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# Galileo Probe

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The Science: After a six-year journey through interplanetary space, the unmanned spacecraft Galileo passed within 370 miles of Jupiter's moon

Europa, revealing an ice-enshrouded world whose surface characteristics suggest an underlying planetary ocean that may harbor extraterrestrial life.

The Scientists:

*William J. O'Neil*, Galileo project manager at the Jet Propulsion Laboratory (JPL)
*Torrence V. Johnson*, JPL Galileo project scientist
*Neal E. Ausman, Jr.*, Galileo mission director at JPL
*Marcia Smith*, probe manager
*Richard E. Young*, probe scientist
*Wesley T. Huntress, Jr.*, associate administrator, NASA Headquarters Office of Space Science
*Donald Ketterer*, NASA Headquarters program manager for Galileo
*Jay Bergstralh*, NASA Headquarters project scientist for Galileo
*Eugene M. Shoemaker* (1928-1997), geologist with the U.S. Geological Survey
*Carolyn Shoemaker* (b. 1929), astronomer with the U.S. Geological Survey
*Donald E. Williams* (b. 1942), commander of STS-34

## Mission Launch

The Galileo mission to Jupiter was formally approved by the United States Congress in 1977, several years before the space shuttle *Columbia* made its maiden flight into Earth orbit. The mission was a cooperative project involving scientists and engineers from the United States, Germany, Canada, Great Britain, France, Sweden, Spain, and Australia. Even though the Voyager 1 and Voyager 2 spacecraft had performed flybys of planet Jupiter and its sixteen moons in 1979, the Galileo mission was envisioned to initiate several novel observations of Jupiter, the most massive gas planet of the solar system, and its principal moons, and conduct exclusive, often in situ, experiments on their fascinating environments.

Galileo was carried aboard the space shuttle *Atlantis* (flight STS-34) and was launched from the shuttle on October 18, 1989. Galileo was the first spacecraft to image the surface of Venus without using radar (a radio-wave pulse detector). Using its near-infrared solid-state imaging camera, it photographed Jupiter's atmospheric banding and its satellites from a half-billion miles away on its way to Venus in December, 1989, and subsequently observed numerous mountain ranges and valleys on Venus's oven-hot surface through its thick atmosphere and clouds on February 10,

1990. The image resolution of Galileo's cameras (the smallest object size that can be detected by them) was around 12 meters, a millionfold improvement over Galileo's original observations.

## Jupiter

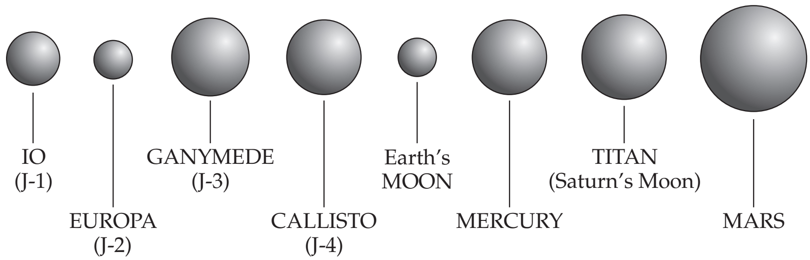
As a planet, Jupiter is by far the largest in the solar system. It has a volume about 1,400 times that of the Earth; in fact, its volume is 1.5 times the combined volume of all the other planets, moons, asteroids, and comets in the solar system. Jupiter is a "gas giant" planet composed of vast amounts of hydrogen gas. The gas runs thousands of kilometers deep. The gases on Jupiter swirl around in massive hurricanes whose sizes are of the order of the size of the Earth. The famous Great Red Spot on Jupiter is in fact a hurricane three times the diameter of Earth; it has been raging in the Jovian atmosphere for more than three hundred years. It is believed that, given its enormous size, Jupiter would have become a thermonuclear reactor (that is, a star like the Sun), if only it were thirty times heavier. Jupiter rotates about its axis much faster than the Earth; hence, a Jovian day is only 9 hours and 48 minutes long. This fast rotation causes Jupiter to be somewhat squashed, or oblate: its equatorial radius is 71,392 kilometers (compared with the Earth's 6,400 kilometers), while its polar radius is about 4,000 kilometers smaller. This causes an object to weigh about 25 percent heavier at Jupiter's poles than at its equator.

