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

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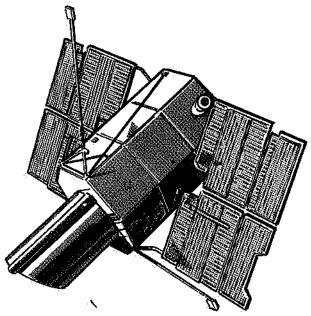

PROJECT: OAO-B
(To be launched no earlier than 11/17/70)

contents

10/23/70

NEWS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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TELS: (202) 962-4155
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OAO-B LAUNCH NOV. 17

The world's largest space astronomy telescope is being readied for orbital flight to learn more about the birth of stars and the future of our galaxy.

Orbiting Astronomical Observatory-B (OAO-B), heaviest scientific satellite under development by the United States, will be launched by the National Aeronautics and Space Administration from Cape Kennedy, Fla., no earlier than Nov. 17, 1970, aboard an Atlas/Centaur rocket.

It will be called OAO-3 if successfully placed in the expected 466-mile circular orbit. From high above the Earth's atmosphere the OAO will observe distant stars and galaxies in the ultraviolet via its onboard 36-inch telescope with a detail previously unobtainable in space astronomy. The spacecraft is scheduled to circle Earth every 100 minutes while inclined 35° to the Equator.

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10/23/70

OAO-B weighs a record 4,680 pounds and stands 10 feet tall. With its 21-foot-wide solar panels unfolded the satellite resembles a giant bat. It is the most complex scientific satellite developed by the United States and contains more than 328,000 parts. It will return astronomical data from space through NASA's worldwide tracking and data acquisition system.

Like its sister observatory, OAO-2 which is still operating after almost two years, OAO-B will study the extremely young, hot stars but much more precisely.

The telescope in OAO-B is named Goddard (for the late Dr. Robert H. Goddard, "father of the modern rocket") Experiment Package (GEP). The principal investigator is Dr. Albert Boggess from NASA's Goddard Space Flight Center, Greenbelt, Md.

The GEP can measure ultraviolet light five times more accurately than the telescope aboard OAO-2. It can also observe stars eight times fainter, down to the 12th magnitude. The largest telescope on OAO-2 is 16 inches.

Ultraviolet light, beyond the blue portion of the electromagnetic spectrum, never reaches Earth-based observatories because of the blanketing effect of the atmosphere.

Some of the young hot stars, which emit most of their light in the ultraviolet, are only hundreds of thousands of years old, mere babies by astronomical standards. By comparison, our Sun is about five billion years old, or middle-aged.

OAO-B observations of young stars will refine astronomers' knowledge of their temperatures and evolution and GEP will also study some peculiar stars like Wolf-Rayet, T-Tauri and pulsating variable stars.

The T-Tauri type stars are probably still in the process of condensing and being formed. They are quite cool (K or M classification).

One of the most important subjects to be closely studied by OAO-B is interstellar dust which many astronomers agree may hold the key to the origin and evolution of stars. It is from interstellar dust that stars are born.

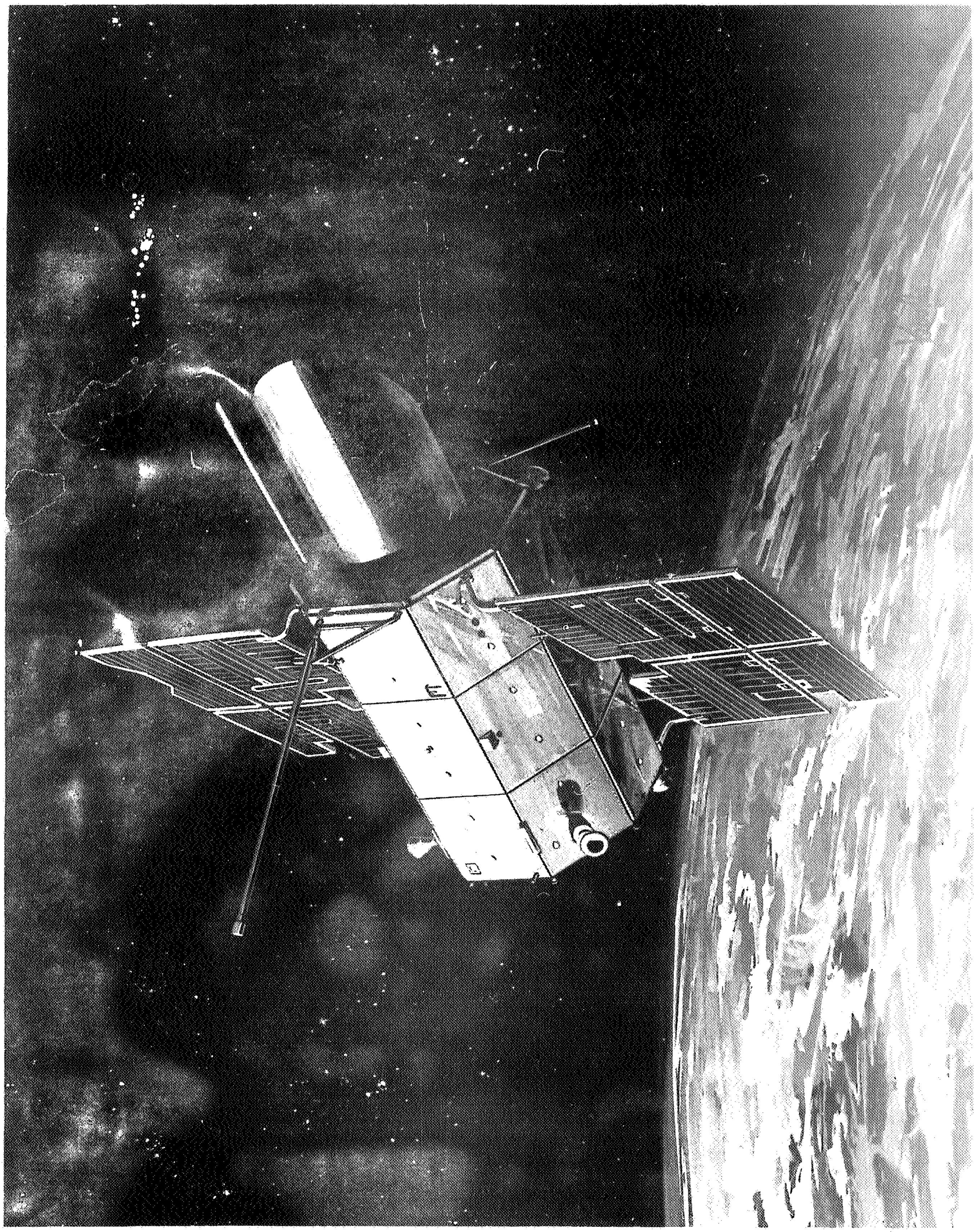
Astronomers remain undecided on the chemical makeup of the solid material which is found in interstellar dust. At one time it was thought to be ice crystals. Later thinking shifted to carbon flakes or smoke. Now the most recent data on dust particles does not quite agree with the latest theories or models.

"I hope to be able to pin down what this solid matter in interstellar dust is," said Dr. Albert Boggess, OAO-B principal investigator. "A greater knowledge of interstellar dust is needed because it is from this dust and material floating around in space that stars are born. Interstellar dust is of considerable significance, cosmologically, in predicting the future course of our galaxy," he said.

There will be an attempt to study the brightest Quasar, 3C273. This Quasar is 13th magnitude in visible light. GEP is designed for about 12th magnitude. With longer observation times, GEP might be able to go beyond 12th magnitude. Quasars, discovered in 1963, are the most distant known celestial systems.

