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NASA News

National Aeronautics and
Space Administration

Washington, D.C. 20546
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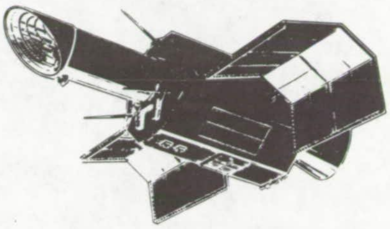
For Release IMMEDIATE

Press Kit

Project International Ultraviolet Explorer

RELEASE NO: 78-8



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NASA News

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Space Administration

Washington, D.C. 20546
AC 202 755-8370

Nicholas Panagakos
Headquarters, Washington, D.C.
(Phone: 202/755-3680)

Joe McRoberts
Goddard Space Flight Center, Greenbelt, Md.
(Phone: 301/982-4955)

For Release:

IMMEDIATE

RELEASE NO: 78-8

ULTRAVIOLET EXPLORER SET FOR LAUNCH

NASA, in cooperation with the European Space Agency (ESA) and the British Science Research Council (SRC), will launch an International Ultraviolet Explorer this month to study a wide range of celestial objects in one of the most important regions of the electromagnetic spectrum.

IUE will be launched into a modified synchronous Earth orbit by a Delta rocket from Cape Canaveral, Fla., about Jan. 26.

-more-

Mailed:
January 20, 1978

With nearly 200 astronomers from 17 countries -- including the Soviet Union -- already selected to conduct observations with IUE, the spacecraft will become one of the most widely used satellites in NASA history. Studies will range from planets in our own solar system to some of the most distant objects in the universe, including quasars, pulsars and black holes in space.

IUE will be examining the spectral region which lies in the ultraviolet (UV) between 1150 Angstroms and 3200 Angstroms, a region inaccessible from the ground. This region includes the fundamental emissions of many of the common elements in the universe (hydrogen, helium, carbon, nitrogen, oxygen).

Data returned by IUE are expected to shed more light on the nature of the different kinds of stars that populate our galaxy; on the material between the stars from which stars are formed; on many of the objects that are emitting radio waves or x-rays; and on nearby galaxies such as the little-understood Seyfert galaxies (see glossary).

Quasars are among the most puzzling objects in the universe. They are estimated to be less than 10 light years in diameter, compared with the 100,000-light-year diameter of a typical galaxy of 100 billion stars; yet, quasars pour out 100 times more energy.

They are the most powerful emitters of energy known. How this enormous energy is generated is a mystery. There is no known physical process to account for it.

It is expected that new knowledge may be obtained by examining in detail relatively nearby quasars in the ultra-violet, and then comparing these data with those from the more distant quasars seen by ground observatories in visible light.

In our own galaxy, the spacecraft will look at hot stars and the outer atmospheres of "cool" stars. Cool stars are stars similar to our own Sun. They are relatively cool at their surfaces but have extremely rarefied outer atmospheres, or coronas, with temperatures of about 555,000 degrees Celsius (one million degrees Fahrenheit). Ground observatories can't study these coronas effectively, but IUE instrumentation will be able to examine them to determine their temperatures, density and chemical composition. The workings of our own Sun are expected to be better understood as a result of these investigations.

The interstellar medium of our galaxy and even the planets of our own solar system will also come in for intensive study.

The gas and dust of the interstellar medium are believed to be the product of exploding stars and the material out of which new stars are born. Scientists are interested in the composition of the "grains" floating in the space between the stars to learn more about them and how our own star was born.

Another target of IUE will be Jupiter and other planets in the solar system. Even though we have taken closeup pictures of the planets and some of their moons, we have little information concerning their emissions in the ultraviolet. Jupiter's giant red spot is of special interest, along with the four larger Jovian moons, Io, Europa, Ganymede and Callisto, and their atmospheres.

IUE will complement and extend observations made by the two NASA Orbiting Astronomical Observatories, OAO-2 and Copernicus, and ESA's TD-1 satellite. IUE will be followed by the 10-ton Space Telescope (ST) which will be launched by the Space Shuttle in 1983.

IUE will provide a rehearsal for one of the most important objectives of the ST -- a system for observing by astronomers of all nations.

The first facilities for such observations have been established for IUE by NASA at the Goddard Space Flight Center, Greenbelt, Md., and by ESA near Madrid, Spain.

With very little spacecraft operations background, astronomers from different countries will be able to use the IUE observatories without undergoing tedious training courses in specialized techniques, will be able to go into the IUE Scientific Control Center at Goddard, for example, identify their targets and begin collecting data much as they would in a ground-based observatory.

Because of IUE's geosynchronous orbit, the astronomers will be able to observe a wide variety of objects repeatedly over long periods of time. Repetition of observations using ground-based equipment has demonstrated that the spectra of many stars vary with time.

The spacecraft is an octagonal structure with the telescope protruding from the top and a fixed solar array on two opposite sides. The spacecraft, when stabilized, is designed to always maintain one side of the two arrays toward the Sun.

