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PROJECT: Atmosphere Explorer-D

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ATMOSPHERE EXPLORER SET FOR LAUNCH

NASA will launch the second in a series of three maneuverable, unmanned spacecraft to explore in detail an area of the Earth's outer atmosphere where important energy transfer, atomic and molecular processes and chemical reactions occur that are critical to the heat balance of the atmosphere.

Atmosphere Explorer-D (Explorer-54 in orbit) is scheduled for launch into a polar orbit about Oct. 1 on board a Delta rocket from the Western Test Range, Lompoc, Calif.

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As in the AE-C or Explorer-51 mission, and another mission scheduled for later this year (AE-E), the spacecraft will be linked through a sophisticated ground computer with scientists in widely scattered parts of the country studying the outer atmosphere.

The area of the upper atmosphere of primary interest is between 130 and 300 kilometers (80 to 120 miles).

The first mission, AE-C or Explorer 51, found the weather in this region is constantly changing with winds 10 times as severe as those normally found on the Earth's surface. For example, the winds may be measured blowing from west to east at 160 knots and a few kilometers higher they will be coming from the opposite direction at the same speed. The usual direction is from dayside to nightside. Prior to AE-C's launch in December 1973 it was believed the atmosphere at this region, the thermosphere, behaved predictably and was relatively stable. Now we know it is very dynamic and unpredictable.

AE-C was the first unmanned spacecraft able to dip in and out of the Earth's atmosphere on a global basis to measure the thermosphere and to give scientists an extended look at this region.

Before the orbit adjustable Atmosphere Explorer, most information on the area came from sounding rockets gathering a few seconds of data, and other satellites slowly falling back to Earth as their orbits decayed.

AE-D will continue the work of its predecessor, sampling regions over both poles that AE-C couldn't reach because of its 68 degree orbit. In fact, AE-C although successfully accomplishing its mission last spring, will be used again to work with AE-D in the first few weeks so that areas of interest at different altitudes can be sampled simultaneously.

Another successful aspect of the previous mission, real time exchange of spacecraft scientific information among participating scientists, will be continued on AE-D and the next one, AE-E, scheduled for launch in November from Cape Canaveral, Fla., into an equatorial orbit.

Should a solar flare or other disturbance phenomenon occur, a central ground computer complex at Goddard Space Flight Center, Greenbelt, Md., will enable the 15 scientist investigators and theorists utilizing the 12 onboard instruments to coordinate their activities while the event is actually happening.

The scientific instruments on AE-D are almost identical to those carried on the previous spacecraft and include a photometer to measure nitric oxide. Nitric oxide is one of the main constituents which control the ozone layer. These measurements of nitric oxide, in conjunction with a direct measurement of ozone scheduled for AE-E, will be a major step forward in understanding the interaction of upper atmosphere constituents with solar ultraviolet light and the resulting impact on Earth's ozone layer.

The main energy input to the atmosphere is known to come from the absorption of solar ultraviolet radiation; but a significant portion comes from the solar wind (a mass of ionized gas flowing out of the Sun) interacting with the atmosphere in the polar regions. An immediate consequence of this interaction can be seen in the aurorae, whose bands of light consume more energy than is used by the entire United States. The magnitude and variability of this high latitude heat source, which during geomagnetic storms causes worldwide radio blackouts, is poorly understood. An important objective of this mission is to investigate these processes and mechanisms.

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The spacecraft will also examine particle fluxes, airglow intensities, plasma densities and temperatures and magnetic fields at the low altitudes where the energy dissipation occurs. These measurements will be used to assess the heat balance and energy conversion mechanisms, as well as the flow of heat or energy from one hemisphere to the other.

The spacecraft design, making use of existing technology, is relatively inexpensive. Costs for all three spacecraft are expected to total about $24 million.

The general configuration of the AE satellite is a 16-sided polyhedron. The drum-shaped spacecraft is 135 centimeters (53.2 inches) in diameter and 115 cm (45 in.) high. It weighs 675 kg (1,488 lb.) including 95 kg (210 lb.) of instrumentation.