OAO has an advanced pointing system in the spacecraft coupled with an error sensor in the GEP telescope which provides a pointing accuracy of one arc second. This is equivalent to a marksman's holding his rifle sight for many minutes on a bullseye two inches in diameter at a distance of six miles.

With a combination of a greater pointing accuracy and a larger telescope, OAO-B can look at more distant stars in greater detail.



The OAO-B spacecraft is similar to OAO-1 and 2 with some modifications. For instance, the command memory capability has been increased so the stored command memory can handle 1,280 two-word commands rather than 256 two-word commands. This permits automatic operation of the spacecraft for longer periods without intervention by ground control.

An inertial reference system using precision gyros will provide a drift rate of less than 10 arc second-per-hour (30 times better than OAO-2) when controlling the spacecraft.

Five gimballed star trackers will be used on OAO-B, one less than on OAO-2.

The most conspicuous difference between OAO-B and OAOs 1 and 2 is the addition of a more effective tubular Sun baffle to allow telescope operation in daylight.

OAO-B is the third in a series of four observatories planned by NASA. OAO-1 was launched in 1966 but failed shortly after it was in orbit due to a malfunction in the power supply system and probable high voltage arcing in the star tracker system.

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OAO-2, launched Dec. 7, 1968, continues to operate and has far exceeded its pre-launch objectives.

Many scientists believe an operational system like OAO could revolutionize observational astronomy.

University of Wisconsin Professor, Dr. Arthur D. Code, one of the OAO-2 principal investigators recently said, "No other observatory on the ground, or in space, to my knowledge, has contributed so much to astronomy in its first 18 months of operation as OAO-2."

OAO-C, scheduled for flight in late 1971 carries the Princeton University 32-inch aperture high resolution telescope. An X-ray experiment provided by University College, London and the University of Leicester will also fly on OAO-C to study the X-ray emission of stars and nebulae and obtain information on the interstellar absorption of helium and the heavier elements.

This experiment was submitted and selected for flight under NASA's program of international cooperation in which scientists and agencies of other countries provide experiments in competition with United States submissions. Foreign experiments selected under this program are funded by the country proposing them and the scientific results are shared by the sponsoring agency and NASA.

NASA is currently investigating the feasibility of orbiting a Large Space Telescope (LST). The LST, with a primary mirror approaching 120-inches in diameter, would weigh more than 20,000 pounds and could be orbited by existing launch vehicles, or the space shuttle in the latter part of this decade.

The Orbiting Astronomical Observatory program is directed by NASA's Office of Space Science and Applications. Project management is under the Goddard Space Flight Center, Greenbelt, Md. Goddard also manages communications and tracking under direction of NASA's Office of Tracking and Data Acquisition.

Launch vehicle management is at the Lewis Research Center, Cleveland, and launch operations are under the direction of the Kennedy Space Center's Unmanned Launch Operations.

Grumman Aerospace Corp., Bethpage, N.Y., is prime contractor for the OAO spacecraft. Kollsman Instrument Corp., Syosset, N.Y., is prime contractor for the Goddard Experiment Package.

Prime contractor for the Atlas-Centaur launch vehicle is General Dynamics-Convair, San Diego. More than 1,000 major subcontractors and vendors scattered around the United States have participated in the OAO effort.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS)

OAO-B FACTS

Spacecraft

Weight:	4,680 pounds (1,000 pounds of scientific experiments)
Shape:	Octagonal cylinder, 7 feet wide, 10 feet long, wing span of 21 feet with solar panels.
Stabilization Control:	Five star trackers and nine gyros coupled with a fine error sensor in the Goddard Experiment Package provide 1 arc second accuracy.

Experiment

Goddard Experiment Package (GEP)

Thirty-eight inch telescope designed to gather moderate resolution data as follows:

- Normal stars--energy distributed in the continuum, blanketing effects, and identification and intensities of strong emission lines.
- Peculiar stars--time-dependent photometry of peculiar stars such as the Wolf-Rayet, T-Tauri and pulsating variable stars.
- Nebular and interstellar media--law of reddening, ultraviolet radiation field, and spectra of emission and reflection nebulae.
- Galaxies and intergalactic media--spectral energy distribution of nearby galactic systems, and magnitude and intensity of Lyman-alpha red shift.

Launch Information

Vehicle:	Two stage Atlas-Centaur
Complex:	36B, Cape Kennedy
Window:	6:28 to 8:30 a.m. EST (approx.)
Date:	Nov. 4, 1970

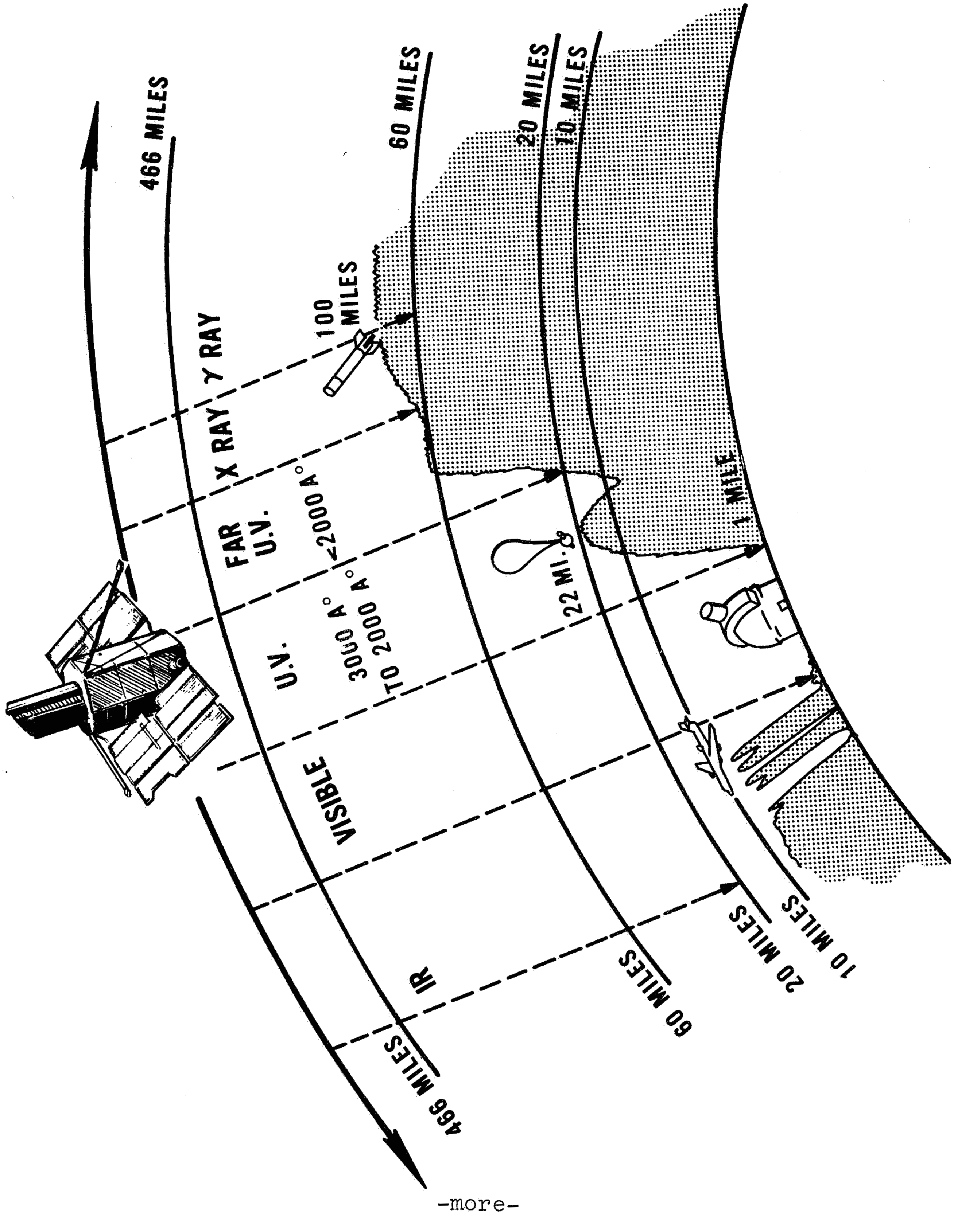
Orbital Elements

Apogee-Perigee	Circular, 466 statute miles
Period:	100 minutes
Inclination:	35 degrees

