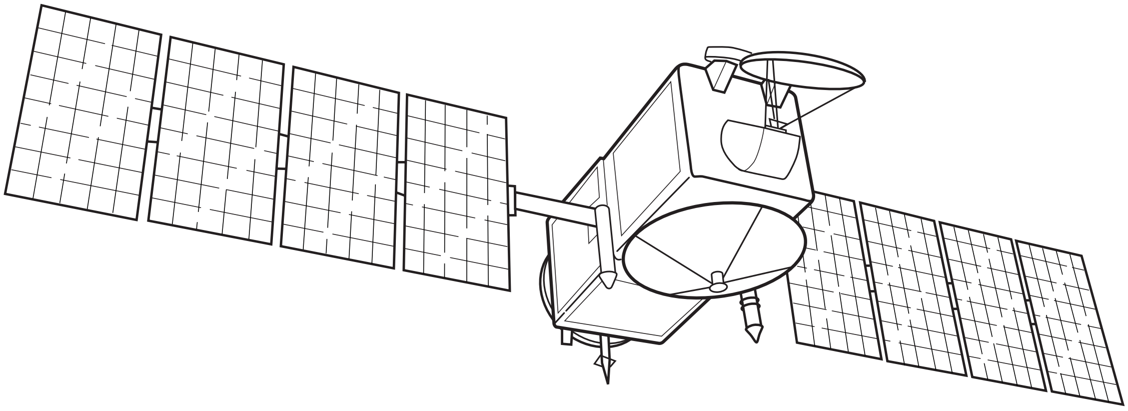
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Jason 1 Launch

Press Kit
December 2001



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RELEASE:

NASA/FRENCH OCEAN-OBSERVING SATELLITE SET TO SOAR

The December 7, 2001, launch of Jason 1, NASA's newest oceanography satellite, will continue the mission started by Topex/Poseidon to monitor global climate interactions between the sea and the atmosphere.

Jason 1 will monitor world ocean circulation, study interactions of the oceans and atmosphere, improve climate predictions and observe events like El Nino. Jason 1 is a joint U.S./French oceanography mission.

"Jason 1 will be a tremendous asset to our oceanography program. It will build upon the research and development efforts done so successfully on Topex/Poseidon, adding operational utility and function," said Dr. Ghassem Asrar, associate administrator for NASA's Earth Science Enterprise, NASA Headquarters, Washington, D.C.

Since the oceans are so large, remote sensing from satellites has proved to be the only way to get global information about these vast, hard-to-measure expanses. Spaceborne altimeters, such as the Poseidon 2 instrument that Jason 1 carries, can calculate ocean heights to within centimeters.

Gary Kunstmann, Jason 1 project manager at NASA's Jet Propulsion Laboratory, Pasadena, Calif., said, "We're very excited about this launch and looking forward to greater knowledge of the whys and hows of the world's climate systems."

Jason 1 is the follow-on to the very successful Topex/Poseidon satellite, a U.S.-French mission that has been making precise measurements of ocean surface topography since 1992.

The ocean and atmosphere transport heat from the equatorial regions toward the icy poles and the atmosphere sends heat through a complex, worldwide pattern of winds. As these winds blow across the oceans, they help drive the currents and exchange heat, moisture and gases with the water. While winds create daily, short-term weather changes, the oceans have a slower, much longer-lasting effect on climate. The powerful forces of wind and water combine to help regulate our planet's climate.

Accurate observations of sea-surface height and ocean winds provide scientists with information about the speed and direction of ocean currents and about the heat stored in the ocean which, in turn, reveals global climate variations. Jason 1 will help scientists in their quest to understand these global climate forces.

Jason 1 will be launched from Vandenberg Air Force Base, Calif., atop a Delta II rocket and will share part of the ride with the Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics, or "Timed," satellite, a joint atmospheric mission of NASA and Johns Hopkins University's Applied Physics Laboratory, Laurel, Md. The new satellite will be carried at the top of the rocket's nose cone and will separate first. Jason 1 should achieve orbit a little more than 55 minutes after launch.

Weighing about 500 kilograms (about 1,100 pounds), Jason 1 is only one-fifth the weight of Topex/Poseidon. After launch, Jason 1 will enter orbit about 10 to15 kilometers (6 to 9 miles) below Topex/Poseidon's 1,337-kilometer-altitude (830-mile) orbit. During the next few weeks, Jason 1 will use its thrusters to raise itself into the same orbital altitude as Topex/Poseidon, and then move in close behind its predecessor, trailing by about 500 kilometers (300 miles).

The two spacecraft will fly in formation, making nearly simultaneous measurements. The science team will compare the data to make sure the instruments are calibrated exactly. This procedure is expected to take about six months. Jason 1 will then assume Topex/Poseidon's former flight path, and the older satellite will move into a parallel ground track midway between two Jason 1 ground tracks. Jason 1's mission is designed to last three years.

Jason 1 carries five instruments: the Poseidon 2 altimeter, the spacecraft's main instrument, to measure altitude; a microwave radiometer to measure atmospheric water vapor; and three precision location-finding instruments.

Jason 1 is a joint project between NASA and France's Centre National d'Etudes Spatiales. The U.S. portion of the mission is managed for NASA's Office of Earth Science, Washington, D.C., by the Jet Propulsion Laboratory, Pasadena, Calif.

More information about the Jason 1 program is available at http://sealevel.jpl.nasa.gov and on the JPL home page at http://jpl.nasa.gov .

- End of General Release -

Media Services Information

NASA Television Transmission

NASA Television is broadcast on the satellite GE-2, transponder 9C, C band, 85 degrees west longitude, frequency 3880.0 MHz, vertical polarization, audio monaural at 6.8 MHz. The tentative schedule for television transmissions for Jason 1/Timed activities is described below; updates will be available from the Jet Propulsion Laboratory, Pasadena, Calif.; Johnson Space Center, Houston, Texas; Kennedy Space Center, Fla.; and NASA Headquarters, Washington, D.C.

Briefings and Television Feed

Mission and science overview news conferences on Jason 1 and Timed will be presented in a news briefing broadcast on NASA Television originating from NASA Headquarters at 1 p.m. EST on Nov. 19, 2001. A pre-launch news briefing will be broadcast on NASA television originating from Vandenberg Air Force Base, Calif., at 11 a.m. PST on Dec. 6.

Status Reports

Status reports on Jason 1 mission activities will be issued by JPL's Media Relations Office. They may be accessed online as noted below.

Launch Media Credentialing

News media representatives who wish to cover the Jason 1/Timed launch in person must be accredited through the NASA Kennedy Space Center's Media Services Office. For information on launch accreditation, contact George Diller at KSC at 321/867-2468. Requests by foreign media to cover the launch in person must also be submitted to the U.S. Air Force's 30th Space Wing Public Affairs Office no later than two weeks before launch.

Internet Information

Information on the Jason 1 mission, including an electronic copy of this press kit, press releases, fact sheets, status reports and images, is available from the Jet Propulsion Laboratory's World Wide Web home page at **http://www.jpl.nasa.gov**. The Jason 1 project operates a home page at **http://sealevel.jpl.nasa.gov** .

