh about two pounds each. They were formed from a heat-treated flat strip into a tubular shape and then flattened under stress and wound onto power-driven drums.

The beryllium copper is aluminum plated and perforated to minimize the boom bending from solar radiation.

Eight-pound tip weights are fixed about four inches from the end of each boom to increase the spacecraft's inertia and thus improve its stability.

The gravity gradient camera can view two lower boom tip targets to gather information on the amount of boom bending from thermal heat.

While in powered flight, the booms will be stored inside the spacecraft as flat tapes on motor driven drums. The spacecraft will initially be spin stabilized. Shortly after the spacecraft de-spin they will be simultaneously deployed into cylindrical tubes 0.5 inches in diameter.

The booms are deployed at the rate of 1/2 foot per second. It will take slightly more than four minutes for the primary booms to extend their full length.

Four motors (DC) are used for controlling the booms. They are used for extending and retracting the rods, and scissoring (opening and closing the X-shaped booms like a scissors).

These booms can be scissored from 13 to 29 degrees off the local vertical. It is estimated that 25 degrees is ideal for stability purposes.

## Damper Boom Subsystem

The damping axis is positioned between the pitch and roll axes and does not lie along a principal axis of the primary body.

The damper boom, also made of beryllium copper, consists of two 45-foot long booms extended in diametrically opposite directions.

The task of the damping boom is to eliminate or dissipate unwanted spacecraft motion so accurate stabilization can be maintained.

## Combination Passive Damper

ATS-E will carry two damping systems to evaluate which is the most efficient. The entire Combination Passive Damper weighs 24 pounds.

An operational satellite might use only one damping system.

One of the ATS-E systems is called Eddy Current Damper (ECD) and the other is a Hysteresis Damper.

Either of the units can be clutched to the damper boom which forces it to move, and therefore, damp out motion which affects the satellite's stability.

The eight-inch-diameter ECD is diamagnetically suspended (floats and is not attached) by doughnut-shaped pyrolytic graphite (like the lead in a pencil) and 16 magnets.

Torsional restraint for the ECD is provided by a crescent-shaped paramagnetic material acted upon by permanent magnets. The wider portion of the thin crescent has a greater attraction for magnets producing the torque that returns the rotor to null position (when the damper boom is parallel to the Earth's curvature) which is the widest portion of the crescent.

Eddy current damping is provided by an aluminum disk and permanent magnets which use the principle that when a conductor is moved through a magnetic field, eddy currents are produced that resist motion and, thus, dissipate energy.

The Hysteresis Damper is shaped like, and is about the same size, as a can of soda pop.

Inside the can-shaped damper is a 1 1/2-inch-diameter disk which is suspended on a thin wire no wider than a human hair. Eight small magnets are suspended around the disk.

As the disk moves through the magnetic field, the dipoles flip, or reverse themselves, from North-South to South-North, etc.