Stadan Tracking Stations	Rosman, N.C.; Quito, Ecuador: Santiago, Chile; Orroral, Australia; Tananarive, Madagascar.
Spacecraft and Tracking Management	NASA/Goddard Space Flight Center, Greenbelt, Md.
Launch Vehicle Management	NASA/Lewis Research Center, Cleveland, Ohio
Launch Operations	NASA/Kennedy Space Center, Fla., Unmanned Launch Operations

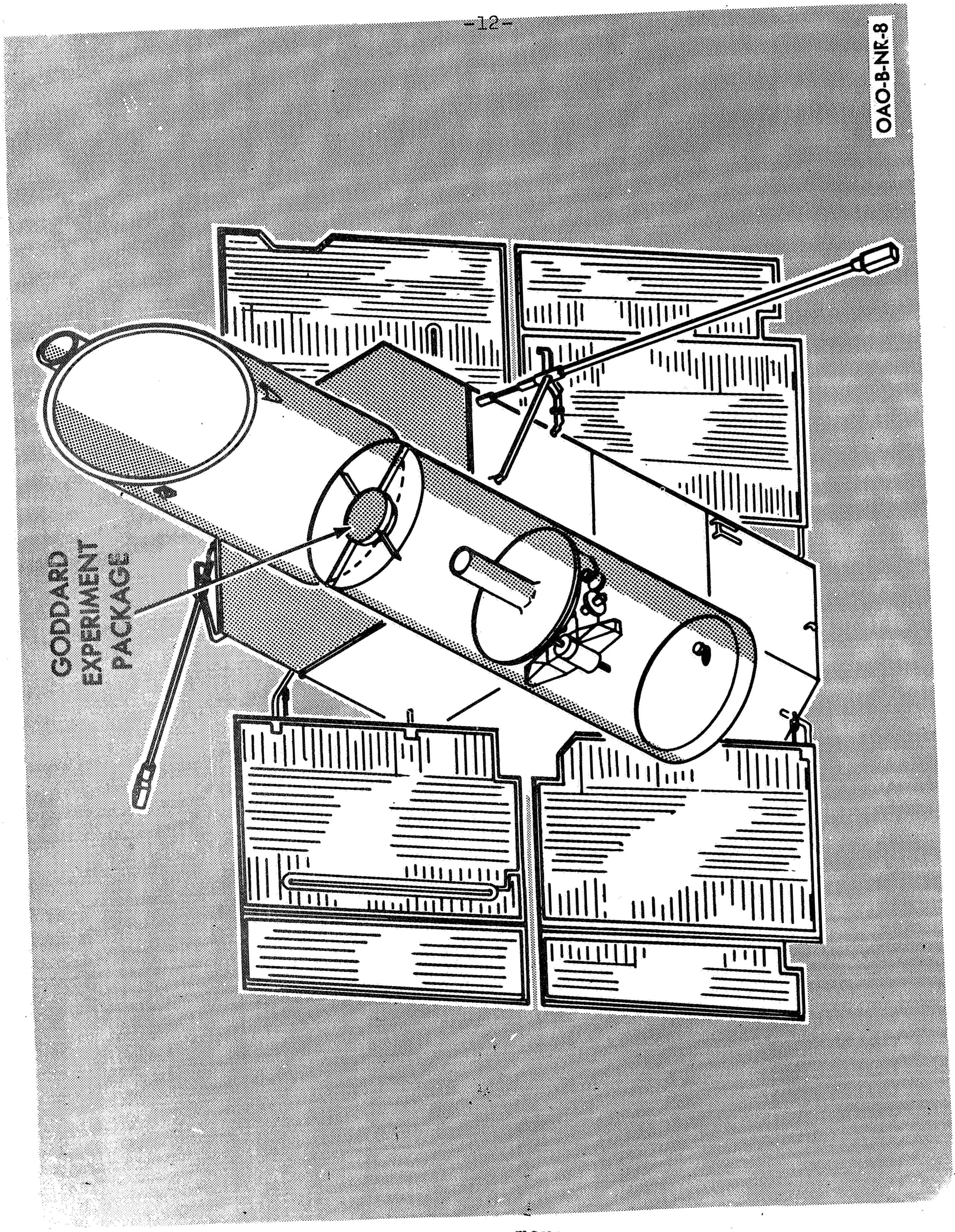
Prime Contractors

Spacecraft:	Grumman Aerospace Corp. Bethpage, New York
Goddard Experiment Package	Kollsman Instrument Corp. Syosset, New York
Launch Vehicle:	General Dynamics-Convair, San Diego, Calif.


466 MILES
60 MILES
20 MILES
10 MILES
100 MILES
X RAY
γ RAY
FAR U.V.
<2000 A°
U.V.
3000 A° TO 2000 A°
VISIBLE
IR
22 MI.
1 MILE
466 MILES
60 MILES
20 MILES
10 MILES

OAO EXPERIMENT BACKGROUND

	University of Wisconsin (OAO 1&2)			SAO (OAO-2)	Goddard (OAO-B)	Princeton Univ. (OAO-C)	University College London/Leicester University Experiment (OAO-C)
	Stellar Photometer	Nebular Photometer	Scanning Spectrometer	Schwarzchild Camera	Spectro-photometer	Spectrometer	X-Ray telescope
Aperture	8 in.	16 in.	41.0 sq. in.	12 in.	38 in.	32 in.	Various
Spectral Range	1000-4250A	2000-3300A	2000-4000A 1000-2000A	1200-2900A	1100-4267A	800-3000A	1-3A, 3-9A, 8-18A & 44-60A
Resolution	Filter	Filter	10-20A, 20-200A	Filter	2A-8A-64A	0.1-0.5A	Filter
Field size	10 and 2 arc min.	30 and 10 arc min.	8 arc min. X 2.5 deg.	2.8 deg. circular	5 arc min. 1 arc min. 5 arc min. X10 arc sec. 5 arc min. X40 arc sec.	--------	Commandable 1 arc min. to 2 degrees
Pointing Accuracy Required	1 arc min.	1 arc min.	1 arc min.	1 arc min.	1 arc. sec.	0.1 arc sec.	1 arc min.
Data type	Analog & Digital	Analog & Digital	Analog & Digital	Analog & Digital	Digital	Digital	Digital


OAO-B-NR-8
GODDARD
EXPERIMENT
PACKAGE

Goddard Experiment Package (GEP)

The 1,000-pound GEP will gather high-resolution spectral data from pointed and extended sources in the ultraviolet region of the spectrum.

GEP Optical System

Employs a relatively fast, 38-inch Cassegrain telescope with a Wright-Schmidt spectrometer usable in the spectral regions from approximately 1,000 to 4,000 Angstrom (A).

With the exception of the quartz secondary mirror, all optics (primary mirror, spectrometer mirror and diffraction gratings) are beryllium.

