NASA

COSMIC BACKGROUND EXPLORER (COBE)

PRESS KIT

Release: 89-172

NOVEMBER 1989

PUBLIC AFFAIRS CONTACTS

Paula Cleggett-Haleim
Office of Space Science and Applications
NASA Headquarters, Washington, D.C.
(Phone: 202/453-1547)

Jim Cast
Office of Space Flight
NASA Headquarters, Washington, D.C.
(Phone: 202/453-8536)

Carter Dove/Jim Elliott
Goddard Space Flight Center, Greenbelt, Md.
(Phone: 301/286-5566)

George Diller/Dick Young
Kennedy Space Center, Fla.
(Phone: 407/867-2468)

CONTENTS

General Press Release
Cosmic Background Explorer Summary------------------------4
The Cosmic Background Explorer Mission--------------------4
    Major Mission Events----------------------------------6
    COBE Mission Phases-----------------------------------7
    Observatory/Instrument Checkout-----------------------7
    Mission Operations------------------------------------9
    Mission Lifetime--------------------------------------9

COBE Science--9
    COBE Science Questions-------------------------------12
    Cobe Instruments-------------------------------------12

Launch Vehicle Preparation-------------------------------14
    Testing and Modifications----------------------------14
    Vehicle Assembly-------------------------------------14
    Launch Pad Refurbishment-----------------------------15
    Delta/COBE Launch Readiness--------------------------15

COBE Mission Management----------------------------------15
Science Working Group------------------------------------16
Contractors--17

GENERAL PRESS RELEASE

NASA SPACECRAFT TO LOOK OUT INTO SPACE, BACK IN TIME

NASA will launch a spacecraft on Nov. 17, 1989, to study the origin and dynamics of the universe, including the theory that the universe began about 15 billion years ago with a cataclysmic explosion -- the Big Bang.

The Cosmic Background Explorer (COBE) spacecraft will be boosted into an Earth polar orbit from Vandenberg Air Force Base, Calif., aboard the final NASA-owned, NASA-launched Delta vehicle.

By measuring the diffuse infrared radiation (cosmic background) that bombards Earth from every direction, COBE's instruments will help clarify such matters as the nature of the primeval explosion -- which started the expansion of the universe and made it uniform -- and the processes leading to the formation of galaxies.

From its orbit 559 miles above Earth, COBE will carry out its cosmic search using three sophisticated instruments: the Differential Microwave Radiometer (DMR), Far Infrared Absolute Spectrophotometer (FIRAS) and Diffuse Infrared Background Experiment (DIRBE).

DMR will determine whether the primeval explosion was equally intense in all directions. Patchy brightness in the cosmic microwave background would unmask the as-yet-unknown "seeds" that led to the formation of such large bodies as galaxies, clusters of galaxies, and clusters of clusters of galaxies. Measurements of equal brightness in all directions would mean the puzzle of how these systems could have condensed since the Big Bang will be even more vexing than it is today.

To distinguish the emissions of our own Milky Way galaxy from the true cosmic background radiation, DMR will measure radiation from space at wavelengths of 3.3, 5.7 and 9.6 millimeters.

FIRAS, covering wavelengths from 0.1 to 10 millimeters, will survey the sky twice during the year-long mission to determine the spectrum (brightness versus wavelength) of the cosmic background radiation from the Big Bang.

- more -

The spectrum that would result from a simple Big Bang can be calculated with great accuracy. Such a spectrum would be smooth and uniform and have no significant releases of energy between the time of the Big Bang and the formation of galaxies. If FIRAS' measurements depart from the predicted spectrum, scientists will know that powerful energy sources existed in the early universe between these times.

These sources may include annihilation of antimatter, matter falling into "black holes," decay of new kinds of elementary particles, explosion of supermassive objects and the turbulent motions that may have caused the formation of galaxies.

FIRAS' sensitivity will be 100 times greater than that achieved so far by equivalent ground-based and balloon-borne instruments. Producing a spectrum for each of 1,000 parts of the sky, the FIRAS data will allow scientists to measure how much light was radiated by the Big Bang.

DIRBE will search for the diffuse glow of the universe beyond our galaxy in the wavelength range from 1 to 300 micrometers. In the final analysis, any uniform infrared radiation that remains will be very rich in information about the early universe. One possible source would be light from primordial galaxies shifted into the far infrared by the expansion of the universe.

The 5,000-pound spacecraft and its three infrared- and microwave-measuring instruments were designed and built for the Office of Space Science and Applications by NASA's Goddard Space Flight Center, Greenbelt, Md. Goddard also will manage the launch and analyze the data returned by COBE during its 1-year nominal mission.

Looking out into space, back in time, the COBE spacecraft will undertake the esoteric task of providing new insights into the origin and evolution of the universe.

- end -

COSMIC BACKGROUND EXPLORER SUMMARY

MISSION: During the 2-year mission, COBE will determine the spectrum of the cosmic background radiation, search for radiation from the very first stars and galaxies and map the cosmic background radiation with unprecedented accuracy. COBE will study the physical conditions in the very early universe and the onset of organization following the Big Bang.

LAUNCH: No earlier than 11/16/89, aboard a Delta 5920 ELV, from Space Launch Complex 2 - West, Western Space and Missile Center, Vandenberg Air Force Base, Calif. Launch window is 1/2 hour beginning at 6:24 a.m. PST. An Advanced Range Instrumentation Aircraft will cover the down-range burn of the Delta rocket.

ORBIT: 559-mile, sun-synchronous, near polar orbit, will circle the globe 14 times a day.

SCIENCE DATA: Once a day, data are transmitted to Goddard Space Flight Center's Wallops Processing Flight Facility then forwarded to the COBE Science Data Center at GSFC.

SPACECRAFT: With 3 solar arrays deployed, 16 feet long, 28 feet in diameter, weighing 5,000 lbs.