Quick Facts

Spacecraft

Size: Satellite support module 954 by 954 by 1000 millimeters (37.5 by 37.5 by 39 inches); payload module 954 by 954 by 1218 millimeters (37.5 by 37.5 by 48 inches)
Mass: 500 kilograms (1,102 pounds)
Solar array: Two wings with two panels each; size 1.5 by 0.8 meter (5 by 2.6 feet) per wing
Power: 1,050 watts at launch, 900 watts at end of mission
Batteries: Nickel cadmium, 24 cells, 40 amp-hours
Propulsion: Four 1-newton thrusters, with a total of 28 kilograms (63.9 pounds) of hydrazine propellant
Instruments: Altimeter, radiometer, satellite tracking system, Global Positioning System receiver, laser retroreflector array

Launch Vehicle

Type: Delta II, Model 7920-10

Mission

Launch: Dec. 7, 2001, from Vandenberg Air Force Base, Calif.
Primary mission: Three years
Orbit: Near circular, 1,336-kilometer (830-mile) altitude at equator; completes one orbit every 112.43 minutes
Orbital inclination: 66 degrees (non-Sun-synchronous orbit)

Program

Cost: $175 million from NASA, which includes $81 million in development costs. France provides the spacecraft. Operational costs are split between NASA and France

Why Study Ocean Surface Topography?

Precise measurements of sea-surface height from space make it possible to map ocean surface topography. They provide a tool for tracking ocean currents, improving our knowledge of global circulation and our understanding of climate change.

A topographic map of Earth's land masses shows where and how high the mountains are, and where and how deep its valleys. It reveals where the land has been smoothed over by glaciers and where volcanoes and earthquakes have carved their signatures on the landscape.

A topographic map of the surface of Earth's oceans is equally revealing, yet in a completely different way. The ocean's surface has hills and valleys, too. Shaped by currents, winds and Earth's gravity, the surface of the ocean tells a larger story about its most basic functions -- how it stores vast amounts of energy from the Sun, how it moves that energy around the globe and how it works together with the atmosphere to create climate and weather.

The Climate Machine: Figuring Out How It Works

Covering more than 70 percent of the planet's surface, the oceans are Earth's most dominant feature. They are also Earth's major storehouse for heat from the Sun. The ocean stores more heat in its top three meters (10 feet) than the entire atmosphere.

The ocean is the single most significant influence on Earth's weather and climate. This great reservoir is constantly exchanging heat and moisture with the atmosphere, driving our weather and controlling the slow, subtle changes in our future climate. Understanding how this heat moves within the oceans and into the atmosphere is critical to understanding global climate.

Working together in a complex interplay of wind and current, the ocean and the atmosphere transport heat from Earth's equatorial regions toward the icy poles. The atmosphere moves heat through a complex, worldwide pattern of winds: As winds blow across the sea surface, they drive the ocean currents. The currents, which travel more slowly than the winds, carry stored heat, slowing releasing it into the atmosphere as moisture.

As the water loses its heat, it becomes cold and heavy and eventually sinks to the ocean bottom. It flows back toward the equator where it rises to the surface again perhaps 10, 100 or even 1,000 years later. This global conveyor belt, collecting and moving heat from the warm tropics to the cold poles, drives the climate on which our lives depend.

To better understand climate and predict future climate change, we need to be able to measure how much heat is in the ocean, pinpoint where it is, and map its movement through ocean currents.

Currents flow around the ocean's hills and valleys just as wind blows around high and low pressures in the atmosphere. Ocean topography, made visible by precise measurement of sea-surface height, provides many answers to these complex questions.

Radar Altimeters for Ocean Topography

Spaceborne radar altimeters have proved to be superb tools for mapping ocean-surface topography. These instruments send a microwave pulse to the ocean's surface and time how long it takes to return. A microwave radiometer corrects any delay that may be caused by water vapor in the path through the atmosphere. Combining that information with the precise location of the spacecraft makes it possible to determine sea-surface height to within a few centimeters (about one inch). The shape of the returning signal also provides information on wind speed and the height of ocean waves.

Spaceborne radar altimetry was used to measure ocean surface topography for the first time by NASA's Seasat satellite in 1978. It was next used on the U.S. Navy's Geosat from 1985 to 1989. In 1979, NASA and JPL began planning a project called the Ocean Topography Experiment, or Topex, to measure the height of the world's oceans. About the same time, France’s space agency, the Centre Nationale d'Etudes Spatiales (CNES), was working on an oceanographic mission called Poseidon. The two agencies decided to work together and created the Topex/Poseidon mission.

NASA provided the satellite and five instruments. For that mission CNES furnished two instruments and the launch on an Ariane 42P rocket from French Guiana in South America. JPL assumed responsibility for project management, and communicates with the satellite through NASA's Tracking and Data Relay Satellite System. Both CNES and NASA provide precision orbit determination and process and distribute data to science investigators around the world.

Launched in August 1992, Topex/Poseidon measures sea-surface height along the same path every 10 days. It has allowed scientists to chart the height of the seas across ocean basins with an accuracy of 4 centimeters (1.5 inches). In its first month of operation, Topex/Poseidon provided more information about the surface height of Earth's oceans than had been collected by ships during the previous century.

Benefits of Ocean Surface Topography

Satellite observations of the oceans have revolutionized our understanding of the global climate. They have given us our first opportunity to track major global ocean events such as El Nino and the first overview of the even larger Pacific Decadal Oscillation--

features that we have not been able to observe directly before.

The social and economic benefits of the nine years of Topex/Poseidon observations, to which Jason 1 will add, include:

☐ Climate research -- modeling changes in the distribution of heat in the oceans provides information on the evolution of weather patterns.

☐ Hurricane forecasting -- altimeter data is incorporated into atmospheric models for hurricane season forecasting.

☐ El Nino and La Nina forecasting -- the ability to identify and track these large ocean/atmosphere phenomena, has lead to better prediction and preparations to mitigate their effects.

☐ Ship routing -- both commercial and recreational vessels use maps of currents, smaller eddies and winds created with altimetry data.

☐ Offshore industries -- cable-laying vessels and offshore oil operations depend on accurate knowledge of ocean circulation to operate safely and efficiently.

☐ Fisheries management -- satellite data identify ocean eddies, important features in migration.

☐ Marine mammal research -- sperm whales, fur seals and other marine mammals can be tracked by knowing the location of nutrient-rich ocean eddies.

☐ Coral reef research -- satellite observations provide a way to monitor ocean systems that are sensitive to changes in ocean temperature and currents.

Science Objectives

The basic science goals of ocean topography missions, including Jason 1 and Topex/Poseidon, are to:

☐ Determine general ocean circulation and to understand its role in Earth's climate.

☐ Study the variation of ocean circulation on time scales from seasonal and annual to decadal and the effects on climate change.

☐ Collaborate with other global ocean monitoring programs to produce routine models of the worldwide oceans for scientific and operational applications.

☐ Study large-scale ocean tides.

☐ Study geophysical processes from their effects on ocean surface topography.

In addition to carrying on the groundbreaking work done by Topex/Poseidon, Jason 1 is expected to:

☐ Measure global sea-height change and provide a continuous view of changing global ocean surface topography.

☐ Calculate the transport of heat and water mass by the oceans.

☐ Increase understanding of ocean circulation and seasonal changes and how the general ocean circulation changes through time.

☐ Provide estimates of significant wave height and wind speeds over the ocean.

☐ Test how scientists compute ocean circulation caused by winds.

