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For Release IMMEDIATE

Press Kit

Project Lageos

RELEASE NO: 76-67

Contents

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SATELLITE MAY AID IN UNDERSTANDING EARTHQUAKE MECHANISMS

A satellite which looks like a giant golf ball will be launched by NASA next month into a 5,900-kilometer (3,600-mile) high orbit to serve as a tool for obtaining information on Earth's crustal movements, polar motion, solid Earth tides and precise locations of various spots on Earth.

The Laser Geodynamic Satellite (Lageos) is scheduled for launch aboard a Delta rocket from the Western Test Range in California May 4 at 4 a.m. EDT.

Lageos will use and demonstrate the capability of laser satellite tracking techniques to make extremely accurate measurements of Earth's rotation and movement of the Earth's crust.

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The useful life of Lageos is estimated at up to 50 years but it will remain in orbit for more than 8 million years.

One important benefit of the pin point accuracy of such measurements could be in a better understanding of the mechanisms which cause earthquakes. NASA expects the U.S. Geological Survey, which is responsible for earthquake research and prediction, to use Lageos to make minute measurements of movements of large land masses called tectonic plates, as well as specific measurements along critical faults, such as the San Andreas fault in California.

Lageos is a solid, heavy, passive satellite with no moving parts or electronic components. Its extremely stable circular orbit will allow it to serve as a geodetic reference for ground observations to be made in support of NASA's Earth dynamics programs.

Lageos is an aluminum sphere with a brass core about 60 centimeters (24 inches) in diameter and weighs 411 kilograms (903 pounds).

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It carries an array of 426 prisms called cube-corner retroreflectors, giving it the "dimpled" appearance of a golf ball.

Retroreflectors are three-dimensional prisms that reflect light -- and, in this case, a laser beam -- back to its source, regardless of the angle at which it is received. The Lageos retroreflectors are made of high-quality fused silica, a synthetic quartz.

A laser pulse beamed from a ground tracking-receiving station to Lageos initiates a timing signal at the ground station that continues until the pulse is bounced back from the satellite and received at the station. By measuring this length of time, the distance between the station and the satellite can be calculated. This process is known as laser ranging.

Movements of the Earth's surface as small as 2 cm (8 in.) can be determined using this technique. By tracking Lageos for a period of several years, characteristics of these motions can be determined, and perhaps correlated with observed Earth dynamics phenomena.

Lageos will be launched into a circular orbit of 5,900 km (3,600 mi.) altitude with an inclination of 110 degrees to the equator. This is high enough to allow simultaneous observations between stations on different continents.

Immediately after separation of the satellite from the apogee kick stage, some tracking data will be available on the satellite's location by means of a small tracking beacon attached to the kick stage. This data will be used initially to target optical tracking instrumentation.

Smithsonian Astrophysical Observatory (SAO) cameras will use the orbital predictions from the tracking beacon data to acquire and photograph Lageos against star fields for a further refinement of orbital position. Using this SAO camera data, the laser ground stations with their narrow beams will be able to locate and reflect off the satellite.

The Lageos project is part of the Earth and Ocean Dynamics Application Program (EODAP) being conducted by the NASA Headquarters Office of Applications.

NASA's Marshall Space Flight Center, Huntsville, Ala., has management responsibility for the design, development and launch of the satellite.

NASA's Goddard Space Flight Center, Greenbelt, Md., has responsibility for the launch vehicle, provision of the solid fuel apogee kick motor and elements of the spacecraft involved in its mounting and separation from the launch vehicle and for the continued mission operations of the ground stations that track and range the satellite.

NASA's Kennedy Space Center, Fla., is responsible for the Lageos launch operations. The KSC Unmanned Launch Operations Western Launch Operations Division is located at Vandenberg Air Force Base near Lompoc, Calif., where the launching will take place.

Program cost, including the satellite and launch vehicle is about $8.5 million.

(END OF GENERAL RELEASE. BACKGROUND INFORMATION FOLLOWS.)

MISSION OBJECTIVES

Lageos is the first NASA satellite dedicated exclusively to laser ranging. It will provide the first opportunity to evaluate satellite laser ranging using a satellite that is more stable than positions on Earth.

Lageos mission objectives are to provide a reference point for laser ranging experiments such as: the monitoring of the motion of tectonic plates, the description of the time-varying behavior of the Earth's polar positions, the maintenance of geodetic reference systems and the more accurate determination of universal time.

The Lageos project represents the first step in the solid-Earth dynamics portion of the NASA Earth and Ocean Dynamics Applications Program (EODAP).

Through this program NASA intends to use space and space-derived techniques for precise monitoring of the Earth's crustal motions (tectonic plate movement, fault motions, polar wobble and rotational rate) to contribute to development of an understanding of earthquakes, their origin and the ability to forecast their occurrence.

NASA in the EODAP program also monitors ocean phenomena such as sea state, currents, surface winds and general ocean circulation on a global basis. Such observations are important to the maritime industries.

Seasat Ocean Dynamics Satellite, scheduled for launch in 1978, will provide data on wave height, wind speed, wind and wave direction, ocean temperature and ocean surface topography. Lageos and its laser ground stations will be used to determine the exact location of stations to be used in calibrating the altimeters on Seasat.

PROGRAM BACKGROUND

The idea of orbiting a compact spherical satellite for laser ranging had been discussed at least as early as the first successful satellite laser observations in 1964. However, substantial improvements in satellite tracking accuracies required some means of attenuating the effects of atmospheric drag and solar photon pressure. One way to do this would be to use a very dense spherical satellite. Even in 1964, the accuracy of laser tracking instrumentation was high enough to make this concept attractive.

