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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

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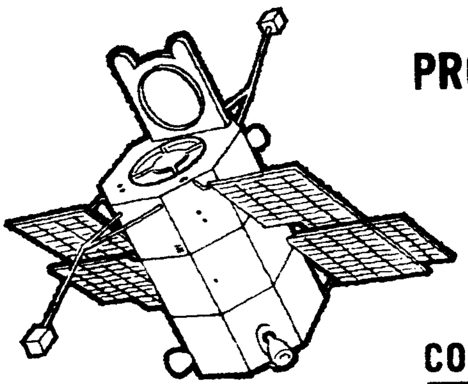
FOR RELEASE: SUNDAY
March 20, 1966

RELEASE NO: 66-60

PRESS KIT



PROJECT: OAO-A1 PRESS KIT
(To be launched no earlier than March 24, 1966)

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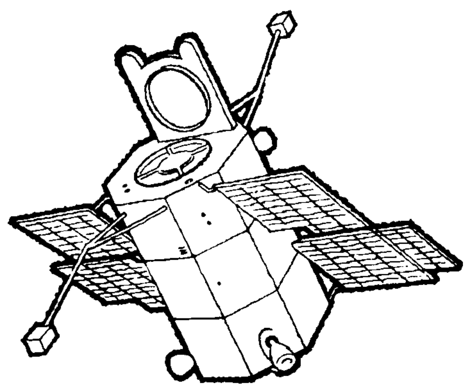

NEWS NASA
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U. S. TO LAUNCH
MOST ADVANCED
UNMANNED SPACECRAFT

The United States will attempt to launch its most advanced unmanned spacecraft from Cape Kennedy on March 24.

It will be the first in a series of four Orbiting Astronomical Observatories (OAO) designed to give astronomers their first sustained look into the universe from above the obscuring and distorting effects of the Earth's atmosphere.

The 3,900-pound observatory will be the heaviest spacecraft ever carried by the Atlas-Agena launch vehicle. OAO's diameter is larger than that of the Agena stage, requiring a special three-section clam-shell shroud to cover both spacecraft and Agena.

-more-

This first OAO will carry four experiments to study the ultraviolet, X-ray and gamma ray regions of the electromagnetic spectrum. These radiations have shorter wavelengths and higher frequencies than visible light and cannot be studied by ground-based observations. Studies of these regions should enable astronomers to define better the chemical composition, pressure and density of stellar objects.

The spacecraft's planned orbit is circular, 500 statute miles above the Earth at an inclination of about 35 degrees, with an orbital period of about 101 minutes. This orbit is designed to carry the spacecraft above the Earth's atmosphere and yet avoid possible harmful effects of exposure to radiation at higher altitudes.

If the launch is successful, this spacecraft will be named OAO I. Prior to launch it is designated OAO-A1.

As the largest, heaviest and most electronically complex unmanned spacecraft ever developed by the United States, the OAO contains more than 440,000 separate parts and 30 miles of electrical wiring.

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Its main body is a ten-foot-long, eight-sided cylinder, seven feet wide. A central tube, four feet in diameter, running through the main body, carries 1,000 pounds of astronomical observing instruments. Electronic equipment is mounted on shelves located in the main structure around the experiment-carrying tube.

With its solar panels extended, the overall width of the spacecraft is 21 feet. Other prominent external characteristics of OAO include two nine and one-half foot-long balance weight booms located at opposite sides near the top of the main body. A cover, or sunshade is mounted at the top of the central experiment tube to protect the optical instruments from the direct rays of the sun.

During the launch phase, OAO's external appendages are folded cocoon-like against the main body. Once in orbit, the solar panels and booms unfold to their operational position giving OAO a bat-like appearance.

OAO represents new milestones of engineering achievement. The challenges posed by an observatory of its magnitude are perhaps best exemplified by the development of the control system which can point scientific instruments with a precision comparable to viewing the width of a pencil at a distance of 75 feet on the first OAO and at a distance of ten miles on OAO-C.

This precise pointing capability is made possible primarily by six telescope star trackers mounted at various locations on the main body.

Other important OAO engineering features include:

-- A data storing capability of up to 8,192 words each containing 25 separate bits of experiment data and/or spacecraft status information, with a total capacity of 204,800 bits of data.

-- An on-board memory system capable of storing 128 different commands which are executed automatically when the observatory is out of range of the three OAO data-acquisition stations located at Rosman, N. C.; Quito, Ecuador, and Santiago, Chile.

This first OAO will carry four scientific experiments designed to study stars and other celestial objects in the ultra-violet, X-ray and gamma ray spectral regions. To date, the total amount of direct scientific observation in these regions, obtained from sounding rockets and balloon flights above the Earth's atmosphere, totals less than an hour.

Thus, even on its maiden mission, the potential offered by OAO in expanding man's knowledge of the universe rank it, in many respects, with the invention of the telescope.

The OAO's experiment tube contains astronomical observing instruments provided by the University of Wisconsin, the Massachusetts Institute of Technology, the Lockheed Missiles and Space Co., and the NASA Goddard Space Flight Center.

The Wisconsin experiment, a series of seven telescopes, is designed to study stars and nebulae in various regions of the ultraviolet spectrum not visible from Earth. It occupies the forward-looking or "top" portion of the experiment tube.

The aft section contains the MIT, Lockheed and Goddard experiments which are concerned with the study of X-ray and gamma ray spectral regions.

The Orbiting Astronomical Observatory program is part of the scientific space exploration program conducted by NASA's Office of Space Science and Applications. OAO project management is under direction of the Goddard Space Flight Center, Greenbelt, Md.

The Atlas-Agena is managed by the Lewis Research Center, Cleveland, O., and launched by Kennedy Space Center, Fla. Development of the OAO-A1 spacecraft was accomplished by the OAO prime contractor, Grumman Aircraft Engineering Corp., Bethpage, N.Y. The Wisconsin experiment was developed by Cook Laboratories, Chicago. Contractors from throughout the country provided various subsystems and instrumentation for the spacecraft.

Contractors for the Atlas Agena are General Dynamics/ Convair, San Diego, and Lockheed Missiles and Space Co., Sunnyvale, Calif.

(END OF GENERAL NEWS RELEASE)

BACKGROUND MATERIAL FOLLOWS

OAO-A1 SPACECRAFT

The world's first in-space astronomical observatory consists of an eight-sided main body ten feet long and seven feet wide. Six sets of solar-cell panels, consisting of two arrays of three panels each covered with more than 74,000 solar cells, give the spacecraft its overall width of 21 feet.

The internal structure arrangement of the main body includes a four-foot-wide central tube where the experiments are mounted, surrounded by vertical trusses and horizontal shelves. The bays formed by the trusses and shelves provide space for mounting spacecraft electronics and data handling systems.

The main body is constructed of riveted or spot-welded aluminum alloy. Extensive use has been made of aluminum honeycomb in locations where high rigidity is needed. A thin nonstructural covering of specially fabricated aluminum coated with Alzak (an aluminum oxide produced by ALCOA) covers the main body except for the experiment opening. The treated-aluminum-covering is designed to protect spacecraft electronics from damage by micrometeorites and is a vital part of the passive thermal control system.