INSTRUMENTS: Differential Microwave Radiometer, Diffuse Infrared Background Experiment and the Far Infrared Absolute Spectrophotometer.

NOTE: a) Explorers are relatively small, free-flying scientific spacecraft. b) COBE is the 65th Explorer mission. c) COBE has the most sensitive detectors ever flown in a space mission. d) COBE will use the 184th and last NASA-owned Delta.

THE COSMIC BACKGROUND EXPLORER MISSION

NASA's COBE mission will produce the most comprehensive observations to date of the early universe.

The wavelength band to be studied by COBE includes the cosmic background radiation or so-called "remnant radiation," believed to be the signature of the primeval cosmic explosion, the "Big Bang." Current theory also holds that this band contains radiation characteristic of the formation of the first galaxies and stars. It also might provide evidence of other exotic and energetic events occurring in the epochs between the Big Bang and the formation of galaxies.

COBE will carry three sophisticated, state-of-the-art instruments to study the background radiation: the Differential Microwave Radiometer (DMR), the Far Infrared Absolute Spectrophotometer (FIRAS) and the Diffuse Infrared Background Experiment (DIRBE).

Because the diffuse cosmic background radiation itself is extremely faint, the COBE spacecraft and its three experiments have been designed to allow observations at unprecedented sensitivities. To that end, the spacecraft will carry the instruments high above the Earth's atmosphere, protect them from the light and heat of the sun and the Earth, supply them with electrical power and commands and transmit the data they accumulate to the ground.

Two of the three science instruments aboard the spacecraft, FIRAS and DIRBE, reside in a Dewar -- a giant "thermos bottle" -- filled with liquid helium to provide a stable, low-temperature environment within 2 degrees Celsius of absolute zero.

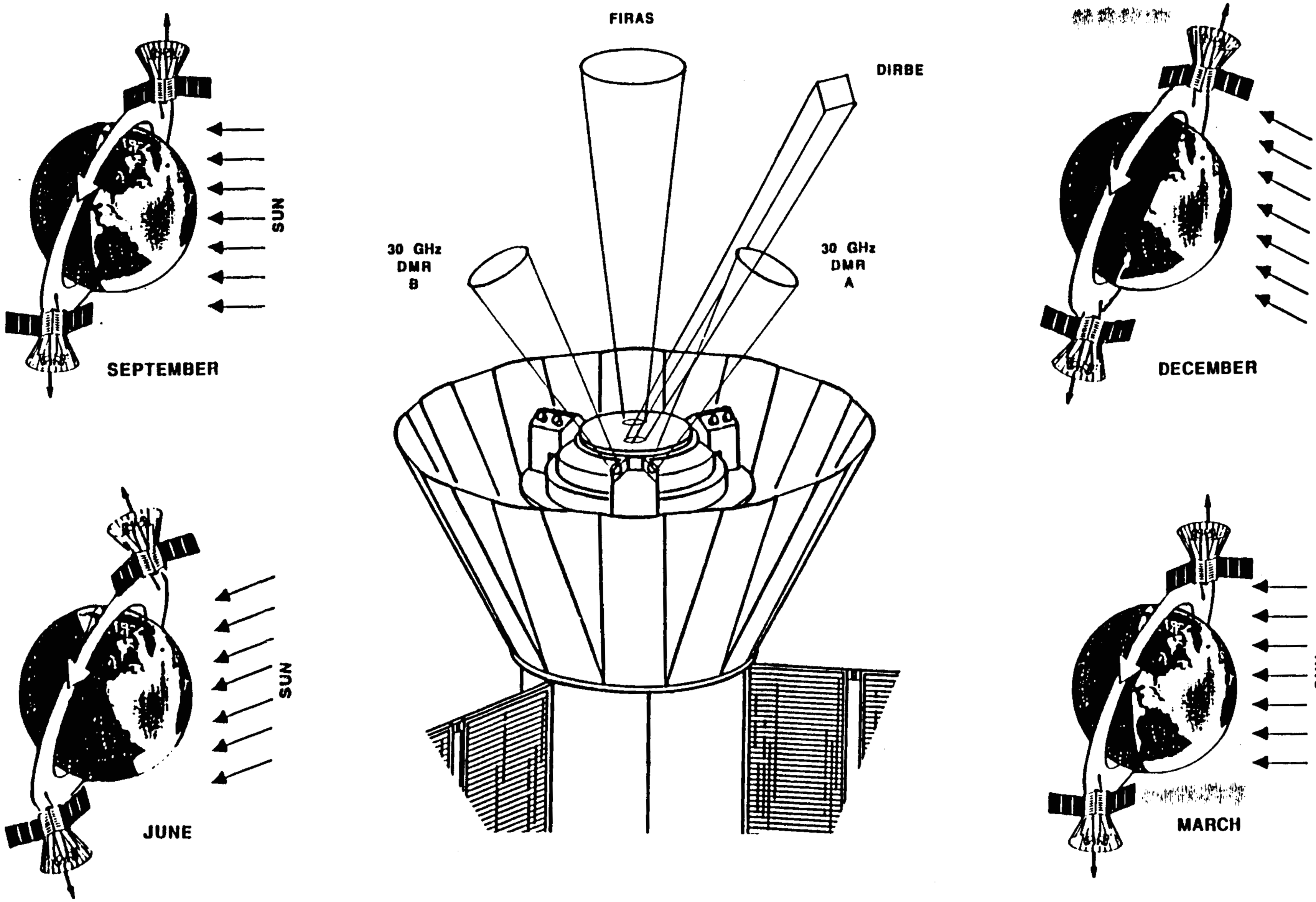
The COBE spacecraft weighs 5,000 pounds, is 16 feet long and is 28 feet in diameter with its three solar panels deployed. The upper half of the observatory is the instrument module, consisting of the three instruments, the liquid helium Dewar and a shield that is deployed when COBE reaches its orbit to protect the instruments from radiation from the sun and the Earth.