Spacecraft structure is of a modular design, allowing easy installation or removal of its various assemblies and components. Total weight is 671 kilograms (1,479 pounds) including the apogee boost motor. It stands 4.3 meters (14 feet) tall and is 1.3 m (4.3 ft.) in diameter at launch. When the solar arrays are unfolded in space, it is 4.3 m (14 ft.) wide. An apogee boost motor propellant places the spacecraft in its eccentric synchronous Earth orbit, 46,000 km (28,800 mi.) by 25,000 km (15,700 mi.).

At that altitude, the spacecraft will appear to drift back and forth over the equator during its expected three-year lifetime, ranging to about 29 degrees North and South latitudes. It will be in constant view from the Goddard station and in view at least 10 hours a day from the Madrid station. Onboard, hydrazine gasjjets will keep the spacecraft on station with a mean longitude of 71 degrees West.

The Goddard Space Flight Center is responsible for the design, integration and testing of IUE, and provides the U.S. ground support facilities. ESA built the solar array and the Madrid ground facilities. Britain's SRC, in collaboration with University College, London, provided the four television camera detectors for transforming the spectral displays into video signals for transmission to the ground.

In accordance with agreements among the three participating agencies, viewing time will be allocated on a one-third, two-thirds basis. NASA will have 16 hours of viewing time and then will turn over the spacecraft to ESA for an eight-hour viewing block which will be shared equally by ESA and the United Kingdom.

Goddard manages the Delta rocket program for NASA. McDonnell Douglas Astronautics Co., Huntington Beach, Calif., is the prime contractor.

(END OF GENERAL RELEASE. BACKGROUND INFORMATION FOLLOWS.)