GEP Sensory Systems

Contains seven detectors--six for UV light and one for visible light. The six UV detectors measure spectral energy distribution in specific narrow bands in the 1,050Å to 4,267Å range and generate data in a train of asynchronous pulses counted by an associated data accumulator in the digital electronics system.

The seventh detector channel acquires data in the visible spectral range for correlating UV intensity and star magnitude.

GEP Electronic Equipment

The analog electronics subsystem consists of the analog electronics assembly, seven detectors and associated electronics. The analog electronics assembly includes most of the analog electronics circuits and some digital circuits, the power supplies and analog status data circuits and the four drive mechanism circuits.

The digital electronics system can decode and store ground commands transmitted over the OAO command system, thereby controlling the operational sequence of the Goddard experiment package.

GEP Fine-Control Error Sensor

Effectiveness of the experiment requires fine guidance within one to two seconds of arc. The fine-control error sensor uses approximately 10 per cent of the starlight flux collected by the primary GEP optics.

Basic function of the sensor is to generate star-pointing error signals in the pitch and yaw control axes and transmit the error signals to the spacecraft stabilization and control subsystem for controlling the fine-attitude pointing of OAO-B.

The sensor also generates a star-presence signal that indicates that the system has acquired the star and is ready to transmit error signals.

If the experiment's optical line-of-sight is within the accuracy limits of the selected range, the sensor generates an accuracy signal indicating that star data acquisition may proceed.

The sensor transmits a star-presence signal, a star-magnitude signal and an error-monitoring signal to the ground to indicate experiment status.

ATLAS-CENTAUR LAUNCH VEHICLE

OAO-B is the second Orbiting Astronomical Observatory launch for the Atlas-Centaur. Centaur successfully launched OAO-2, December 7, 1968. OAO-B is 233 pounds heavier than OAO-2, weighing in at 4,680 pounds. Because of the increased weight, it will be placed in a slightly lower orbit of about 466 miles. OAO-2 is in a nearly circular orbit about 480 miles.

OAO-B is the 13th operational launch for Centaur which was developed and is launched under the direction of NASA's Lewis Research Center, Cleveland. The first seven operational missions for Centaur were launches of Surveyor spacecraft to the Moon. This very successful series proved the great value of high energy upper stages in the U.S. space program.

Since that time Atlas-Centaurs have successfully launched OAO-2, ATS-5 and two Mariner spacecraft to Mars.

The Centaur is powered with two improved RL-10 engines, designated RL-10, A-3-3. The RL-10 was the first operational hydrogen-fueled engine developed for the space program.

Centaur carries insulation panels and a nose fairing which are jettisoned after the vehicle leaves the Earth's atmosphere. The insulation panels, weighing about 1,200 pounds, surround the second stage propellant tanks to prevent the heat of air friction from causing excessive boil-off of liquid hydrogen during flight through the atmosphere. The nose fairing protects the payload from the same heat environment.

Launch Vehicle Characteristics

Liftoff weight including spacecraft:		324,267 pounds
Liftoff height:		135 feet 4 inches
Launch Complex:		36 B
Launch Azimuth:		60 degrees
	Atlas Booster	**Centaur Stage**
Weight:	279,474 lbs.	40,103 lbs.
Height:	70 feet	65 feet, 4 inches (with payload fairing)
Thrust:	395,000 lbs. (sea level)	30,000 lbs. (vacuum)
Propellants:	Liquid oxygen and RP-1	Liquid hydrogen and liquid oxygen
Propulsion:	MA-5 system (2-168,000 lb. thrust engines, 1-58,000 lb. sustainer engine and 2-670 lb. thrust vernier engines.)	Two 15,000 pound thrust RL-10 engines. 14 small hydrogen peroxide thrusters.
Velocity:	5,318 mph at BECO 6,412 mph at SECO	15,754 mph at s/c separation
Guidance:	Pre-programmed autopilot through BECO. Switch to Centaur inertial guidance for sustainer phase.	Inertail guidance

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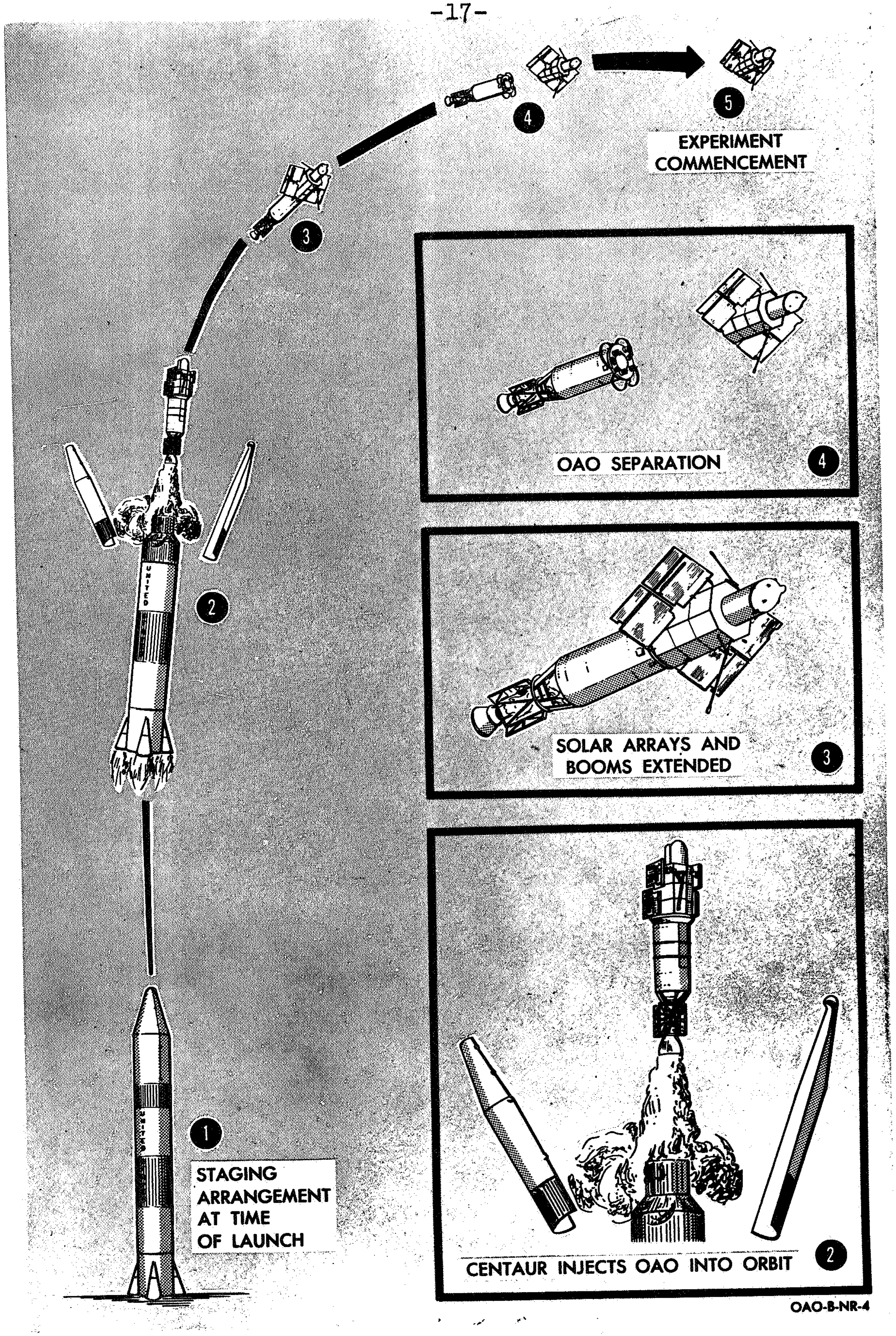

EXPERIMENT COMMENCEMENT
5
4
3
OAO SEPARATION
4
SOLAR ARRAYS AND BOOMS EXTENDED
3
2
1
STAGING ARRANGEMENT AT TIME OF LAUNCH
CENTAUR INJECTS OAO INTO ORBIT
2
OAO-B-NR-4

Flight Sequence

Atlas Phase

After liftoff, AC-21 will rise vertically for about 15 seconds before beginning its pitch program. Beginning at two seconds after liftoff and continuing until T-20 seconds the vehicle will roll to the desired flight azimuth of 60 degrees.