Directly under the instrument module is the spacecraft module which includes the mechanical support structure, the attitude control system and the spacecraft and instrument electronics. To allow its instruments to scan the sky, COBE will spin on its axis at a rate of 0.8 rpm.

COBE's attitude control system will keep the spin axis pointed almost directly away from the Earth and 94 degrees away from the sun. The sophisticated attitude control system is comprised of sun and Earth sensors, reaction wheels to provide control torque from the Earth's magnetic field, a pair of large rotating momentum wheels, electromagnets to transfer excess angular momentum from the spacecraft to the Earth's magnetic field and a complex set of control electronics.

Monitoring of the status of the spacecraft and operational commands from the ground will go through the Tracking and Data Relay Satellite System (TDRSS). The science data from the instruments will be recorded on two onboard tape recorders and played back to a ground receiving station at Wallops Island, Va., once a day. These data then will be forwarded to the science team at the COBE Science Data Center, Goddard Space Flight Center, Greenbelt, Md.

COBE will be launched by a two-stage Delta 5920 launch vehicle from Space Launch Complex 2 West at the Western Space and Missile Center, Vandenberg Air Force Base, Calif.



COBE Instrument Fields of View and Solar Alignments

COBE will be placed into a circular, near polar orbit 559 miles above the surface of the Earth. Because the plane of the orbit will be inclined 99 degrees to the Equator, the orbital plane will precess (turn) approximately 1 degree per day, thus maintaining a constant orientation of the spacecraft and its orbit with respect to the sun.

COBE's nominal mission lifetime is 1 year, allowing its instruments to scan the entire sky at least twice. The actual operational lifetime of the FIRAS and DIRBE instruments may be somewhat longer and will be determined by the rate at which the liquid helium boils away as heat flows into the dewar. It is anticipated that the spacecraft will be operated for a second year to allow the DMR to repeat its scans of the sky and achieve even greater sensitivity.

The Delta 5920 is approximately 116 feet long and a maximum of 8 feet in diameter. The first stage is a modified Thor booster incorporating nine Castor 4A strap-on, solid-fuel rocket motors. The first stage main engine is gimbal-mounted and uses liquid oxygen and kerosene. The second stage has a gimbal-mounted, pressure-fed restartable engine fueled with liquid nitrogen tetroxide and aerozene 50.

Injection into the final mission orbit is accomplished at completion of the second burn of the Delta second stage, approximately 1 hour after lift-off. An 8-foot diameter fairing protects the spacecraft from aerodynamic heating during the boost and is jettisoned as soon as the vehicle leaves the sensible atmosphere (shortly after second stage ignition). The fairing separation initiates signals to the spacecraft to properly configure the dewar vent valves in the observatory cryogenic cooler.

MAJOR MISSION EVENTS

Once the final mission orbit is reached, the Delta reorients to the required separation attitude and the Delta inertial guidance computer sends a signal to the spacecraft signal conditioning unit to start deployment. That sequence begins with the RF/thermal shield deployment prior to spacecraft separation from the second stage.

The COBE spacecraft is attached to the second stage Delta by a 6019 payload attach fitting. Because the spacecraft requires a near-zero tip-off rate at separation, a two-step release system, consisting of three explosive nuts and a secondary latch system will be used. At spacecraft separation, the Delta vehicle second stage will use cold gas to back away from the COBE spacecraft.

The signal conditioning unit then initiates momentum wheel spin-up, solar array deployment, transmitter turn-on and antenna deployment. The dewar cover is deployed by ground command approximately 4 days after separation.

Three solar arrays provide 712 watts of power to the 5,000-lb. spacecraft. During solar eclipses, batteries will be used to support the power loads and will be recharged during the sunlit portion of the orbit.

COBE MISSION PHASES

LAUNCH

Location: Space Launch Complex 2-West (SLC-2W), Western Space and Missile Center, Vandenberg Air Force Base, Calif.

Time/Date: 6:24 a.m. (PST),Thurs., Nov. 17, 1989 with a launch window of 30 minutes.

Launch vehicle: Delta expendable launch vehicle (ELV) model 5920.

EARLY ORBIT

Liftoff (LO) +57 min., 21 sec.: The COBE spacecraft will be placed into its operational orbit of 559 miles by the second stage of the Delta 5920.

LO+60 min., 28 sec.: The Delta ELV sends discrete signals to start COBE's signal conditioning unit (SCU) -- a sophisticated electronic timer -- as the Delta is reoriented to the attitude required for the spacecraft to separate from the Delta.

LO+60 min., 29 sec.: The COBE SCU turns on the telemetry transmitter.