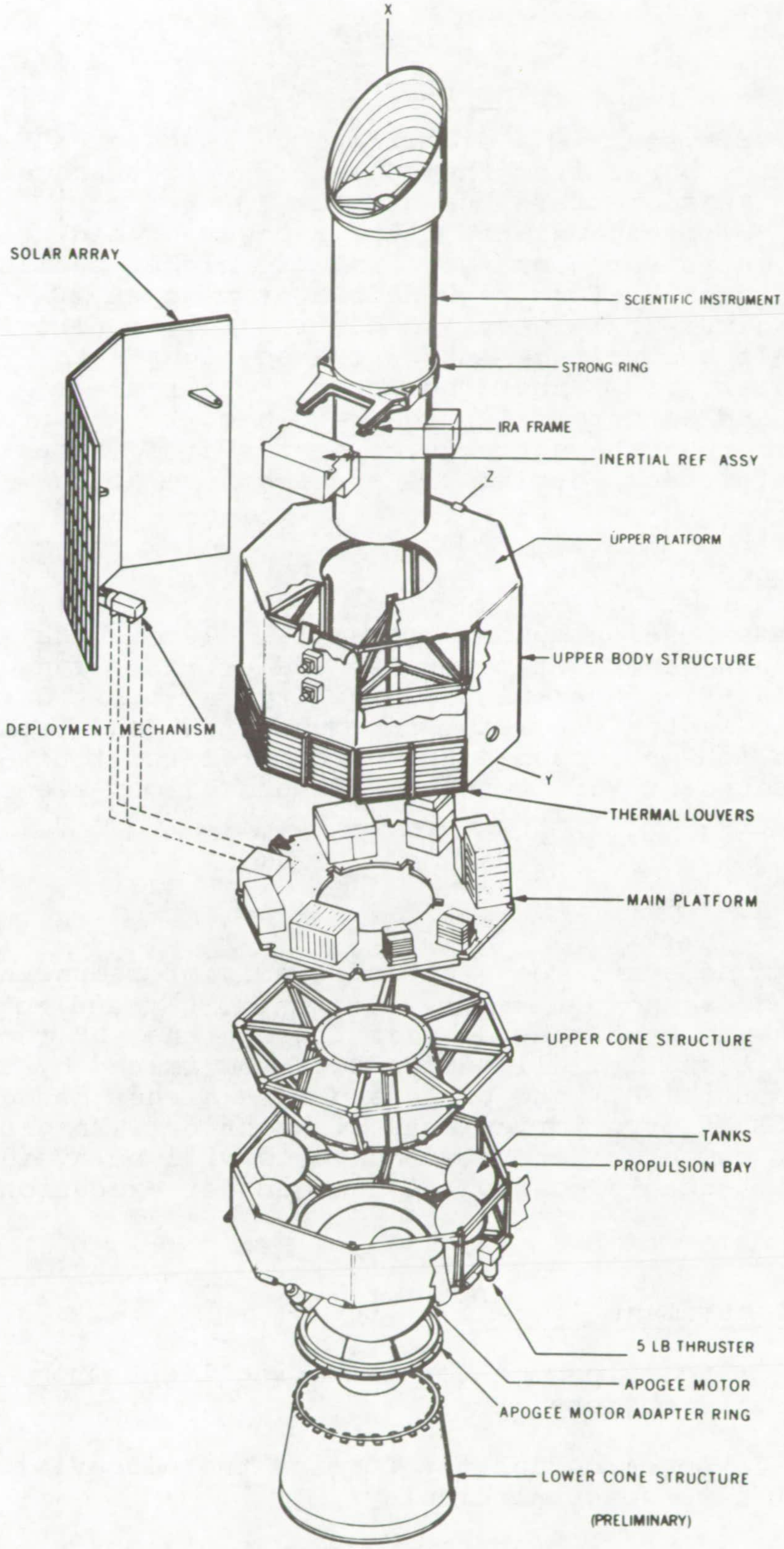
THE SPACECRAFT

The IUE is an octagonal structure with the telescope protruding from the top and a fixed solar array on two opposite sides. It is designed to maintain one face of the array toward the Sun when stabilized. Thermal control is provided by a set of thermal louvers on the dark side of the spacecraft which regulate the heat loss to space.

Most of the electronic equipment is mounted on a honeycomb platform adjacent to the louvers where the temperature will be maintained between 0 degrees and 40 degrees C. A solid propellant kick motor is used to accelerate the spacecraft to near synchronous velocity at the apogee of the transfer orbit. An auxiliary propulsion system utilizing hydrazine monopropellant occupies the lower portion of the octagonal body. The hydrazine auxiliary propulsion system (HAPS) will provide active nutation control, attitude control, spin-despin functions, east-west station keeping, momentum unloading and trajectory error correction.

The spacecraft structure is of modular design allowing easy installation or removal of its various assemblies or the components that it supports. The primary structural elements are:

- Strong Ring
- IRA Frame
- Upper Body Structure
- Main Platform
- Upper Cone Structure
- Propulsion Bay Structure
- Apogee Motor Adapter Ring
- Lower Cone Structure
- Upper Platforms



Exploded View of Spacecraft.

Power

The power system is a direct energy transfer (DET) system by which power from the solar array is transferred directly to the spacecraft bus at near 100 per cent efficiency. Elipse power and daytime power exceeding the solar array output are obtained from two nickel-cadmium batteries through a boost regulator operating at 90 per cent minimum efficiency. A control unit monitors the spacecraft bus voltage and generates signals to drive the solar array shunt regulator, battery charge controller, and battery discharge regulator in the proper sequence such that the spacecraft power system is operated at maximum efficiency during all modes of operation.

Communications

The communication system transmits telemetry data, receives ground generated commands, and provides range and range rate (R&RR) measurement capability for orbit determination. This system consists of redundant S-Band transmitters with four selectable power amplifiers, four S-Band antennas, redundant VHF transponders, and a four-element VHF antenna system.

Command System

The command system consists of a pair of redundant command decoders and a command relay unit. Ground commands can be processed by either decoder through the VHF receiver system. Additionally, all commands can be issued by the onboard computer (OBC) and processed with either decoder. Command conflict or priority establishment between ground generated or computer generated commands will be avoided by use of time-shared control of the decoder execution logic.

Scientific Instrument Systems

- Reflecting telescope for gathering light from celestial objects.
- Echelle spectrograph for forming the ultraviolet light into spectral displays.
- Television camera detectors for transforming the spectral displays into video signals suitable for telemetering.

Telescope

The telescope is a 45 cm (17.5 in.) diameter f/15 Cassegrain design, the function of which is to collect optical radiation from astonomical sources and present it to the spectrographs. The telescope will provide point-source images of about 1 arc-sec on-axis at its focal plane. The useful field of view of the telescope, 16 minutes of arc in diameter, is used to identify the desired target star for fine pointing.

- Clear aperture — 45 cm (17.5 in.) diameter
- Length — 130 cm (46 in.)
- Effective focal length — 675 cm (263 in.)
- Effective focal ratio — f/15

Spectrographs

Light from the telescope may be directed into either of two spectrographs which are able to analyze ultraviolet radiation with a resolution about 0.1A. The short wavelength spectrograph is a three element Echelle system, containing an off-axis paraboloid as collimator, an Echelle grating, and a spherical first order grating that is used to separate the Echelle orders and to focus the resulting spectral display on the television camera. The long wavelength spectograph is identical, except that two 45 degree flats are inserted to shift the light rays diverging from the entrance aperture so that they will not interfere with the rays falling on the short wavelength collimator. Either spectrograph may be converted to a low dispersion instrument by inserting a flat in front of the Echelle grating so that the only dispersion is provided by the spherical grating.

Target Acquisition and Fine Error Sensing

Two redundant fine error sensors, each capable of multi-mode operation, accomplish the dual role of a field camera, target recognition and acquisition, and of an error sensor for pointing error generation. The field camera mode provides the observer with an image of the star field. This image is displayed on the ground in real time so that a guide star and the target star can be identified.

The Fine Error Sensor is then commanded to track the guide star and provide offset data so that the target star can be placed in the spectrograph aperture by the control system.

UV Spectrum Detectors

Each of the two spectrographs incorporates two UV-sensitive television cameras which are used respectively as prime and back-up spectrum detectors, either camera being selectable on command.