Overall program direction is the responsibility of NASA's Office of Space Science, Washington, D.C., with Goddard Space Flight Center providing the spacecraft and rocket direct management. Launch operations have been assigned to Kennedy Space Center's Western Test Range, Operations Division. RCA Corp., Princeton, N.J., is the spacecraft prime contractor and McDonnell Douglas Corp., Huntington Beach, Calif., builds the launch vehicle.

(END OF GENERAL RELEASE. BACKGROUND INFORMATION FOLLOWS.)

MISSION DESCRIPTION

Atmosphere Explorers C, D and E mark a new approach in scientific spacecraft. They differ in the orbit flown, in the team approach taken by the investigators, in the degree of interaction between the investigators and the spacecraft and data operations, and in the rapidity with which data must be acquired, processed and analyzed.

The data of each investigator are available to all investigators, and the investigators interact as a team to contribute to operational decisions.

These second generation Atmosphere Explorers represent a logical continuation and extension of a basic program in aeronomy being conducted by NASA. The first aeronomy satellite, Explorer 17, was launched April 2, 1963, and another, Explorer 32, in May 1966.

The resulting new data and concepts indicated the need for conducting measurements during flights in a way that would permit separating the effects of local time, latitude and altitude.

The results of these missions demonstrated the need to conduct satellite measurements at significantly lower altitudes. In particular, it became evident that the behavior of the upper thermosphere is strongly governed by the lower thermosphere, because most of the solar ultraviolet energy is absorbed at altitudes below those normally attainable by satellites. Experimental study of the lower thermosphere thus became a primary goal of the aeronomy program.

AE-D will be placed initially in a highly eccentric orbit with 90 degrees inclination, perigee near 157 km (93 mi.) and apogee of 3,800 km (2,375 mi.). At intervals of several weeks perigee may be lowered for brief periods to the lowest altitude consistent with spacecraft and instrument safety.

Over a period of months the apogee will be allowed to fall and, through the use of propulsion, a sequence of circular orbits will be established at each of several preselected altitudes in the range of 250 to 700 km (150-420 mi.). This circular orbit phase of the mission will continue until the fuel is nearly depleted, perhaps a year after launch. In the final phase the remaining fuel may be used to place the satellite in a stable orbit that will provide optimum long range sampling. This final orbit will be complementary with the orbit of the remaining AE mission.

The AE spacecraft has an orbit-adjust propulsion system carrying 168 kg (370 lb.) of fuel and employing three hydrazine thrusters to provide a means of adjusting perigee and apogee altitudes. Firing will be done primarily in the despin mode with the spacecraft in either the standard or inverted position to either increase or decrease the velocity and, therefore, change the orbit. A backup spinning thrust mode will also be provided. The main thrust will be a 1.8 kg (3.96 lb.) flight qualified unit. Spacecraft dynamics and errors must be small enough to allow velocity increments of 2.5 m (8.15 ft.) per second without exceeding the spacecraft altitude errors. It is expected to use 2.3 kg (5.06 lb.) or propellant for each "up" or "down" excursion using approximately six pounds of propellant for one maneuver. Design considerations make the AE spacecraft capable of withstanding aerodynamic heating effects at a perigee of 120 km (72 mi.) while spinning and 150 km (90 mi.) when despun.

AE-D MISSION FACTS AT A GLANCE

Launch:	From Western Test Range, Lompoc, California.
Launch Vehicle:	Two stage Delta with nine solid fuel strap-on motors.
Nominal Orbit:	Apogee: 3800 kilometers (2,375 miles) Perigee: 157 kilometers (93 miles) Period: 127 minutes Inclination: 90 degrees
Operating Lifetime:	At least one year
Spacecraft Weight:	675 kilograms (1,488 pounds)
Structure:	Drum-shaped (16-sided polyhedron), 137 centimeters (53.2 inches) in diameter and 117 centimeters (45 inches) high. Consists of two shells, inner and outer, with solar cells, telemetry antennas and viewing ports on outer shell. Inner shell holds 12 scientific instruments and four engineering measurements (95 kilograms, 212 pounds), electronic packages, attitude control system, hydrazine thruster subsystem.
Power System:	Solar cells on exterior of spacecraft, redundant nickel cadmium batteries. Provides 120 watts of power during normal operation.
Communications and Data Handling:	Telemetry, tracking and command and control and the antennas.