A strong motivation for attaining orbit accuracies of 10 cm (4 in.) or better emerged from a seminar on solid-Earth and ocean physics convened by NASA at Williamstown, Mass., in August 1969. Geophysicists at this seminar suggested that satellite techniques be applied to the measurement of crustal motions, both on a global scale and in somewhat more detail in active fault zones. This new information would increase understanding of solid-earth dynamics and earthquake research.

COLLECTING DATA FROM LAGEOS

Lageos investigations will be carried out in two phases and will take many years to complete. The validation/applications phase will take the four years during which measuring accuracies to better than 10 cm (4 in.) will be perfected. Measurement techniques developed and validated during Phase I will be applied during the post-1980 years. As a result, and as more stations are added to the network, ultimately up to 14, accuracies will improve to better than 5 cm (2 in.).

Lageos scientists expect to measure tectonic plate motion using a global network of tracking stations. The goal is to detect shifts in the massive plates underlying the Earth's surface to within one centimeter (.4 in.) per year averaged over four years. This could be important in understanding and possibly forecasting earthquakes, changes in polar motion, Earth and ocean tides, Earth rotation and vertical motions between sites.

There will be both stationary and mobile laser ranging stations. Two stations on each tectonic plate will be required to provide data on plate motions. Three or more stations will monitor each fault. Nine stations, seven mobile, are planned by 1978.

The mobile stations will spend an average of four months at a site. One or two months will be required for transportation to the next site. Sites will be reoccupied on two-year cycles. Thirteen laser tracking locations for the mobile stations are required and are designed so that the mobile system can be relocated to within one-tenth of a centimeter (.04 in.) of the position previously occupied.

These measurements from the different locations will provide the base from which plate motions can be determined by analyzing variations in locations of the different sites with respect to each other.

The project will be conducted in collaboration with other government agencies, the Smithsonian Astrophysical Observatory network of four laser stations and with sites and laser stations in foreign countries.

All data will be sent to Goddard Center for archival purposes and for dissemination to investigators. SAO also will disseminate data returned from its network and forward it to Goddard for archival purposes.

Fault Measurements

Observations of changes in plate movement across selected faults, such as the San Andreas Fault in California, will be given priority and are expected to be important in understanding the occurrence of earthquakes in this area of the United States. Fault measurements to within a few centimeters are planned for the next six to eight years.

Goddard Center has been conducting a laser measuring project called the San Andreas Fault Experiment (SAFE) for the past four years, in cooperation with universities and other government agencies. The project is designed to detect shifts occurring along the boundary of the North American and Pacific plates to aid in developing a tectonic model of the western United States.

LAGEOS DESCRIPTION

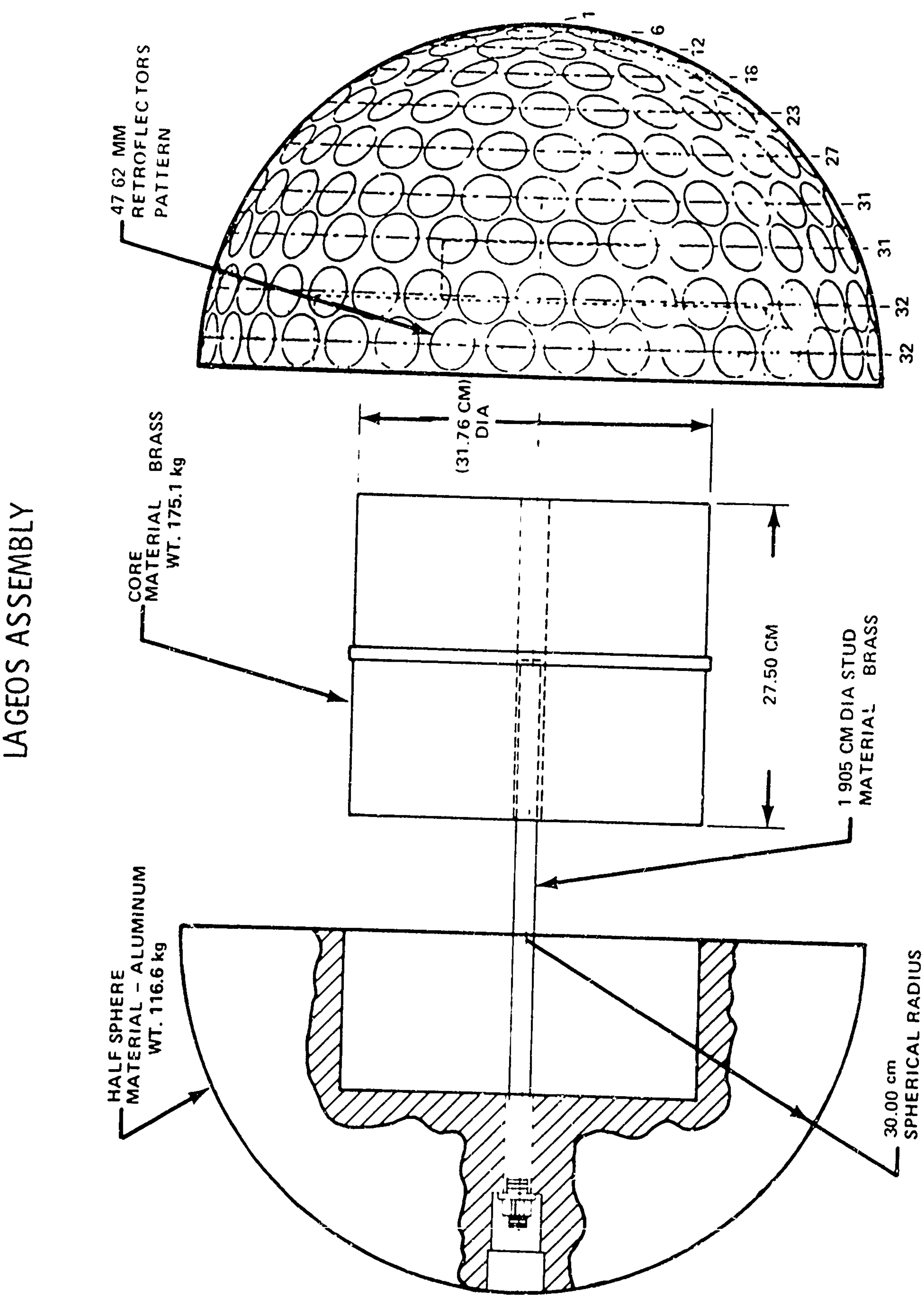
Mass	411 kg (903 lb.)
Diameter	60 cm (24 in.)
Number of retroreflectors	426
Diameter	3.8 cm (1.5 in.)
Material:	
Hemispheres	Aluminum
Core	Brass
Attached fitting and nuts	Stainless steel
Retroreflectors	Fused silica
Retroreflector mounts	KEL-F (plastic)