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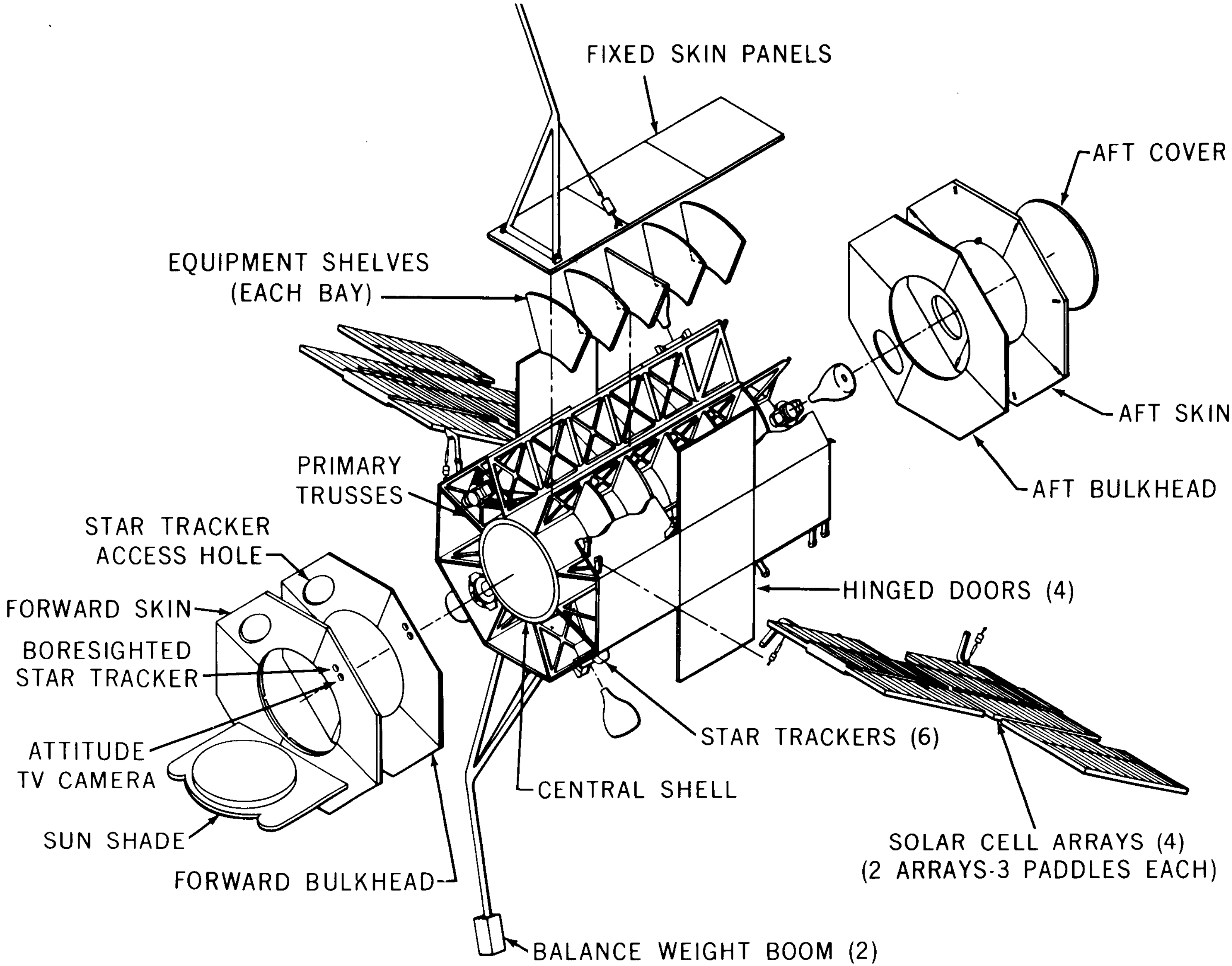


Exploded View of OAO Spacecraft

ATTITUDE CONTROL SYSTEM

Success of the OAO-A1 mission depends on the ability of the 3,900-pound observatory to point its astronomical instruments at pre-selected objects in space. The OAO control system is one of the most advanced ever developed.

After launching and separation from the Agena D upper stage rocket, the control system will first reduce the separation tumbling rate and stabilize itself on the Sun. Once Sun stabilization is achieved, a stellar reference point will be established by a pre-programmed, on-board set of stored commands or through ground command. The spacecraft will then be turned automatically to the desired pointing direction. This pointing direction must be precisely maintained to permit experiment observations.

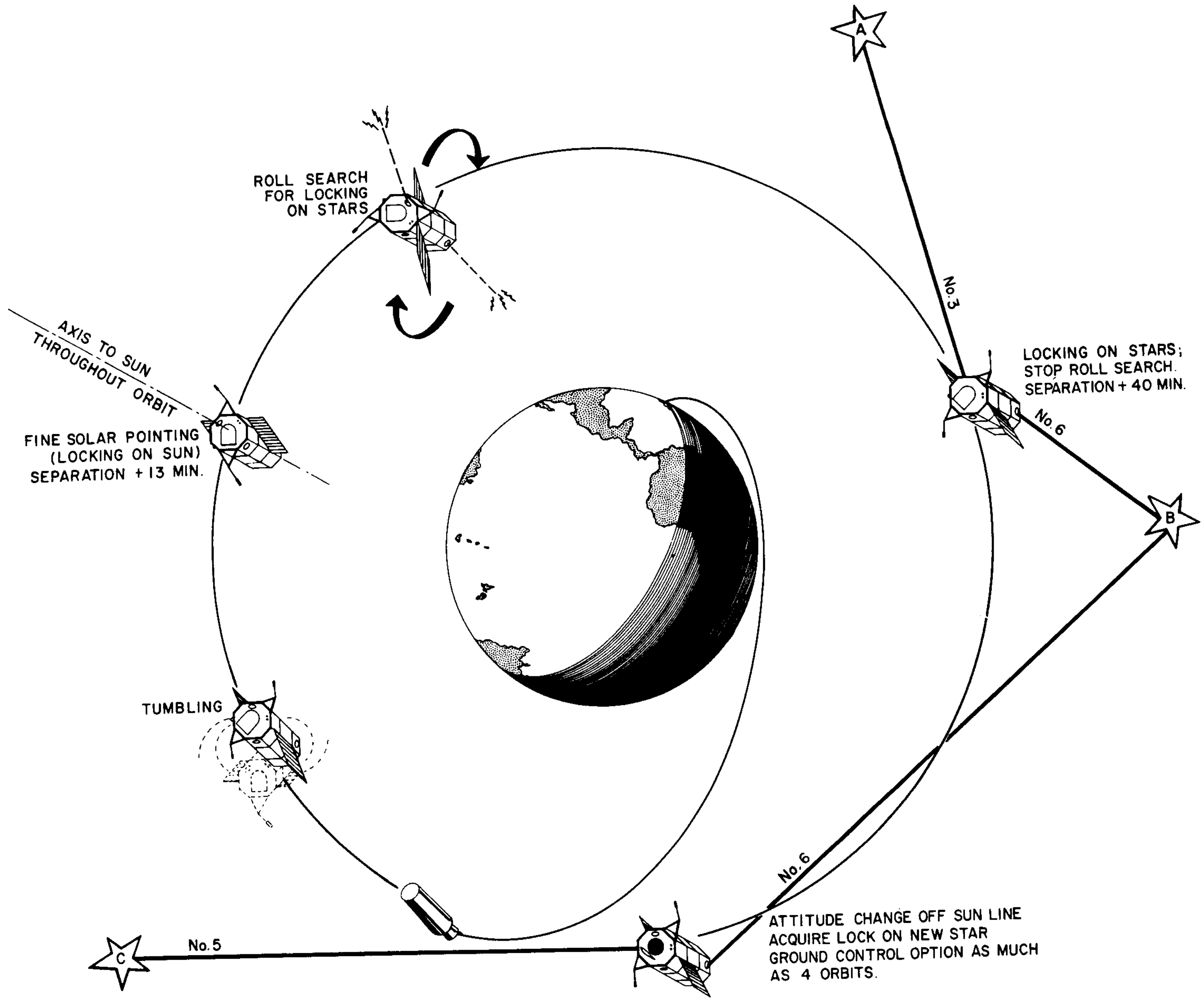
The equipment used to sense OAO motions consists of rate gyros to measure initial tumbling rates, solar sensors to establish the direction of the Sun, and six gimbaled star trackers--the heart of the system. The star trackers are designed to acquire selected guide stars, track them continuously and at the same time to measure their direction with respect to the spacecraft axes.

Included as a backup is a wide-angle TV camera with a reticle for angle measurements and a fixed star tracker which will be bore-sighted to the optical axis of the Wisconsin experiment to improve spacecraft pointing accuracy.

To initiate control maneuvers, the spacecraft uses a nitrogen gas jet system--used primarily for initial stabilization--a coarse momentum wheel system for large angle reorientation and a fine momentum wheel system for star tracker control.

The key to the OAO control system is the star tracker system. It must be able to point the observatory to an accuracy of one minute of arc and maintain this pointing direction within 15 arc seconds for 50 minutes. This accuracy is needed to assure that desired "target" stars fall within the field of view of the experiments.

Each star tracker is a small 3.5-inch reflecting telescope mounted in two degree-of-freedom mechanical gimbals. The incoming target star image is split into two light beams to provide error signals about the two gimbal axes. The beams are modulated by a system of vibrating reeds, detected by a photomultiplier and electrically separated into error signals.



OAO Star Acquisition

The resulting error signals are then used to drive dc*torquer motors in the gimbal axes. Gimbal angles are measured by variable capacitance transducers with a resolution of about five arc seconds.

Two trackers are sufficient to provide pointing information under normal operating conditions. However, six trackers are used to allow for occultation of guide stars by the Earth, to maintain proper reference when the spacecraft shifts guide stars and for redundancy to improve the lifetime of the observatory.

THE COMMUNICATIONS SYSTEM

The communications system of the OAO includes equipment to receive command signals from the ground and to transmit tracking signals, command verification signals, and spacecraft and experiment data. The equipment consists of four radio links:

Radio PCM/AM command, transmitting on 148 Mc.

Radio tracking beacon, transmitting on 136 Mc.

Wideband PCM/NRZ/FM telemetry, transmitting on 400 Mc.