Telemetry:	Pulse-coded Modulation (PCM) operating at 137.23 MHz, VHF 2289.50 MHz S-Band
Tracking and Data Acquisition:	Stations of the Spaceflight Tracking and Data Network (STDN) operated by GSFC.

LAUNCH VEHICLE OPERATIONS

For AE-D, a two stage Delta 2910 launch vehicle will be used. The vehicle has an overall length of approximately 35 meters (116 feet) and a maximum body diameter of 2.48 meters (8 feet). The nominal launch weight is 130,913 kilograms (290,920 pounds), including the nine booster thrust-augmentation solid motors.

The standard 8-foot diameter Delta fairing protects the spacecraft from aerodynamic heating during the boost flight and, is jettisoned as soon as the vehicle leaves the sensible atmosphere shortly after second stage ignition.

Guidance

An all-inertial guidance system consisting of an inertial sensor package and digital guidance computer controls the vehicle and sequence of operations from liftoff to spacecraft separation. The sensor package provides vehicle attitude and acceleration information to the guidance computer. The guidance computer generates vehicle steering commands to each stage to correct trajectory deviations by comparing computed position and velocity against prestored values.

In addition, the guidance computations perform the functions of timing and staging as well as issuing preprogrammed command attitude rates during the open loop and coast guidance phases.

First Stage

The first stage is a McDonnell Douglas Astronautics Company modified Thor booster incorporating nine strap-on Thiokol solid fuel rocket motors. The booster is powered by a Rocketdyne RS-27 engine using liquid oxygen and liquid hydrocarbon propellants. The main engine is gimbal-mounted to provide pitch and yaw control from liftoff to main engine cutoff (MECO). Two liquid propellant vernier engines provide roll control throughout first stage operation and pitch and yaw control from MECO to stages I-II separation.

Second Stage

The second stage is powered by a TRW TR-201 liquid fuel pressure fed engine which is also gimbal mounted to provide pitch and yaw control through second stage burn. A nitrogen gas system using eight fixed nozzles provides roll control during powered and coast flight as well as pitch and yaw control during coast periods after second stage cutoff. Two fixed nozzles, fed by the propellant tank helium pressurization system, provide retro-thrust after spacecraft separation.

After second stage burnout, the vehicle will be reoriented so that the spacecraft spin axis is normal to the orbit plane. The desired orbital spin rate will be achieved by rolling the vehicle prior to spacecraft separation.

Spacecraft Separation

Approximately 3 minutes 20 seconds after second stage burnout, AE-D separates from the Delta second stage at a planned altitude of 160 km (87 mi.), at which time NASA ground tracking and command facilities take over.

MAJOR AE-D/DELTA FLIGHT EVENTS

Event	Time Minutes/Seconds	Altitude Kilometers	N.Miles	S.Miles
Liftoff	0:00	0	0	0
Six Solid Motors Burnout	0:38	6.0	3.2	3.7
Three Solid Motors Ignite	0:39	6.1	3.3	3.8
Three Solid Motors Burnout	1:18	22.2	12	13.8
Jettison Nine Motor Casings	1:27	25.9	14	16.1
Main Engine Cutoff (MECO)	3:50	113.0	61	70.2
Vernier Engine Cutoff (VECO)	3:56	120.4	65	74.8
Stage I/II Separation	3:58	122.1	66	75.9
Stage II Ignition Signal	4:02	127.8	69	79.4
Jettison Fairing	4:34	157.4	85	97.8
Stage II Cutoff (SECO)	9:09	227.7	123	141.5
Stage II/Spacecraft Separation	12:30	161.1	87	100.1