After 153 seconds of flight, the booster engines are shut down (BECO) and jettisoned three seconds later. The Centaur guidance system then takes over flight control. The Atlas sustainer engine continues to propell the AC-21 vehicle to an altitude of 145 miles. Prior to sustainer engine shut down, the second stage insulation panels are jettisoned.

The Atlas and Centaur stages are then separated by an explosive shaped charge that slices through the interstage adapter. Retro-rockets mounted on the Atlas slow the spent Atlas stage.

Centaur Phase

At four minutes four seconds into the flight, the Centaur's two RL-10 engines are ignited for a planned 7 minute 31 second burn. This will place Centaur and the spacecraft into a near circular orbit at an altitude of approximately 466 miles.

Twelve seconds after main engine start, the nose fairing around the spacecraft is separated. At main engine start plus 25 seconds, Centaur initiates a right yaw maneuver to attain the final orbital inclination of 35 degrees. The original launch azimuth was 60 degrees to avoid the Bermuda area during reentry of the Atlas sustainer engine and tank and the nose fairing.

Separation

Separation of the OAO spacecraft takes place by firing explosive bolts on a V-shaped metal band holding the spacecraft to the adapter. Compressed springs then push the spacecraft away from the launch vehicle at a rate of about 3.2 feet per second.

Retro Maneuver

Five minutes after spacecraft separation, the Centaur stage attitude control thrusters are used to reorient the vehicle. The 50-pound thrust vernier engines are then fired to settle the propellants. The remaining liquid oxygen and liquid hydrogen are vented overboard to provide enough thrust to place the Centaur stage in a slightly different orbit from the spacecraft.

The final Centaur orbit will have an apogee of 493 miles and perigee of 436 miles.

Launch Window

The OAO-B launch window opens at approximately 6:28 a.m. EST Nov. 4 and closes two hours later. In case of delays, the window opens 22 minutes earlier each day through Nov. 16.

Atlas-Centaur Flight Sequence

EVENT	NOMINAL TIME MINUTES SECONDS	ALTITUDE STATUTE MILES	SURFACE RANGE STATUTE MILES	VELOCITY MPH
Liftoff	0	0	0	0
Booster Engine Cutoff	2' 33"	52.5	35	5,318
Booster Jettison	2' 36"	56.1	37.9	5,360
Jettison Insulation Panels	3' 18"	104.5	80.2	5,811
Sustainer Engine Cutoff	3' 52"	145.1	120.7	6,412
Atlas Separation	3' 54"	147.5	123.2	6,387
Centaur Engine Start	4' 4"	160.9	135.3	6,260
Jettison Nose Fairing	4' 16"	172.2	150.5	6,263
Centaur Engine Cutoff	11' 35"	470.1	1,131.4	15,750
Spacecraft Deploy Solar Panels	11' 45"	470.1	1,170.5	15,756
Extend Spacecraft Balance Booms	11' 59"	470.1	1,229.1	15,755
Spacecraft Separation	12' 25"	470.2	1,326.8	15,754
Start Centaur Reorientation	17' 30"	470.5	2,523.7	15,753
Start Centaur Retrothrust	18' 55"	470.3	2,895.3	15,754
End Retrothrust	56' 34"	439.1	6,919.6	15,877

LAUNCH OPERATIONS

The John F. Kennedy Space Center (KSC), and its Unmanned Launch Operations (ULO) Directorate plays a key role in the preparation and launch of an Atlas-Centaur vehicle carrying the OAO.

The spacecraft is brought from GSFC, by truck to the Hangar AE, Cape Kennedy, about three weeks before launch, where it is placed in a clean room for final preparations.

In addition to providing the necessary spacecraft support services during final launch preparations, ULO is responsible for mating the spacecraft to the adapter ring of the launch vehicle and encapsulating the spacecraft with a fairing. From that point to launch, the ULO monitors the environmental conditioning of the spacecraft to assure that no contaminants come into contact with it.

In providing launch operations, KSC handles scheduling of test milestones and review of data to assure that the launch vehicle has met all of its test requirements and is ready for launch.

Major milestones leading to Atlas-Centaur launch of an OAO spacecraft include:

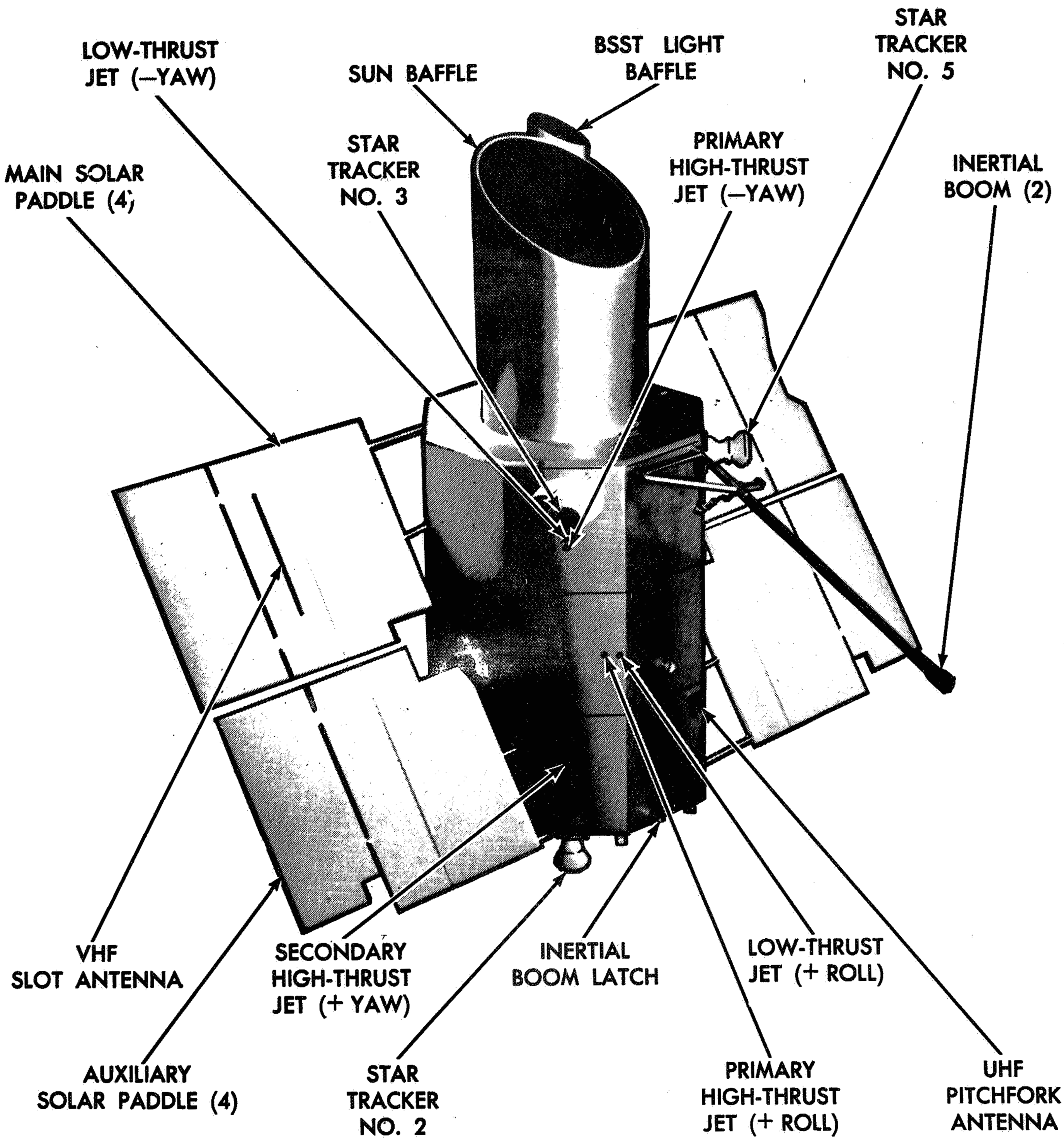
*Terminal Countdown Demonstration (TCD), about five weeks prior to launch, which primarily demonstrates that all of the functions leading to the countdown can be performed. It is an end-to-end check of all systems and includes propellant loading of both launch vehicle stages to assure the tanks and facilities are ready for the countdown.