Narrowband PCM/PSK telemetry, transmitting on 136 Mc.

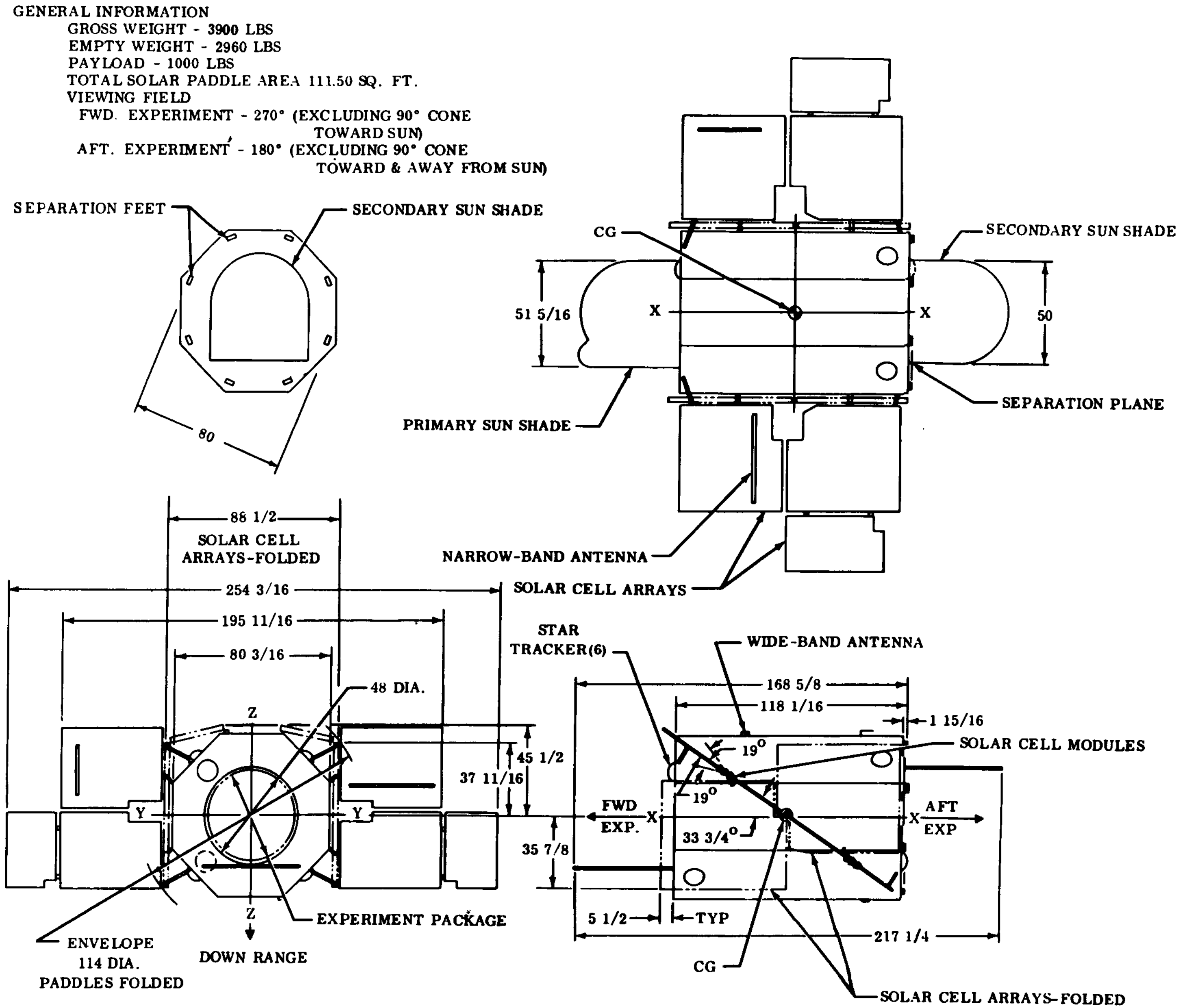
*direct current

The radio command system includes two pairs of command receivers used with two VHF (very high frequency) antennas in what is described as a diversity receiving system. These receivers, used with each of the antennas for redundancy, provide the basic radio link for ground control of spacecraft subsystems and the experiments.

The radio tracking beacons (two are used for redundancy) are designed to provide continuous signals to permit ground tracking of the spacecraft by the world-wide NASA Satellite Tracking and Data Acquisition Network (STADAN).

The wideband telemetry link consists of two identical transmitters (either of which may be selected by ground command) to transmit analog and digital data from the experiments and spacecraft. Data to be transmitted will be selected by ground command. Analog data will be transmitted in real time only; digital data will be transmitted either in real time or from on board storage at rates up to 50,000 bits per second.

The narrowband telemetry link consists of two identical transmitters (either of which may be selected by ground command) to transmit information from the spacecraft subsystems' environmental instrumentation, and signals from the command



OAO-A1 Dimensions

system transmitted to the ground for verification. This link will also be used as a back up to the wideband link.

Two pairs or sets of antenna radiators will also be employed on OAO-A1. From a functional standpoint, excluding the redundancy of transmitters and receivers, an antenna set will operate with the tracking beacon and narrowband-telemetry transmitters at approximately 136 Mc, and with the command receivers at approximately 148 Mc. Finally, a UHF (ultrahigh frequency) antenna set will be used with the wideband-telemetry transmitter at approximately 400 Mc. This antenna arrangement provides omnidirectional coverage about the observatory, and its polarization characteristics are compatible with those of the ground systems.

Operating commands for OAO will be transmitted from specially equipped STADAN stations located at Rosman, N. C.; Quito, Ecuador; and Santiago, Chile. The command program will be directed through the OAO Control Center located at the Goddard Space Flight Center.

DATA PROCESSING SYSTEM

The OAO on-board data-processing subsystem has circuitry and storage capabilities to verify, decode, store, and distribute digital data and transmit this information from storage on ground command. The system provides timing signals for internal synchronization of the data-processing subsystem as well as for use by the experiment and spacecraft housekeeping functions. The system includes spacecraft and experiment data-handling equipment to accept digital data, accept and convert analog data to digital data, and to assemble the data into a format suitable for storage or real-time transmission to the ground.

The command decoder can handle two classes of commands, real-time and stored. Real-time commands are those designed to be executed immediately after having been verified in the spacecraft from a bit-by-bit comparison of the command with its complement as received from the ground station. Stored commands are those placed in storage for execution at a later time. Stored commands will have on-board verification by complement comparison before storage. In addition, all commands will be retransmitted to the ground and the contents of the command storage may be transmitted to the ground over the narrowband-telemetry link, to permit ground verification. Stored commands will be programmable for times between 0 and 1,023 minutes, and can be executed in one-minute increments.

If two or more commands have the same time code, they will be executed within the same minute increment, in the same order in which they were received.

The three types of OAO-A1 commands are (a) control, (b) experiment, and (c) pointing. Control commands--those intended to control spacecraft equipments--will turn equipment off and on, change operation modes, and program operations. Experiment commands will control experimenter equipment. The command word, containing a maximum of 30 operational instruction bits, will be sent to the experiment serial over one of 26 preselected channel address wires. Pointing commands will consist of the star tracker gimbal-angle commands and coarse wheel-slewing commands needed to orient the observatory.

The command storage capacity is 128 commands. The data-storage instrument uses ferrite-core memory devices in which stored data will not be destroyed by readout or loss of power. The OAO-A1 data-storage capacity is 4,096 words--25 bits per word--when operating in a 100 percent redundant mode. It is capable of nonredundant operation with the capacity doubled to 8,192 words.

Data will be storable in parallel form. Read-in time for parallel data will be approximately 10 microseconds per word. The stored data will be read out in serial form under control of the data programmer, and routed through either the wideband or the narrowband transmitter system. The data programmer will select the appropriate data-read rate.

A system clock, which provides the timing signals or pulses required by the observatory, will synchronize all data words and command words. The clock will also provide 1,024 minutes of elapsed time, available in one-minute increments, for timing correlation of command input data plus experiment and spacecraft output data. Spacecraft data-handling equipment will process spacecraft status data. Approximately 400 time-multiplexed data channels will be available.

Analog data will be encoded to an accuracy of eight binary bits. Encoded analog data and data originally generated in binary form will be assembled into a format suitable for storage or real-time PCM/PSK (Pulse-code modulation, phase-shift-keyed) transmission to the ground over the narrowband-transmitter system.

Experiment data-handling equipment on the spacecraft will accept, convert, and assemble experiment and selected status data into a format suitable either for storage or for real-time transmission to the ground as a PCM pulse train. Real-time transmission of experiment data will back up the data-storage system. During real-time transmission, data sources will be sampled in a cyclic time sequence controlled by a real-time programmer included as part of the experiment data-handling equipment.