The aluminum sphere, retroflector mounting hardware and handling fixture for the satellite were designed, developed and manufactured by Marshall Space Flight Center.

The design of Lageos evolved from several trade-offs which proved necessary for achievement of program objectives. For example, the satellite had to be as heavy as possible in order to offset the effects of drag and of variations in Earth's gravity, yet light enough to be placed in a high orbit by the Delta launch vehicle.

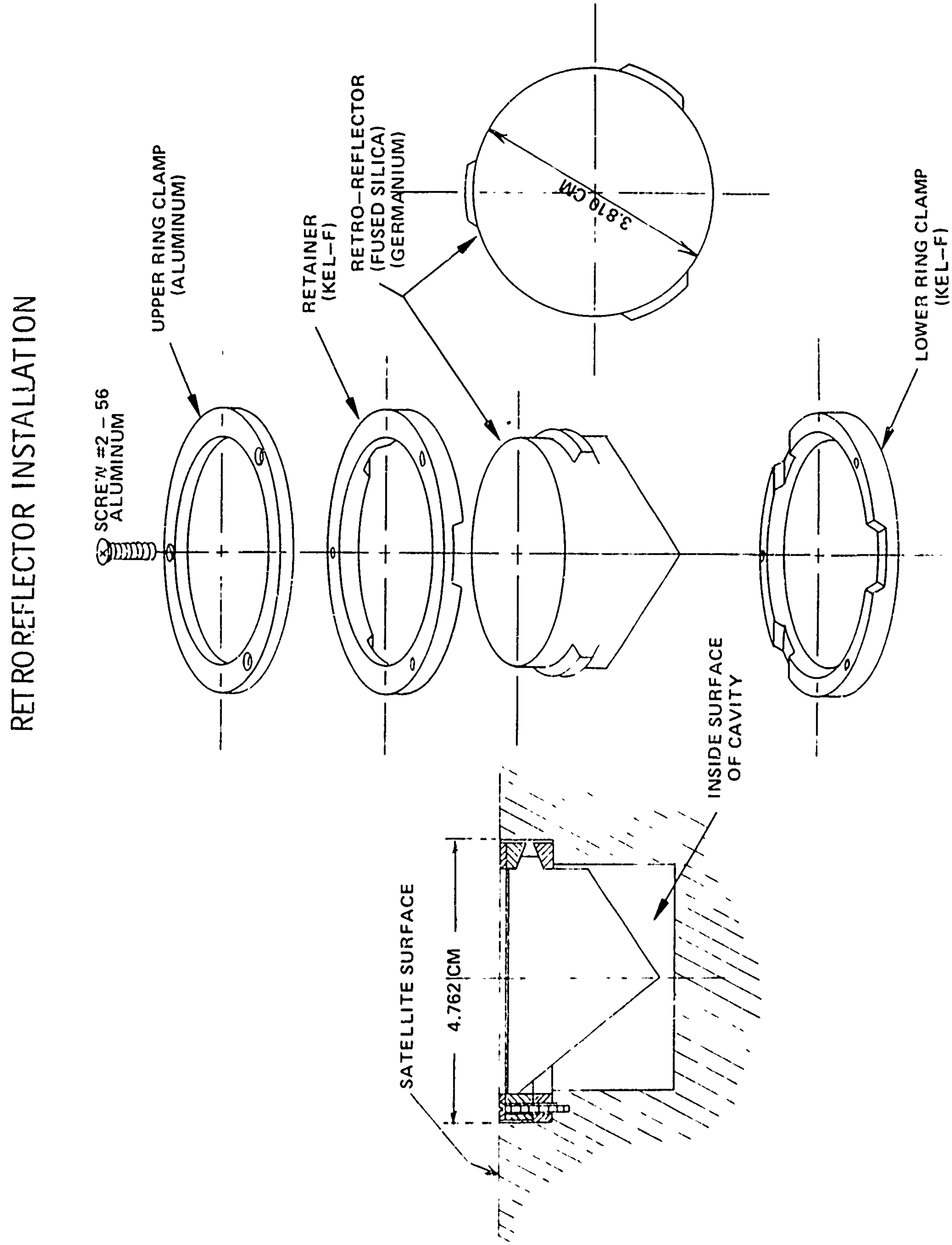
The satellite had to be big enough to accommodate a large number of retroreflectors, but small enough not to be affected by solar radiation drag. Aluminum would have been too light for the entire body of the sphere, while brass would have weighed too much. Design engineers finally decided on combining two aluminum hemispheres bolted together around a brass core to provide a large mass/surface ratio. Materials were selected to reduce magnetic effects between the satellite and the Earth's magnetic field.