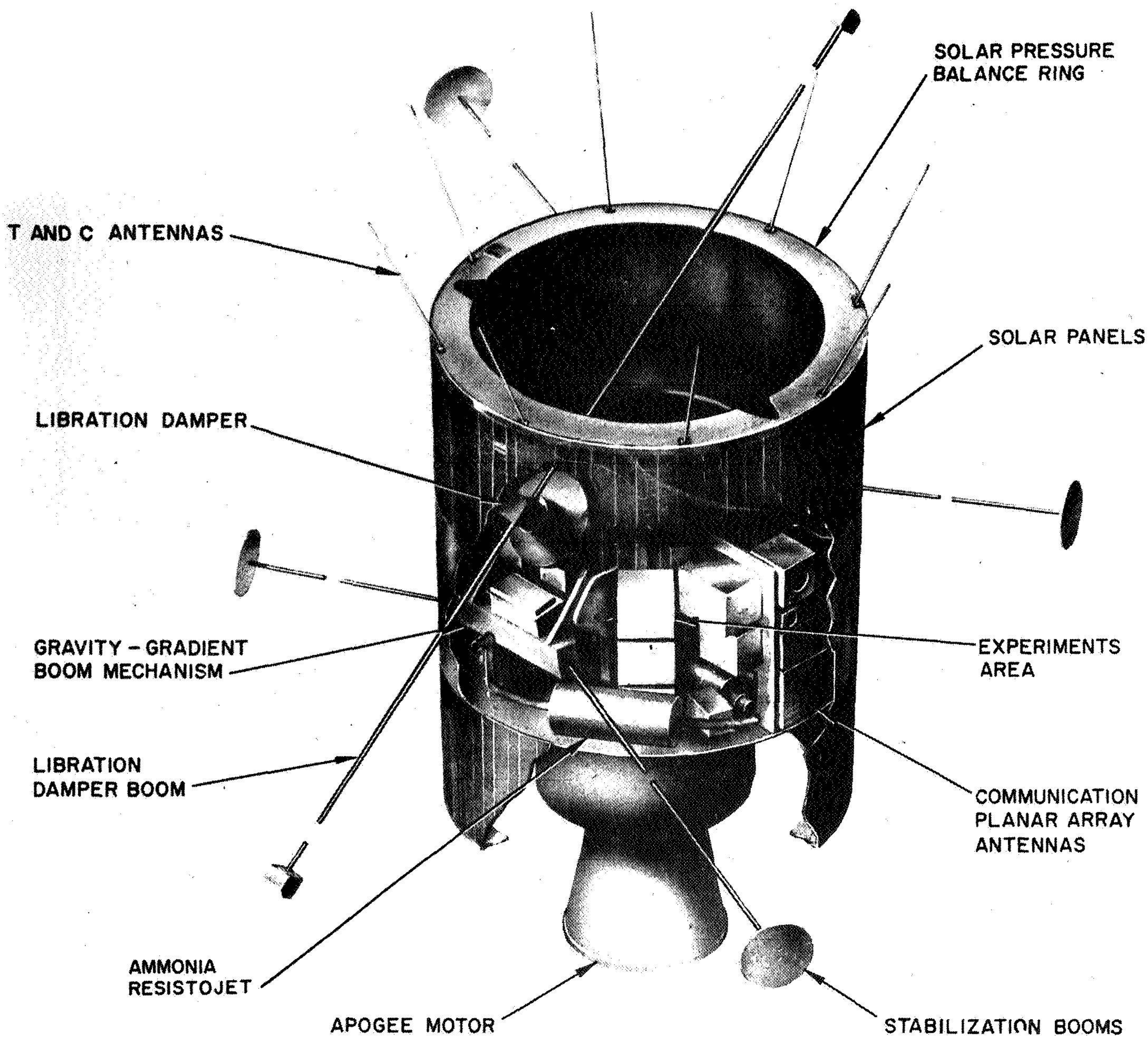
<u>Attitude Sensor System</u>

This subsystem consists of several types of sensors which are used in combination to determine the position of the satellite with respect to the local vertical within one degree.

The ATS-E attitude sensors include a solar aspect sensor system, one infrared Earth sensor, a polarized antenna (supplementary) and a commercial (525 lines) television camera.

The Solar Aspect Sensor, capable of angle determination to within one degree, is a digital system composed of a single electronics unit and five solar detector assemblies. The detectors are positioned on the top, bottom and sides of the ATS-E spacecraft.

Each of the solar detectors has a 128-degree rectangular field of view.




ATS-E SPACECRAFT

## Infrared Sensors

The infrared Earth sensor is a scanner type. A small circular mirror is suspended on pivots which are driven by pulsed electrical coils.

The mirror's movement causes the field of view of a telescope to scan back and forth in space with a total sweep which covers the Earth from edge to edge.

## Gravity-Gradient Television Camera

The standard (525 lines) television camera is being carried on ATS-E to observe the thermal bending characteristics of the gravity-gradient booms as well as verify the satellite's sensory data.

Fastened to the ends of the four booms are nine-inch diameter targets to enhance the motion picture coverage. On TV monitors, the targets will be about the size of a star.

The television camera subsystem is composed of optics, camera sensor and associated camera electronics.

A wide-angle lens is used which has a focal length of 10 mm. This results in an angular field of 65 degrees in the horizontal plane and 49 degrees in the vertical plane.

The frame rate is 30 cycles per second.