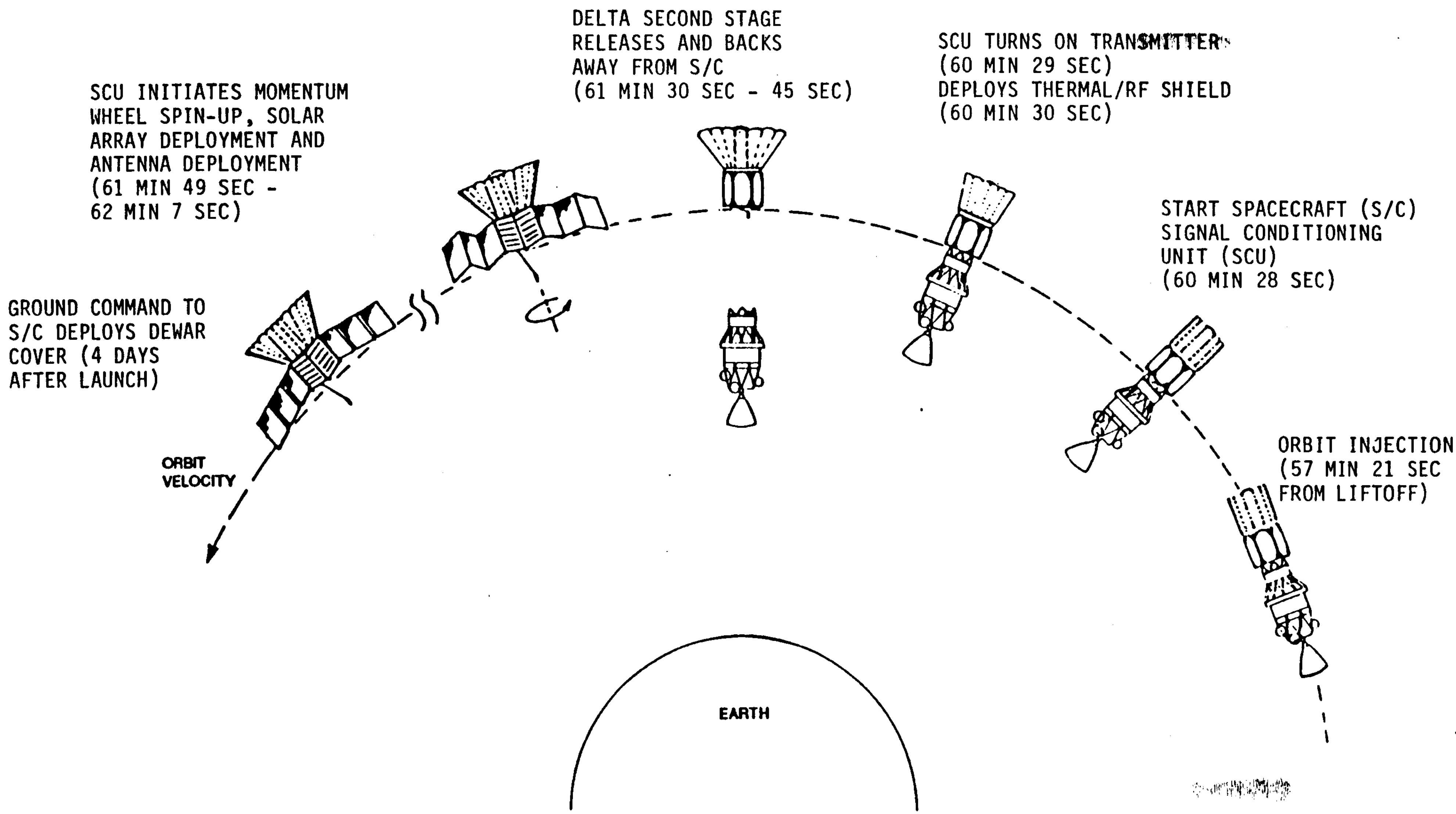
LO+60 min., 30 sec.: The SCU initiates thermal/radio frequency shield deployment.

LO+61 min., 30-45 sec.: The Delta second stage releases and backs away from the COBE.

LO+61 min., 49 sec. to 62 min., 7 sec.: The SCU initiates momentum wheel spin-up, solar array deployment and antenna deployment.

OBSERVATORY/INSTRUMENT CHECK-OUT

There will be a 14-day checkout phase, followed by an additional 16-day instrument characterization and calibration phase. During this phase, transition to normal survey operations will occur. After initial ground contact at separation, communications between COBE and the Earth will be via the Tracking and Data Relay Satellite System (TDRSS). During observatory checkout, TDRSS support on an every orbit basis will be requested, to be gradually reduced over a transition period.



COBE ORBIT INJECTION AND DEPLOYMENTS

Once the observatory and instruments have been fully checked, characterized and calibrated (approximately 30 days after launch), an S-band, single access forward and return link will be required for up to 2 hours per day. The 2-hour total time will be scheduled over a 24-hour period on an every-other-orbit basis (15 orbits per day).

The observatory engineering checkout extends from day 1 through day 3; the instrument engineering checkout goes from day 3 through day 14; and the instrument characterization and calibration phase lasts from day 15 through day 30. In addition, the day-to-day schedule will plan the following.

Day 1: RF acquisition, attitude stabilization and spacecraft subsystem initialization.

Day 2: Differential Microwave Radiometer (DMR) instrument power up and calibration, and spacecraft subsystem checkout (including attitude maneuvers).

Day 3: Far Infrared Absolute Spectrophotometer (FIRAS) and Diffuse Infrared Background Explorer (DIRBE) instrument power up.

Day 4: Attitude maneuver and dewar cover ejection (by ground command from the Payload Operations Control Center at GSFC).

Day 5: FIRAS instrument mechanism unlatching and additional instrument engineering checkout.

Day 6: Spacecraft spin-up to operational spin rate (0.815 rpm).

Day 7: Attitude pitch maneuver checkout.

Day 8: Attitude roll maneuver checkout and additional instrument checkout.

Day 9-11: Instrument checkout aided by attitude roll and pitch maneuvers.

Day 12-14: Instrument checkout and survey mode parameters adjustments.

During the characterization and calibration phase, the instruments collect science data, are calibrated and are further characterized as orbital and astronomical events occur.

By day 30 the instruments have been calibrated, characterized and adjusted to proceed with normal survey operations.

MISSION OPERATIONS

The COBE flight operations team will control the COBE spacecraft from the Payload Operations Control Center, Goddard Space Flight Center, Greenbelt, Md., 24 hours a day, 7 days a week following launch. During this time, the following data events are programmed daily:

o Real-time contact by the flight operations team through TDRSS every other COBE orbit. This contact will allow for up-link of stored commands once a day; monitoring of subsystems for health and safety; collection of tracking data and updating of the COBE clock drift. This will maintain clock accuracy within 10 milliseconds of Universal Time.

o One onboard tape recorder playback transmitted each day to Wallops Flight Facility (WFF), Va., for data relay to the COBE Science Data Room at Goddard Space Flight Center. At the 655.4 kilobits per second data dump rate, 24 hours of recorded data can be transmitted to Wallops in about 9 minutes.