POWER SUPPLY

The basic power source for the observatory is an array of 74,618, glass-covered, p-on-n, silicon solar cells mounted on six panels to convert solar energy into electrical energy. A nickel-cadmium storage battery, rechargeable from the solar cells, will supply power while the OAO-A1 is in the Earth's shadow, and for short peak requirements which exceed the instantaneous capability of the solar array.

Anticipated power requirements for the complete observatory are 405 watts average per orbit, with short peak demands as high as 980 watts. Of this power, 30 watts average and 60 watts peak will be available to the experimenters. Nominal supply voltage for the observatory will be 28 volts.

SPACECRAFT THERMAL CONTROL

OAO-A1 thermal control is a passive system accomplished by isolating the internal spacecraft structure from both internal and external heat sources. The objective is to permit the observatory's internal structure to operate in a constant termperature environment with only minor changes, thereby minimizing thermal distortions during flight.

The spacecraft surface, which is the primary source of external heat, is isolated from the internal structure by insulation consisting of nylon fittings. Furthermore, the design of the spacecraft outer surface permits distortion due to thermal effects without imposing loads on the internal structure.

The observatory's electronic equipment is the primary source of internal heat. The heat is isolated from the internal structure, as much as possible, by insulating mounting brackets to reduce heat conduction, and by enclosures of foil-type insulation which reduce radiant heat effects.

The observatory's equipment has an operational temperature range of approximately 0° to 100° F.

Environmentally, the OAO's internal structure will be subjected to a temperature range of from -40° or $+5^{\circ}$ F.

OAO-A1 SCIENTIFIC OBJECTIVES

Until the advent of the space age, astronomers studied the universe under the obscuring and distorting effects of the Earth's atmosphere. These studies were largely limited to relatively small portions in the visible light radio-frequency spectral regions.

Despite these handicaps, contributions by astronomers over the centuries have immeasurably extended man's understanding of the solar system and the universe.

With the OAO, the opportunity now exists to greatly extend the frontiers of astronomy, by placing observing instruments above the atmosphere. For the first time, the ultraviolet, x-ray, and gamma ray regions of the spectrum will become accessible to study for extended periods of time. No longer will observations be restricted because of the twinkling effect of the atmosphere, nor will light in the night sky limit the detection of faint objects.

The scientific potential offered by the OAO spacecraft series--conducting studies throughout the entire electromagnetic spectrum--should have a great impact on the future course of stellar astronomy.

Some of the present and potential areas of OAO investigation include:

- Study of very hot stars radiating strongly in ultraviolet light.
- Study of x-ray and gamma ray radiation.
- Greater insights into the process of star evolution.
- Study of galaxies in ultraviolet light to determine aging effects.
- Observation in infrared to permit the first look at the center of our galaxy.
- Study of planetary radiations in the ultraviolet and infrared.
- The use of telescopes of great resolution on future OAO spacecraft could give astronomers a look at objects near the edge of the universe.

SCIENTIFIC EXPERIMENTS ASSIGNED TO FUTURE OAOS

Experiments for the next three OAO spacecraft are:

- OAO-B, scheduled to be launched in early 1967, will fly the Goddard Experiment Package (GEP), an instrument of moderate resolution to do absolute spectrophotometry in the ultraviolet region.
- OAO-A2, carrying the ultraviolet sky survey Celescope instrument of the Smithsonian Astrophysical Observatory and a repeat of the University of Wisconsin experiment, will be launched late in 1967.
- OAO-C, scheduled for mid-1968, will carry a high resolution ultraviolet optical instrument developed by Princeton University and a stellar and nebular x-ray instrument developed jointly by the University College, London, and the University of Leicester, England.

ORIGINS OF THE OAO PROGRAM

Shortly after the launching of Sputnik I by the USSR in 1957, Dr. Lloyd, V. Berkner, chairman of the Space Science Board of the National Academy of Science, requested 200 U.S. scientists to submit recommendations to him for scientific experiments which could be performed by a satellite with a 100-pound payload. Much of NASA's early scientific space effort was based on the replies to Dr. Berkner's request.

In May 1959, the requirements of various proposed experiments were formulated in detail, and some general engineering approaches were discussed. On the basis of material developed, a group from the Ames Research Center prepared a set of preliminary engineering specifications for Orbiting Astronomical Observatory spacecraft.

Final specifications prepared by the original OAO project team headed by Robert R. Ziemer, Project Manager, were circulated to industry in the spring of 1960. In October 1960, the Grumman Aircraft Engineering Corporation, Bethpage, N. Y., was formally designated as the prime contractor for the spacecraft system.

OAO-A1 SCIENTIFIC EXPERIMENTS

The four astronomical experiments slated for flight on board OAO-A1 are designed to cover a broad range of measurements in non-visible spectral regions. They include the University of Wisconsin broad band ultraviolet telescope package, detection devices to study soft x-rays and more energetic light called gamma rays. Through its complex ground spacecraft attitude control system, OAO-A1 will be aimed at individual objects in space with a precision never before attained by an orbiting satellite. What the experiments "see" will be radioed back to Earth in the form of digital data for analysis by the experimenters.

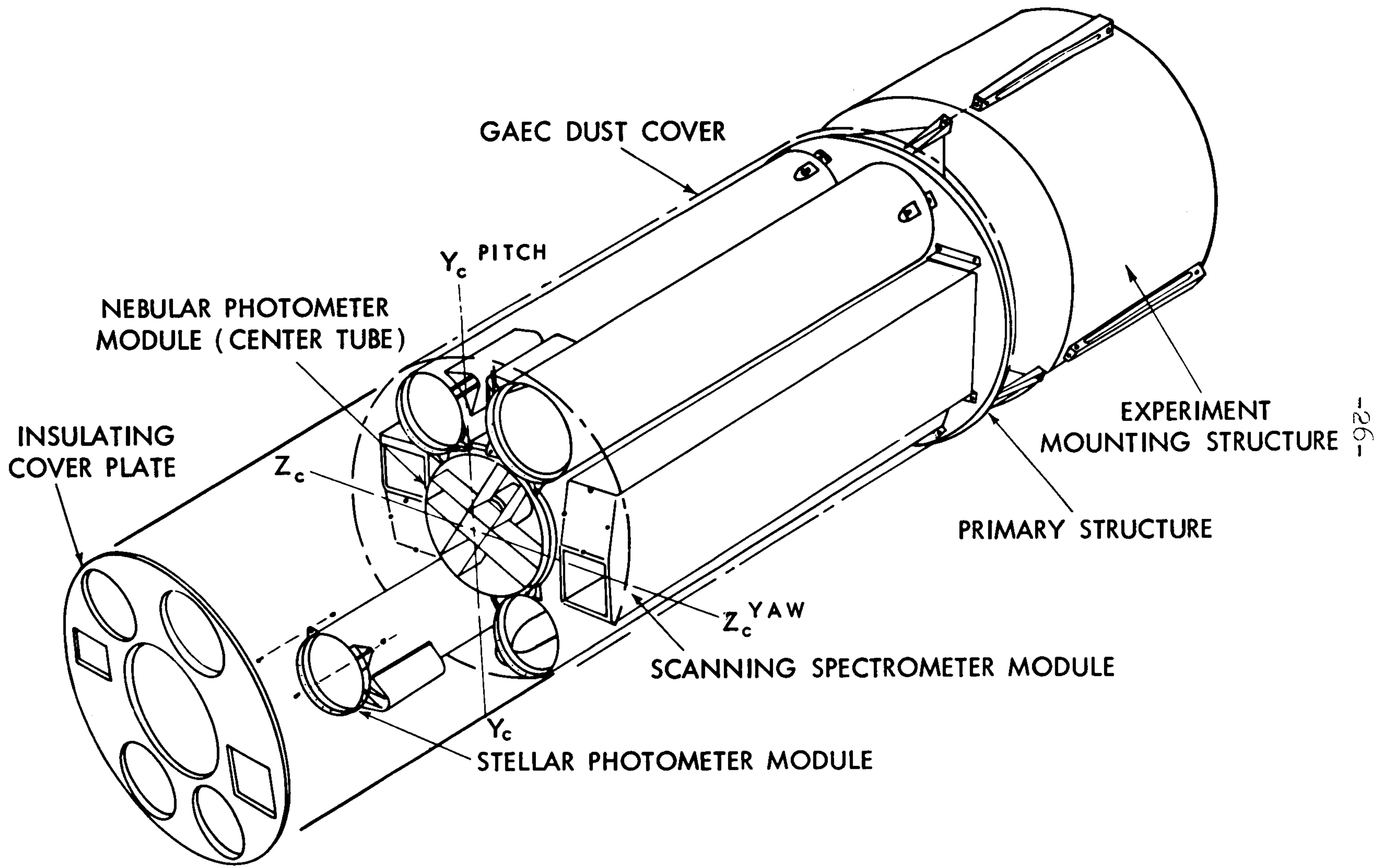
THE UNIVERSITY OF WISCONSIN EXPERIMENT

This experiment, a complex series of special ultraviolet telescopes and associated electronics, is designed to conduct a detailed study of emissions in ultraviolet light from about 200 stars and nebulae. The ultraviolet spectrum is near to the blue band of the visible light portion of the spectrum. The experiment's range of operation is from about 1,000 to 4,200 Angstroms. (Angstrom is a unit of measurement about 254 millionths of an inch long used to measure the length of light waves.)