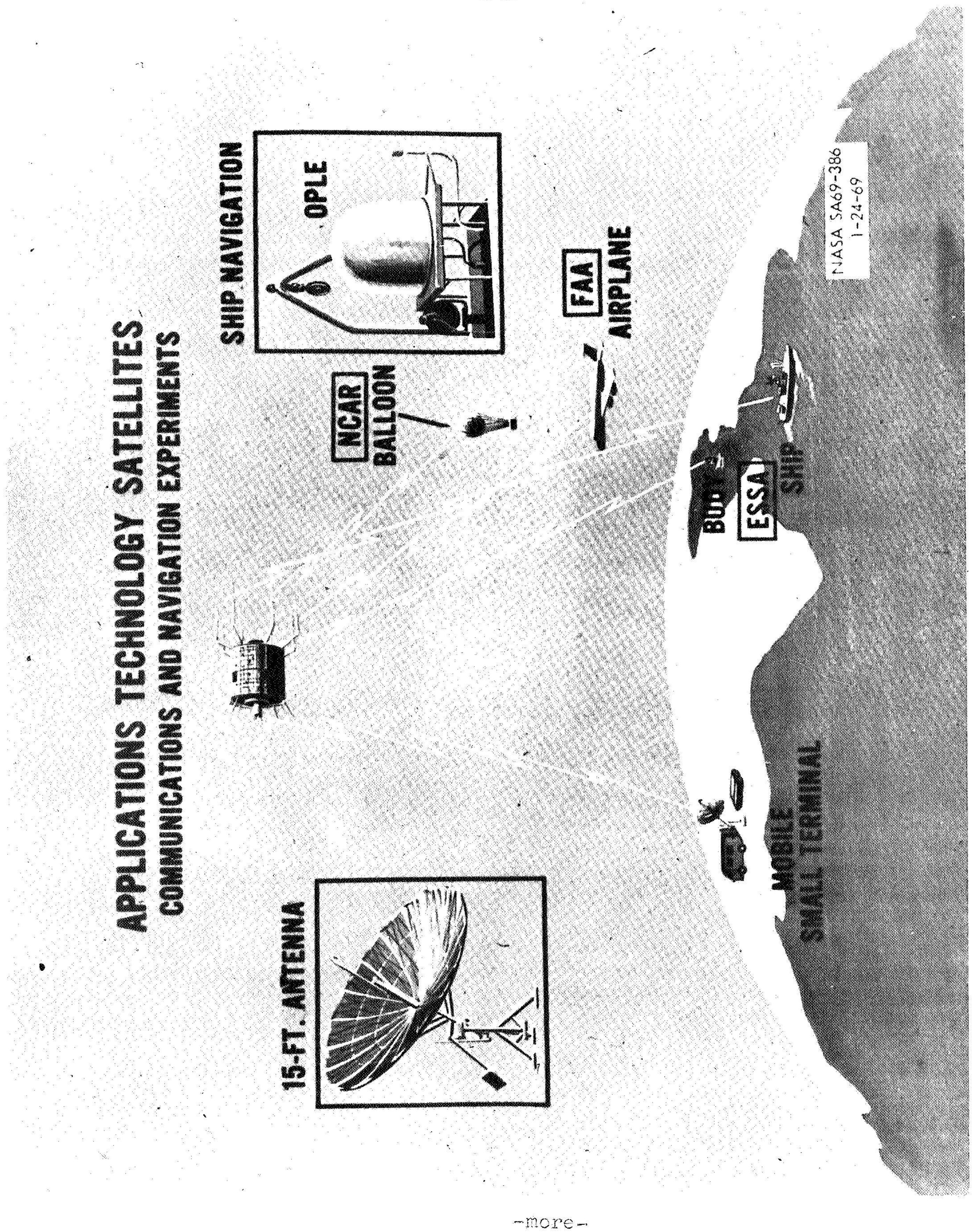
## Power Control Unit

The overall gravity-gradient stabilization system is tied together electrically by a single unit called Power Control Unit (PCU).

The PCU incorporates all power, command and telemetry interfaces between the spacecraft and the gravity-gradient system.

It also contains the necessary spacecraft interface equipment for all gravity-gradient system diagnostic measurement.

When commanded from the ground, the PCU will provide power to the various attitude sensing and control devices associated with the gravity-gradient stabilization system.


APPLICATIONS TECHNOLOGY SATELLITES
COMMUNICATIONS AND NAVIGATION EXPERIMENTS
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NCAR
BALLOON
FAA
AIRPLANE
BUOY
ESSA
SHIP
MOBILE
SMALL TERMINAL
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Orbital Maneuvers

The X-shaped configuration of the satellite makes it ideal for operating experiments and conducting one of the key ATS-E experiments -- varying the length and angle of the long gravity-gradient rods.

NASA officials want to determine how much the rods can be shortended and scissored (opened and closed like scissors) without affecting, to any great extent, the satellite's stability.

During these maneuvers, ATS-E will perform several turn-around (in slow motion) maneuvers. It will roll,pitch and yaw, and in some cases completely flip over (a complete flip-over will take about three hours).

When the rods are shortened, ATS-E will increase its spin and vice versa, similar to a figure skater spinning up with folded arms and slowing down by extending the arms.

It is possible that the spacecraft might be inverted, or upside down, during initial stabilization. If so, the spacecraft can be turned over by extending or retracting the long booms, or by firing small micropound subliming rockets.

These two, small subliming rockets produce a thrust of 600 micropounds, which is equivalent to the weight of a small sewing needle.

## Communications Experiments

Microwave Communications Experiment

This experiment will be conducted at C-band, and for the first time, L-band, frequencies.

The C-band communication experiment, operating at 6,000 megahertz receive, 24,000 megahertz transmit frequency range, will investigate techniques for transmitting voice (1,200 one-way or 600 two-way circuits), television, telegraph and digital data simultaneously between multiple ground stations via the spacecraft C-band repeater.

The ATS ground stations will conduct experiments by using the spacecraft C-band transponder as a multiplexing telephone relay repeater.

In progressive stages, signals will be transmitted via the spacecraft first from one test station to another, then back and forth between two test stations, and finally among various combinations of test and supporting stations. Stations in foreign countries will participate in these demonstrations.

In addition, the ATS ground stations will conduct experiments designed to demonstrate the feasibility of transmitting color television and other wide-band signals via the ATS-E.

The L-band communications experiment objectives are:

Determine the reliability of aircraft voice communications;

Determine the accuracy of a system for aircraft position location and tracking;

Determine the capability of an aircraft data link;

Investigate aircraft multiple access operation.

The L-band, operating in the 1550-1650 MHz range, has several advantages over other systems. The bandwidth is less crowded, L-band is highly efficient, and it takes 1,000 times less space than other systems.

Millimeter Wave Experiment

The millimeter wave experiment on ATS-E is the first of its kind.

It has been designed to provide information about millimeter wave propagation characteristics of the Earth's atmosphere, and the effects of weather on these characteristics, to allow designers to efficiently use this portion of the electromagnetic spectrum for wide-band communications and other scientific purposes.

Millimeter waves, which range generally from the high microwave region above 10 GHz to the beginning of the infrared spectrum, are promising for future Earth-space communications applications because of the such advantages as:

Wideband capabilities;

Plasma penetration capability;

Reduced spectrum crowding;

Private or secure links; and

Reduced size and weight of components.

Of particular interest to experimenters is the prospect of reduced spectrum crowding since there are practically no systems presently operating in the millimeter wave band.

For example, just one small portion of the lower end of the millimeter/sub-millimeter band, that area between 30 GHz and 100 GHz, provides more than twice the space that has been available for all uses since the beginning of radio.

Before such systems can be developed, however, additional data is required to determine atmospheric affects on the propagation of wideband signals, hence the millimeter wave experiment on ATS-E.

The 40-pound millimeter wave unit contains dual antennas, one for transmitting from the spacecraft and a second for receiving signals from Earth. The package includes an all-solid state transmitter, consumes about 40 watts of power and is less than one cubic foot in volume.

## Environmental Measurements Experiments (EME)

The EME is a package of scientific experiments designed to gain additional knowledge of the near-Earth environment. The package contains six scientific experiments, one encoder, a command interface unit, and necessary power supplies.

Westinghouse Electric Corp., Baltimore, Md., is the package integrator.