There will be a minimum of three passes within range of the WFF ground station each day. These passes will be a minimum of 10 minutes long and will occur at nearly the same time each day. This regularity will be used to routinely schedule the data acquisitions.

MISSION LIFETIME

COBE is planned to operate for 24 months following launch. The nominal mission lifetime is 12 months. Minimum mission lifetimes to complete an all-sky survey are 6 months for FIRAS and DIRBE and 12 months for DMR. FIRAS and DIRBE are planned to operate until the liquid cryogen is exhausted, while the short wavelength dectors on DIRBE can operate somewhat longer, current estimate is 14 months. DMR is planned to operate for the full 24 months.

COBE SCIENCE

Cosmology, the study of the earliest beginnings and the largest structures in the universe, has been the subject of speculation for thousands of years. Early in the twentieth century a remarkable combination of technology and new physical theory led scientists to put forward the Big Bang theory of the origin and evolution of the universe.

Some 25 years ago that theory received its strongest observational support to date with the discovery of the cosmic background radiation. COBE's mission is to investigate the cosmic background radiation in sufficient detail to uncover the nature of the fundamental processes which have shaped the universe as seen today.

The first step in the evolution of modern cosmology was development of the general theory of relativity by Albert Einstein. Subsequently, in 1917, Willem de Sitter applied Einstein's equations to the universe as a whole with the startling result that the universe was not required to be static, but instead that the universe was likely in a state of expansion or collapse.

In the 1920's, Edwin Hubble provided the first observational confirmation of this picture through his pioneering work on faint nebulae. Hubble proved that many of the nebulae were galaxies, huge collections of stars similar to the Milky Way galaxy, and also showed that these distant galaxies were receding from the Earth. The nature of the recession was that the farther a galaxy lies from the Earth, the higher is its recessional velocity.

Since the universe was observed to be in a state of expansion, it was natural to deduce that the universe was smaller in the past. In fact, the evidence has led to the astounding conclusion that the galaxies were crowded together into a small, extremely dense volume, whose explosive expansion began some 15 billion years ago and has been dubbed The Big Bang.

In the 1940's, George Gamow, Ralph Alpher and Robert Herman theorized that the early universe was not only extraordinarily dense, but also was extremely hot. This led them to suggest that the nuclear reactions taking place in such a hot, dense environment accounted for the abundances of hydrogen and helium seen in the universe today, together with a small fraction of heavier elements.

Alpher and Herman showed that another consequence of the hot Big Bang theory is that the universe should be filled with the radiation emitted by the hot matter. That is, if scientists can look out in space, back in time to that distant early epoch, then they should see the glow of the initial fireball.

In 1964, Arno Penzias and Robert Wilson of the Bell Telephone Laboratories, using a new and very sensitive microwave receiver and antenna, found an unexplained source of noise or static which came to their antenna equally from all parts of the sky. Their discovery sparked a number of independent observations and theoretical analyses to characterize the background radiation which they had found. Today the evidence is overwhelming that Penzias and Wilson provided the first glimpse back to the primeval fireball which emerged from the Big Bang.

Since the initial measurements, study of the cosmic background radiation has been the subject of hundreds of experiments throughout the world, using ground-based, balloon- and rocket-borne telescopes. Because the radiation is faint and easily distorted by the Earth's atmosphere, the investigation of the relic radiation from such sites is limited confirmation of the general shape of the spectrum and its overall uniformity.

- more -

However, hidden in the details of the spectral shape and spatial distribution of the background radiation are essential clues to the nature of the fundamental processes which shaped the early universe and produced the universe as it appears today.

COBE's instruments are designed to make full use of the vantage point of space to examine the cosmic background radiation with unprecedented sensitivity across a broad range of wavelengths. COBE will scan the sky to look for spatial non-uniformities at a sensitivity level many times what has been possible to date. It will search the spectrum of the relic radiation for deviations from the simplest predicted shape, and it will carefully dissect the radiation at shorter wavelengths to look for evidence of the first stars and galaxies.

COBE's search for variations in the brightness of the cosmic background radiation across the sky is designed to probe the mystery surrounding the formation of galaxies and clusters of galaxies in the universe.

To the present level of measurement accuracy, the background radiation appears smooth, characteristic of an early universe with an extraordinary degree of uniformity in its density and temperature. Yet examination of the present day universe reveals a great deal of non-uniformity: stars are collected into galaxies, galaxies are gathered into clusters and even these gigantic clusters of galaxies may themselves be clustered into even more immense structures. Enormous voids, regions of space with almost no galaxies, exist between the clusters.

Theory indicates that the seeds of this universal structure must have been present in the early universe and the imprint of these seeds must be found as brightness variations in the relic radiation. COBE has the sensitivity to search for the smallest conceivable brightness differences which are consistent with modern theory.

COBE's investigation of the detailed spectral shape of the remnant radiation is motivated by the suggestion that enormously powerful and energetic processes may have taken place in the interval of time after the Big Bang and before the formation of galaxies. For example, if massive black holes existed and swallowed large quantities of matter, the resulting energy release would have been sufficient to distort the spectrum of the fireball radiation to a degree measureable by COBE.

Exotic processes, some of which have been suggested on the basis of modern theories of high energy particle physics, also have the potential of releasing immense quantities of radiative energy into the early universe and distorting the spectrum of the cosmic background radiation. COBE will characterize the shape of the spectrum of the relic radiation at such a level of precision as to allow detailed study of the nature of these postulated energetic events.

COBE's measurement of the diffuse background at wavelengths shorter than those characteristic of the remnant radiation from the initial fireball is intended to look for the radiation from the earliest stages of galaxy and star formation. This faint signature must be detected against the foreground radiation from the solar system, the Milky Way galaxy and other nearby galaxies.

Detection of this signature requires the observational sensitivity and stability that has been carefully engineered into the COBE system. Study of the radiation from the protogalaxies and protostars will aid scientists to probe into the nature of galaxy and star formation.