STRAIGHT-EIGHT DELTA FACTS AND FIGURES

Height: 35.4 meters (116 feet) including shroud

Maximum diameter: 2.4 m (8 ft.) without attached solids

Liftoff weight: 131,959 kilograms (290,920 pounds)

Liftoff thrust: 1,725,780 newtons (387,816 pounds) including strap-on solids

First Stage-- (liquid only) consists of an extended long tank Thor, produced by McDonnell Douglas. The RS-27 engines, produced by the Rocketdyne Division of Rockwell International, have the following characteristics:

diameter--2.4 m (8 ft.)

Height--21.3 m (70 ft.)

propellants--RJ-1 kerosene as the fuel and liquid oxygen as the oxidizer

thrust--912,000 N (205,000 lbs.)

burning time--about 3.48 minutes

weight--about 84,000 kg (185,000 lbs.) excluding strap-on solids

Strap-on solids consist of nine solid propellant rockets produced by the Thiokol Chemical Corporation, with the following features:

diameter--0.8m (31 inches)

height--7 m (23.6 ft.)

total weight--40,300 kg (88,650 lbs.) for nine
4,475 kg (9,850 lbs.) each

thrust--2,083,000 N (468,000 lbs.) for nine
231,400 N (52,000 lbs.) each

burning time--38 seconds

<u>Second Stage</u>--Produced by McDonnell Douglas Astronautics Co., utilizing a TRW TR-201 rocket engine. Major contractors for the vehicle inertial guidance system located on the second stage are Hamilton Standard, Teledyne and Delco. Characteristics are:

diameter--1.5 m (5 ft.) plus 2.4 m (8 ft.) attached ring

height--6.4 m (21 ft.)

weight--6,180 kg (13,596 lbs.)

propellants--liquid, consisting of Aerozene 50 for the fuel and Nitrogen Tetroxide (N_2O_4) for the oxidizer

thrust--about 42,923 N (9,650 lbs.)

total burning time--335 seconds

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SPACECRAFT DESCRIPTION

The Atmosphere Explorer spacecraft is 135 cm (53.2 in.) in diameter and 115 cm (45 in.) high. The spacecraft including experiments will weigh approximately 675 kg (1,488 lb.). Solar cells mounted on the top and sides of the outer shells will supply electrical power for the spacecraft and experiments. Various sensors and probes will project through the outer skin to collect data and provide spacecraft attitude control information. The spacecraft is equipped with hydrazine thrusters to provide orbit adjustment capability, thus permitting data collection over a great range of orbits.

Structural Subsystem

The spacecraft structure consists of reinforced platforms for equipment mounting, an adapter section for launch vehicle compatibility, a suitable number of reinforced handling and lifting pads, and the outer covers.

Thermal Subsystem

Aerodynamic heating as well as solar heating in both the spin and despin modes will contribute to the spacecraft thermal input. Active thermal control provided by a thermally actuated set of louvres on the bottom of the spacecraft that along with heat sinks, insulation and isolation will confine the temperatures of the spacecraft internal equipment to a range of 10 degrees C to 35 degrees C (40 degrees F. to 95 degrees F.).

Attitude Control Subsystem

The attitude control subsystem has a momentum wheel for spinning body stabilization, magnetic torquers for orientation and momentum control, nutation dampers for oscillation control and attitude sensors.

Orbit Adjust Propulsion Subsystem

The orbit-adjust propulsion subsystem uses one or more hydrazine thrusters to provide a means for adjusting perigee and apogee altitudes.

The main thruster is a 1.8 kg (4 lb.) flight-qualified unit. Spacecraft dynamics and alignment errors will be small enough to allow velocity increments of 2.5 m (8.2 ft.) per second without exceeding the spacecraft attitude errors. The spacecraft tankage system is capable of carrying 168 kg (370 lb.) of propellant to produce a total change in velocity of approximately 600 m (1,980 ft.) per second.