The UV spectrum, which the spectrograph optics focuses at the faceplate of the selected camera, is converted in wavelength to visible light and, at the same time, increased in light intensity, by means of a proximity focused wavelength converterdiode. The fiberoptic output window of this converter is optically coupled to the fiberoptic input window of a light-sensitive secondary emission conduction (SEC) vidicon tube. In a manner analogous to a photographic emulsion, the target of the SEC tube can "accumulate" an image of the spectrum. The exposure time can be varied to suit the intensity of the spectral features of the target star -- for a faint star, exposures up to a few hours may be required. When the exposure is terminated, the integrated image is "read out." Unlike normal broadcast TV cameras, the IUE cameras are operated in a digital (rather than analog) mode, using a 256 level gray scale, permitting accurate measurement of intensity of each of more than 1/2 million picture elements. Following read-out, the video data are transmitted to ground where they processed by computer using image processing software jointly produced by the U.K. and Goddard Center. This software is an advanced development of NASA's JPL VICAR computer program and the IUE software enables correction of effects such as photocathode and target non-uniformities and geometric distortions which are inherent in the SEC tubes. This software also permits the image, either "raw" as seen by the camera, or corrected to be reconstituted in the form of a "photograph" or to be plotted in terms of intensity as a function of wavelength.

Development and space qualification of the camera system involved U.K. and U.S. industry in the solution of a number of difficult technological problems which included production of light-weight, low-volume, high-stability, high-voltage supplies with output commandable up to 14KV and the development of extremely high quality UV-to-visible converters.

Thermal

The thermal system is designed to maintain proper temperature control of all onboard systems in sunlight for all solar aspect angles of from 0° (Sun on aft end of spacecraft) to 135° in the X-Z plane, and to withstand eclipse periods up to 74 minutes. To achieve the desired temperature control the thermal design employs a combination of passive and active thermal control. Three sets of thermal louvers located on the anti-sun side of the middle portion of the structure provide active thermal control for most onboard subsystems. These louvers are supplemented with black passive radiators. The remaining portions of the spacecraft surfaces are covered with a combination of multilayer insulation and special thermal coatings. Circular heat pipes mounted concentrically to the bottom of the main equipment shelf will minimize thermal gradients.

GROUND SYSTEM

The spacecraft and ground system together comprise an observatory, the facilities of which--both orbiting and on the ground--will be made available to selected guest observers. Most of these observers will need to have only a limited, superficial knowledge of the technical details and use of software systems for processing of scientific data. Instead, as astronomers, they will use the observatory in much the same manner as they would use, for example, Palomar or Lick Observatories.

Because the IUE spacecraft will be in a synchronous orbit, it will be in continuous contact with the ground systems and, therefore, the ground system can be designed to function much like a typical ground-based observatory. Resident astronomers and other trained personnel will assist the observer with all aspects of his observing program. The guest observer will leave the facility with final processed data in a form suitable for detailed interpretation and analysis.

Mission Operations

Orbiting with a geosynchronous period at a mean longitude of 71 degrees W., the spacecraft will be in continuous contact with the U.S. ground observatory. A second site--the European ground observatory Madrid, operated by ESA--will be capable of viewing the spacecraft for extended periods of at least 10 hours each day. In accordance with the international agreements, NASA will conduct observations for 16 hours per day and the European ground observatory will conduct 10 hours of observations per day on the average. Health and safety of the spacecraft is the responsibility of NASA and will be monitored from Goddard Center 24 hours per day.

Because the total IUE system is conceived to functionally resemble a typical ground-based astronomical observatory with operations conducted in real time 24 hours per day, a unique dedicated ground system is an integral part of the total system. The IUE includes both the IUE flight system and the IUE ground system. The IUE Ground System is defined to include both a U.S. ground observatory and a European ground observatory. The U.S. ground observatory includes:

- Ground station (This is the dedicated IUE telemetry/command station at the Goddard Center Network Test and Training Facility.)

- Scientific Operations Center,
- Operation Control Center

Two Xerox Data Systems (XDS) "Sigma Series" computers will be used to support all functions of the U.S. ground observatory. One, a Sigma 5 will support real-time command and control of the spacecraft and real-time image display for the observing programs. The second, a Sigma 9 will fulfill two roles: that of backup to the Sigma 5 on an "as needed" basis and as the central computer for "near real-time" image processing. Physically, both will be located within the OCC. Remote terminals to the SOC are provided.