COBE SCIENCE QUESTIONS

COBE will produce a complete map of the sky at each of 100 different wavelengths to answer three primary questions:

1. What is the variation in brightness of the cosmic background radiation across the sky?

2. Does the cosmic background radiation have the spectrum predicted by contemporary cosmological theory?

3. Can we detect the accumulated light from the first stars and galaxies?

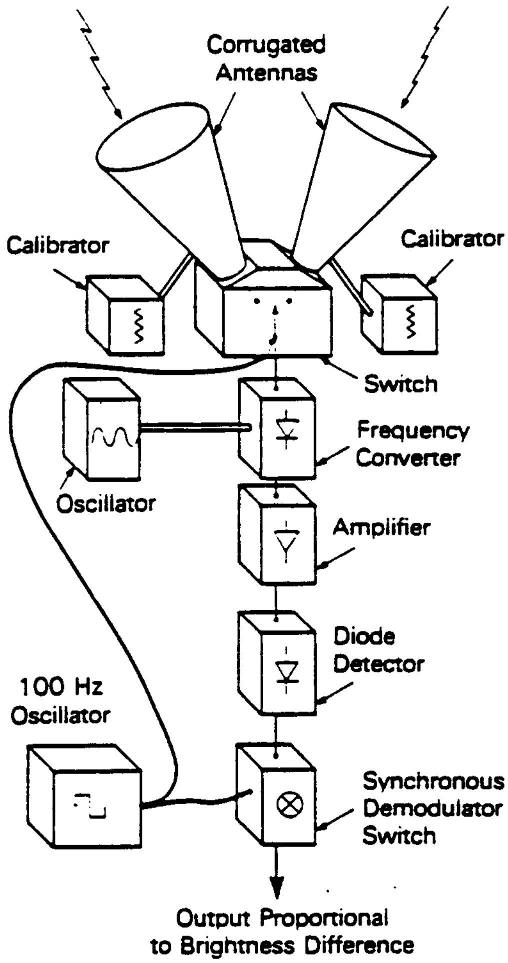
COBE INSTRUMENTS

COBE's three instruments -- the Differential Microwave Radiometer, the Far Infrared Absolute Spectrophotometer and the Diffuse Infrared Background Experiment -- will be able to observe the entire sky at least twice during the nominal mission lifetime of one year.

Differential Microwave Radiometer (DMR)

This instrument will search for minute differences in the brightness of background radiation between different parts of the sky. The DMR is capable of detecting brightness variations that are many times fainter than limits set by current observations and may reveal previously undiscovered physical phenomena.

To distinguish the radiation of our galaxy from the true cosmic background radiation, the DMR will map the sky at three wavelengths: 3.3, 5.7, and 9.6 millimeters. To accomplish this, it will have six receivers, two for each wavelength, mounted so that neither the sun nor Earth will shine directly on them. Each receiver will sensitively measure the difference in microwave power entering two antennae looking at different parts of the sky.



DMR Functional Diagram

Far Infrared Absolute Spectrophotometer (FIRAS)

This instrument will survey the sky to search for deviations in the spectrum of the cosmic background radiation from spectrum predicted on the basis of the simple Big Bang model. FIRAS, as well as the DMR, can resolve the sky into 1,000 separate picture elements and will produce a spectrum for each element. Scientists will be able to compare the spectrum produced by COBE against predicted spectra with at least 100 times better accuracy than ever before.

FIRAS looks out along the spin axis of the spacecraft. It does not scan the sky as rapidly as the other two instruments onboard COBE but will nevertheless scan the entire sky twice during the nominal mission.

FIRAS will detect radiation by using a trumpet-shaped cone antenna. Four detectors, each a tiny silicon resistance thermometer glued to a piece of blackened diamond only one thousandth of an inch thick, are used to detect the radiation collected by the cone antenna. The diamond absorbs the infinitesimal heat from the cosmic background radiation and conducts this heat to the thermometer where the temperature is measured electrically.

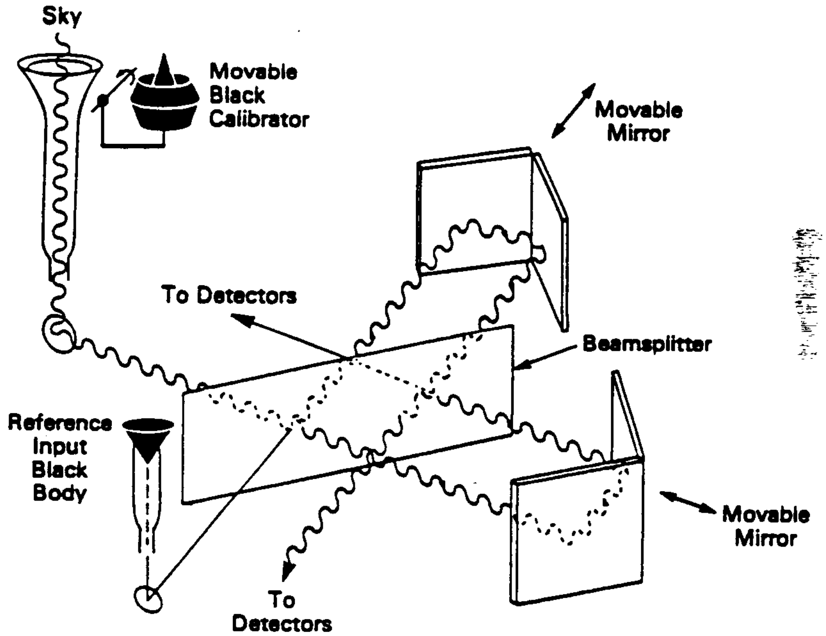
The data collected by FIRAS will be carefully analyzed to determine any deviations from the theoretically predicted spectrum. Even the slightest discrepancy between measurement and theory will have great significance for cosmology.