The resulting information, in terms of spectral energy distribution and time-varying spectral intensity, will enable astronomers to better define the chemical composition, pressure and density of stellar objects. This information could result in revision of present theories of stellar origin and evolution. The actual measurements will be obtained by photometers, stored on board the spacecraft, and transmitted to Earth by telemetry.

Developed by the Space Astronomy Laboratory of the University of Wisconsin under direction of Professor Arthur D. Code, the experiment consists of three basic photometric systems:

University of Wisconsin UV Experiment



1. A multicolor filter photometer system intended primarily for measurement of stars, consisting of four eight-inch telescopes, each sending information to a separate three-color filter photometer.

2. A multicolor filter photometer system designed primarily to study nebulae, consisting of a 16-inch telescope.

3. A scanning spectrometer system employing two objective grating spectrometers with an aperture of about six by eight inches.

In general terms, the experiment works as follows: The stellar photometer telescopes and associated mechanisms measure the intensity of incoming ultraviolet light and convert these measurements into electrical signals. By using a rotating filter wheel, measurements at different wavelengths are obtained. The nebular photometer performs similarly. The spectrometer spreads the star light into a "rainbow" allowing the independent measurement of various wavelengths (colors) without the need for filters.

The experiment is controlled by a complex electronic system containing more than 450 encapsulated digital circuit modules located on an equipment shelf of the spacecraft's main body.

The experiment optics are protected by a sunshade located at the top of the spacecraft. During the launch phase the sunshade will be closed over the experiment tube. After orbit is attained, the sunshade will be opened to permit experiment operation. If the OAO-A1 control system is inadvertently pointed toward the Sun, the shade will close automatically to keep out potentially damaging solar rays.

THE MIT GAMMA RAY EXPERIMENT

This high-energy gamma ray detector device, developed by Dr. W. L. Kraushaar of the Massachusetts Institute of Technology, was first flown on board the Explorer XI by NASA in April 1961. However, since the satellite was not designed to be precisely stabilized, the detector, although it operated for 141 hours, viewed the sky haphazardly and could not be aimed at gamma ray sources. The short operating life resulted from the high orbit of this satellite since the experiment could operate only below the radiation belts

With the stabilized OAO-A1 and lower orbit this problem should be overcome and the detector--a "sandwich" crystal scintillator--should be a most useful tool to measure the intensity and arrival direction of high energy gamma rays. These rays are believed to result from the collision of cosmic rays and the gas which exists in the space between stars. By learning the point of origin of high energy gamma rays, the question of the origin of cosmic rays may be answered. The study of high energy gamma rays for this purpose is important since, unlike cosmic rays, gamma rays are electrically neutral and thus can travel through interstellar space undeflected by magnetic fields.

THE LOCKHEED X-RAY EXPERIMENT

The study of recently discovered sources of so-called soft X-rays, as a result of sounding rocket investigations, is the purpose of this experiment developed by the Lockheed Missiles and Space Co., under the direction of Dr. Philip C. Fisher at the Lockheed Palo Alto Research Laboratories.

Although X-ray emissions from the Sun have been studied for about 15 years, no other stellar source of X-rays was known until 1962. Since then, based on investigations conducted with sounding rockets, about ten different celestial X-ray sources have been discovered. Current theories suggest that these sources are located within our own galaxy. This is particularly significant since the quantity of this radiation is possibly a million times greater than similar radiation from the Sun.

The Lockheed device, a gas proportional counter similar in many respects to a Geiger counter, will be at least ten times more sensitive than devices flown previously on board sounding rockets. Its purpose is to better map and define X-ray sources. Results from this experiment could add substantially to our knowledge of stellar evolution.

THE GODDARD LOW ENERGY GAMMA RAY EXPERIMENT

This device, developed under the direction of Kenneth Frost at the Goddard Space Flight Center, consists of an anticoincidence shielded detector designed for flight on board the Orbiting Solar Observatory E spacecraft, modified for observation of low energy gamma rays.

It will look for sources of photons in the two to 180 Kev range throughout the celestial sphere. Previously detected X-ray sources below 10 Kev will be examined for the presence of a high energy component of their spectra out to 180 Kev. The directionality of the detector and the attitude control of OAO will permit identification of the sector of the sky from which the photons originate.

Data from this experiment, along with data from other experiments operating at lower energy, should provide a knowledge of the spectra of X-ray sources over a wide energy range. This knowledge will aid in suggesting and evaluating possible causes of X-ray emission in the sources examined.

ATLAS-AGENA D LAUNCH VEHICLE

OAO-A1 will be placed in its 500-mile circular orbit by an Atlas-Agena D launch vehicle. OAO is the heaviest payload ever carried by this vehicle combination.

Because of the large diameter of the OAO spacecraft, the special three-section shroud developed to cover it will enclose the Agena second stage as well as the spacecraft.

The launch vehicle portion of this mission will be longer than usual in that there is a coast of 50 minutes in a transfer orbit before the Agena fires for a second time to circularize the orbit. The Agena second burn and injection will occur when the Agena/OAO spacecraft combination is south of Australia.

AGENA STAGE

The Agena airframe consists of a forward section, a tank section, an aft section and a booster adapter section. The forward section, or forward equipment rack, houses and supports the flight control system helium tank, electrical power equipment, and communications and control equipment. The aft section houses and supports the propulsion system and associated control mechanisms, and the attitude control gas supply tank. The booster adapter section encloses the Agena aft section and remains with the Atlas when it separates from the Agena.

Propulsion is provided by a liquid propellant rocket engine system using regenerative cooling. The fuel is unsymmetrical dimethylhydrazine (UDMH) and the oxidizer is inhibited, red fuming nitric acid (IRFNA). The mixture is hypergolic and, in the Agena, produces a thrust of 16,000 pounds for 240 seconds in a vacuum.

A helium storage system mounted in the forward equipment rack provides pressurization for the propellant tanks. The tanks are provided with sumps at the aft ends to contain propellants at the inlets to the fuel and oxidizer pumps.

The sump design incorporates a fine mesh containment screen that permits flow of propellants into the sump as a result of the acceleration forces during powered flight, and inhibits return flow during vehicle coast periods. This feature eliminates the requirement for ullage rockets for propellant positioning.

OAO SHROUD

The shroud for the OAO spacecraft encloses both the Agena and the spacecraft and is approximately the same diameter as the Atlas vehicle. Because the OAO spacecraft, in its folded configuration, is larger in diameter than the Agena, a shroud designed to cover only the spacecraft would have resulted in a large hammer-head configuration unfavorable both aerodynamically and structurally.