### Tri-Directional Medium Energy Particle Detector (University of California at Berkeley)

This experiment measures protons with energies between 30 kev and 250 kev and electrons with energies between 30 kev and 300 kev along two axes of the spacecraft. Three identical scintillator photomultiplier detectors are used. One is oriented on an axis perpendicular to the magnetic field, one along the magnetic field lines in the southern direction, and the third along the magnetic field lines in the northern direction.

### Uni-Directional Low-Energy Particle Detector (Lockheed Palo Alto Research Laboratory)

This experiment studies low energy (auroral) particles fluxes at a synchronous altitude.

Eleven individual sensors capable of measuring the fluxes of both protons and electrons in each of nine energy groups are provided. Nine sensor apertures are arranged on the spacecraft to admit particle fluxes from a direction of 11 degrees with respect to the thrust tube axis. Electrons within the 0.5 to 50 kev range and protons of 1 kev, 5 kev, 20 kev, 60 kev, and 100 kev are measured.

Bi-Directional Low-Energy Particle Detector (University of California at San Diego

This experiment maps the distribution of low energy (60 ev to 60 kev) electrons and protons on a constant line of force so that correlation studies between these particle fluxes and the visible aurora can be performed. These studies will be conducted to determine the nature of the accelerating mechanism in the magnetosphere. Studies of the rapid time variations of the shape of the spectra and location of any peaks in the particle distribution will also be conducted.

Omni-Directional High-Energy Particle Detector (University of California at San Diego

This experiment measures electrons in 12 discrete energy ranges between 0.5 and 5 Mev and the flux of solar cosmic rays in the 12 to 24 Mev energy range. Three high energy electron detectors are used to make measurements.

Solar Radio Burst Experiment (NASA-GSFC)

This experiment measures the effects of solar radio bursts at 32 discrete frequencies between 50 kHz to 4 MHz. The 124-foot gravity-gradient booms are used as the receiving antennas and a dual swept radiometer as the measuring device.

Electric Field Experiment (NASA-GSFC)

This experiment measures the electric field in the magnetosphere utilizing the gravity-gradient booms as long cylindrical Langmuir probes. High-impedance voltmeters are used to measure the potentials of the booms relative to each other and relative to the spacecraft.

## REACTION CONTROL SUBSYSTEMS

Six types of reaction control subsystems will be used for the ATS-E mission. These are a cold-gas nitrogen subsystem for spin-up, a hydrazine subsystem for inclination and eccentricity adjustments and for initial station-keeping; two microthrust subsystems (resistojet and ion engine) for station-keeping during the gravity-gradient-stabilization phase; subliming solid-jet subsystem to invert the spacecraft if it is incorrectly oriented; and an active nutation control system to reduce nutation during the transfer orbit.

Spacecraft spin-up is accomplished through blowdown of a gaseous nitrogen subsystem into a pair of tangentially located nozzles.

The hydrazine subsystem has a thrust capability of five pounds.

### Resistojet Subsystem

The resistojet subsystem nozzles are positioned to propel the spacecraft in an East-West direction with a thrust of about 50 micropounds.

The resistojet uses liquid ammonia for fuel.

The 10.2-pound ion engine subsystem produces a controlled thrust from 5 to 20 micropounds. Although the primary objective of the ion engine is experimental, it will also be used as a back-up east-west station-keeping system.

The two primary objectives of the test are the demonstration and measurement of thrust, and an assessment of the radio frequency interference generated by the ion engine and its associated electronics.

Secondary objectives are to demonstrate thrust level control and thrust vector control.

The entire ion engine experiment measures four by 10 by 12 inches.

One-tenth of a pound of cesium is stored in the reservoir which is sufficient to supply maximum thrust of 20 micropounds continuously for over a year.