Initial plans were to build both a full-scale prototype ground test satellite and a flight satellite. When the planned ground test model completed basic testing without adverse effects, a decision was made to use it as the flight unit and eliminate duplication.


LAGEOS ASSEMBLY
47.62 MM
RETROFLECTORS
PATTERN
1
6
12
16
23
27
31
31
32
32
32
(31.76 CM)
DIA
CORE
MATERIAL BRASS
WT. 175.1 kg
27.50 CM
1.905 CM DIA STUD
MATERIAL BRASS
TOTAL WEIGHT 410.9 Kg
HALF SPHERE
MATERIAL – ALUMINUM
WT. 116.6 kg
30.00 cm
SPHERICAL RADIUS

-more-

RETROREFLECTOR INSTALLATION



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The Lageos orbit was selected to reduce gravitational distortions and the satellite itself has been optimized to maintain a precise stable orbit that will last for millions of years. Because there are no active parts, Lageos will give geophysicists a stable reference system from which to accurately measure relative crustal motions of the Earth for many decades.

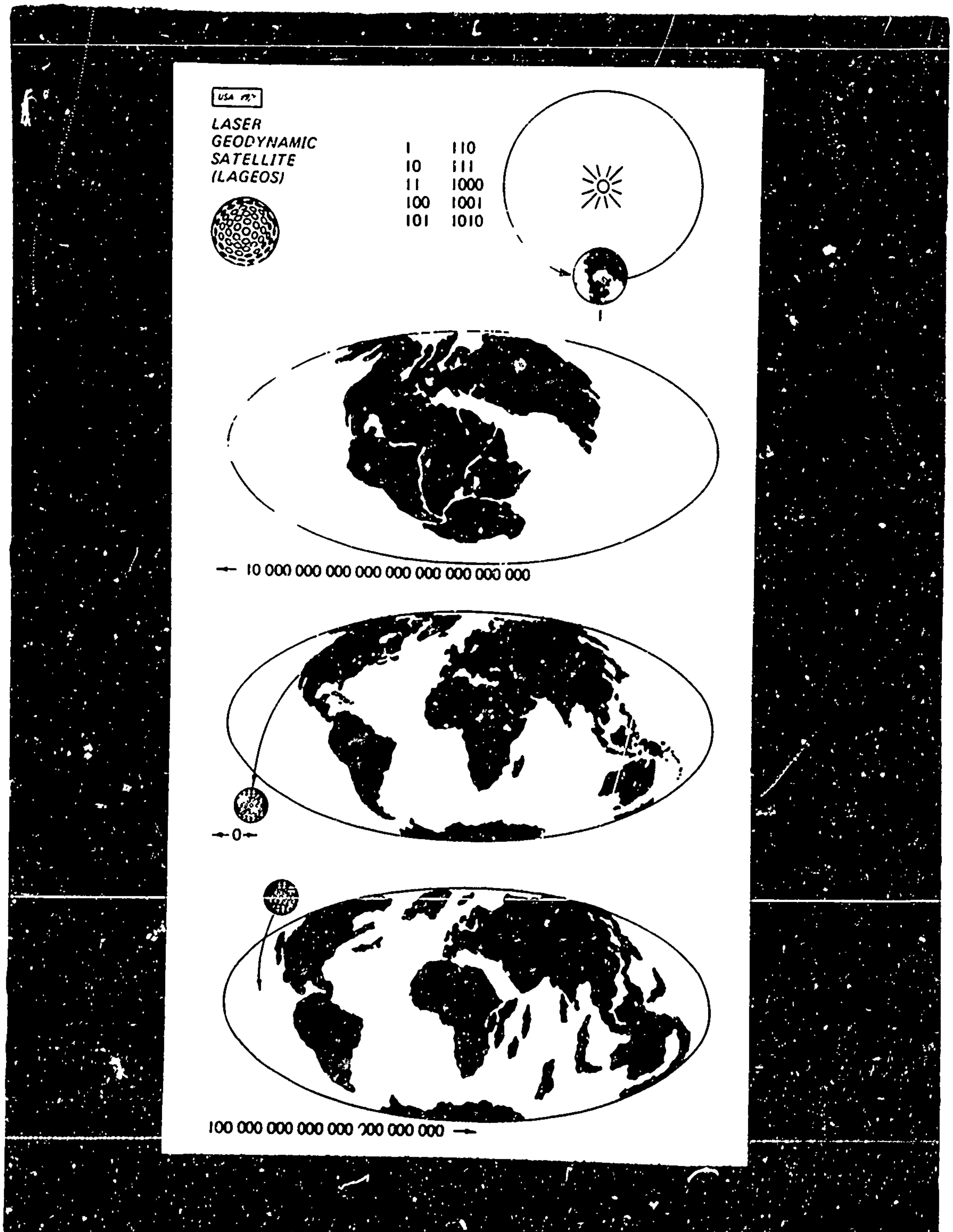
MESSAGE TO THE FUTURE

A message has been sealed inside Lageos in the event it should be retrieved from orbit or discovered after its return to Earth some 10 million years from now.

The message was prepared by Dr. Carl Sagan of the Laboratory for Planetary Studies at Cornell University, Ithaca, N.Y. Two copies of the message, which is etched on stainless steel sheets measuring 10 by 18 cm (4 by 7 in.), are installed in the satellite -- one at each end of the bolt connecting the two hemispheres which make up Lageos.