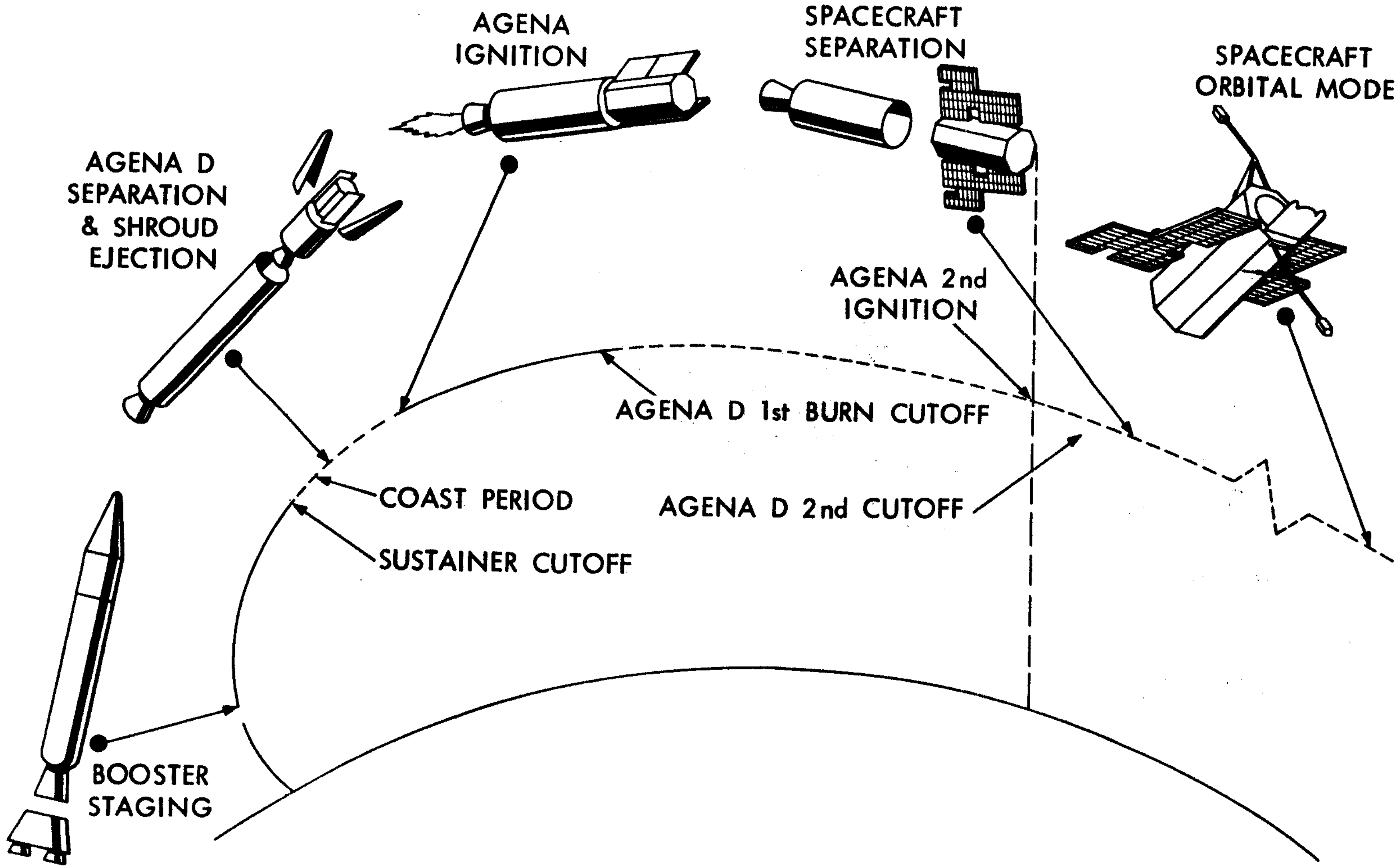
The present shroud, built by General Dynamics/Convair under Lewis contract, is composed of three fairings. The nose fairing is constructed primarily of fiberglass; the mid and aft fairings are aluminum.

The nose and mid fairings are jettisoned after Atlas sustainer engine cut-off during vernier firing in clam shell fashion and the aft fairing remains with the Atlas at the separation of Atlas from Agena.

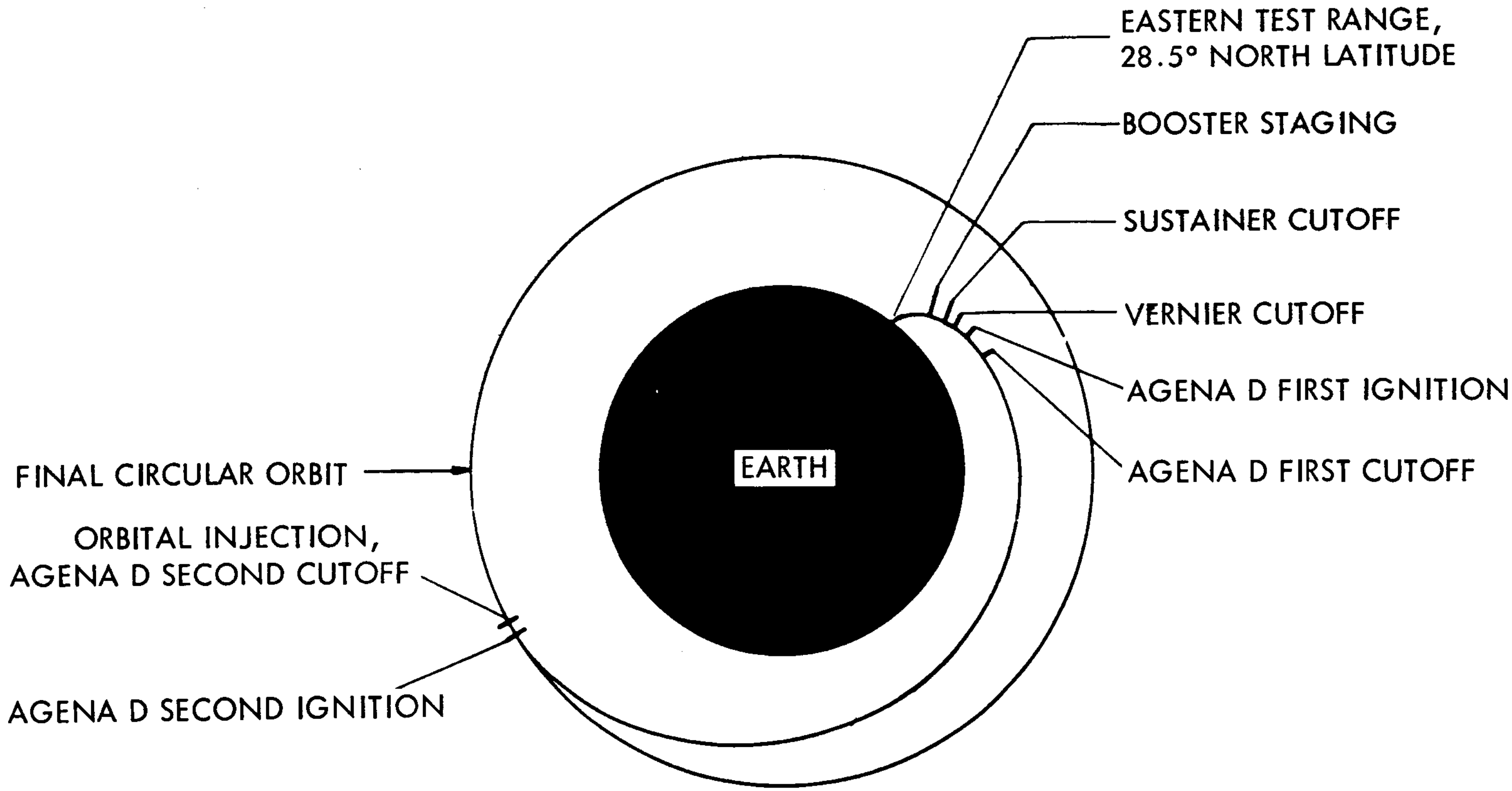
THE FLIGHT PLAN

The Atlas booster, using liquid oxygen and RP-1 kerosene-type fuel, launches Agena and the OAO-A1 from Pad 12 at Cape Kennedy. The Atlas rolls to a trajectory azimuth of 67° east of north during the vertical ascent after lift-off. This unusual northward launch is dictated by spacecraft communications which require contact with Rosman, N. C., for the first several orbits.

BECO (booster engine cutoff), followed by booster separation, occurs some 140 seconds after liftoff. The sustainer engine continues the boost phase for some 120 seconds longer. Some 4 1/2 minutes into the flight, the shroud is jettisoned. Atlas has boosted the Agena/OAO to an altitude of 100 miles at vernier engine cutoff (VECO).