Active Nutation Control Subsystem

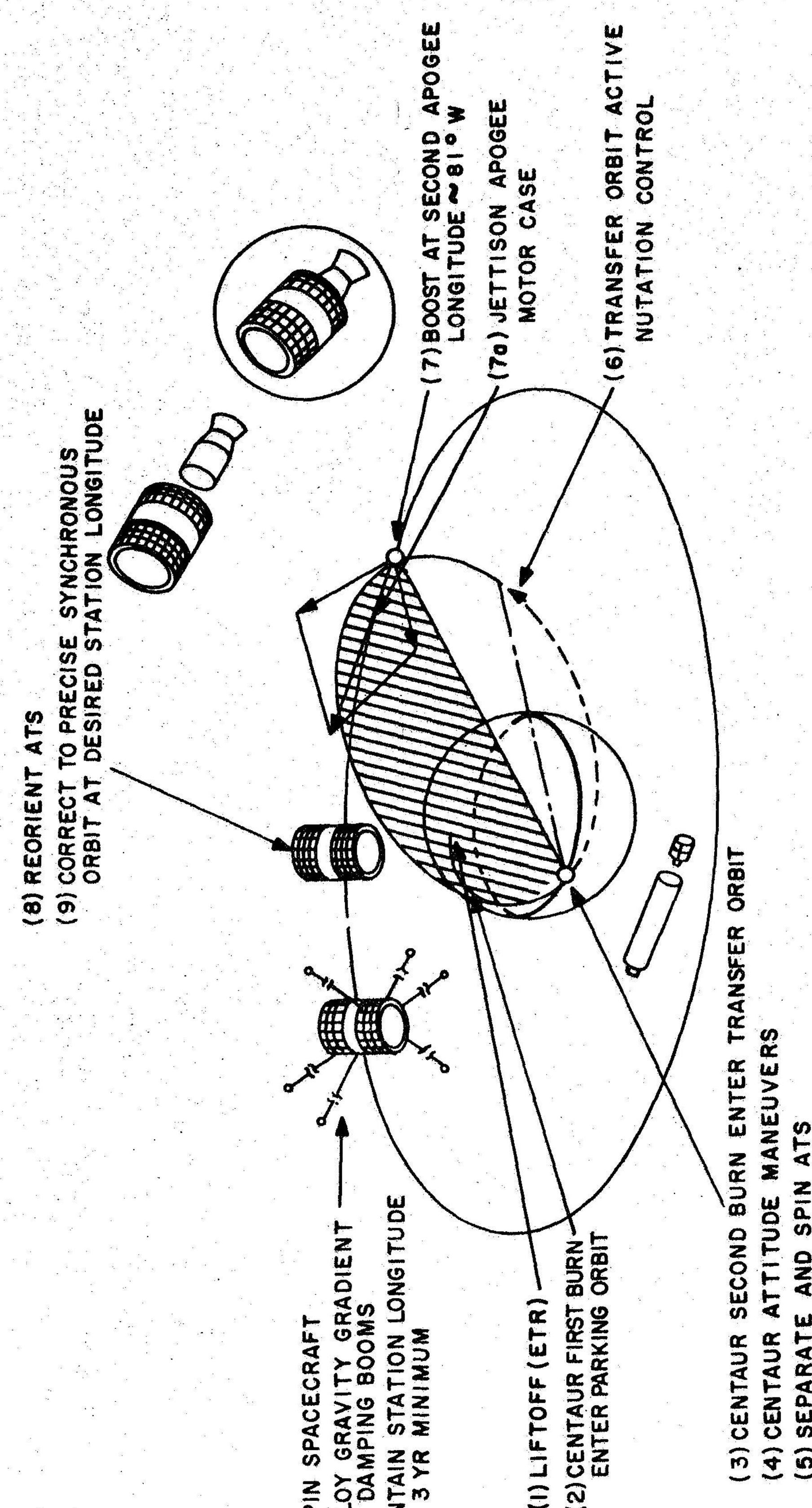
During the transfer orbit, prior to apogee motor ejection, the spacecraft does not have long term spin axis stability. In order to ensure an adequately small nutation angle throughout the transfer orbit phase of the mission, active nutation control capability has been included to remove nutation by an on-board automatic control system or by ground command whenever required.

The Subliming Solid Jet Subsystem on ATS-E consists of two jet systems, one on each side of the spacecraft, which produce a thrust of 600 micropounds.

Because of its very small thrust (one quarter of one gram) one of the jets must fire for about an hour to turn the spacecraft completely over.

A solid ammonia salt, which resembles camphor or moth balls, is used as a propellant in this jet system.

When heated, the salt turns slowly to gas at low pressure and passes through a tiny rocket nozzle to produce thrust.




ATS-E ORBIT GEOMETRY

## SPACECRAFT SEPARATION EVENTS

ATS-E will be injected into a synchronous orbit 107 degrees west longitude at the Equator about 400 miles West of Quito, Ecuador, and some 10 hours after the final Centaur burn.

This coast period will be one of the longest ever achieved for a spinning rotating about its unstable axis. To counteract any possible spacecraft wobble during coast phase (similar to a spinning top when it slows down), hydrazine jets in the satellite's active nutation control system will fire automatically if necessary.

### Apogee Motor Firing

The apogee injection motor, developed by JPL, is basically identical to the one used for ATS I, III and IV. It weighs 841 pounds fully loaded, produces 6,250 pounds of thrust, is scheduled to burn for 43 seconds and delivers a velocity increase of 4,678 fps. The nominal apogee motor firing time is about 10 hours after liftoff from Cape Kennedy. The apogee motor is then separated from the ATS-E.