☐ Improve forecasting of climatic events like El Nino and of global climate in general.

☐ Describe the nature of ocean dynamics and develop a global view of Earth's oceans.

☐ Monitor the variation of global mean sea level and its relation to global climate change.

The Legacy of Topex/Poseidon

Topex/Poseidon was the first mission to map global ocean surface topography with sufficient accuracy for studying ocean circulation. It has been making precise measurements of sea-surface height continuously since it was launched in August 1992.

The Topex/Poseidon mission has lead to major discoveries about our planet and how it works. It has changed our view of the oceans forever. Following in its footsteps, Jason 1 will continue to build on Topex/Poseidon's record of achievements. Topex/Poseidon mission to map ocean surface topography has lead to important fundamental discoveries in the following areas.

Ocean Variability

Topex/Poseidon showed the surprising variability of the ocean, how much it changes from season to season and year to year. The traditional notion of a quasi-steady, large-scale pattern of global circulation is gone. We now know that the ocean is changing rapidly on all scales -- from huge features such as El Ninos, which can cover the entire equatorial Pacific, to tiny eddies swirling off the large Gulf Stream in the Atlantic.

Changes in the height of the global ocean due to ocean currents and thermal differences ranges two meters (6.5 feet). Before Topex/Poseidon, we didn't know how much those heights fluctuate. The height of sea surface over a vast area (larger than the United States) can move up and down by 20 centimeters (8 inches) in just 20 days. During a recent El Nino, the eastern Pacific was 20 to 40 centimeters (8 to 16 inches) above normal, while the western Pacific dropped 20 to 30 centimeters (8 to 12 inches).

At any instant, a large part of the ocean is full of turbulent eddies. More salt and heat is transported by these eddies than by the weak steady currents as previously thought.

Planetary Waves

Topex/Poseidon showed us the importance of planetary-scale waves, such as Rossby and Kelvin waves. No one had realized how ubiquitous these waves are. Thousands of kilometers wide, these waves, are driven by wind under the influence of Earth's rotation and are important mechanisms for transmitting climate signals across the large ocean basins. At high latitudes, they travel twice as fast as we thought before, showing that the ocean responds much more quickly to climate changes than we knew before Topex/Poseidon.

Ocean Tides

Topex/Poseidon's precise measurements have brought our knowledge of ocean tides to an unprecedented level. The change of water level due to tidal motion in the deep ocean is known everywhere on the globe to within one inch. This new knowledge has revised our notions about how tides dissipate. Instead of losing all their energy over shallow seas near the coasts, as used to be thought, about one third of tidal energy is actually lost to the deep ocean. There the energy is consumed by mixing water of different properties, a fundamental mechanism in the physics governing the general circulation of the ocean.

Ocean Models

Topex/Poseidon has revolutionized ocean modeling. Its observations provide the first global data for improving the performance of numerical ocean models that are a key component of any climate prediction models. For example, Topex/Poseidon data have guided the development of the first model that is able to simulate the precise course of the Gulf Stream.

Monitoring the Global Oceans

Topex/Poseidon lets us see the global ocean from 66 degrees north to 66 degrees south at practically the same time. Continuous global coverage of the ocean surface topography provides a new effective way to monitor changes such as El Nino and La Nina. With this observational tool, we have learned more about the physics of these phenomena and consequently have improved the skills of predictive models.

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Measurements of sea-surface height also allow us to monitor the changes of the global mean sea level, an effective indicator of the consequence of global temperature change. In ten years we can establish the rate of change that used to take 30 years of sparse tide gauge observation.

The Transition from Topex/Poseidon to Jason 1

In addition to supporting the research that has benefited from Topex/Poseidon, Jason 1 will also provide valuable new information, including studies of the following areas.

☐ **Long-Term Change:** Topex/Poseidon has taught us the ocean is changing on all scales. Some of these changes are on time scales longer than the life span of a single satellite mission, and they often have important climatic consequences. One example is the Pacific Decadal Oscillation. This is a 20-year or longer oscillation of sea-surface temperature and topography between the eastern tropical Pacific and a surrounding horseshoe-like pattern extending from the central north Pacific through the western tropics to the central South Pacific. The cycles of Pacific Decadal Oscillation influence the fish populations in the North Pacific and the climate of North America and the rest of the world. They also regulate the frequency and strength of El Nino and La Nina. The continuation of observations by Jason 1 following Topex/Poseidon will provide the first set of data covering this poorly understood but important phenomenon.

☐ **Water and Heat Transport:** With new technologies, Jason 1 is expected to reduce the measurement errors by more than 1 centimeter (approximately one-half inch) compared to Topex/Poseidon. This is a significant improvement, because a mere one-centimeter error over a few kilometers (miles) or longer gives an error in water transport of 5 megatons per second, which is equivalent to 25 times the discharge rate of the Amazon or 15 percent of the amount of water transported through the Florida Straits. The amount of heat carried by 5 megatons per second of water is about 200 trillion watts. This represents about 20 percent of the heat transported by ocean currents northward in the North Atlantic Ocean, the heat responsible for the relatively mild winters of northern Europe. This improvement in accuracy becomes especially important when we extend the study of ocean changes from years to decades and attempt to make long-term predictions, in which small errors accumulate to overwhelm any predictive skills.

Why Operate Topex/Poseidon and Jason 1 Together?

To make sure Jason 1 will continue the Topex/Poseidon data record without any biases between the two measurements, it is extremely beneficial to have overlap between the two missions to allow comparisons of near-simultaneous measurements of the same spot of the ocean by the two satellites. Such cross-calibration is fundamental to the establishment of a long data record for global change studies.

Mission Overview

Jason 1's purpose is to precisely map the topography of the ocean's surface seamlessly continuing the measurements begun by its predecessor, Topex/Poseidon, in August 1992.

Following the same ground track as Topex/Poseidon, Jason 1 will assume the older spacecraft's near-circular orbit (inclined 66 degrees to Earth's equator) at an altitude of 1,336 kilometers (830 miles) above the equator. It will complete one orbit every 112.43 minutes, and return to the same point on Earth every ten days.

Once Jason 1 is in place, Topex/Poseidon may be moved to the side, providing additional measurements of ocean-surface topography for as long as the older spacecraft remains healthy.

On the ground, raw altimetry data will be processed into three primary products: the distance between the satellite and the sea surface, average wave height and wind speed.