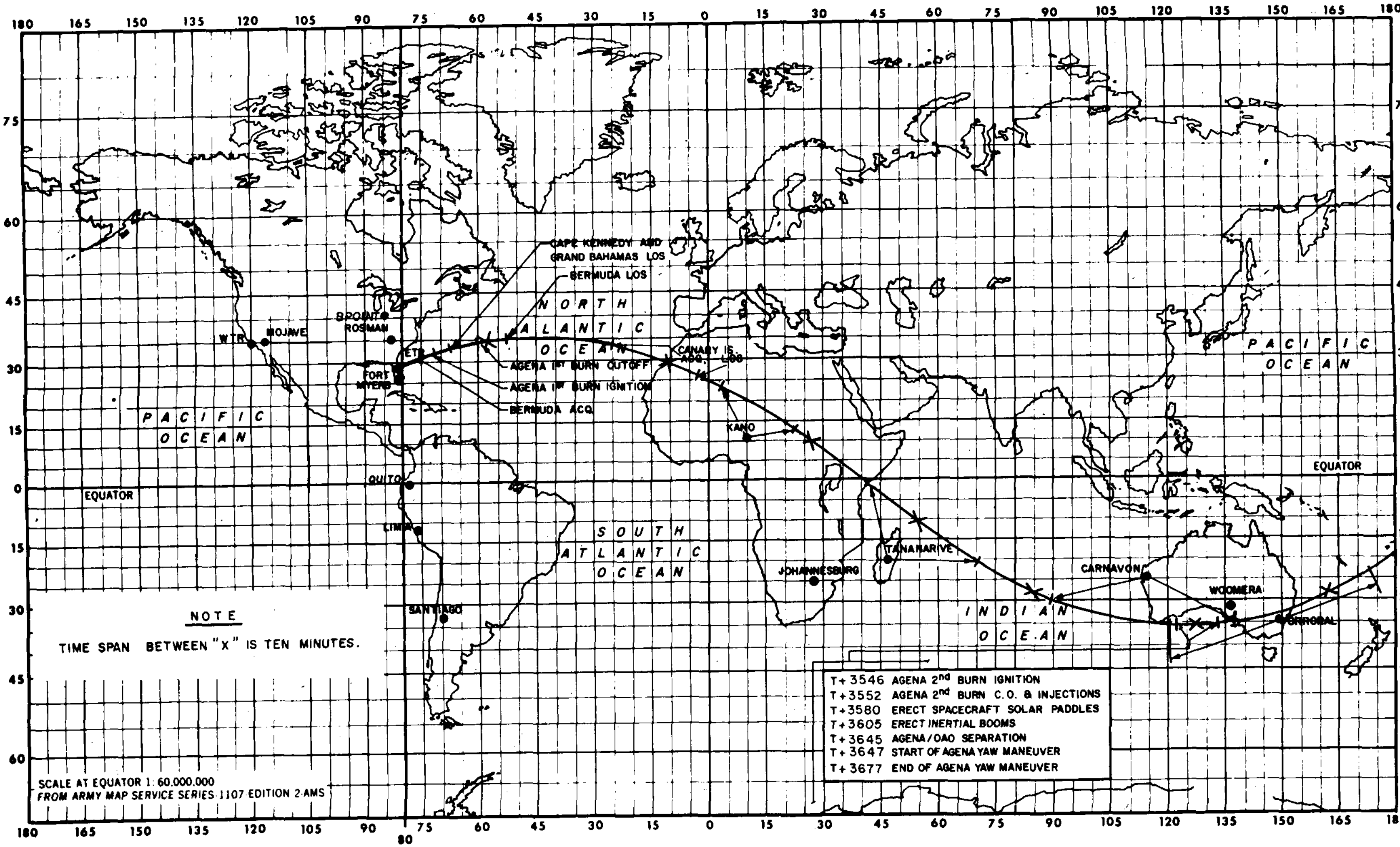


OAO Launch Phase



A-A

OAO-A1 Orbit Plane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BERMUDA LOS
NORTH ATLANTIC OCEAN
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AGENA 1st BURN IGNITION
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KANO
PACIFIC OCEAN
EQUATOR
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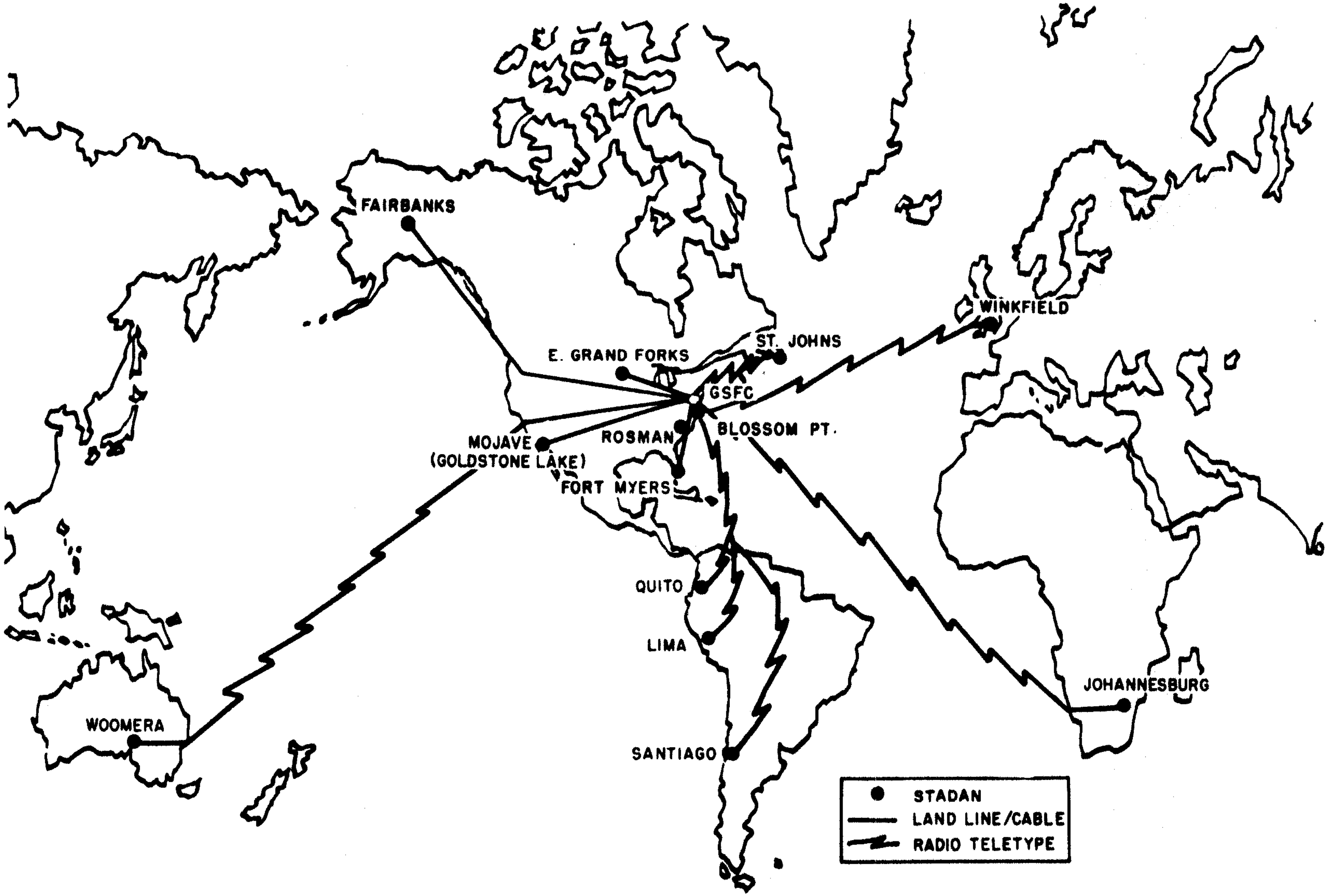
NOTE
TIME SPAN BETWEEN "X" IS TEN MINUTES.
T+3546 AGENA 2nd BURN IGNITION
T+3552 AGENA 2nd BURN C.O. & INJECTIONS
T+3580 ERECT SPACECRAFT SOLAR PADDLES
T+3605 ERECT INERTIAL BOOMS
T+3645 AGENA/OAO SEPARATION
T+3647 START OF AGENA YAW MANEUVER
T+3677 END OF AGENA YAW MANEUVER
SCALE AT EQUATOR 1:60,000,000
FROM ARMY MAP SERVICE SERIES 1107 EDITION 2-AMS

After VECO the Agena/OAO separates from the Atlas and the Agena rocket engine ignites to place the Agena/OAO into a transfer orbit of approximately 86 miles perigee and 500 miles apogee. Agena/OAO coasts about 50 minutes to the apogee of the transfer orbit where the Agena rocket engine reignites to circularize the orbit. Agena then injects the OAO into a 500 mile circular orbit inclined 35° to the equator. After the OAO separates from the Agena, the Agena yaws to a heading 90° from the flight path.

OAO GROUND OPERATIONS

Ground control operations for OAO are directed from the OAO Control Center at the Goddard Space Flight Center and three remote-control stations at Rosman, North Carolina; Quito, Ecuador; and Santiago, Chile, which are part of the Satellite Tracking and Data Acquisition Network.

Each remote-control station, while performing its regular STADAN satellite tracking and data-acquisition functions, will also use specialized equipment and additional personnel to provide the special operational and control facilities required for OAO. This equipment includes an 85-foot parabolic antenna at the Rosman station, and 40-foot parabolic antennas at Quito, Ecuador, and Santiago, Chile.



OAO Tracking and Data-Acquisition Network

Functions of the OAO ground control system are to:

- Receive, record, and display OAO status and experiment data.
- Evaluate performance of the spacecraft and the experiment apparatus.
- Generate and transmit command information to the spacecraft.
- Provide a link between the spacecraft in orbit and the experimenter on the ground.

The OAO control center at Goddard is designed to coordinate and direct the overall operation of the OAO system on a round-the-clock basis. Its prime functions include:

- Checking the satellite for operational readiness.
- Preparing a predicted status of the spacecraft and experiment report for each pass over each remote-control station.
- Generating complete sequences of commands for transmission through each remote-control station to the satellite for proper execution of the experiment program.
- Transmitting the sequence of commands and predicted status data to the appropriate remote-control station.