*The Flight Acceptance Composite Test (FACT) occurs about three weeks prior to launch to demonstrate that the vehicle is electrically ready for final launch preparations. It includes running the computer and programmer through past flight events and monitoring the data to assure correct response to all signals with umbilicals ejected. Usually, the spacecraft is erected one or two days after this test.

*The Countdown Readiness Test is conducted about four days before launch. It verifies the ability of the launch vehicle to go through post-flight events and validates the umbilical system again. This is often the only time that spacecraft systems are up with launch vehicle systems prior to launch. The range support elements participate along with the spacecraft and launch vehicle just as during launch.

*F-1 Day Functional Test involves final preparations in getting the entire space vehicle ready for launch, preparing ground support equipment, completing readiness procedures and installing ordnance on the launch vehicle.

The final countdown is picked up at T-450 minutes. All systems are checked against readiness procedures, establishing the integrity of the vehicle and ground support equipment interface prior to tower removal at T-120 minutes. Loading of cryogenic propellants (liquid oxygen and liquid hydrogen) begins at T-80 minutes, culminating in complete vehicle readiness at T-5 minutes. The terminal count begins at this point and the space vehicle goes on internal power. The launch team begins monitoring all systems and topping off and venting propellant and purge systems. At T-10 seconds, the automatic release sequence is initiated and the space vehicle is clear for liftoff.


LOW-THRUST
JET (—YAW)
SUN BAFFLE
BSST LIGHT
BAFFLE
STAR
TRACKER
NO. 5
MAIN SOLAR
PADDLE (4)
STAR
TRACKER
NO. 3
PRIMARY
HIGH-THRUST
JET (—YAW)
INERTIAL
BOOM (2)
VHF
SLOT ANTENNA
SECONDARY
HIGH-THRUST
JET (+ YAW)
INERTIAL
BOOM LATCH
LOW-THRUST
JET (+ ROLL)
AUXILIARY
SOLAR PADDLE (4)
STAR
TRACKER
NO. 2
PRIMARY
HIGH-THRUST
JET (+ ROLL)
UHF
PITCHFORK
ANTENNA

OAO-B

-more-

OAO-B MISSION

There are two primary reasons for the OAO-B launch window. The first constraint deals with the operational conflict if OAO-2 and B are over a ground station at about the same time. Officials want to have sufficient time between passes of the two spacecraft to collect scientific data and to send commands to the spacecraft.

The second launch constraint is a requirement to have at least 35 minutes of sunlight remaining after spacecraft separation from Centaur to allow enough time to acquire the sunline and then to transfer control of OAO-B to the Rate And Position Sensor (RAPS) before entering spacecraft darkness.

OAO-B Separation

OAO-B solar panels will deploy 11 min. 43 sec. after lift-off; spacecraft booms will deploy 11 min 58 sec. after lift; and the OAO-B spacecraft will separate from the burned out Centaur stage at 12 min. 23 seconds after lift-off.

OAO-B Mission Events

Survival

Little will be done with the observatory the first day of orbit. It will be in a "sunbathing" or survival condition with a minimum expenditure of gas and operations under automatic control.

Operations personnel will analyze data to determine that the spacecraft stabilized properly, battery charging is safe, thermal conditions are within predictions and the solar array output (power system) is normal.

Observatory Checkout

After the survival phase is complete (about one day after launch), the Inertial Reference Unit (IRU) will be checked out. Also, a thorough checkout of all spacecraft systems will be made beginning on day two.

Initial turn-on of all spacecraft subsystems, including the Goddard Experiment Package, will occur while the observatory is still being controlled in the sunbathing mode.

During this spacecraft checkout, extreme caution will be taken prior to turning on high voltage subsystems. This permits proper outgasing and reduces the likelihood of electrical arcing or corona.

High voltage systems will be turned on initially only when the spacecraft is under Rate and Position Sensor (RAPS) control, or IRU control (hold on wheels or hold on wheels and jets). With this automatic control, the spacecraft's attitude remains fixed for extended periods without having to use the star trackers.

The first high voltage subsystem to be turned on, a star tracker, will occur no sooner than orbit 24 on the second day. The remaining four star trackers will be turned on during orbit 26.

Experiment Turn-On

The GEP telescope will be turned on for the first time about the 57th orbit on the 4th day.

Normal operation of the spacecraft and GEP will start about eight days after launching.