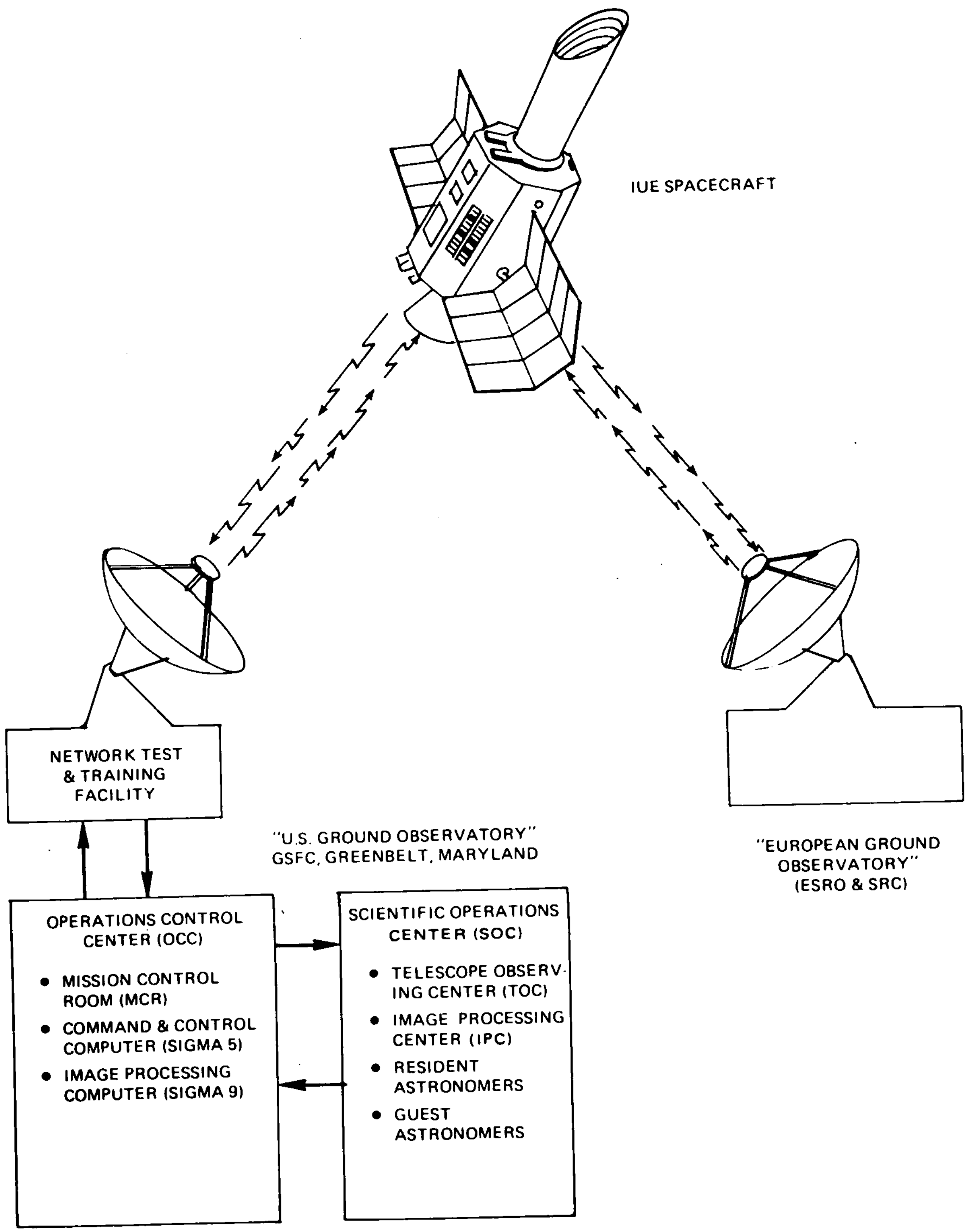
Scientific Operations Center (SOC)

Here, the planning, administrative, and management aspects of the observatory will be conducted. Space for resident astronomers and guest observers is provided. Routing real time observing programs will be conducted from the Telescope Observing Center (TOC) within this facility. Image processing will be performed by the Image Processing Center (IPC), also within this facility, by means of communication lines to/from the Sigma 9 computer located in the OCC.

Operations Control Center (OCC)

The OCC is the nerve center of the observatory Both computers are installed here. Either can process data, format command sequences, and generate real time displays of images in support of the real time operations conducted in the Mission Control Room (MCR), also a part of the OCC.

In the MCR, spacecraft controllers will monitor the status of the spacecraft and its subsystems, initial checkout of the scientific instrument as well as special observing programs will be performed from the MCR. The MCR will "hand off" the spacecraft to the European Ground observatory, and during the eight-hour ESA/SRC period of control and observing, will maintain a monitoring and standby control capability should the need arise.



IUE Observatory.

Operations at the European ground observatory will be very similar to those described above. Main differences stem from the fact that in the ESA case the IUE operations are conducted from a single building where the OCC and SOC are located side by side. Another important difference is that a single Sigma 9 computer is used. For eight hours a day it will be dedicated to spacecraft control while for the remaining time it will be devoted to image processing activities.