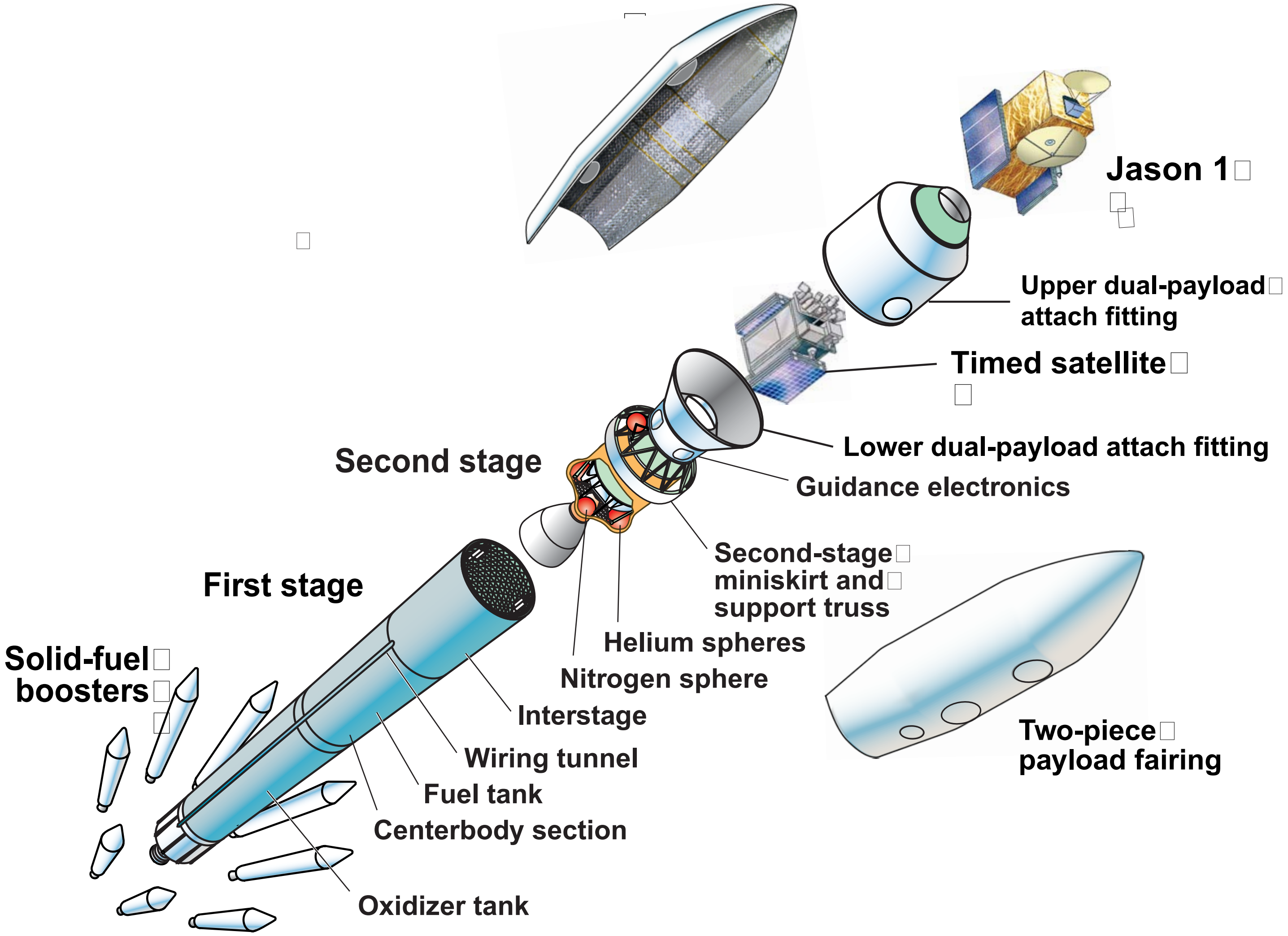
Launch Vehicle

Jason 1 will be launched on a Delta II model 7920-10C rocket. Manufactured by the Boeing Company, the Delta II is a modern version of the Thor intermediate-range ballistic missiles developed in the 1960s.

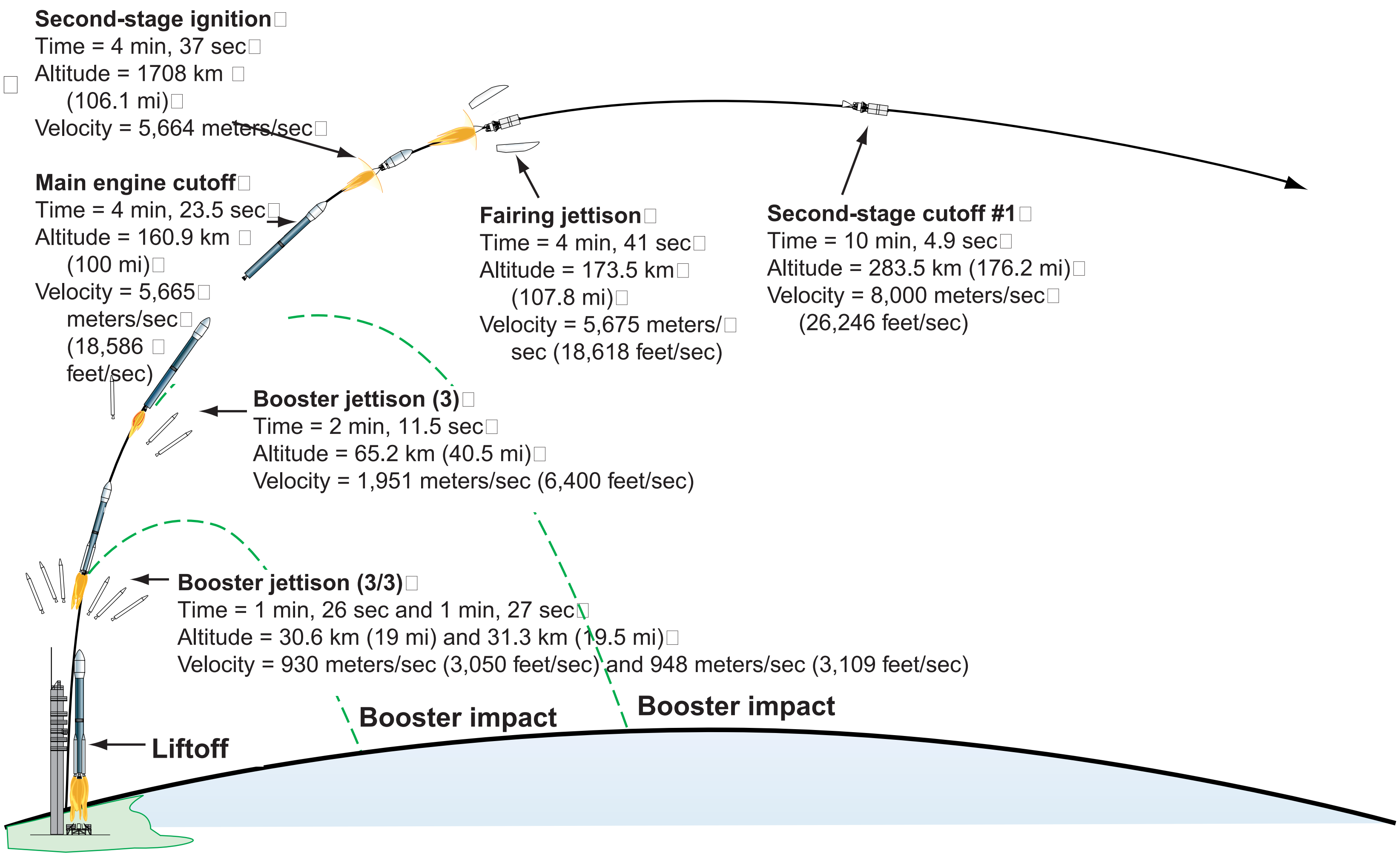
For the Jason 1 launch, the Delta II rocket has two liquid propellant stages with nine strap-on solid-fuel boosters. The boosters are strap-on motors built by Alliant Techsystems. Six of the solid-fuel boosters are ignited at liftoff, and three are lit once the rocket is airborne. Each of the boosters is 1 meter (3.28 feet) in diameter and 13 meters (42.6 feet) long; each contains 11,765 kilograms (25,937 pounds) of a propellant called hydroxyl-terminated polybutadiene and provides an average thrust of 485,458 newtons (109,135 pounds-force) at liftoff.