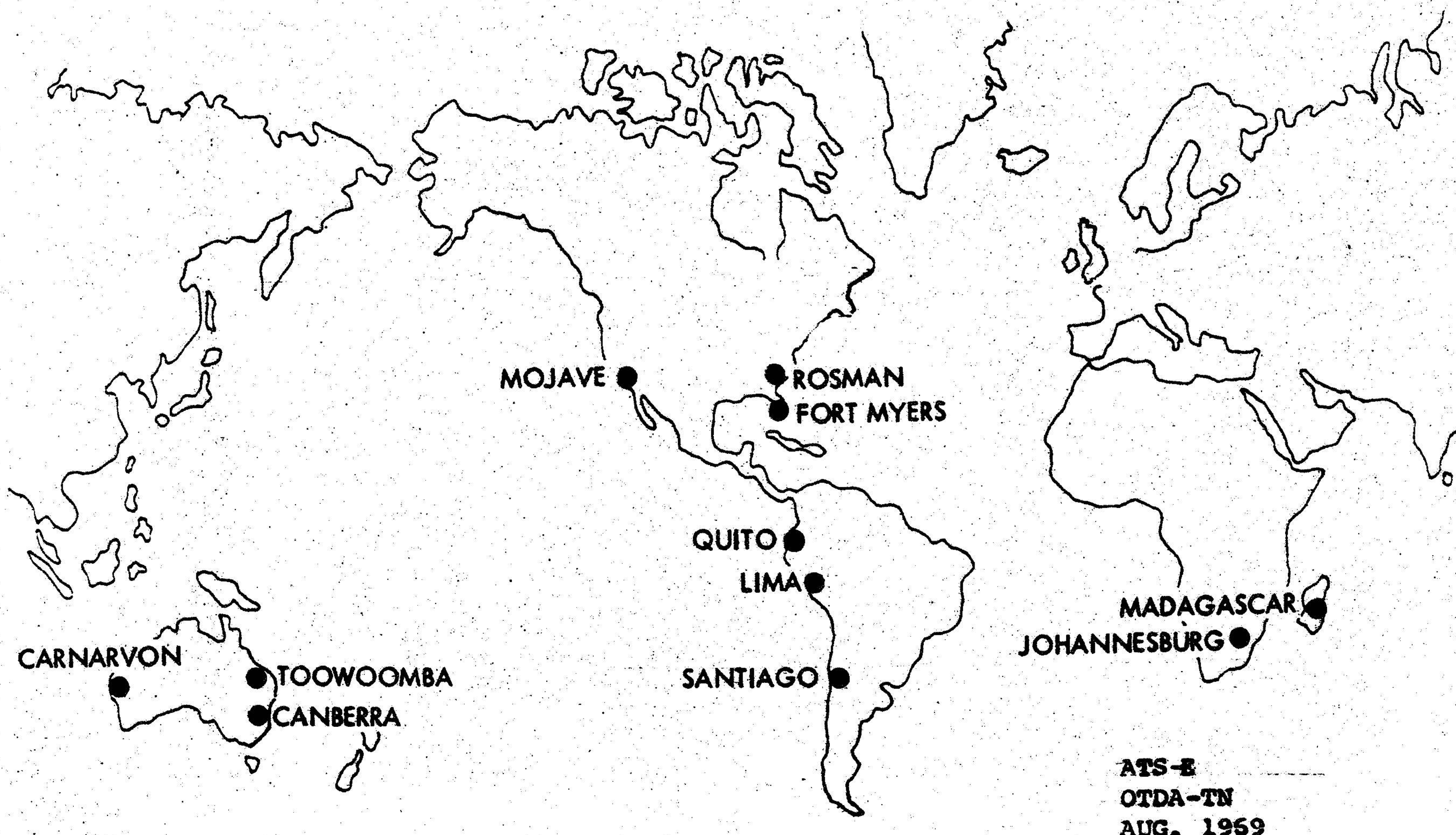
### Gravity Gradient Boom Extension Sequence

The four 124-foot-long damper booms will not be extended until the ATS-E is on station (108 - 112 degrees West Longitude) about one week after launching.

ATS-E will be spinning at about 105 rpm after it separates from the burned out apogee kick motor. When the spacecraft is on station, a two-stage yo yo (weights on approximately 40-foot wires) de-spin system will reduce the spin rate to near zero.

After the precise spin rate of near zero has been determined, a ground command from Rosman, N.C., will be sent to ATS-E for boom deployment.

# SPACE TRACKING AND DATA ACQUISITION NETWORK




ATS-E
OTDA-TN
AUG. 1969

THE ATLAS-CENTAUR LAUNCH VEHICLE

This mission will be the twelfth operational use of the high energy Centaur. The ATS-E vehicle is designated Atlas-Centaur 18.

The launch vehicle's task is to place the ATS-E spacecraft on a transfer ellipse with an apogee of 22,728 statute miles and perigee of 1,336 miles. Centaur is programmed to orient and release the spacecraft within one degree of the attitude necessary for firing its solid motor to achieve a nearly synchronous orbit.

The final orbit of the ATS-E spacecraft will have an apogee of 22,735 miles and perigee of 22,237 miles. It will then appear to hover over a point on the Equator about 1,870 miles west of South America.

The eleven previous operational Centaur flights have included launches of seven Surveyor spacecraft to the Moon; an Applications Technology Satellite (ATS-D); an Orbiting Astronomical Observatory (OAO-A2); and two Mariner '69 spacecraft to fly by Mars. Centaur, which was developed under the direction of NASA's Lewis Research Center, was the nation's first vehicle to use the liquid hydrogen-liquid oxygen propellant combination in an upper stage.

AC-18 consists of an Atlas-SLV-3C booster combined with a Centaur second stage. Both stages measure 10 feet in diameter and both rely on pressurization for structural integrity.

The Centaur second stage including the nose fairing is 48 feet long. It is powered by two improved RL-10 engines, designated RL-10 A-3-3. The RL-10 was the first hydrogen-fueled engine developed for the space program.

Centaur carries insulation panels and a nose fairing which are jettisoned after the vehicle leaves the Earth's atmosphere. The insulation panels, weighing 1,145 pounds, surround the second stage propellant tanks to prevent the heat of air friction from causing excessive boil-off of liquid hydrogen wile in the atmosphere. The nose fairing protects the payload from the same heat environment.

In the ATS-E mission, the Centaur will use 14 small thrusters, powered by hydrogen peroxide, to provide attitude control and to keep the propellant settled during the coast period. The thrusters include: four 50-lb thrust vernier engines; four 3.5 lb. and two 6 lb. thrust attitude control thrusters; and four 3 lb. settling thrusters.

## Atlas Phase

After liftoff AC-18 will rise vertically for about 15 seconds, during which time it is rolled to the desired flight plan azimuth of 97 degrees. During booster engine flight the vehicle is steered by the Atlas autopilot.

After 153 seconds of flight, the booster engines are shut down (BECO) and jettisoned three seconds later. Eight seconds following BECO, the Centaur guidance system then takes over flight control. The Atlas sustainer engine continues to propel the AC-18 vehicle to an altitude of 84.6 miles. Prior to sustainer engine shutdown at T + 249 seconds, the second stage insulation panels are jettisoned, followed by the nose fairings.