Guest Observers

The IUE is an international facility which is open to both U.S. and foreign guest observers. U.S.-based guest observers will come to Goddard Center and perform their programs at the IUE Scientific Operations Center which will accommodate six to eight guest observers at one time. It is anticipated that a typical visit will last about one week and that each astronomer will have one or two observing sessions per day. At the conclusion of this visit the guest observer will have all of his data in final reduced form. Observational data will be made available to the National Space Science Data Center at Goddard after the observer has had an appropriate time for analysis and interpretation. The ESA ground observatory is similarly an international facility where guest astronomers from the ESA member states plus other European and non-European countries will conduct their observations.

DELTA LAUNCH VEHICLE

Delta 138 with its IUE spacecraft payload will be launched from Pad A, northernmost of the two launch pads at Complex 17, Cape Canaveral Air Force Station, Fla.

The second stage of Delta 138 arrived at Cape Canaveral Air Force Station in September 1977. The first stage and interstage arrived in November 1977.

The Delta first stage and interstage were erected on Pad A Nov. 29. The nine solid strap-on rocket motors were mounted in place around the base of the first stage Nov. 30. The second stage was erected Dec. 1.

The IUE spacecraft was received by the Kennedy Space Center Dec. 20 and underwent initial processing in Hangar AE.

It was moved to Explosive Safe Area 60 Jan. 12 for fuel loading and apogee boost motor installation. The spacecraft was mated with the Delta third stage Jan. 18.

The third stage spacecraft assembly was moved to Pad A and mated with Delta 138 Jan. 19. The payload fairing, to protect the spacecraft on its flight through the atmosphere, will be put in place Jan. 24.

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

First Stage

The first stage is a McDonnell Douglas modified Thor booster incorporating nine Castor II strap-on Thiokol solid fuel rocket motors. The booster is powered by a Rocketdyne 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).

Second Stage

The second stage is powered by the TRW-built TR201 liquid fuel, pressure fed engine that also is gimbal mounted to provide pitch and yaw control during powered flight. A cold gas system provides pitch, yaw and roll control during coast and after second stage cutoffs. The engine is capable of multiple restarts. The second stage also houses the Delta inertial guidance system which provides guidance control and sequencing of the vehicle from liftoff through third stage spinup.

Third Stage

The third stage is the Thiokol TE-364-4 spin stabilized solid propellant Thiokol motor. It is secured in the spin table mounted to the second stage. The firing of the eight solid propellant rockets fixed to the spin table accomplishes spinup of the third stage spacecraft assembly.

Injection Into Transfer Orbit

The Delta vehicle will inject IUE into a transfer orbit having an apogee of 46,342 km (28,784 mi.) a perigee of 167 km (104 mi.) and an inclination of 28.7 degrees. NASA's Spaceflight Tracking and Data Network will provide telemetry, tracking and ranging support until the spacecraft is placed in its final synchronous orbit.

IUE LAUNCH PROFILE

The first two stages of the Delta 2914 place the spacecraft into a low altitude parking orbit 167 km (104 mi.) near the first equatorial crossings. Spinup to 60 rpm, followed by injection into a transfer orbit using the Delta third stage, occurs after approximately 30 minutes in parking orbit.

Following burnout of the Delta third stage and spacecraft separation, IUE will be in transfer orbit.

Apogee Boost Motor

At apogee, the motor is commanded to ignite by ground command from Goddard Center. A backup command sequence is provided by the onboard computer to perform the burn sequence if something should happen to the ground command link. With an ABM firing at apogee, the spacecraft will be placed at the desired station point, a geographic longitude of the ascending node of 44 degrees west, and the orbit will be targeted for zero drift. If some drift does occur, the hydrazine propulsion system will be used to place the spacecraft "on station."

LAUNCH SEQUENCE FOR IUE

Event	Time	Altitude Miles	Altitude Kilometers	Velocity Mph	Velocity Km/Hr
Liftoff	0 sec.	0	0	915	1,472
Six Solid Motor Burnout	38 sec.	3.5	5.6	1,543	2,483
Three Solid Motor Ignition	39 sec.	3.5	5.6	1,545	2,486
Three Solid Motor Burnout	1 min. 17 sec.	12.7	20	2,661	4,282
Nine Solid Motor Jettison	1 min. 27 sec.	16	26	2,875	4,626
Main Engine Cutoff (MECO)	3 min. 42 sec.	58	93	12,060	19,405
First/Second Stage Separation	3 min. 49 sec.	61	98	12,077	19,432
Second Stage Ignition	3 min. 55 sec.	63	102	12,064	19,411
Fairing Jettison	4 min. 33 sec.	78	126	12,458	20,045
First Cutoff Stage II (SECO-1)	8 min. 47 sec.	102	164	17,467	28,104
Restart Stage II	40 min. 12 sec.	107	172	17,446	28,070
Final Cutoff Stage II (SECO-2)	40 min. 30 sec.	107	172	17,954	28,888
Third Stage Spinup	41 min. 20 sec.	106	170	17,957	28,892
Second/Third Stage Separation	41 min. 22 sec.	106	170	17,957	28,892
Third Stage Ignition	42 min. 3 sec.	107	172	17,956	28,891
Third Stage Burnout	42 min. 47 sec.	109	176	23,273	37,447
Third Stage/Spacecraft Separation	43 min. 50 sec.	127	204	23,217	37,356