In its upper center the message displays the simplest counting scheme, binary arithmetic, which uses only zeros and ones. The numbers one through 10 in binary notation are shown. At upper right is a schematic drawing of the Earth in orbit around the Sun, an arrow indicating the direction of motion. The arrowhead points to the right, the convention adopted for indicating the future. All arrows accompanying numbers are such "arrows of time." Under the Earth's orbit is the binary number one, denoting the period of time used on the plaque -- one revolution of the Earth about the Sun, or one year.

The remainder of the Lageos plaque consists of three maps of the Earth's surface, all in a common projection which permits the entire surface of our planet to be viewed at once. Beneath the first map is an arrowhead pointing left, denoting the past, and connected to a large binary number. In decimal notation this number is equivalent to about 268 million years ago. The map shows the approximate configuration of the continents in the Permian period, about 225 million years ago. The binary number could have been made more accurate, but was "rounded off" to avoid giving the impression of spurious accuracy. Since detailed knowledge of continental drift is still very limited, all the continents are shown together in one mass, sometimes called "Pangaea."


USA
LASER
GEODYNAMIC
SATELLITE
(LAGEOS)
1 110
10 111
11 1000
100 1001
101 1010
← 10 000 000 000 000 000 000 000 000 000
←0←
100 000 000 000 000 000 000 000 →

The close fit of South America into West Africa was one of the first hints that continental drift actually occurs. Australia is shown as lying originally between Antarctica and West Africa; in other reconstructions, it is thought to have been in contact with Western Antarctica. These maps are not intended to be a precise representation of continental drift, but rather a means of portraying dramatically the existence and extent of continental drift.

The middle map displays the present configuration of the continents. Below it is a symbol indicating zero years, and arrows denoting simultaneously the past and the future; that is, the present. This map represents the zero point in time for the other two maps. Lageos is shown being launched into space from the Western Test Range at Vandenberg Air Force Base in California.

The final map is coded by an arrow pointing to the right and a binary number, again rounded off, denoting an epoch 8.4 million years from now -- very roughly, the estimated lifetime of the Lageos spacecraft. The satellite is shown returning to the Earth. Many important changes in the Earth's surface are shown, including the drift of Vandenberg Air Force Base and the rest of Southern California out into the Pacific Ocean. This separation, along the San Andreas Fault, is an expected consequence of the crustal motions which Lageos is designed to investigate. Many of the other changes in the map of the Earth shown are little more than guesses. Our knowledge of them should be significantly improved by Lageos.

Whoever comes upon the Lageos plaque need only compare a current map of the Earth's geography with that in the lower two maps to calculate roughly the time between his own epoch and ours. Drift rates of about an inch per year can, in fact, be estimated by comparing the bottom two maps. Thus, the prime objective of Lageos and the method of telling time of the spacecraft's plaque are identical.

Lageos will return to Earth at a time in the future more distant than the time in the past of the origin of the human species. The Earth will surely have changed profoundly by that future time and not only with respect to the disposition of its continents. Whoever is inhabiting Earth in that distant epoch may appreciate a little greeting card from the remote past.

LAUNCH SEQUENCE

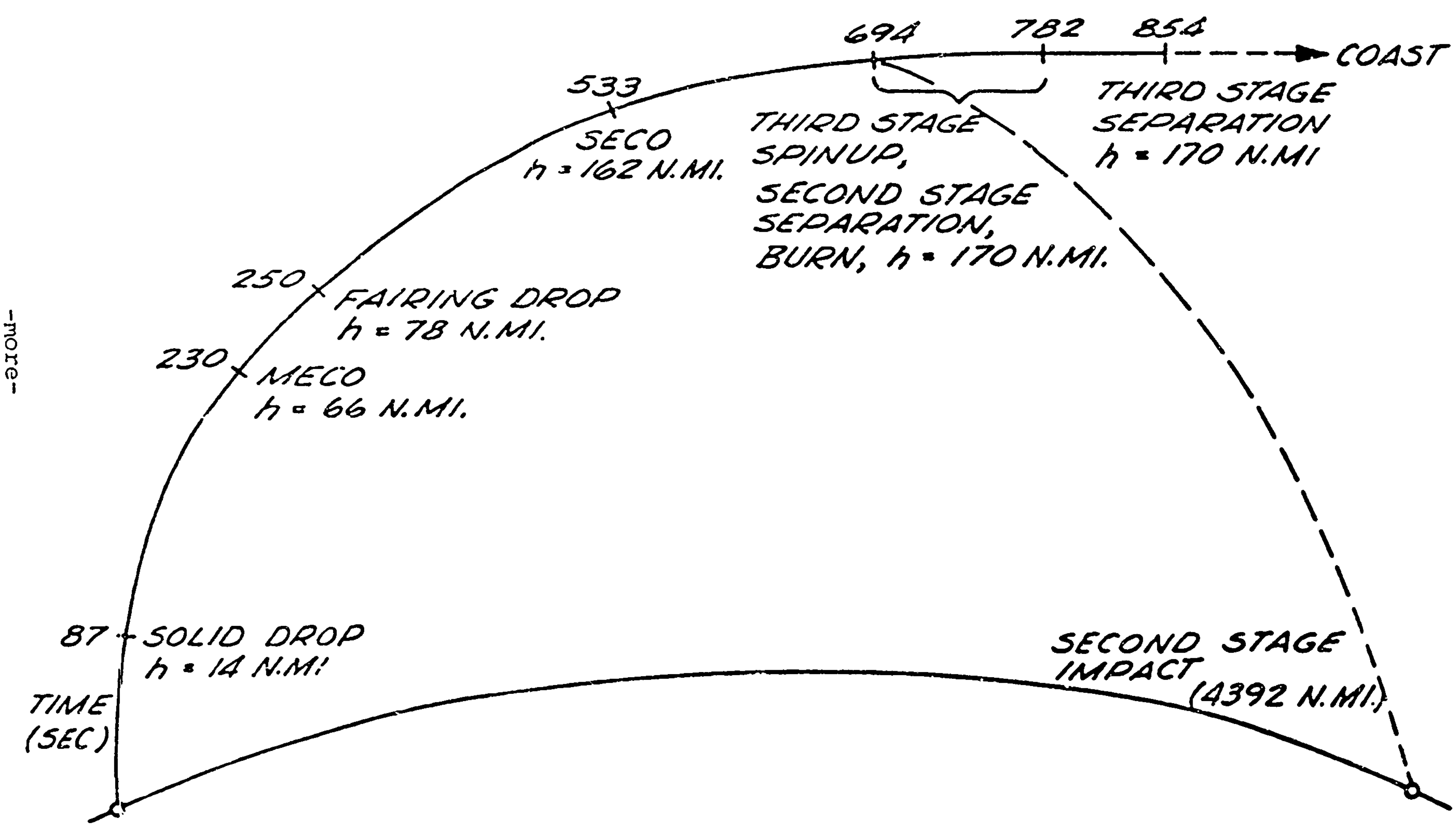
The Lageos spacecraft will be launched from the Western Test Range (WTR) at Vandenberg Air Force Base, Lompoc, Calif., by a Delta 2913 three-stage, thrust-augmented launch vehicle into a near circular orbit having an altitude of 5,900 km (3,600 mi.) and inclination of 110 degrees. The launch window opens at 4 a.m. EDT and is four hours in duration. The typical flight events that occur from launch to orbit are:

Event	Time (Seconds)
Liftoff	0
Six solid motors burnout	38.6
Three solid motors ignite	39.0
Three solid motors burnout	77.8
Jettison solid motors casings	87.0
First stage booster engine cutoff (MECO)	229.9
Jettison booster	237.9
Second stage engine ignition	243.3
Jettison fairing	325.0
Second stage engine cutoff (SECO-1)	529.1
Begin spin-up maneuver	690.1
Payload/apogee kick motor separation	850.1
Spacecraft separation	5,457.4

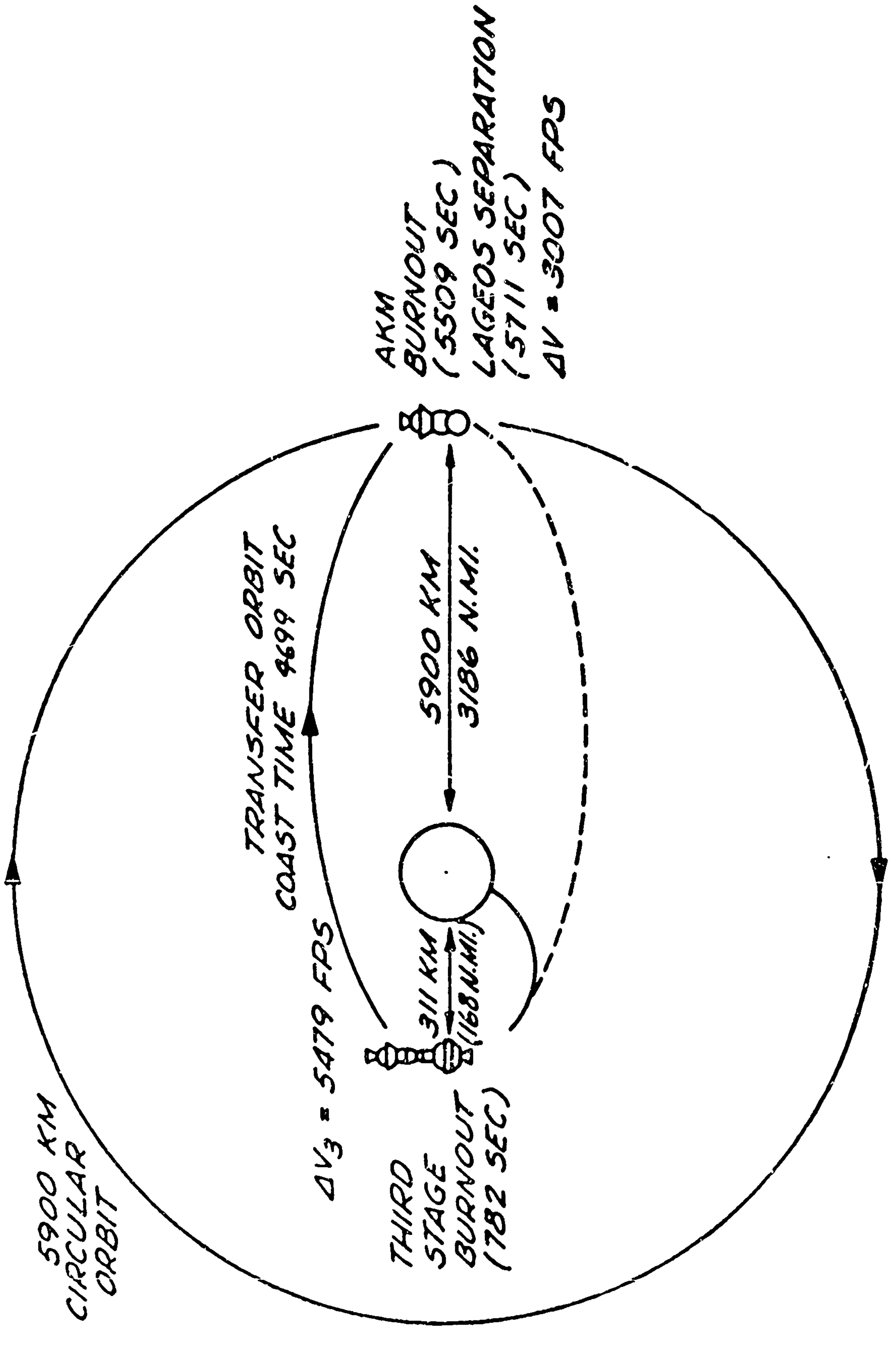
Sequence of Events

The boost portion of flight from liftoff to second stage engine cutoff places the third stage apogee kick motor and satellite into an orbit with an apogee of 169 km (115 mi.). The second stage burns out before the apogee point to allow an adequate coast time for an attitude maneuver, a guidance attitude pointing, third stage spin-up and second stage separation. At apogee, the third stage is ignited placing the apogee kick motor/spacecraft into a new orbit with an apogee of 5,900 km (3,600 mi.). The apogee kick motor/spacecraft coasts to apogee where it is ignited placing the Lageos spacecraft into the final required circular orbit.

LAGEOS
FLIGHT PROFILE - 2913 VEHICLE