Diffuse Infrared Background Experiment (DIRBE)

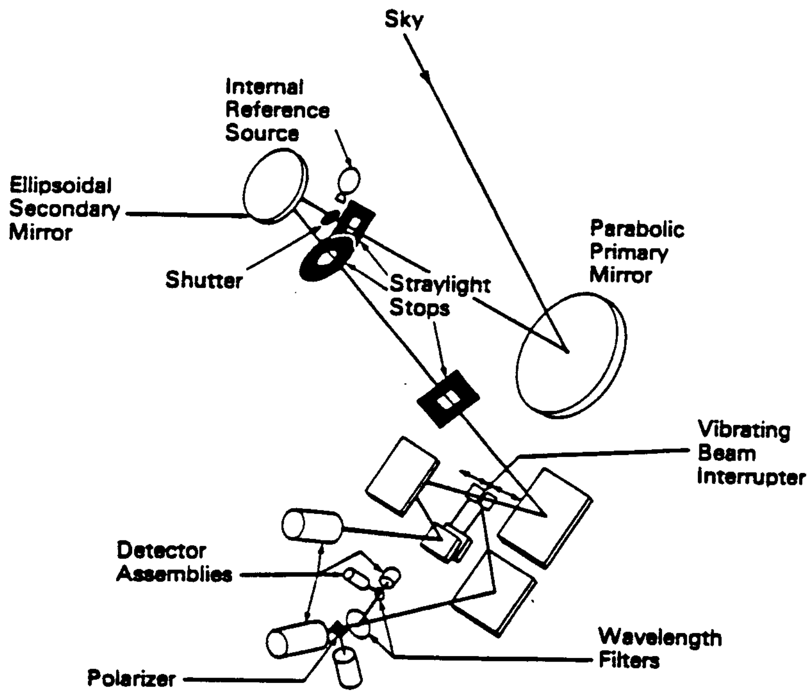
This instrument will search for the light from the earliest stars and galaxies, luminous energy that is thought to have been produced some 200 million years after the Big Bang. DIRBE operates in the infrared part of the spectrum, covering a wavelength range of 1 to 300 micrometers in 10 discrete bands.

It is an off-axis Gregorian telescope with baffles, stops, and super-polished mirrors, which will minimize response to unwanted "stray" light coming from outside its field-of-view. This design allows DIRBE to achieve the measurement accuracy necessary to distinguish between nearby objects and those at cosmological distances.

DIRBE will not focus on a single object, but will instead measure the collective glow of millions of objects. It will measure emission from warm dust in the Solar System and the Milky Way galaxy so precisely that scientists should be able to detect the uniform glow from the first stars and galaxies even if it is only 1 percent as bright as our local celestial environment.



FIRAS Functional Diagram



DIRBE Functional Diagram

Analysis of DIRBE data is complicated by the many kinds of known celestial objects as well as by the motion of the Earth within the interplanetary dust cloud. When analysis is complete, a faint and uniform residual signal may remain after all known sources have been understood and subtracted. The small residue would be the long-sought light of first, primordial objects.

DELTA/COBE LAUNCH VEHICLE PREPARATIONS

The COBE will be launched from Vandenberg Air Force Base, Calif., aboard a Delta expendable launch vehicle by a 90-member NASA/McDonnell Douglas launch team based at NASA's Kennedy Space Center, Fla.

Testing and Modifications

The first stage of the Delta arrived Feb. 9 at Cape Canaveral Air Force Station in Florida. There it underwent mission-specific modifications and electrical testing. This stage is a standard Delta 1 booster upgraded with the Castor 4A strap-on solid rocket motors used on the Delta 2 launch vehicle.

The Delta booster underwent about a month of testing and checkout of its hydraulic, propulsion and electrical systems. Following the completion of modifications and testing, the booster was shipped to Vandenberg Air Force Base, Calif. It arrived there on April 1, to await its scheduled erection on the launch pad.

The Delta second stage arrived at the Cape on Dec. 15, 1988, and underwent electrical and mechanical modifications to support the COBE mission. This included attachment of a retro package containing two propulsion nozzles to allow the stage to back away from the spacecraft following separation. This second stage modification is necessary since the COBE spacecraft does not require a third stage to achieve its final orbit. The Delta second stage was shipped to California in early May.

Before shipment to Vandenberg, the first and second stages were electrically mated for a simulated flight test, an exercise which simulates inflight events. Before shipping the flight vehicle to Vandenberg, a pathfinder vehicle was erected on the launch pad to validate equipment and procedures and also to serve as a "dry run" for pad personnel.

Vehicle Assembly

After arrival in California and temporary storage, the Delta was erected on Space Launch Complex 2-West. The first stage was raised into position on Aug. 16. The nine Castor 4A strap-on solid rockets, which augment thrust during the boost phase, were fastened to the first stage in sets of three beginning on Aug. 14. The second stage was hoisted atop the Delta first stage on Sept. 29.

Launch Pad Refurbishment

KSC personnel have been involved in extensive refurbishment activities at the West Coast launch site for more than 2 years. SLC-2 West has been inactive since the Landsat 5 launch on March 1, 1984.

COBE/Delta Launch Readiness

A Simulated Flight, a post lift-off test which exercises the onboard systems active during ascent, occurred on Oct. 11. Final testing of the vehicle for launch includes first-stage tanking with RP-1 fuel, a highly refined kerosene, and the cryogenic liquid oxygen. This occurred on Oct. 27, together with a practice countdown and launch team certification.

The COBE satellite was scheduled for mating with the Delta vehicle 2 days later to be followed by vehicle/spacecraft integrated testing.

The next significant milestone occurs 3 days before launch with the final loading of the RP-1 propellant. Two days before launch, the second stage will be loaded with storable propellants. The liquid oxygen is loaded during the terminal count beginning at the T-75 minute mark.

NASA has been launching the Delta rocket since 1960. Delta/COBE is the final official NASA launch of a NASA-owned Delta vehicle.