Power Subsystem

Spacecraft power is supplied by a subsystem consisting of a negative N-on-P solar array, redundant nickel cadmium (NiCd) batteries and the associated power distribution unit, chargers, power regulators and converters.

The solar array covers the top and sides of the spacecraft. The spacecraft bus voltage is 24.5 volts.

Communications and Data Handling

The communications and data-handling subsystem consist of four distinct areas: telemetry, tracking, command and control, and the antennas.

Telemetering of instrument and spacecraft data is accomplished via redundant encoders, spacecraft clocks, tape recorders and S-Band and VHF transmitters.

Tracking is via transponders and 0.25-watt beacons.

Spacecraft command and control will be accomplished by utilizing a PCM instruction command system and omnidirectional VHF and S-Band antennas.

Engineering Measurements System (EMS)

The EMS is a set of sensors that provides essential engineering data for the operation and evaluation of the spacecraft system and scientific instrumentation. Pressure gauges and accelerometers are required for control of orbit adjustments and evaluation of drag performance.

SCIENTIFIC INSTRUMENTS

AE-D carries 12 scientific instruments. These will perform simultaneous measurements of incoming solar radiation and Earth's atmosphere to provide information on the physical processes that govern the composition of the lower thermosphere and the ionosphere, thus making possible study of the closely interlocking cause-and-effect relationships that control Earth's near-space environment.

Ultraviolet (Nitric Oxide) Photometer

The ultraviolet nitric oxide (UVNO) photometer will measure the ultraviolet radiation from the upper atmosphere to determine the distribution of nitric oxide in the Earth's atmosphere as a function of altitude, location and time.

Investigator: C. A. Barth, University of Colorado

Cylindrical Electrostatic Probe

The cylindrical electrostatic probe (CEP) will obtain measurements of electron temperature and concentration required for the studies of the thermal and particle balance of the thermosphere. In addition, the probe measurements will be employed in conjunction with concurrent ionosphere spacecraft in studies relating the structure and behavior of the lower F-region to that of the upper F-region.

Investigator: Larry Brace, Goddard Space Flight Center.

Atmosphere Density Accelerometer

The atmosphere density accelerometer (MESA) will measure the neutral density of the atmosphere in the altitude range 120-400 km (75-250 mi.) by measurements of spacecraft deceleration due to aerodynamic drag. Accurate knowledge of the neutral density and its variations is required for a comprehensive understanding of the processes and energy mechanisms which control the structure and behavior of the upper atmosphere.

Investigator: K. Champion, Air Force Cambridge Research Laboratories

Photoelectron Spectrometer

The photoelectron spectrometer (PES) will measure the intensity and energy distribution of the photoelectron flux in the thermosphere in the 2 to 100 electron volt (ev) range, and primary electrons from 50 ev to 500 ev. It will provide high resolution data on the photoelectron energy spectrum and will monitor the energetic particle flux to above 100 kev.

Investigator: J. Doering, Johns Hopkins University

Retarding Potential Analyzer

The retarding potential analyzer (RPA) will provide accurate measurements of ion temperature, concentration and composition. In addition, the instrument will measure the ion drift velocity and the thermal and suprathermal electron energy distributions.

Investigator: W.B. Hanson, University of Texas at Dallas

Visual Airglow Photometer

The visual airglow photometer (VAE) will provide detailed data on the rates of excitation of the atomic and molecular constitutents in the thermosphere.

Measurements will be made of dayglow, aurora and nightglow phenomena.

Investigator: P.B. Hayes, University of Michigan

Solar Extreme Ultraviolet Spectrophotometer

The solar extreme ultraviolet spectrophotometer (EUVS) will measure the spectral distribution of intensity in the wavelength range extending from 140 to 1,850 Angstroms. The instrument consists of 24 monochromators, 12 of which will record intensities at certain fixed wavelengths which are critical to studies of atmospheric structure and to an understanding of mechanisms of dissipation of the input radiant energy. Each of the remaining monochromators will scan a limited wavelength range to give, in total, complete coverage of the 140 to 1,850 A region.