- Receiving status and experimental data from the remote-control stations.
- Analyzing any portion of the OAO system and adapting the system to function even if deteriorated conditions exist in either the spacecraft or the ground equipment.

The ground operation system will be able to operate in any of four modes: (a) the initial stabilization and orientation mode, (b) checkout mode, (c) normal operational mode, or (d) backup mode. Duration of contact with the spacecraft during each orbit will average 10.4 minutes for any of the three data-acquisition stations.

DATA REDUCTION PROCEDURES

The data-reduction facility at GSFC will receive by mail all OAO-A1 data recorded at the remote stations. The Goddard facility will then decommutate, edit, and reproduce data in the proper format. Equipment used for OAO data processing includes a PCM synchronizer-decommutator, a computer format control buffer, an IBM-7094 computer, a small IBM-1401 computer, digital printers, plotters, and various quick-look instruments.

The purpose of the data-reduction facility is to provide services needed by experimenters for the first stages of data reduction.

Experimental data will be put into the form requested by the experimenter, using digital magnetic tapes and a format compatible with the 7094 computer.

At a minimum, the data will be reproduced in the form in which they were recorded on board the observatory.

The data-reduction facility will handle two types of data for the OAO: scientific experimental data and a status-data time history. Most of the work will be related to processing the experimental data. The data will be maintained in various categories with one category for each experiment and others for status data and for orbital data. Data will be forwarded to experimenters for analysis after preliminary reduction at Goddard. Scientific results will be reported to the scientific community by the experimenters.

FACT SHEET

ORBITING ASTRONOMICAL OBSERVATORY (OAO-A1)

SPACECRAFT

Weight	3,900 pounds, including 1,000 pounds of scientific experiment instruments.
Main Body	Octagonal cylinder, about seven feet wide and ten feet long.
Appendages	(a) Solar panels, six panels with three each mounted at 180 degrees on sides of main body, with 74,000 solar cells and total area of 114 square feet. Extended width of panels is 21 feet.
	(b) Two balance weight booms nine and one-half feet long which are extended after injection into orbit, mounted opposite each other.
	(c) One sunshade: Four feet, 10 inches long; four feet, three inches wide.
Power System	Spacecraft voltage is 28 volts, direct current; overall observatory power requirements are 405 watts average, with experiment average power requirements of 30 watts.

COMMUNICATION AND DATA-HANDLING SUBSYSTEM

Wideband telemetry (PCM/NRZ/FM)	(a) Two 7-watt, 400-Mc RF transmitters (redundant). (b) Two data-handling units.
Narrowband telemetry (PCM/PSK)	Two 1.6-watt, 136-Mc RF transmitters (redundant).
Radio Command	Four command receivers (dual redundant pairs with combiner in each redundant pair).
Tracking (CW)	Two 100-mw, 136-Mc RF transmitters (redundant).
Systems clock	Contains the logic circuitry providing timing and synchronization signals for observatory equipment.

STABILIZATION AND CONTROL SUBSYSTEM:

Sensors Sun Sensors	(a) Eight coarse sensors (four on pitch axis, four on yaw axis) used in initial stabilization. (b) Eight fine sensors (four on pitch axis, four on yaw axis) - used in initial stabilization.
Rate gyros	Three gyros, one for each axis, the voltage output for each being proportional to the angular rate about its sensing axis used during initial stabilization.
Star Trackers	(a) Six gimbaled trackers, each mounted on a 2-degrees-of-freedom gimbal system. (b) One boresighted star tracker aligned with the experiment optical axis.
Stellar TV Camera	One TV camera provides a backup system for determining spacecraft attitude.
Magnetic unloaders	Three torquing bars (one per axis) - Magnetic unloaders reduce inertia-wheel speed.
Actuators Reaction gas jets Primary jets	(a) Six high-pressure jets used during initial stabilization. (b) Six low-pressure jets used to remove momentum from the fine inertia wheels.
Secondary jets	Six high-pressure jets for backup during initial stabilization.
Inertia wheels Coarse wheels	Three wheels, one for each axis, used to slew the spacecraft upon command.
Fine wheels	Three wheels, one for each axis used to fine-point the spacecraft, capable of an accuracy within 0.1 second of arc.

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TRACKING AND DATA-ACQUISITION STATIONS (operated under supervision of OAO Control Center, Goddard Space Flight Center):

Tracking Stations	STADAN network
Data-acquisition stations	(a) Rosman, N.C. (b) Quito, Ecuador (c) Santiago, Chile

LAUNCH PHASE

Launch Site	Complex 12, Cape Kennedy, Fla.
Launch Rocket	Atlas-Agena D.
Orbit	500-statute-mile, circular orbit inclined 35 degrees to the Equator.
Orbital Period	101 minutes nominal.

PROJECT MANAGEMENT-	NASA Goddard Space Flight Center, Greenbelt, Md.
PRIME OAO CONTRACTOR	Grumman Aircraft Engineering Corporation, Bethpage, N.Y.
LAUNCH VEHICLE CONTRACTORS	General Dynamics/Convair, San Diego, Calif. Lockheed Missiles and Space Co., Sunnyvale, Calif.

OAO-A1 EXPERIMENTS

Principal Investigators	Experiment Title	Brief Description
Professor Arthur Code and Dr. T. E. Houck, University of Wisconsin, Madison, Wis.	University of Wisconsin Experiment Package	Broad-band ultra-violet photometry device with seven independent observing instruments to view spectral energy distribution and varying intensities of selected stars and nebulae in Angstrom regions from 1100 to 3000.
Dr. W. L. Kraushaar, Massachusetts Institute of Technology, Cambridge, Mass. (now at the University of Wisconsin)	MIT Gamma Ray Experiment	Same high-energy cosmic gamma ray device as flown on Explorer XI, April 27, 1961. Will measure intensity and arrival direction of gamma rays.
Dr. P. C. Fisher, Lockheed Missiles and Space Co., Sunnyvale, Calif.	Lockheed X-Ray Experiment	A series of detectors designed to study sources of X-ray emissions in the sky. Originally developed for sounding rocket flight.
Mr. Kenneth Frost, Goddard Space Flight Center, Greenbelt, Md.	Goddard Gamma Ray Experiment	A series of detectors designed originally for flight on board sounding rockets to survey the celestial sphere for sources of photons in the two to 180 Kev range.

THE OAO-A1 TEAM

NASA HEADQUARTERS

Dr. Homer E. Newell	Associate Administrator for Space Science and Applications
Jesse L. Mitchell	Acting Director, Physics and Astronomy Programs Division, OSSA
Dr. Nancy G. Roman	Chief of Astronomy
C. Dixson Ashworth	Program Manager, Astronomical Observatories
Allan H. Sures	Associate Program Manager, OAO
Joseph B. Mahon	Agena Program Manager

GODDARD SPACE FLIGHT CENTER

Dr. John F. Clark	Acting Director
Dr. John W. Townsend, Jr.	Deputy Director
Robert E. Bourdeau	Assistant Director for Projects
Robert R. Ziemer	OAO Project Manager
Dr. James E. Kupperian, Jr.	OAO Project Scientist
Albert G. Ferris	OAO Tracking Scientist and Project Operations Manager
Robert W. Stroup	Experiment Systems Manager
Dale H. Scott	Spacecraft Systems Manager

KENNEDY SPACE CENTER

Robert H. Gray	Assistant Director for Unmanned Launch Operations

LEWIS RESEARCH CENTER

Dr. Seymour C. Himmel	Assistant Director for Launch Vehicles
H. Warren Plohr	Agena Project Manager
Richard P. Geye	Agena Project Engineer for OAO

PRIME CONTRACTOR - GRUMMAN AIRCRAFT ENGINEERING CORPORATION

Dr. Ralph Tripp	Program Director
Donald A. Imgram	Project Engineer

MAJOR OAO SUBCONTRACTORS

Ground Operations and Tracking Site Equipment, Westinghouse Electric Corp., Air Arm Division, Baltimore, Md.

Spacecraft Guidance and Control Subsystem, General Electric Co., Missiles and Space Vehicles Division, Philadelphia, Pa.

Star Trackers (subcontract to General Electric), Kollsman Instrument Corp., Elmhurst, N.Y.

Spacecraft Data Processing Subsystem, International Business Machines, Federal Systems Division and Space Guidance Center, Owego, N.Y.

Television Camera, Radio Corporation of America, Astro-Electronics Division, Princeton, N.J.

Wisconsin Experiment Package, Cook Laboratories, Chicago, Ill.

Communications, Hughes Aircraft Co., Santa Monica, Calif.; Data Handling, Radiation, Inc., Melbourne, Fla.;

Solar Array, Spectrolab, Sylmar, Calif.;

Battery, Gulton Industries, Metuchen, N.J.

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