Tracking

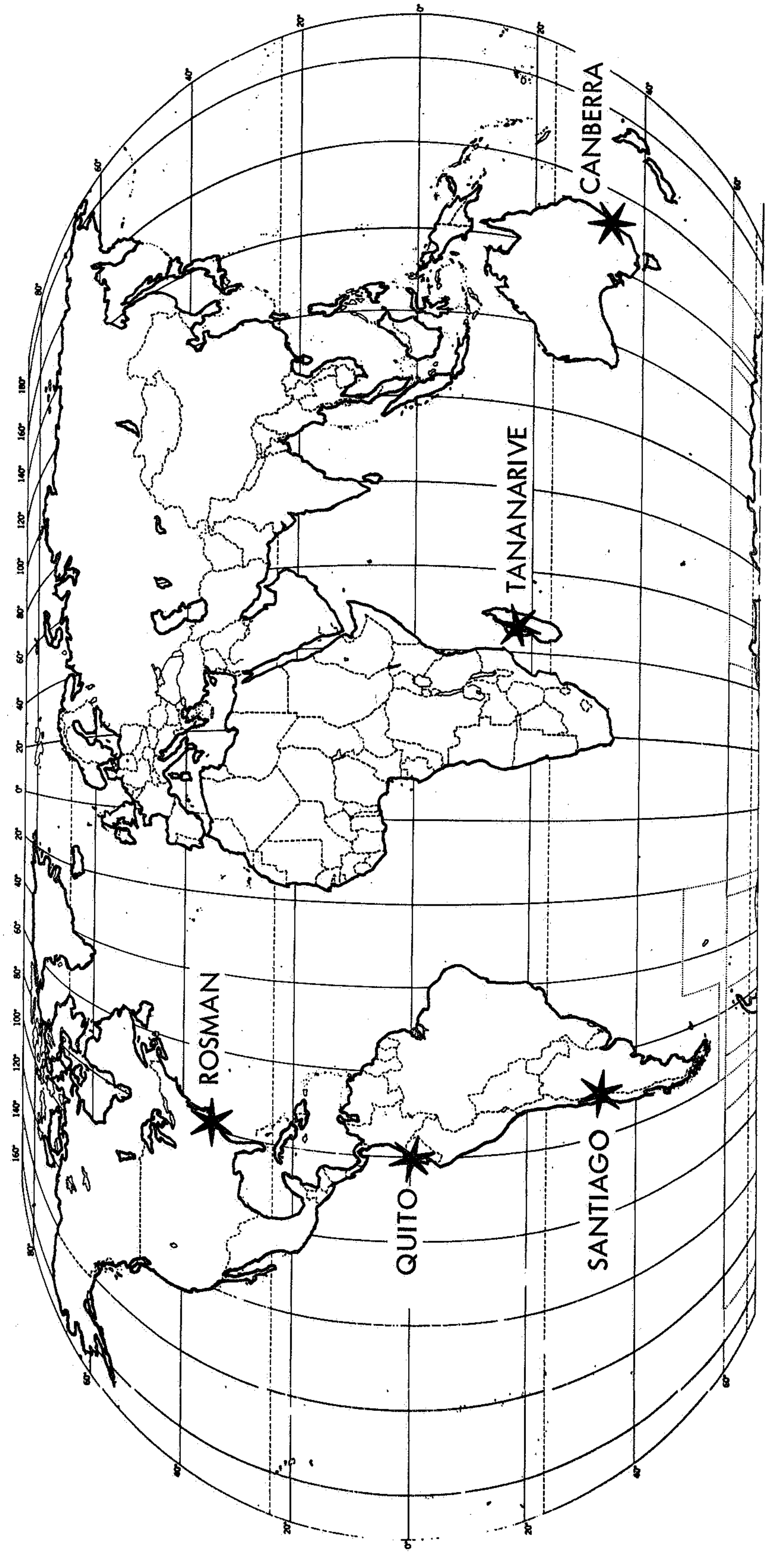
OAO-B, one of the most complex scientific satellites, will be literally flown from the ground through the facilities of NASA's STADAN (Satellite Tracking and Data Acquisition Network). Because the network already is carrying on with the similarly complex OAO-2, the presence of the new satellite in orbit will double the work load.

Major stations of the STADAN system for OAO are Rosman, N.C.; Quito, Ecuador; Santiago, Chile; Orroral Valley, Australia; and Tananarive, Madagascar. Other NASA stations will support the flight as needed.

The entire OAO-B mission is controlled by a computer program of more than 250,000 instructions. The computer continuously monitors hundreds of items of condition on the spacecraft and compares them with predicted values of the flight plan.

The computer calculates and issues gimbal angles for the on-board star trackers so that OAO will lock onto the correct stars among the 50,000 it will ultimately study, and every attempted change of position and condition will be analyzed as a means of preventing incorect operation.

SATELLITE NETWORK



The computer controlled operation of OAO-2 resulted in major modifications and changes in the operation when the spacecraft developed control troubles in 1969. With prompt warning from the computer-tracking combination, the operators of the satellite were able to avert trouble and keep the satellite returning data on all of its experiments.

OAO RESULTS

OAO-1 was orbited April 8, 1966. It failed shortly after obtaining orbit due to a malfunction in the power supply system and probable high voltage arcing in the star tracker system.

Several modifications to the OAO system were incorporated into the OAO-2 spacecraft as a result of the first flight failure.

Launched into orbit December 7, 1968, OAO-2 has far exceeded all pre-launch engineering and scientific objectives. The world's first successful space observatory is approaching two years of operation. During that time it has been available for collecting scientific data 88 per cent of the time since it was launched.

Engineering

OAO-2 has exceeded its pointing accuracy requirement of one minute of arc by a factor of two.

In-orbit attitude determinations have been made using on-board sun sensors and magnetometers. Using these attitude determinations it has demonstrated that star searches can be performed using the gimballed star trackers and thereby re-establishing stellar reference control of spacecraft attitude.

The rate and position sensor (RAPS) inertial system proved the feasibility of inertial stabilization with star tracker update to maintain accurate pointing attitude.

Data processing subsystem has stored and returned millions of experiment and spacecraft information bits.

Although OAO-2 is an unmanned observatory, it is literally flown from the ground by a team of 25 Earth-based astronauts who work around-the-clock at Goddard. To date, hundreds of thousands of commands have been sent to OAO-2 and more than 30 billion data bits have been transmitted to the ground.

Scientific

The OAO-2 science package consists of two experiments and 11 telescopes. Seven of the telescopes, provided by the University of Wisconsin, are studying individual stars for long periods of times as well as interstellar dust and certain planets in our solar system. The remaining four telescopes are in Smithsonian Astrophysical Observatory (SAO) experiment. These telescopes are taking stellar pictures of the sky to provide astronomers with the first stellar maps of our universe in the ultraviolet. The faintness of the Moon in ultraviolet indicates either that it reflects less ultraviolet light than expected, or that the Sun is somewhat fainter in ultraviolet than the most recent observations and theories would suggest.

During more than 16 months of operation, the Smithsonian Celescope experiment observed 3003 star fields, taking 8701 photographs which covered about 10 percent of the sky and about 20 percent of the sky region near the Milky Way containing the majority of ultraviolet objects.

The photographs provide data for more than 25,000 stars in each of three ultraviolet regions of the spectrum. The experiment also observed the Moon, the Comet Tago-Sato-Kosaka, and the planets Mars and Jupiter in ultraviolet light.

In addition, nearly all of the shortest-wavelength photographs contained bright sky-background light in the 1216-Angstrom wavelength caused by the scattering of hydrogen emission from the Sun by hydrogen in the Earth's outer atmosphere beyond the 500-mile height of the OAO spacecraft. For the first time, this hydrogen scattering was observed in a consistent manner over an extended period.

Many astronomers believe that the full impact from OAO-2 will not be felt for several years, and that practically all phases of optical astronomy will be affected as a result of the observatory findings.

Also, some noted scientists believe that some theories of cosmology will have to be modified and others discarded as a result of OAO-2 data.

Some of the major OAO-2 scientific accomplishments include:

*Discovery of a huge hydrogen cloud a million miles in diameter around Comet Tago-Sato-Kosaka.

*Discovery that hottest stars are even hotter than suspected, are aging faster than suspected and are burning hydrogen at a very rapid rate.

*Evidence that normal galaxies are unexpectedly bright (the Andromeda galaxy) in the ultraviolet. If this is common among distant galaxies, this discovery may have significant cosmological consequence.

*Discovered ozone in the planet Mars which is very important in the determination of the entire oxygen and carbon dioxide chemistry of the planet.

*Is painstakingly conducting a survey of stars in the ultraviolet impossible from the ground because of Earth's atmosphere.

incorrect

~~*Remarkable, and unexpected discovery, has been that "dark nebulae" are brighter in shorter wavelengths than the bright diffuse nebulae that appear on visible light photographs. This discovery will be very important to future theories on the nature of interstellar grains and physical properties of the clouds from which stars are born.~~

*Observed nova outburst (stellar explosion) of Nova Serpentis from immediately after maximum through the next two months. This represented an excellent example of the reasons many astronomers want observatories in space continuously for constant surveillance (not hampered by clouds or Earth's atmosphere) of stellar phenomena.