The main body of the Delta's first stage has a Rocketdyne RS-27 main engine fueled by a liquid propellant mixture of highly refined kerosene and oxygen. It is 26.1 meters (about 86 feet) long and 2.4 meters (8 feet) in diameter. The upper stage is 2.4 meters (8 feet) in diameter and 6 meters (19.7 feet) long. It is powered by an Aerojet AJ10-118K engine that uses the same propellant types as the first stage does.

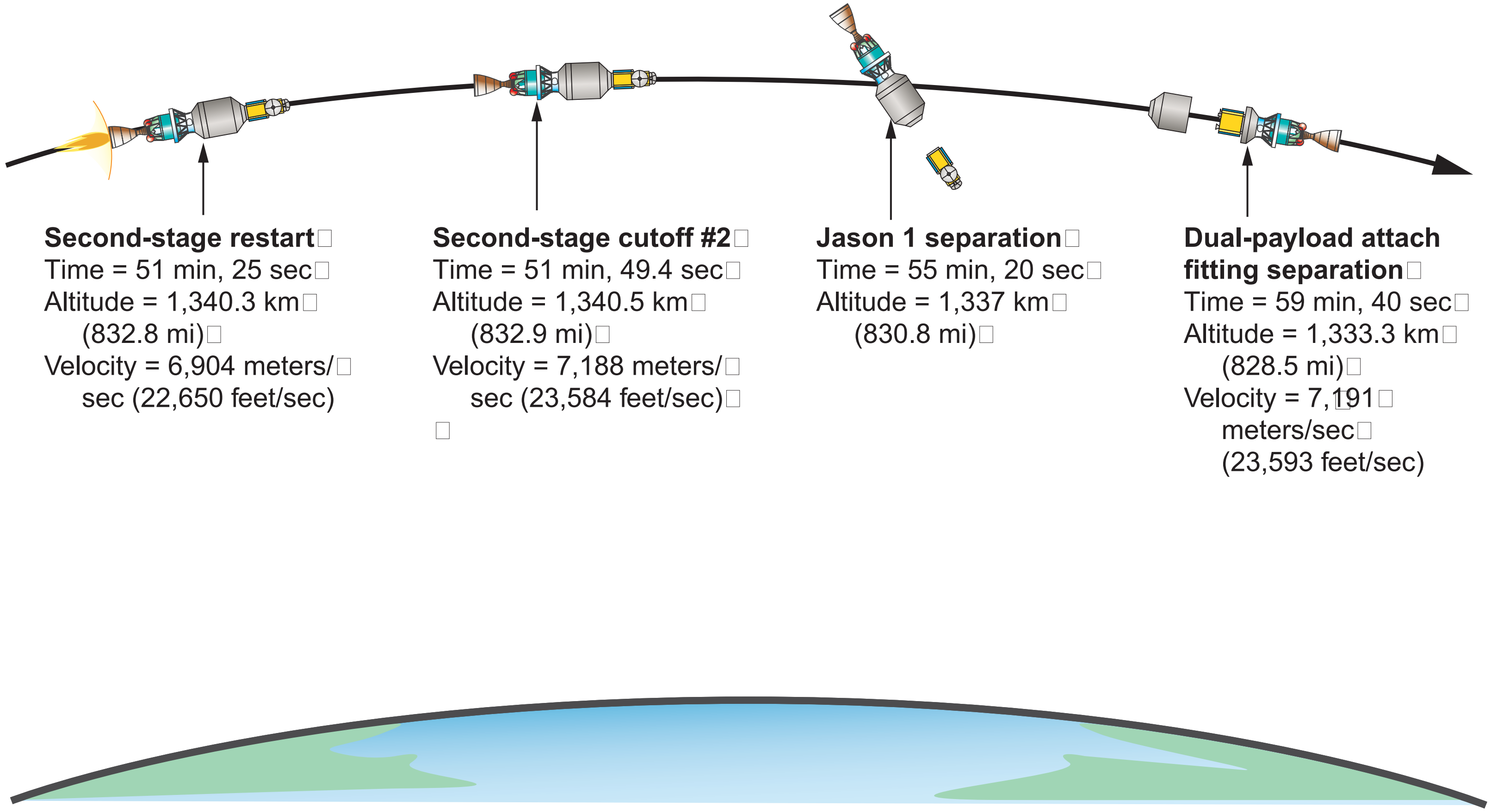
The rocket is equipped with a dual payload attach fitting system that allows it to carry two satellites at once. Jason 1 will share the launch vehicle with the Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics, or “Timed,” satellite. The latter is a spacecraft that will make measurements of portions of Earth's atmosphere called the mesosphere and lower thermosphere-ionosphere at altitudes between about 50 and



Delta II launch vehicle



Launch boost phase



Second-stage restart
Time = 51 min, 25 sec
Altitude = 1,340.3 km
(832.8 mi)
Velocity = 6,904 meters/sec (22,650 feet/sec)

Second-stage cutoff #2
Time = 51 min, 49.4 sec
Altitude = 1,340.5 km
(832.9 mi)
Velocity = 7,188 meters/sec (23,584 feet/sec)

Jason 1 separation
Time = 55 min, 20 sec
Altitude = 1,337 km
(830.8 mi)

Dual-payload attach fitting separation
Time = 59 min, 40 sec
Altitude = 1,333.3 km
(828.5 mi)
Velocity = 7,191 meters/sec
(23,593 feet/sec)

Launch injection phase

200 kilometers (about 31 and 124 miles). It is a mission of NASA and the John Hopkins University Applied Physics Laboratory, Laurel, Maryland.

The Jason 1 spacecraft will be contained inside the top of the Delta II rocket's 3-meter-tall (10-foot-tall) two-piece payload fairing; the Timed satellite will be below. At launch, the Delta II will stand 40 meters (131 feet) tall with a mass of 208,652 kilograms (230 tons).

Launch Timing

Jason 1 will be launched at a specific time based on the science requirements of the mission. Unlike spacecraft destined to other planets, the launches of Earth-orbiting satellites do not need to be timed based on the alignment of the planets. The only constraint is the time of day that will place the satellite in the proper orbit. For Jason 1, the launch time is designed to place the satellite in an orbit plane very close to, but not exactly the same as, the orbit plane of Topex/Poseidon.

The launch period planned for Jason 1 extends from December 7 to January 12. The launch window falls earlier by a little more than 12 minutes each day.

Liftoff

Jason 1 will set off on its journey to join its predecessor Topex/Poseidon from Space Launch Complex-2W at Vandenberg Air Force Base in California. The launch countdown will begin about 10 hours before liftoff.

Half a second before liftoff, the Delta II's first-stage engine and six of the rocket's nine solid-fuel boosters will ignite. At liftoff, the rocket will begin a vertical ascent. Seven seconds later the Delta II will tilt towards the southeast, crossing the California coastline and heading upward and out over the open Pacific Ocean.

Thirty-three seconds after liftoff, the rocket will reach the speed of sound. About half a minute later (at one minute, four seconds after launch) the first six solid-fuel boosters will burn out, and two seconds later, the final three boosters will ignite.