COBE MISSION MANAGEMENT

The Office of Space Science and Applications (OSSA), NASA Headquarters, is responsible for the overall direction and evaluation of the COBE Program. The Director of the Astrophysics Division has the Headquarter responsibility for COBE.

The Goddard Space Flight Center (GSFC) has Project Management responsibility for the design, development, testing, operation and analysis of the data. The Office of Space Operations, NASA Headquarters, has overall tracking and data acquisition responsibility. The Delta launch vehicle project management is the responsibility of GSFC as part of the NASA Expendable Launch Vehicle Program under the Office of Space Flight. The responsible personnel within these areas are:

L.A. Fisk, Associate Administrator for Space Science and Applications
A.V. Diaz, Deputy Associate Administrator for Space Science and Applications
C.J. Pellerin, Jr., Program Director
D.A. Gilman, Program Manager
L. Caroff, Program Scientist

W.B. Lenoir, Associate Administrator for Space Flight
J.B. Mahon, Deputy Associate Administrator for Space Flight
C.R. Gunn, Director, Unmanned Launch Vehicles and Upper Stages
P.T. Eaton, Chief, Small and Medium Launch Vehicles Branch
C.T. Force, Associate Administrator for Space Operations
J.W. Townsend, Jr., Center Director, GSFC
J.H. Trainor, Associate Director, GSFC
Peter Burr, Director, Flight Projects
D.L. Fahnestock, Director of Mission Operations and Data Analysis, GSFC
J.R. Busse, Director of Engineering, GSFC
R. Mattson, COBE Project Manager, GSFC
J.M. Beckham, Delta Project Manager, GSFC
J.C. Mather, Project Scientist and Principal Investigator for FIRAS, GSFC
N.W. Boggess, Deputy Project Scientist for Data, GSFC
D.K. McCarthy, Deputy COBE Project Manager, GSFC
J. Peddicord, Deputy Project Manager/Resources, GSFC
J.F. Turtil, Systems Engineer, GSFC
A.D. Fragomeni, Observatory Manager, GSFC
E.W. Young, Instruments Manager, GSFC
J.L. Wolfgang, Software Systems Manager, GSFC
R.G. Sanford, Mission Operations Manager, GSFC
Gen. F. S. McCartney, Center Director, KSC
J.T. Conway, Director, Payload Management and Operations
J.L. WomackDirector, Expendable Vehicles
S.M. Francois, Chief, Launch Operations Division
L. J. Holloway, Director, McDonnell Douglas Space Systems, Cape Canaveral Air Force Station.

SCIENCE WORKING GROUP

Dr. Charles L. Bennett, GSFC, Deputy Principal Investigator for Differential Microwave Radiometer (DMR)
Dr. Nancy W. Boggess, GSFC, Deputy Project Scientist for Data
Dr. Edward S. Cheng, GSFC
Dr. Eli Dwek, GSFC
Dr. Lawrence Caroff, Program Scientist, NASA Headquarters
Dr. Samuel Gulkis, Jet Propulsion Laboratory,
Dr. Michael G. Hauser, GSFC, Principal Investigator for Diffuse Infrared Background Experiment (DIRBE)
Dr. Michael A. Janssen, Jet Propulsion Laboratory
Dr. Thomas Kelsall, GSFC, Deputy Principal Investigaor for DIRBE
Dr. Philip M. Lubin, University of California at Santa Barbara
Dr. John C. Mather, GSFC, Project Scientist, Principal Investigator for Far Infrared Absolute Spectrophotometer
Dr. Stephan S. Meyer, Massachusetts Institute of Technology
Dr. S. Harvey Moseley, Jr., GSFC
Dr. Thomas L. Murdock, General Research Corporation
Dr. Richard A. Shafer, GSFC
Dr. Robert F. Silverberg, GSFC
Dr. George F. Smoot, University of California at Berkeley, Principal Investigator for DMR

Dr. Rainer Weiss, Massachusetts Institute of Technology, Chairman of Science Working Group
Dr. David T. Wilkinson, Princeton University
Dr. Edward L. Wright, University of California, Los Angeles, Data Team Leader

CONTRACTORS

COMPANY	SUBSYSTEM/COMPONENT
Ball Aerospace Systems Div. P.O. Box 1062, Boulder, CO	Dewar
Solarex 1335 Piccard Drive Rockville, MD 20850	Solar Arrays
McDonnell Douglas Astronautics Co. P.O. Box 516 St. Louis, MO 63166	Batteries Delta Launch Vehicle Launch Support Services
Motorola, Inc. 2501 S. Price Road Chandler, AZ 85248	Transponder
Ball Aerospace Systems Division Communications Systems Colorado Engineering Center 10 Longs Peak Drive Broomfield, CO 80020	Antenna
Gulton Industries, Inc. 6600 Gulton, NE Albuquerque, NM 87109	Command/data handling
General Electric Bldg. 10-5-3 Front and Cooper Camden, NJK 18102	Tape recorder
Engineering and Economic Research 10289 Aerospace Road Seabrook, MD 20706	Harness
Information Development and Applications, Inc. 10759 Tucker St. Beltsville, MD 20705	Instrument electronics
Digital Equipment Corp. 8301 Professional Pl. Landover, MD 20785	Instrument ground support equipment

ST System Corp. 4400 Forbes Blvd. Lanham, MD 20706	Software
Barnes Engineering Company 88 Longhill Cross Roads P.O. Box 867 Shelton, CT 06484	Earth scanner assembly
Applied Physics Laboratory Johns Hopkins Road Laurel, MD 20707	Momentum management assembly
Bendix Field Engineering Company Teterboro, NJ 07608	Reaction wheels
ADCOLE Corporation 669 Forest St. Marlkborough, MA 01752	Sun sensors
Northrop Precision Products Div. 100 Morse St., Norwood, MA 02062	Gyros
Northrop Services, Inc. 108 Powers Court, Sterling, VA	Integration and test
Swales 5050 Powder Mill Road, Beltsville, MD	Mechanical design

- end -