NASA Facts

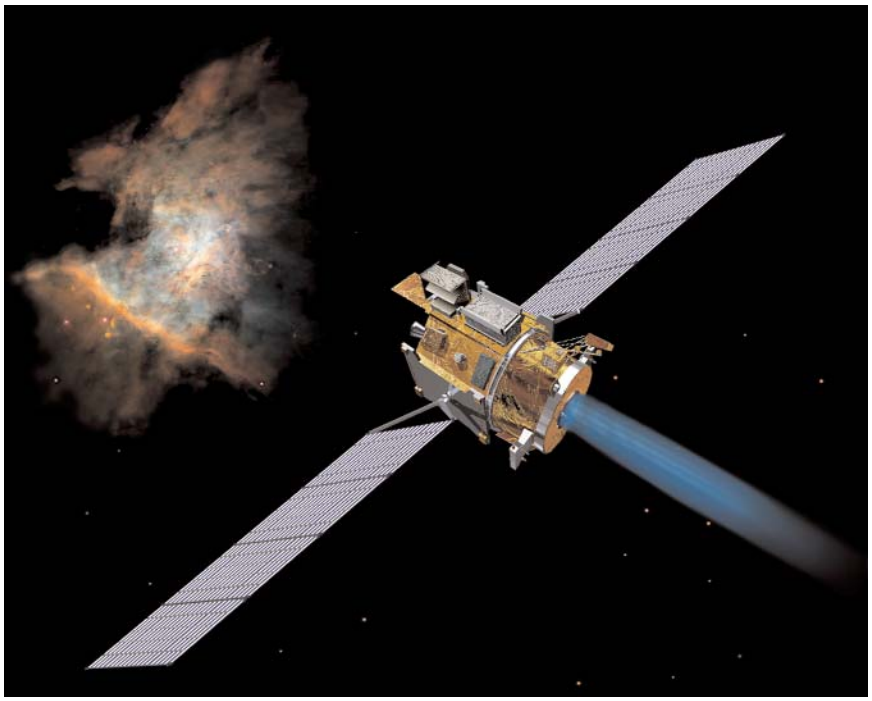
National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109

Deep Space 1

Deep Space 1 is the first mission of NASA's New Millennium Program for flight-testing exotic, high-risk technologies. Its successful technologies helped it go on to explore comet Borrelly's rocky core and surrounding cloud of dust and gas.

Deep Space 1 demonstrated 12 cutting-edge technologies, including ion propulsion, a kind of solar-electric propulsion. It was the first spacecraft to rely on ion propulsion for its main source of thrust, rather than conventional chemical propulsion systems. Its technologies will help enable many ambitious space-exploring and Earth-exploring missions in coming decades.



Deep Space 1 was launched October 24, 1998, and rigorously tested the new technologies in the following months. As a bonus, after those successful tests, the spacecraft flew within 27 kilometers (about 17 miles) of asteroid Braille on July 29, 1999. Deep Space 1 exceeded its requirements and in September 1999 began an ambitious extended mission. NASA took advantage of the ion propulsion and other systems to target a chancy but exciting encounter with a comet. The spacecraft, by then an experienced explorer, flew by comet Borrelly on September 22, 2001.

In addition to ion propulsion, the mission tested autonomous solar system navigation and other autonomous systems, advanced solar concentrator arrays, two highly compact science instruments, and a variety of sophisticated telecommunications and microelectronics systems.

Ion propulsion had been proposed and studied for decades before Deep Space 1 became the first spacecraft to use an ion-propulsion engine as its primary propulsion source in deep space. This futuristic engine, using heavy but inert xenon gas as propellant, was driven by more than 2,000 watts from large solar arrays. The ion engine completed 10,000 hours of operation — 50 times beyond its originally required lifetime — in April 2000 on its way to rendezvous with comet Borrelly. It has now operated for nearly 14,000 hours.

In November 1999, during the extended mission, the star tracker used for determining the spacecraft's orientation in the zero gravity of space failed. The star

tracker was not one of the new technologies the mission was testing. Although this critical loss had been considered a mission-ending failure, engineers developed new ways to operate the probe. They radioed software to it in June 2000 that included using the camera on board to serve as a replacement navigational tool, enabling the mission to continue. The operation was one of the most successful robotic space rescues in the history of space exploration.

Comets were formed when the solar system formed, so scientists expect that studying them may reveal clues to the origin and evolution of the solar system. When Deep Space 1 approached comet Borrelly in September 2001, the spacecraft used its two advanced science instruments, originally designed for testing during the primary mission, to collect important data on the comet's environment and its icy, rocky nucleus. It also used sensors that were included on the flight to diagnose the ion-propulsion system. Deep Space 1 took black-and-white pictures, used infrared spectra to analyze the comet's surface, measured and identified gases coming from the comet, and measured the interaction of solar wind with the comet.

The comet encounter presented many challenges for Deep Space 1. The comet's coma, a cloud of gas and dust being shed from the nucleus, made the nucleus difficult to find. However, Deep Space 1 was able to snap the best close-up pictures so far of a comet. At the time of the encounter, the spacecraft had been in space for three times its planned mission life. The craft was rapidly running out of the conventional propellant used for turning and for holding steady. Although its recovery following the loss of the star tracker restored most of the spacecraft's capabilities, accurate pointing during the comet encounter was difficult. For these and other reasons, the encounter was very risky. But given that Deep Space 1 had already completed a very successful mission and considering the scientific value of studying comets, NASA considered this a worthwhile risk.

Since launch, Deep Space 1 has been in orbit around the Sun. By the time of the comet encounter it had circled the Sun twice.

Deep Space 1 began as part of NASA's New Millennium Program, started in 1994. The Jet Propulsion Laboratory manages the program for NASA's Office of Space Science, Washington, D.C. Dr. Marc Rayman is the project manager. Spectrum Astro Inc. of Gilbert, Ariz., was the industrial partner for spacecraft development before launch. JPL is managed for NASA by the California Institute of Technology in Pasadena.

Further information is available online at Deep Space 1's home page, http://nmp.jpl.nasa.gov/ds1 .

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Technologies flight-tested on Deep Space 1

- ❑ Ion propulsion system
- ❑ Solar concentrator arrays producing more power for lower cost
- ❑ Autonomous navigation to allow the spacecraft to navigate without help from Earth
- ❑ Autonomous "remote agent" flight software with artificial intelligence for onboard decisions
- ❑ Beacon monitor to summarize spacecraft health and then signal whether detailed communications are urgent or not, for efficient use of ground-based antennas
- ❑ Miniature integrated camera and spectrometer for scientific observations
- ❑ Plasma experiment using a small package of instruments for studying charged particles in space
- ❑ Small deep-space transponder for communications
- ❑ Ka-band (microwave) solid-state power amplifier for enabling communications use of low power and a small onboard antenna
- ❑ Low-power electronics
- ❑ Multifunctional structure combining electronic and thermal-control features into load-bearing structural panels
- ❑ Power actuation and switching module for smaller, more-efficient electronics