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TRACKING, COMMAND AND DATA ACQUISITION

Goddard Space Flight Center is responsible for providing STDN network support for the spacecraft and launch vehicle during launch and transfer orbit operations. For geosynchronous orbit operations, Goddard will provide command, telemetry acquisition and realtime data transmission from the Network Test and Training Facility (NTTF) station at Goddard. Additional STDN stations will be scheduled to backup NTTF as needed. They will use existing standard equipment and communication links. VHF range and range-rate tracking is required of a STDN station for station keeping. The STDN station at Merritt Island, Fla., will provide prelaunch preparation and checkout support for the launch vehicle and the spacecraft. For the launch and transfer orbit phases, all STDN stations that view the spacecraft will support IUE. The primary STDN station supporting the IUE mission will be the NTTF at Goddard. Daily, the NTTF will provide 16-hour continuous support for all command and data acquisition functions for the realtime operations conducted in the SOC and/or OCC. Backup support to ESA will be provided during the remaining eight hours when the spacecraft is under the control of the European ground observatory.

IUE/DELTA TEAM

NASA Headquarters

Dr. Noel W. Hinners	Associate Administrator for Space Science
Andrew Stofan	Deputy Associate Administrator, Space Science
T. Bland Norris	Director, Astrophysics Programs
John R. Holtz	Director, Explorers, Sounding Rockets, Balloons, Airborne
Leon Dondey	Manager, Astronomy Explorers
Dr. Nancy Roman	Program Scientist
John F. Yardley	Associate Administrator for Space Flight
Joseph B. Mahon	Director, Expendable Launch Vehicles
Peter Eaton	Manager, Delta

Goddard Space Flight Center

Dr. Robert S. Cooper	Director
Robert E. Smylie	Deputy Director
Robert N. Lindley	Director of Projects
Robert C. Baumann	Associate Director for Space Transportation Systems
Donald V. Fordyce	Associate Director for Projects
Gerald W. Longanecker	Project Manager
Dr. Albert Boggess	Project Scientist
Frank A. Carr	Deputy Project Manager/ Technical
Jack W. Peddicord	Deputy Project Manager/ Resources
Kenneth O. Sizemore	Spacecraft Manager
Dennis C. Evans	Scientific Instrument Manager
Charles F. Fuechsel	Mission Operations Manager
Ivan J. Mason	Project Operations Director
Dr. Donald K. West	Observatory Administrator
Thomas E. Ryan	Mission Support Manager
William E. Hawkins	Network Support Manager
Thomas Janoski	Network Operations Manager
David W. Grimes	Delta Project Manager
John Langmead	Deputy Delta Project Manager, Resources
Robert Goss	Mission Analysis and Integration Manager, Delta Project Office
Frank Lawrence	Delta Mission Integration Manager

<u>Kennedy Space Center</u>

Lee R. Scherer	Director
Dr. Walter J. Kapryan	Director, Space Vehicle Operations
George F. Page	Director, Expendable Vehicles
W. C. Thacker	Chief, Delta Operations
Wayne McCall	Chief Engineer, Delta
John Dunn	Spacecraft Coordinator

<u>United Kingdom</u>

M. O. Robbins	Director for Astronomy, Space Radio and Science, SRC Headquarters
Dr. F. Horner	Director, Appleton Laboratory
Peter J. Barker	Project Manager
Prof. Robert Wilson	Project Director and Senior Scientist, University College, London

<u>European Space Agency</u>

Roy Gibson	Director General
Dr. Ernst Trendelenberg	Director of Scientific and Meteorological Programs
Prof. Gianni Formica	Director of the European Space Operations Center
Maurice Delahais	Head of Scientific Programmes Department
Dr. Edgar Page	Head of Space Science Department
Dr. F. Duccio Macchetto	ESA Project Manager

CONTRACTORS

Prime Contractors

Goddard Space Flight Center Greenbelt, Md.	Spacecraft
McDonnell Douglas Astronautics Co. Huntington Beach, Calif.	Delta

Major Subcontractors

Hamilton Standard Division United Aircraft Corp. Windsor Locks, Conn.	Hydrazine Auxiliary Propulsion System
Bendix Corp. Guidance Systems Division Teterboro, N.J.	Inertial Reference Assembly and Reaction Wheels
Bendix Corp. Aerospace Systems Division Ann Arbor, Mich.	Experiment Display Systems
Bendix Field Engineering Corp. Columbia, Md.	Ground Station Operations Support
Information, Development and Applications, Inc. (IDEAS) Beltsville, Md.	Electronic Fabrication and Testing Support
Ball Brothers Research Corp. Boulder, Colo.	Fine Error Sensors and Panoramic Attitude Sensors
Computer Sciences Corp. Systems Sciences Division Silver Spring, Md.	Ground Station and Control Center Software Support
MRC Corp. Hunt Valley, Md.	Mechanical Fabrication Support
Adcole Corp. Waltham, Mass.	Sun Sensor Assemblies
Ithaco, Inc. Ithaca, N.Y.	Wheel Drive Assemblies

Major Subcontractors (cont'd.)