Three of the six spent boosters will be discarded one minute, 26 seconds after launch, followed by the next three boosters one second later. The final three boosters will be jettisoned two minutes, 12 seconds after liftoff, when their propellant has been exhausted.

The first stage will stop firing about four minutes, 24 seconds after launch as the rocket passes west of Mexico's Baja California peninsula. About eight seconds later, the first stage will be discarded, and six seconds later the Delta II's second stage ignites.

Four minutes, 41 seconds after launch, the rocket's nose cone, or fairing, will separate in two halves like a clamshell and fall away. The second-stage engine will shut down about 10 minutes, 5 seconds after liftoff, and the rocket and its payload will coast for 41 minutes and 20 seconds. At this point, it will be heading south and passing between the tip of South America and Antarctica.

About 51 minutes, 25 seconds after liftoff, the second-stage engine will restart to bring Jason 1 into its orbit. Just off the coast of Madagascar, Jason 1 will separate about 55 minutes, 20 seconds after liftoff. Within a few seconds, the tracking station at Hartebeesthoek, South Africa, should pick up Jason 1's confirmation signal.

The launch vehicle's second stage will then re-ignite to begin moving the Timed satellite to an entirely different orbit.

The Tandem Mission

Jason 1 will enter orbit about 10 to 15 kilometers (6 to 9 miles) below Topex/Poseidon's 1,337 kilometer (830 mile) altitude. It will lag between one and 10 minutes behind Topex/Poseidon in a nearly identical orbit. Jason 1 will quickly deploy its solar array, power up its instruments and rotate its altimeter to point to geodetic nadir -- essentially straight down, the shortest path to the ocean.

Over the course of the next 20 or 40 days, Jason 1 will maneuver to take over the same ground track as Topex/Poseidon. First, using its thrusters, Jason 1 will raise itself into the same orbital altitude as Topex/Poseidon's. Then, it will move in close behind its predecessor, trailing about 60 seconds, roughly 500 kilometers (300 miles).

Then, as the two spacecraft fly in line together, they will be making nearly simultaneous measurements of the same sea-surface from the same altitude. Members of the science team will make careful comparisons of the data to be sure the instruments are calibrated exactly, a procedure expected to take about six months.

When the cross-calibration process is complete, Topex/Poseidon will be commanded to move aside to a parallel ground track midway between two adjacent Jason 1 ground tracks. Jason 1 will remain in place, now seamlessly continuing the data collection begun by Topex/Poseidon nine years ago.

Satellite Operations

Topex/Poseidon and Jason 1 each have their own ground control system, which controls spacecraft orbit and collects, processes and distributes its data.

From launch through the on-orbit checkout phase, satellite control and operations for Jason 1 will be handled by CNES's Satellite Control Center in Toulouse, France. During this period, the Project Operation Control Center at JPL in Pasadena, Calif., will route telemetry from two U.S. Earth tracking stations to Toulouse. It will also monitor the instruments provided by NASA and will act as a backup to the French control center for satellite monitoring and control.

At the end of the assessment period, expected to be about 30 to 50 days, routine operations will transfer to the operation center at JPL. The center will control the satellite and its instruments for the remainder of the mission. The CNES control center will continue to monitor the satellite, perform navigation functions and conduct performance analyses.

A network of three ground stations will communicate with the satellite passing on commands from the control and operation centers and receiving data. Two of the tracking stations are managed by NASA's Wallops Flight Facility, Wallops Island, Va. Located at Wallops Island and at Poker Flat, Alaska, they each have a 5-meter-diameter (16.4-foot) dish antenna. The third tracking station, managed by CNES, is in Aussaguel, France. It has a 3-meter-diameter (9.8-foot) dish antenna.

Ground control for the precision altimeter (the primary science instrument) and for the Doppler Orbitography and Radiolocation Integrated by Satellite (DORIS) system, Jason 1's primary location system, is located at the Toulouse Space Center.

During launch, the network of ground stations will be supplemented by tracking stations in South Africa, Milindi, Diego Garcia, Hawaii and Nuku Hiva. The ground station in Hartebeesthoek, South Africa, will be used to confirm separation of Jason 1 from the Delta II.

Science Data Processing

Once received on the ground, the raw data from Jason 1, along with data from Topex/Poseidon, will be processed by both CNES and NASA. For CNES, Jason 1 science data processing will be handled by the Centre Multimission Altimetrique for altimetric data and the Service d'Orbitographie Mission for precise orbitography data. Data from Jason 1 processed at JPL will be sent for distribution to the U.S. Physical Oceanography Distributed Active Archive Center.

Jason 1 Spacecraft

Built in France by Alcatel Space Industries, Jason 1 is the first of a new family of mini-satellites. It is five times lighter and almost three times cheaper than its predecessor Topex/Poseidon.

Jason 1's main structure, or "bus," is a multi-purpose platform under the trade name Proteus, developed as part of a long-term partnership between CNES and Alcatel Space Industries. The bus houses most of the electronics required for the satellite to function, as well as the dedicated mission instruments. The satellite platform, with its two star trackers, has a mass of 275 kilograms (626 pounds). The frame of this three-axis stabilized satellite is approximately rectangular, measuring 1.9 by 1.9 by 3.3 meters high (6 by 6 by 11 feet). The spacecraft will have a total launch mass of 500 kilograms (1,102 lbs.), including its launch adapter, balance weight and propellant.

Once the satellite is placed into orbit, it will deploy two sets of solar panels with a total surface of 9.5 square meters (102 square feet) that will generate the energy for the platform and payload.

While Jason 1 is designed to last for three years, its resistance to radiation at its orbiting altitude of 1,336 kilometers (830 miles), is sufficient to ensure five years of operation. The satellite will carry 28 kilograms (62 pounds) of propellant, enough for this length of time.

Instruments

The spacecraft will carry a payload of five instruments: the Poseidon 2 altimeter, the mission's main instrument, to measure altitude; the Jason Microwave Radiometer to measure atmospheric water vapor; and three location-finding systems used successfully in Topex/Poseidon. These are the DORIS Doppler orbitography beacon receiver; the laser retroreflector array; and an advanced Global Positioning System receiver called the Turbo Rogue. These instruments will provide full redundancy and measurements for at least five years.

Poseidon 2 Altimeter

Supplied by CNES, the Poseidon 2 solid-state altimeter is Jason 1's primary instrument. It measures the distance from the satellite to Earth's surface by sending radar waves to the sea surface and measuring how long they take to bounce back. In addition to sea-surface height, the instrument can also provide data on wave height and wind speed.

Derived from France's experimental Poseidon 1 altimeter on the Topex/Poseidon spacecraft, the Poseidon 2 altimeter is smaller and lighter than its predecessor. It is a compact, low-power, low-mass radar altimeter that emits pulses at two frequencies. From the signal round-trip time, the distance between is surface and spacecraft can be calculated precisely after applying corrections for atmospheric conditions, such as water vapor, that can affect how long it takes the signals' return time.

The antenna, located on the "nadir" or bottom face of the satellite, is 1.2 meters (about 4 feet) in diameter. The dual frequencies are 13.6 gigahertz, which transmits on Ku-band, and 5.3 gigahertz, which uses C-band. The second frequency is used to determine electron content in the atmosphere. These two frequencies also serve to measure the amount of rain in the atmosphere.