As of September 8, 1970, the OAO-2 experiment status was as follows:

University of Wisconsin

Unique Objects viewed	1069
Number of Observations	5127
Average Observations/Day	13

Smithsonian

Number of Observations	3494
Number of pictures	8577
Average Observations/Day	16

Scientific papers produced as a result of the OAO-2 mission include:

Bless, R. C. 1970 - Review of Ultraviolet and Visual Continuum Observations and Comparison with Models, "Ultraviolet Stellar Spectra and Ground-Based Observations" Houziaux and Butler (Ed.) page 73 IAU.

Bless, R. C., Code, A. D., Houck, T. E., Lillie, C. F., and McNall, J. F. 1970 - OAO Observations of Sco X-1, "Non-Solar X and Y Ray Astronomy," Gratton (Ed.) page 176, IAU.

Bless, R. C. and Savage, B. D. 1970 - Observations of Interstellar Extinction in the Ultraviolet with the OAO Satellite, "Ultraviolet Stellar Spectra and Ground-Based Observations" Houziaux and Butler (Ed.) page 28, IAU.

Code, Arthur D. 1969 - The Future of Photometry and Moderate-Resolution Spectrophotometry in Space Astronomy - "Optical Telescope Technology" NASA SP-233, page 13.

Code, Arthur D. 1969 - Photoelectric Photometry from a Space Vehicle, PASP 81, 475.

Code, A. D. - 1970 - Survey on new results (Stellar Observations), Proceedings IAU Symposium No. 41.

Code, A. D. and Bless, R. C. 1970 - Observations of Strong Stellar Lines with the OAO, "Ultraviolet Stellar Spectra and Ground-Based Observations" Houziaux and Butler (Ed.) page 173, IAU.

Code, A. D., Houck, T. E.,McNall, J. F., Bless, R. C. and Lillie, C. F., 1970 - Ultraviolet Photometry from the Orbiting Astronomical Observatory I. Instrumentation and Operation. Ap. J. 161, 377.

Doherty, L. R. 1970 - "OAO observations of MgII Emission in Late-Type Stars," Proc. Roy. Soc. (in press)

Fairchild, Edward T. 1970 - use of Synchrotron Radiation from an Electron Storage Ring as an Absolute Standard of Radiant Flux for Wavelengths from 1000 to 3000 Å. Proceedings IAU Symposium No. 41.

Gaide, Albert 1970 - Absolute UV Calibration of Rocket Photometers Used to Update the OAO Calibration, Proceedings IAU Symposium No. 41.

Gilra, Daya P. 1970 - "The Composition of Interstellar Grains," Nature (in press).

Savage, B. D. and Code, A. D. 1970 - "Observations of Interstellar Lyman-Alpha with the OAO, Ultraviolet Stellar Spectra and Ground-Based Observations." Houziaux and Butler (Ed.) page 302, IAU.

Wallace, L. Broadfoot, L. Caldwell, J., Savage, B. D., Code, A. D., Sagen, C. and Owen, T. 1970 - The Detection of Ozone in Mars, Ap. J. letters (submitted for publication).

"Ultraviolet Photometry of Stars Obtained with the Celescope Experiment in the Orbiting Astronomical Observatory, by Robert J. Davis, presented at IAU Symposium No. 36, Lunteren, Netherlands, 24-27 June 1969; published in Ultraviolet Stellar Spectra and Ground-Based Observations, ed. by Houziaux and Butler, pp. 109-119, copyright 1970 by the IAU.

Guest Observer

A guest observer program was initiated for the OAO-2 mission. This program broadens astronomical participation to obtain increased scientific return from the spacecraft.

The guest observer tells NASA what observation he would like the OAO to make, for example look at a certain galaxy or star. Then when the instrument is pointed in that direction and the primary experiment requirements satisfied, the guest observer experiments can be conducted.

Fourteen guest observer proposal were approved for OAO-2 and 342 observations were made during the first year of operation. Of the 14 observers, four were from other nations.

On the OAO-B mission, 25 potential guest observers, eight from overseas, have inquired about participating during the approximately 10 percent of the observing time available for the program. About half are interested in planetary observations. Ten to twenty guest observers can be accommodated each year.

Guest observations will not begin until about three months after launch so that the Principal Investigator can make his initial observations.

OAO-B TEAM

NASA Headquarters

Dr. John E. Naugle	Associate Administrator for Space Science & Applications
Mr. Jesse L. Mitchell	Director, Physics & Astronomy Programs, OSSA
Dr. Nancy G. Roman	Chief of Astronomy, OSSA
Mr. D. Dixon Ashworth	OAO Program Manager
Mr. F. R. Schmidt	Centaur Program Manager

Goddard Space Flight Center

Dr. John F. Clark	Director
Mr. Joseph Purcell	OAO Project Manager
Dr. James E. Kupperian, Jr.	OAO Project Scientist
Dr. Albert Boggess	Principal Investigator

Kennedy Space Center

Dr. Kurt H. Debus	Director
Mr. John J. Neilon	Director, Unmanned Launch Operations (ULO)
Mr. John Gossett	Manager, Centaur Operations, ULO
Mr. Donald Sheppard	Chief, Spacecraft Operations, ULO

Lewis Research Center

Mr. Bruce T. Lundin	Director
Mr. Seymour C. Himmel	Assistant Director for Rockets & Vehicles
Mr. Edmund R. Jonash	Chief, Launch Vehicles Division
Mr. W. R. Dunbar	Centaur Project Manager

Industry

Mr. R. E. Marshall	Program Manager Inertial Reference Unit Charles Stark Draper Laboratory
Mr. Theodore H. Moorman	OAO Program Manager Grumman Aerospace Corp.
Mr. Leon J. Mintz	GEP Program Manager Kollsman Instrument Corp.
Mr. Dean Davis	Centaur Program Manager General Dynamics -Convair
Mr. O. H. Reed	Base Manager General Dynamic Convair

Industry Team

Prime Contractors	Responsibility
Grumman Aerospace Corp. Bethpage, N.Y.	OAO-B Spacecraft
Charles Stark Draper Laboratory Cambridge, Mass.	Inertial Reference Unit
Kollsman Instrument Corp. Syosset, N.Y.	Goddard Experiment Package (GEP)
General Dynamics-Convair San Diego, Calif.	Atlas-Centaur Launch Vehicle

Major Spacecraft Subcontractors

Company	Responsibility
Adcole Corp. Waltham, Mass.	Solar aspect sensors
Arco Great Neck, New York	Electrical components
AVCO Corp. Electronics Division Cincinnati	OAO command receiver
Bendix Corporation Electric Power Division Eatontown, N. J.	OAO power control unit, power regulator unit, and diode box
Dalmo Victor Co. Belmont, Calif.	Magnetic unloading system
Granger Associates Bohemia, N. Y.	Diplexer and hybrid junction
Fairchild Hiller Corp. Space and Electronic Systems Division Germantown, Md.	Thermal control louvers
General Electric Co. Spacecraft Department Valley Forge, Pa.	Stabilization and Control System
Gulton Industries Alkaline Battery Division Metuchen, N. J.	Storage battery
Gulton Industries Engineered Magnetics Division Hawthorne, Calif.	Voltage inverter/regulator converter
Hughes Aircraft Co. Culver City, Calif.	Solid state transmitters
IBM Federal Systems Division Owego, N. Y.	Primary processor and data storage/programmer and star-tracker sequence controller and spacecraft system controller unit equipment

ITT Federal Laboratories San Fernando, Calif.	Boresight star tracker
Kollsman Instrument Corp. Syosset, N. Y.	Gimbal star trackers
Magnetic Control Company ADC-Product Division Minneapolis	Current sensors (OAO)
Radiation Corp. Melbourne, Fla.	Spacecraft data handling equipment/Experimenters data handling equipment
Spectro-Laboratory Sylmar, Calif.	Solar arrays

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