LAGEOS ORBIT PROFILE



DELTA LAUNCH VEHICLE DESCRIPTION

The launch vehicle for the Lageos spacecraft is a three-stage Delta 2913. The first stage is an extended long-tank Thor booster augmented by nine Thiokol Castor-II strap-on solid fuel rocket motors. The booster is powered by a Rocketdyne RS-27 engine that uses liquid oxygen and liquid hydrocarbon propellants. Two liquid propellant vernier engines provide roll control throughout first stage operation. The second stage is powered by a TRW TR-201 liquid fuel, pressure-fed engine that uses nitrogen tetroxide and Aerozene 50 propellants. A nitrogen gas system using eight fixed nozzles provides roll control during the powered and the coast flight. Two fixed nozzles fed by the propellant tank helium pressurization system provide retrothrust after third stage separation. The third stage uses a spin-stabilized Thiokol TE-364-4 solid propellant motor secured on a spin table mounted to the second stage. The firing of two to eight solid propellant rockets fixed to the spin table accomplishes spin-up of the third stage assembly.

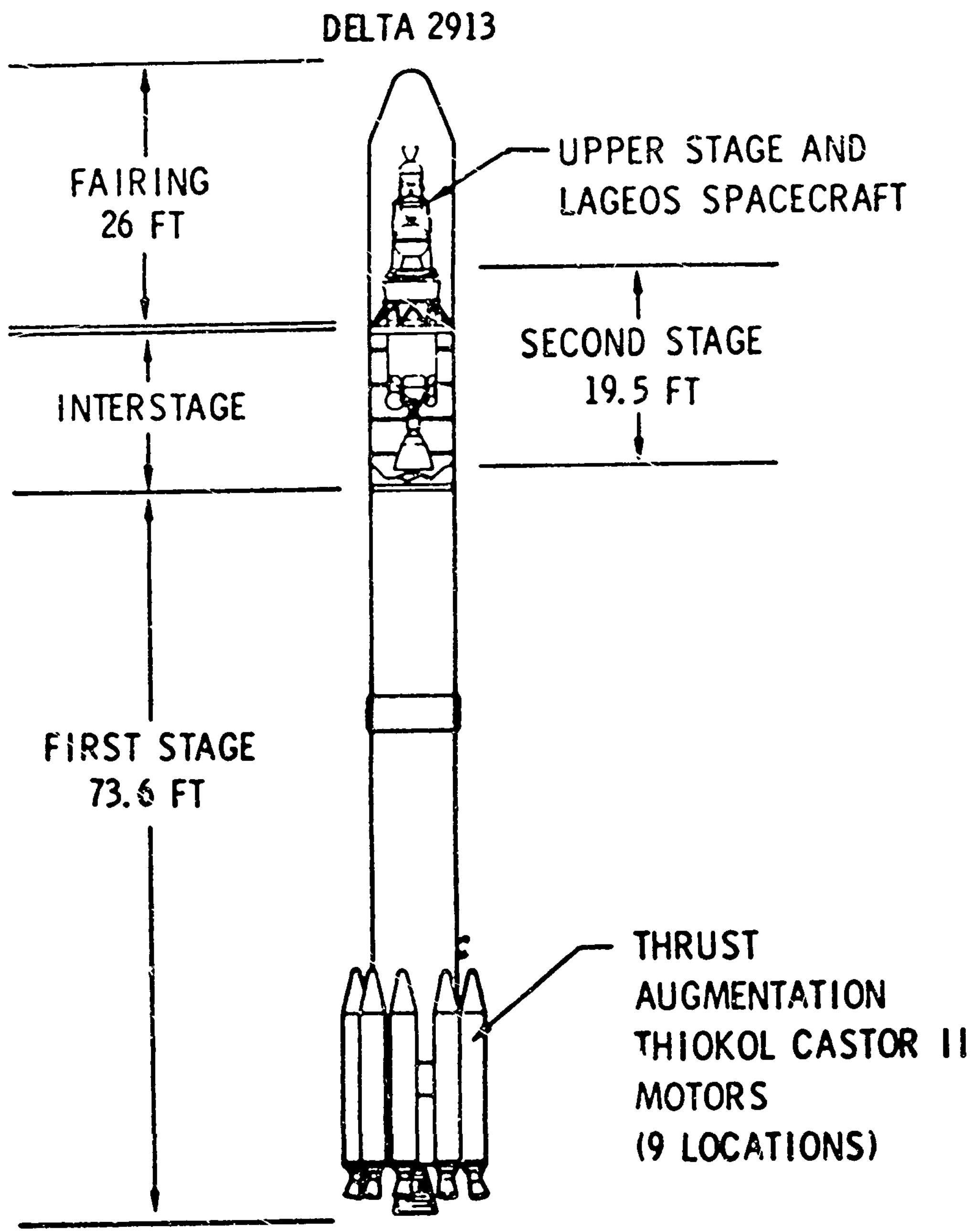
Characteristics of the Delta 2913 Launch Vehicle