The Atlas and Centaur stages are then severed by an explosive charge and separated by retrorockets mounted on the Atlas.

## Centaur Phase

Centaur's engines are then ignited for a planned first burn of 379 seconds. The burn will place the Centaur and the spacecraft into a highly elliptical parking orbit with an apogee of 3,235 miles and a perigee of 112 miles. Early during this burn, the vehicle performs a yaw maneuver to the left (North) which reduces the inclination of the orbit. Rotating the plane of the orbit also increases the altitude the vehicle will have when it crosses the equator for the first time. This high altitude is required to maximize spacecraft capability.

As Centaur's engines are shut down and the coast period begins, two 50-pound thrust hydrogen-peroxide vernier engines are fired for 76 seconds to settle the propellants.

Two hydrogen-peroxide ullage rockets, each with three pounds of thrust, are then fired continuously during the coast period of 25 minutes to retain the propellants in the lower part of the tanks.

About 40 seconds before the Centaur's main engines are ignited for second burn, the two 50-pound vernier thrusters are used again to insure proper propellant settling.

Approximately 36 minutes into the flight, as the vehicle is crossing the Equator for the first time, the hydrogen fueled main engines are ignited again. At the end of the 71-second burn, Centaur and spacecraft will have achieved a new orbit with an apogee of 22,728 miles and a perigee of 1,336 miles in a plane inclined closer to the equatorial plane. The second burn command and duration of the burn are determined by Centaur's inertial guidance system, as are all command and steering functions following booster engine cutoff and jettison.

## Separation

Following Centaur main engine second shutdown, the Centaur is turned approximately 150 degrees to orient the spacecraft properly for separation. In terms of accuracy, this maneuver is one of the most critical of the flight. Separation takes place by firing explosive bolts on a V-shaped metal band holding together two parts of the spacecraft adapter. Compressed springs then push the spacecraft away from the launch vehicle at a rate of about 1.5 feet per second.

## Retro Maneuver

Five seconds after the spacecraft separation, the Centaur attitude control thrusters are used to reorient the vehicle. The 50-lb. thrust vernier engines are then fired for eight seconds and the three-lb. vernier engines for 100 seconds; the excess propellants then are allowed to flow through the main engines to place the Centaur in a different orbit from the spacecraft.

Following separation the spacecraft continues in its 22,728 by 1,336 mile transfer ellipse. After coasting for 1.5 orbits, the spacecraft fires its apogee motor at the apogee of the transfer ellipse to establish it in a near circular orbit of 22,735 by 22,237 miles.

## Launch Window

The ATS-E launch window opens at 6:53 a.m. EDT, on August 12 and closes at 7:53 a.m. EDT. The one hour window continues through August 20, opening one minute earlier every two days. In the following days the window opens earlier and increases its length until reaching its maximum duration of 80 minutes on August 28 and 29. The present launch opportunity is defined only through September 1.

ATLAS-CENTAUR FLIGHT SEQUENCE

| Event | Nominal Time, Seconds | Altitude Statute Miles | Surface Range, Statute Miles | Velocity MPH |
|---|---|---|---|---|
| Liftoff | 0 | 0 | 0 | 0 |
| Booster Engine Cutoff | 152.9 | 36.4 | 53.0 | 5,677.3 |
| Booster Jettison | 156.0 | 38.7 | 59.0 | 5,856.6 |
| Jettison Insulation Panels | 197.9 | 61.4 | 127.4 | 6,689.8 |
| Jettison Nose Fairing | 234.9 | 78.6 | 196.8 | 7,690.0 |
| Sustainer Engine Cutoff | 248.9 | 84.6 | 227.2 | 8,161.0 |
| Atlas Separation | 250.8 | 85.5 | 231.5 | 8,156.4 |
| Centaur Engine First Start | 260.4 | 89.2 | 252.2 | 8,122.3 |
| Centaur Engine First Cutoff | 639.6 | 140.7 | 1495.8 | 18,609.7 |
| Centaur Second Burn | 2141.0 | 1570.2 | 7229.1 | 13,882.8 |
| Centaur Engine Second Cutoff | 2212.2 | 1651.4 | 7438.2 | 17,707.0 |
| Spacecraft Separation | 2347.2 | 1818.4 | 7872.2 | 17,355.2 |
| Start Centaur Reorientation | 2352.2 | 1825.1 | 7887.7 | 17,340.9 |
| Start Centaur Retrothrust | 2409.2 | 1904.6 | 8061.6 | 17,174.5 |

## Launch Vehicle Characteristics

| | | |
|---|---|---|
| Liftoff weight including spacecraft: | | 323,815 lbs. |
| Liftoff height: | | 118 ft. |
| Launch Complex: | | 36-A |
| Launch Azimuth: | | 97 degrees |
| | SLV-3C Booster | Centaur Stage |
| Weight: | 283,845 lbs. | 38,075 lbs. |
| Height: | 79 ft. including interstage adapter | 48 ft. with payload fairing |
| Thrust: | 395,000 lbs. at sea level | 30,000 lbs. in vacuum |
| Propellants: | Liquid oxygen and RP-1 | Liquid hydrogen and liquid oxygen |
| Propulsion: | MA-5 system: two 168,000-lb. thrust engines, one 58,000-lb. sustainer engine and two 670-lb. thrust vernier engines. | Two 15,000-lb. thrust RL-10 engines. Fourteen small hydrogen peroxide thrusters |
| Velocity: | 5677 mph at BECO. 8161 mph at SECO. | 17,355 mph at spacecraft separation |
| Guidance: | Pre-programmed autopilot through BECO. Switch to Centaur inertial guidance for sustainer phase. | Inertial guidance |

## ATS RESULTS

ATS 1 and 3, launched in 1966 and 1967 respectively far exceeded their test objectives.