The instrument is capable of measuring the distance between the satellite and the sea surface with an accuracy of 2 centimeters (1 inch) every second along the satellite track. Poseidon 2 was developed for CNES by Alcatel Space Industries.

Doppler Tracking

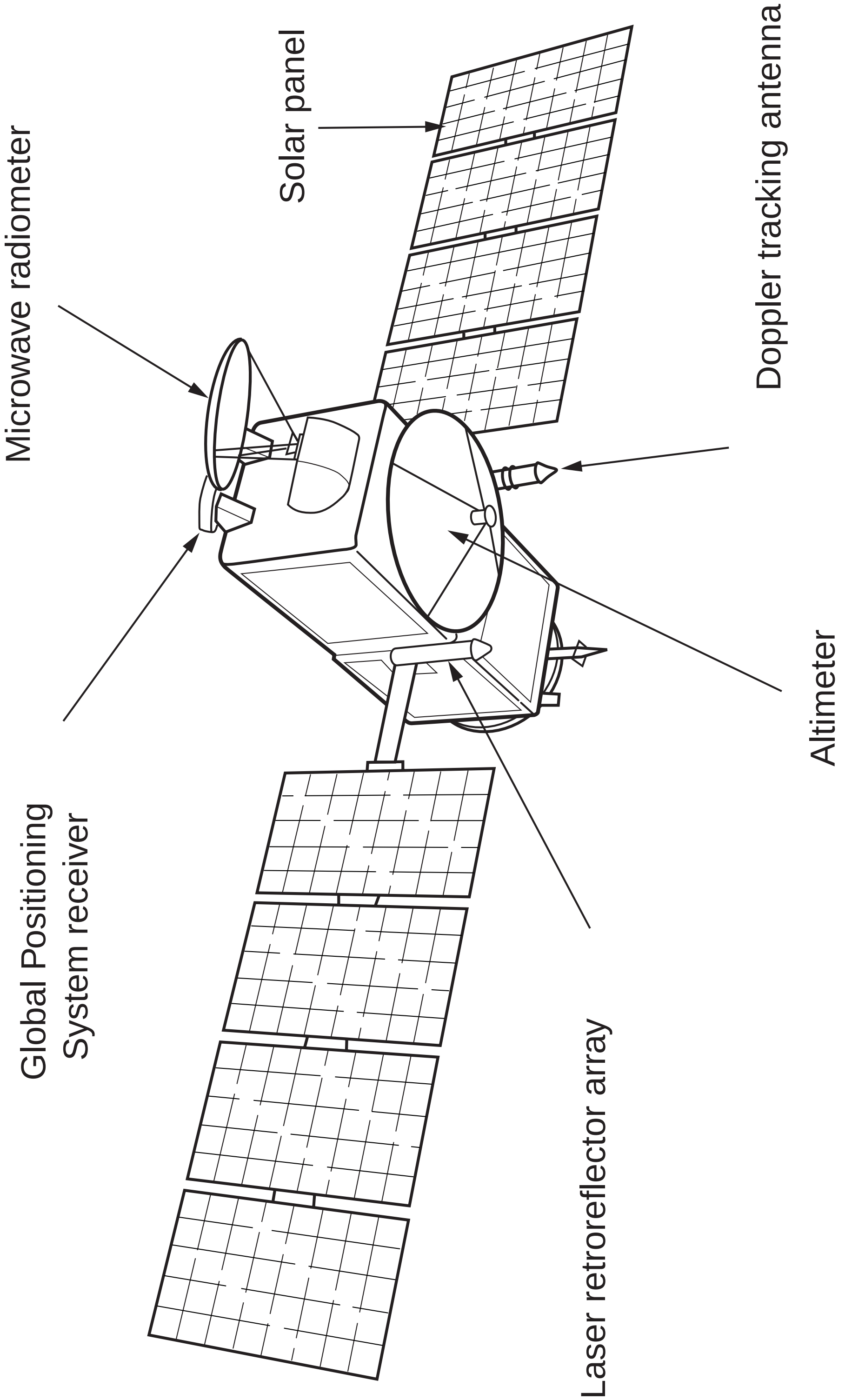
An essential element of Jason 1's success is the ability to pinpoint the satellite's location in orbit. The Doppler Orbitography and Radiolocation Integrated by Satellite, or Doris, system provides much of this information.

The system includes a ground network of 50 beacons around the world to constantly record the satellite's location. As the spacecraft flies over, they send signals at two frequencies to a receiver on the Jason 1 satellite. The receiver picks up these signals and measures the shift in the frequency (called the Doppler shift) between the signal sent and the one received.

These measurements are sent to the Doris Orbitography Service at France's Toulouse Space Center, where the satellite's trajectory and position are calculated. Currently, Topex/Poseidon's position can be located to within 2 or 3 centimeters (1 inch). For Jason 1, that figure is hoped to be within 1 centimeter (about one-half inch).

The receiver on Jason 1 is a second-generation device with an improved capability to receive two beacons simultaneously. Improvements and additions to the Doppler system make it possible for satellites to navigate autonomously. The receiver has a function that will allow it to calculate the precise position of the satellite on the fly. Mission planners believe it will provide positioning within 10 centimeters (4 inches), which may make use of real-time altimetry data possible.

The receiver on Jason 1 is a miniaturized version of the receiver on the European Space Agency's Envisat satellite. The system was developed by CNES and built by Thales (formerly Dassault Electronique). It has redundant electronics and a single antenna.



Jason 1 satellite

Microwave Radiometer

Jason 1 surveys sea level heights by measuring the time it takes for pulses generated by the onboard radar altimeter to bounce back to the satellite from the ocean surface. Water vapor in the atmosphere can delay the return of radar pulses to the satellite, interfering with the accuracy of sea level measurements. By measuring atmospheric water content, we determine how to correct for the radar signal delay. This is done with a microwave radiometer that is tuned to frequencies sensitive to water vapor emission.

The radiometer collects radiation emitted by the ocean surface and the atmosphere at three frequencies: 18.7, 23.8 and 34.0 gigahertz (GHz). The signals measured by the radiometer are affected by surface winds and clouds as well as atmospheric water vapor content. The different sensitivities of the three frequencies to each of these effects allow an accurate determination of water vapor abundance. The 23.8 GHz channel is the primary water vapor sensor. The 34.0 GHz channel provides for the correction for non-raining clouds, and the 18.7 GHz channel is sensitive to wind-driven variations in emission from the sea surface. The instrument provides a radiometric brightness temperature for each frequency. We process the brightness temperatures along with calibration data to tell us how much Jason 1's radar signal is slowed by water vapor content in the atmosphere.

The radiometer was developed, fabricated, tested and calibrated at JPL. The receivers use technology developed by TRW, and the reflector was provided by Composite Optics Inc.

Turbo Rogue Space Receiver

The ability to determine Jason 1's precise position in orbit is critical in interpreting altimetry data. The receiver is one of three location systems onboard Jason 1. They are used together to measure the satellite's position. The receiver uses the Global Position System (GPS) constellation of 28 navigational satellites for this purpose.