## Arrival and Data Gathering

In 1994, while the Galileo spacecraft was approaching Jupiter, it became a direct witness to an astounding astrophysical event. The Comet Shoemaker-Levy 9 (SL-9) had broken up into several small fragments and was expected to plunge directly into Jupiter's atmosphere.

Galileo spent much of the year 1995 preparing for the dual-craft arrival at Jupiter on December 7. In July, 1995, the Galileo probe and the orbiter spacecraft separated to fly their independent missions to Jupiter. After the probe had separated for atmospheric entry, the orbiter's main engine was fired to aim it to go into orbit around Jupiter. The probe entered with an initial velocity of 170,000 kilometers per hour, decelerating for two minutes, then plunging into the wind-torn clouds beneath its Dacron parachute, sending measurements for almost an hour. The orbiter, meanwhile, measured the Jovian environment, received a gravity assist from Io, received and recorded the probe data, then fired its main engine to become the first artificial satellite of Jupiter. The successful arrival was enthusiastically cel-

Sizes of the Jovian Moons Relative to Other Bodies




ebrated at NASA Headquarters on December 7, 1995. On December 9, Galileo began relaying the probe data to Earth.

Galileo continued to gather data from the Jovian system for nearly five years after its arrival. The first Ganymede and Io encounters began June 27, 1996, and a second Ganymede encounter on September 6, 1996. The first encounter with Callisto occurred on November 2, 1996, and with Europa on December 19, 1996. Each encounter involved a one-week, high-rate observation of Jupiter and at least one satellite. Each flyby brought Galileo to within a few hundred kilometers of the satellites and gave it a gravity assist into the next orbit. In January, 1997, Galileo and Jupiter entered another superior conjunction, after which the orbiter continued its close flybys for another year. On February 20, 1997, the Galileo orbiter encountered Europa for a second time. It encountered Ganymede on April 5, 1997, at a distance of only 3,095 kilometers, nineteen times closer than Voyager 2, and, again, on May 7, 1997. This time it got within 1,600 kilometers of the satellite—thirty-seven times closer than Voyager 2. On June 25, 1997, the probe glided to within 415 kilometers of Callisto. It reencountered it on September 17, 1997. Between November 6, 1997, and February 1, 1999, Galileo played tag with Europa nine times, swooping down on its icy surface. On May 5, 1999, Galileo began another four-visit tour of Callisto, ending on September 16, 1999.

In late 1999 and early 2000, the Galileo spacecraft dipped closer to Jupiter than it had been since it first went into orbit around the giant planet in 1995. These maneuvers allowed Galileo to make three flybys of the volcanically active moon Io and also made possible new high-quality images of Thebe, Amalthea, and Metis, which lie very close to Jupiter, inside the orbit of Io. Volcanic calderas, lava flows, and cliffs could be seen in a false-color image of a region near the south pole of Jupiter's volcanic moon, Io. Combining a black-and-white image taken by the Galileo spacecraft on February 22, 2000, with lower-resolution color images taken by Galileo on July 3, 1999, JPL scientists created the image. Included in the image are three small volcanic calderas about 10 to 20 kilometers in diameter.

The fourteen-year odyssey of Galileo concluded on September 21, 2003, with a controlled plunge into the outer atmosphere of Jupiter while the spacecraft was on its thirty-fifth orbit. The spacecraft passed into Jupiter's shadow and the Deep Space Network received its final signal from Galileo at 12:43:14 Pacific daylight time, or 19:43:14 Coordinated Universal Time (UTC). Galileo hit the outer atmosphere just south of the gas giant's equator at a speed of 48.3 kilometers per second. Due to the time delay in receipt of light signals, this message arrived 46 minutes after Galileo was crushed, vaporized, and dispersed into Jupiter's dense atmosphere.

## Impact

Galileo mission data provided answers to many questions regarding Jupiter and its large assembly of satellites, which are sometimes compared to a miniature solar system. The data have cast light on the Jovian moons' atmospheres, Jupiter's large magnetosphere, its unique ring system, the geologic history of the Jovian system, the volcanic characteristics of Io, the possibility of any liquid water under Europa's ice crust, and, perhaps most important, clues to the early history of the solar system, which help our understanding of our own planet and its relationship to the universe. The Galileo mission required several new technologies to be developed, which are already paying off handsomely in terms of the knowledge gained (and to be gained further) via Galileo's operations.

**See also** Jupiter's Great Red Spot; Voyager Missions.

## Further Reading

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