ATS 1 is in a synchronous orbit above the Equator 151 degrees West Longitude, over Christmas Island in the Pacific. All of the communications and meterological experiments on ATS 1 continue to operate. During the recovery of Apollo 11, ATS 1 was the primary communications system between President Nixon on the USS Hornet and the White House.

ATS 3, in synchronous orbit above the mouth of the Amazon (46 degrees West Longitude), is still operating. However, television has been temporarily cancelled because of a problem with the mechanical de-spun antenna. It continues to take high quality meteorological photos and the VHF communications experiment is still working.

ATS 2 and 4, launched in 1967 and 1968 respectively, were declared mission failures because of booster malfunctions which prevented the satellites from achieving their desired orbits. The gravity gradient experiment, which was the primary test on both missions, could not operate properly in the highly elliptical orbits. However, the communications and weather experiments on both spacecraft worked satisfactorily.

The meteorological, communications and technological results from the ATS 1 and 3 are as follows:

### Meteorological

Two black-and-white and one color camera from synchronous orbit have provided new knowledge on the behavior of weather systems. Meteorologists have been particularly interested in cloud photos of short duration weather phenomena, tornadoes, which cannot be tracked from operational satellites in low earth orbit.

More than 12,000 black-and-white and color photos of the Earth's disk have been taken on an almost daily basis since ATS 1 was launched.

The ATS weather photos have also supported all of the manned Apollo flights.

Of particular interest are the ATS 3 still photos taken over the midwest portion of the United States during the 1968 tornado watch. Movies of these pictures have been made, and meteorologists are studying the film for the possibility of making tornado predictions in the future.

The red channel of the color ATS 3 camera is no longer working, but the camera is still producing high quality green and blue pictures (in monochrome) which are being used for weather research. The red channel is being reconstructed from the spectral composition of the other channels.

While the color camera was working, it demonstrated the value of color photos for clearer delineation between clouds and surface features and in the determination of cloud heights--and important meteorological ingredient for better long range weather prediction.

Another significant meteorological experiment successfully demonstrated has been the Omega Position Location Equipment (OPLE) test.

On the Baltimore/Washington Parkway, the OPLE system was able to determine the location of a specially equipped station wagon traveling 60 miles an hour to within 2,000 feet of the Parkway's course. This accuracy was achieved by cancelling out systematic errors which were determined by repeated trials.

OPLE was also able to track a small craft in the Chesapeake Bay, a NASA calibration (tracking station checkout aircraft) plane, and a U.S. Coast and Geodetic Ship, the Discoverer, with a high degree of accuracy.

The OPLE tests have been designed so future satellites can track hundreds of balloons in the atmosphere to learn more about wind circulation--one of the key factors in better weather prediction.

OPLE can also track floating oceanographic buoys to learn more about water current velocity, temperature and direction which could be helpful not only to meteorologists (about 90 per cent of precipitation originates over water) but fisherman. The location of schools of fish frequently is a function of temperature.

Communications

Possibly the most significant space/Earth application results have been from the Very High Frequency (VHF) communications experiments aboard ATS 1 and 3.

Several thousand hours of tests so far have shown that ground-to-aircraft and aircraft-to-aircraft communications via a satellite are more reliable than conventional High Frequency (HF) ground-to-air communications.

VHF reliability, using ATS 3, is much better than the average systems currently in use over the oceans.

Five domestic airlines (Pan American, TWA, American, Eastern and United) and the Federal Aviation Agency have participated in highly successful tests, including the use of a small mobile ground station weighing less than 75 pounds.

As a non-communication experiment, the VHF tests have demonstrated ease of collecting remote weather data for world-wide distribution.

The VHF experiment has contributed to such applications disciplines as communications, navigation, meteorology and Earth resources.

Another communications experiment, which has operated successfully, is Super High Frequency (SHF), or microwave experiment. Stations participating in this experiment have been able to simultaneously send traffic and receive from each other (voice, color and black-and-white television, telegraph and digital data).

A low cost SHF antenna system, which has already been demonstrated, can be carried in a standard family station wagon and erected in less than one hour.

Scientific Experiments

Correlation between energetic electron measurements on ATS 1 and balloon observations from Fairbanks, Alaska verifies that outer radiation zone trapped electrons and precipitated auroral electrons are responding to the same external mechanism, rather than the radiation belt being the source of auroral particles.

Technological

Synchronous orbiting satellites are exposed to two main forces, one which constantly nudges the satellite in an easterly or westerly direction, and another in the north/south direction.

The east/west drift (except at points over the equator south of California and India) is caused by the elliptical equatorial cross-section of the Earth. The north/south drift is caused from the gravitational attraction between the satellite (ATS), the Moon and the Sun. The ability to counter these forces is called "station-keeping."

North/south station keeping for long lived spacecraft requires about 20 times more energy than east/west, and was proven with the hydrazine system on ATS-3.

Although ATS 4 was declared a failure, the ion engine experiment aboard that spacecraft was successful.

## THE ATS-E TEAM

The following are responsible for the Applications Technology Satellite program:

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|---|---|
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| Richard Katucki | Manager, Passive Altitude Control Systems, General Electric Co. |
| Deane Davis | Centaur Program Manager, General Dynamics/Convair, San Diego, Calif. |

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