The Turbo Rogue receiver continuously tracks the radio signals transmitted by up to 16 GPS satellites at once. The receiver measures the phase of the GPS carrier signals with better than 1 millimeter (1/25th of an inch) precision and measures the "pseudo-range" between Jason 1 and each GPS spacecraft being tracked with better than 10 centimeter (4 inches) precision. (Pseudo-range is a measurement of the transmit time of the signal between satellites. The measurement contains certain timing errors, which can later be corrected to recover the true range.)

To achieve the mission's orbit accuracy goal, we need detailed knowledge of Jason 1 and its behavior so that we can model the forces that act on it. In ground processing, the receiver's GPS readings will enable continuous determination of the Jason 1 orbit with an accuracy of 1 to 2 centimeters (about half an inch). To interpret the altimetry data we also need to know Earth's gravity field very precisely, as it is an important reference for sea-surface height. Turbo Rogue measurements of variations in Jason 1's orbital motion in relation to Earth's center will improve our overall knowledge of Earth's gravity field.

The Turbo Rogue hardware, software and ground support equipment were designed and tested by JPL. The flight unit was fabricated by Spectrum Astro Inc.

Laser Retroreflector Array

The Laser Retroreflector Array is one of Jason 1's three location systems used together to measure the satellite's position in orbit. The ability to determine a satellite's precise position in orbit is critical in interpreting altimetry data used for measuring ocean surface topography. The array is used to calibrate the other Jason 1 location systems and to verify the altimeter's height measurements.

The array is a set of mirrors onboard the satellite that provides a target for laser-tracking measurements from ground stations. By analyzing the round-trip time of the laser beam, mission officials can locate very precisely where the satellite is on its orbit. They analyze the laser tracking data to calculate the satellite's altitude to within a few millimeters. Because there are a small number (10 to 15) of ground stations and laser beams are sensitive to weather conditions, it is not possible to track the satellite continuously using the array of mirrors. That is why other location systems are needed onboard the satellite.

Jason 1's reflector array consists of nine quartz corner cube reflectors arrayed on a circular structure on the satellite's "nadir," or Earth-facing, side. A corner cube reflector is a special type of mirror that always reflects an incoming light beam back in the direction from which it came. The retroreflectors are optimized for a wavelength of 532 nanometers in the green portion of the color spectrum, providing a field of view of about 100 degrees.

The Laser Retroreflector Array was manufactured by ITE Inc. for NASA's Goddard Space Flight Center.

Command and Data Handling

All of the spacecraft's computing functions are performed by the spacecraft's data-handling unit. The heart of this subsystem is a computer processor known as an MA 31750. With 128 16-bit Kword of non-volatile memory, 256 kword of random access memory and three gigabits of dynamic RAM mass memory, the subsystem runs Jason 1's flight software and controls the spacecraft through interface electronics. It also handles all the payload data transmitted to Earth each time the satellite is in visibility of a ground station.

Interface electronics make use of computer cards to communicate with external peripherals. Onboard timekeeping is provided by the Proteus platform's GPS receiver.

The data-handling unit weighs 28.5 kilograms (62.8 pounds).

Telecommunications

Jason 1 communicates with Earth through a radio transmitter and receiver, both of which operate in the microwave S-band, using two small spiral-shaped medium-gain antennas. The two main ground stations are in Poker Flat, Alaska, and Aussaguel, France, with a backup station at Wallops, Va.

The telecommunication subsystem weighs 7.7 kilograms (16.9 pounds).

Electrical Power

All of the spacecraft's power is generated, stored and distributed by the electrical power subsystem. The 28-volt power comes from a pair of solar wings with classical silicon cells. The arrays are extended in orbit on opposite sides of the satellite's main platform. Two small drive motors keep the arrays pointed at the Sun.

Each array consists of four panels, each 1.5 by 0.8 meters (5 by 2.6 feet), representing a total surface of 9.8 square meters (105 square feet). The solar array generates up to 1,050 watts at launch, 900 watts at end of mission. The spacecraft's normal requirements will be 450 watts, 280 watts for the platform and 170 watts for the payload.

Power is also provided during eclipses by a 24-cell 40-amp-hour nickel cadmium battery.

The electrical power subsystem weighs 54.7 kilograms (120.6 pounds). The solar array weighs 43 kilograms (94.8 pounds) and the battery 46.6 kilograms (102.7 pounds).

Guidance, Navigation and Control

In normal mode, Jason 1 maintains its altimeter antenna always pointing vertically towards Earth's surface. The spacecraft determines its orientation at any given time using one of two star trackers in combination with two of three onboard gyroscopes. Fine-tuning of the satellite's attitude is carried out by four small gyro-like devices called reaction wheels. The spacecraft also determines its orientation using eight coarse Sun sensors, a three-axis magnetometer and three magnetotorquer bars.

The star trackers can track stars of magnitude 4.3 or brighter. They process the data to recognize any star patterns as they pass through the tracker's field of view.
The guidance, navigation and control subsystem weighs 37.3 kilograms (82.2 pounds).

Propulsion

Jason 1 can adjust its orbit by firing any combination of its four onboard thrusters, each of which provides 1 newton of thrust. The thrusters use hydrazine propellant.

In addition to miscellaneous tubing, thruster valves and filters, the propulsion subsystem also includes a spherical 42-centimeter-diameter (16.5-inch) propellant tank containing the hydrazine, pressurized with gaseous nitrogen.

The propulsion subsystem (without the hydrazine) weighs 6.1 kilograms (13.4 pounds).

Thermal Control

The thermal control subsystem is responsible for maintaining the temperatures of each component on the spacecraft within its allowable limits. It does this using a combination of active and passive control elements. The active components are electrical heaters. The passive components are thermal radiators and thermal multilayer insulation blankets. The outer layer of the blanket is a gold-colored kapton material.

The thermal control subsystem weighs 12.2 kilograms (26.9 pounds).

Flight Software

Jason 1 receives its commands and sequences from Earth and translates them into spacecraft actions. The flight software is capable of running time-tagged commands, as well as executing immediate commands as they are received.

The flight software is responsible for a number of autonomous functions, such as attitude control and fault protection, which involve frequent internal checks to determine whether a problem has occurred. If the software senses a problem, it will automatically perform a number of preset actions to resolve the problem or put the spacecraft in a safe mode until the ground can respond.

Backups

Most systems on the spacecraft are fully redundant. This means that, in the event of a device failure, there is a backup system or function to compensate.

A software fault protection system is used to protect the spacecraft from reasonable, credible faults. In case of anomaly, the software places the spacecraft in a Sun-pointing safe mode, allowing time for analysis and recovery while maintaining it in an acceptable situation, with regard to power, thermal control, attitude and link budget.

Program/Project Management

Jason 1 is a joint project between NASA and France's Centre National d'Etudes Spatiales (CNES). The Jet Propulsion Laboratory, Pasadena, Calif., manages the program for NASA's Earth Science Enterprise.

Dr. Ghassem Asrar is the associate administrator for NASA's Earth Science Enterprise, NASA Headquarters, Washington, D.C. Dr. Jack Kaye is director of the Earth Science Enterprise Research Division, and Dr. Eric Lindstrom is oceanography program scientist for the enterprise.

At JPL, the Jason 1 project manager is Gary Kunstmann, and the project scientist is Dr. Lee-Lueng Fu.

At CNES, the Jason 1 project manager is Philippe Escudier, and the project scientist is Yves Menard.

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