Investigator: H.E. Hinteregger, Air Force Cambridge Research Laboratories

Magnetic Ion Mass Spectrometer

The magnetic ion mass spectrometer (MIMS) will give absolute concentrations of each positive ion species in the ionosphere in the mass range 1 to 64 amu to achieve a quantitative understanding of the physical, chemical and dynamic processes that take place in the thermosphere.

Investigator: J.H. Hoffman, University of Texas at Dallas

Low Energy Electron Spectrometer

The low energy electron (LEE) spectrometer will monitor the energy input to the thermosphere from electrons in the energy range 0.2 to 25 kev, determine the characteristics of field aligned currents in the transauroral zone, and whether electric fields parellel to the magnetic field lines exist and are the cause of the field aligned currents, and, if so, obtain their location and strength; and will study the magnetospheric substorm precipitation with complete electron measurements.

Investigator: R.A. Hoffman, Goddard Space Flight Center

Open-Source Neutral Mass Spectrometer

The open-source neutral mass spectrometer (OSS) will measure the concentrations and distributions of the neutral gas constituents in the thermosphere. These data are expected to determine the instantaneous and global distributions of neutral hydrogen, helium, atomic and molecular oxygen, nitrogen and argon, and the total mass density above an altitude of approximately 120 km (75 mi.). In addition, this spectrometer will provide quantitative measurements of trace constituents.

Investigator: A.O. Nier, University of Minnesota

Neutral Atmosphere Composition Spectrometer

The neutral atmosphere composition spectrometer (NACE) uses a closed source mass spectrometer to measure the neutral atmospheric concentrations of gases of mass 1 to 46 amu.

Investigator: A.E. Hedin, Goddard Space Flight Center

Neutral Atmosphere Temperature Spectrometer

The neutral atmosphere temperature spectrometer (NATE) will provide direct measurements of the kinetic temperature of the neutral gas in the thermosphere, the molecular nitrogen density, and the total neutral gas density.

Investigator: N. Spencer, Goddard Space Flight Center

TRACKING AND DATA ACQUISITION

Tracking data will be forwarded from the ground stations to the Goddard Center by means of ground and/or radio links.

In order to provide the ability to readjust the orbit if too low after a firing, a tracking/compute capability will be provided to permit verification of the new orbit within 15 minutes.

There will also be requirements for forwarding other data to permit processing within two hours after acquisition and for forwarding the remainder within 24 hours.

AE Operations Control Center

All telemetry data will flow through the AE Operations Control Center where command verifications, information on spacecraft and attitude data (for orbit and attitude verifications) will be stripped out and the remaining data transmitted to the central processor.

Data Processing and Analysis Plan

In order to optimize the scientific return and achieve maximum utilization of the variable orbit capabilities of the AE spacecraft, an on-line central processing analysis system is provided for performing the majority of data reduction and analysis for the investigators and theorists which comprise the Aeronomy Team. Providing short turn-around times (one to several days) on analysis of selected aeronomy problems will permit adaptive mission planning while the spacecraft is in approximately the same location. For example, the Aeronomy Team may want to study a particular latitude in the northern hemisphere at a perigee of 150 km (90 mi.) during a highly disturbed condition for three consecutive days after noting the condition existing during a one day low perigee excursion. The adaptive planning will be made possible by means of the fast turn-around analytical capability within the central processor. The whole spacecraft may, thus, be operated like a laboratory instrument.

AE-D/DELTA TEAM

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Henry R. Van Goey	Manager, Western Launch Operations Division
Wilmer Thacker	Chief, Delta Operations
Carl Latham	Spacecraft Coordinator

Contractors

AE-D Spacecraft	RCA Corporation, Astro Electronics Division Hightstown, N.J.
Delta Launch Vehicle	McDonnell Douglas Astronautics Company Huntington Beach, California

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