Item	First Stage*	Second Stage	Third Stage
Propulsion	RS-27	TR-201	TE-364-4
Thrust	90,720 kg (199,584 lb.)	4,264 kg (9,380 lb.)	7,804 kg (17,168 lb.)
Fuel Type	LOX & RP-1	N_2O_4 and Aerozene 50	Solid Propellant
Fuel Weight	80,741 kg (177,630 lb.)	4,672 kg (10,278 lb.)	1,039 kg (2,285 lb.)
Gross Weight	85,277 kg (187,609 lb.)	5,443 kg (11,974 lb.)	1,116 kg (2,465 lb.)
Guidance	Delta inertial guidance system	Delta inertial guidance system	None (spin stabilized)
Tracking Aids	None**	C-band transponder	Spacecraft, when attached

*Augmented by nine Thiokol TX-354-5 Castor II solid-fuel rocket motors, each with a thrust of 23,587 kg (51,871 lb.) fuel weight of 3,629 kg (7,983 lb.) and gross weight of 4,536 kg (9,979 lb.).

**Uses second stage tracking aid.

LAGEOS
2913 LAUNCH VEHICLE



The spacecraft, including an apogee kick motor (AKM), is attached to the Delta third stage. The fairing, used to protect the spacecraft from aerodynamic heating during the boost flight, will be jettisoned as soon as the vehicle leaves the atmosphere.

An inertial guidance system consisting of an inertial sensor package and a digital guidance computer will control the vehicle and the sequence of operations from liftoff to spacecraft separation. The sensor package provides vehicle attitude and acceleration information to the guidance computer. This computer generates steering commands to the first and second stages, when each stage is firing, to correct trajectory deviation by comparing computed position and velocity against prestored values.

LAUNCH OPERATIONS

NASA launch operations from its West Coast facility are conducted by the Kennedy Space Center's Expendable Vehicles Directorate, Western Launch Operations Division (WLOD). This facility is located at Vandenberg Air Force Base near Lompoc, Calif., approximately 125 miles northwest of Los Angeles and 280 miles south of San Francisco. Launch facilities are located on a promontory which juts into the Pacific Ocean near Point Arguello. This makes it possible to launch to the south and place payloads in polar and near-polar orbits without over-flying populated areas.

Lageos will be launched by Delta 123 from Space Launch Complex 2 West (SLC 2 W), which has been extensively uprated over the years to accept the various Delta configurations, including the powerful new version now in use. The Lageos mission will be the first Delta launch this year from this complex.

Preparations for the launch of Lageos began Feb. 2 with the arrival of the Delta 123 four stages and the spacecraft for preliminary checkout and erection. The booster was erected March 3 and the second stage March 18. The third and fourth stage (apogee kick motor) with previously mated spacecraft assembly which had been in protective covers and stored in the SLC 2 W shelter, was mated to the second stage on April 1.

KSC personnel are permanently assigned at WLOD and supplemented by a management and technical group from KSC in Florida during final preparations and the launch countdown.

LAGEOS/DELTA PROGRAM/PROJECT MANAGEMENT

NASA Headquarters

Leonard Jaffe	Acting Associate Administrator for Applications
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Robert L. Spencer	Lageos Program Manager
John F. Yardley	Associate Administrator for Space Flight
Joseph B. Mahon	Director, Expendable Launch Vehicles
Peter Eaton	Manager, Delta Launch Vehicle
Gerald M. Truszynski	Associate Administrator for Tracking and Data Acquisition

Marshall Space Flight Center

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Lowell K. Zoller	Manager, Special Projects Office
Charles W. Johnson	Manager, Lageos Project
Lewis L. McNair	Chief Engineer, Lageos Project

Goddard Space Flight Center

Dr. John F. Clark	Director
Robert N. Lindley	Director of Projects
Chris C. Stephanides	Lageos Project Manager, Orbital Phase

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Thomas E. McGunigal	Laser Tracking Systems Research Development
Wiley W. White	Laser Network Manager
Robert Baumann	Associate Director of Projects for Delta
William Russell	Deputy Project Manager for Delta/Technical
Robert Goss	Chief, Mission Integration and Analysis
George D. Baker	Chief, Mission Integration

Kennedy Space Center

Lee R. Scherer	Director
George F. Page	Director, Expendable Vehicles
Henry R. Van Goey	Manager, KSC Western Launch Operations Division
Wilmer "Bud" Thacker	Chief, Delta Operations, Launch Vehicle Engineering Branch, WLOD
Carl Latham	Lageos Spacecraft Coordinator, WLOD

Contractors

Bendix Corp. Ann Arbor, Mich.	Satellite Assembly Operation
Perkin-Elmer Corp. Norwalk, Conn.	Laser retroreflectors
McDonnell Douglas Corp. Huntington Beach, Calif.	Launch Vehicle
Smithsonian Astrophysical Observatory Cambridge, Mass.	Technical and Scientific Support
Bendix Corp. Ann Arbor, Mich.	Technical and Scientific Support

April 15, 1976