Sperry Rand Corp. Sperry Support Services Huntsville, Ala.	Quality Assurance Support
Parsons Corp. of California Stockton, Calif.	Structural Fabrication Support
General Electric Co. Battery Business Dept. Dayton, Ohio	Spacecraft Batteries
General Electric Co. Space Division Beltsville, Md.	Mechanical and Electronic Design and Fabrication Support
Applied Optics Center Corp. Burlington, Calif.	Scientific Instrument Optics
Zeta Laboratories, Inc. Mountain View, Calif.	S-Band Transmitter Modules
Aydin Monitor Systems Ft. Washington, Pa.	Sequential Decoders

United Kingdom Contractors

Marconi Space and Defense Systems Applied Electronics Laboratories (prime)	Spectrograph Camera Systems
Westinghouse Electric Corp. Electronic Tube Division	SEC Vidicon Tubes
ITT, Electro-Optical Products Division Tube and Sensor Labs	UV Image Converter Tubes
Solar Systems, Inc.	Alignment, Focus and Deflection Coil Assemblies
Royal Aircraft Establishment Space Department	Electronics Parts Control
Atomic Energy Research Establishment	Failure Analysis Support

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United Kingdom Contractors (cont'd.)

Yarsley Research Laboratories Ltd.	Materials Consultants
University of Surrey Department of Mechanical Engineering	Experimental Stress Analysis

ESA Contractors

Snias, France	Solar Arrays
AEG, Germany	Solar Cells
Harris Semiconductor Division Harris Intertype Corp. Melbourne Fla.	Integrated Circuits
Thiokol Corp. Elkton Division Elkton, Md.	Apogee Boost Motors
Westinghouse Electric Corp. Electronic Tube Division Elmira, N.Y.	SEC Vidicon Tubes
Westinghouse Electric Corp. Baltimore, Md.	Central Processor and Power
Motorola, Inc. Government Electronics Division Scottsdale, Ariz.	Random Access Memories
RCA Corp. Astro Electronics Division Princeton, N.J.	Thermal Louvers
RCA Service Co. Lanham, Md.	Control Center and Flight Operations Support
Systron-Donner Corp. Concord, Calif.	Nutation Sensor Assemblies
ITT Electro-Optical Products Division Tube and Sensor Labs Ft. Wayne, Ind.	UV Image Converter Tubes

ESA Contractors (cont'd.)

Boeing Aerospace Co. Seattle, Wash.	Radiation and Shielding Studies
OAO Corp. Beltsville, Md.	Mission Support Services
TRW, Inc. TRW Systems Group Redondo Beach, Calif.	Integrated Circuits
Telefile Computer Products, Inc. Irving, Calif.	Ground Computer Equipment
Perkin-Elmer Corp. Boller & Chivens Division South Pasadena, Calif.	Camera Selector Mechanism
Perkin-Elmer Corp. Applied Optics Division Costa Mesa, Calif.	Scientific Instrument Optics

GLOSSARY

Binary Star	A pair of stars orbiting about each other under mutual gravitational attraction.
Black Holes	Objects resulting from complete gravitational collapse beyond that of a neutron star. The accompanying gravitational field is so intense that no radiation can escape.
Electromagnetic Spectrum	The ordered array of known electromagnetic radiations, extending from those with the shortest wavelengths, cosmic rays, through gamma rays, X-rays, ultraviolet radiation, visible radiation and including microwave and all other wavelengths of radio energy.
Exploding Galaxies	Violent, energetic explosions centered in certain galactic nuclei where the total mass of ejected material is comparable to 5 million average stars. Jets of gas 1,000 light years long are typical.
Galaxy	A large system of stars held together by mutual gravitational attraction.
Neutron Stars	Remnants of supernovae explosions. They consist of ultra-dense matter composed almost entirely of neutrons which have been squeezed together by the force of gravity exerted by the collapsing matter.
Pulsars	Believed to be rotating neutron stars. The intensity of their radiation in the electromagnetic spectrum is modulated by the period of rotation. Additional periodicities have also been observed.
Quasars	Quasi-Stellar Objects. Very controversial. Quasars seem to be the size of large stars, yet they emit energy at all wavelengths comparable to that of a thousand galaxies. Characterized by very large redshifts.
Seyfert Galaxies	Unusual spiral galaxies characterized by small, extremely bright nuclei containing one to 10 billion stars. They are orders of magnitude brighter in the X-ray than in the visible part of the spectrum.

Supernova — A catastrophic stellar explosion ocurring near the end of a star's life in which the star collapses and explodes, manufacturing the heavy elements which it spews out into space. Visible luminosity may reach 100 million times that of the Sun.

Ultraviolet Radiation — Electromagnetic radiation of shorter wavelength than visible radiation; roughly, radiation in the wavelength interval from 100 to 400 Angstroms.

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