

THE VALUE OF PERFORMANCE.

**NORTHROP GRUMMAN**



## *Deep Space 1*

*NASA New Millennium Program  
Technology Demonstration Spacecraft*

**D**eep Space 1 (DS1) was the first of NASA's New Millennium series of low-cost, high return technology demonstration spacecraft. Launched on October 24, 1998, DS1 demonstrated 12 technologies and was the first interplanetary spacecraft to utilize a solar electric (ion) engine as its primary means of propulsion. DS1 technologies included concentrator solar arrays, new communications equipment, autonomous optical navigation, a miniaturized camera, an imaging spectrometer, and the Xenon Ion Propulsion System (XIPS). The XIPS provided about 10 times the specific impulse (ratio of thrust to propellant used) of that of chemical propulsion. DS1 was also the first spacecraft to employ autonomous navigation in deep space.

DS1's camera and spectrometer took pictures and collected composite data of asteroid Braille when it came to within 16 miles during the space vehicle's fly-by in July 1999. In September 1999, NASA sent DS1 on an extended mission to conduct comet science. In September 2001, DS1 executed a flawless encounter with comet Borrelly at about 137 million miles from Earth, yielding the best pictures and other scientific data ever collected at a comet to date.

DS1 had traveled nearly 1.5 billion miles to intersect Borrelly's path. DS1 came to within 1,400 miles of the comet. The mission was again extended for a few more months of renewed technology testing, devoting some time to all of the hardware technologies. DS1 was finally retired after 1,151 days (3.2 years) of operation in space on December 18, 2001 with its fuel supply exhausted. The ion engine had operated for 16,246 hours and had consumed about 72 kilograms of xenon propellant.

### ***Facts At A Glance***

- A NASA/JPL-Northrop Grumman joint effort
- Launched October 1998 into a Highly Elliptical Solar Orbit (HEO) with a 2-year design life
- DS1 successfully completed a flyby of asteroid Braille in July 1999
- DS1 successfully completed a flyby of comet Borrelly in September 2001
- 12 breakthrough technologies demonstrated during mission
- Mission terminated with fuel exhausted at 3.2 years after flying 1.5 billion miles
- DS1 was the first interplanetary spacecraft to utilize a solar electric (ion) engine as its primary means of propulsion
- DS1 was the first to employ autonomous navigation in deep space

### ***Customer***

Jet Propulsion Laboratory

## Specifications

### Spacecraft

Launch Mass:	486.3 kg (1,072 lb.)
Solar Arrays:	GaAs/Ge, 2500 W EOL
Orbit:	0.99 x 1.32 AU @ 0.4° inclination, 0.143 eccentricity
Stabilization:	3-axis
Pointing:	206 arcsec control, 15 arcsec knowledge
Data Storage:	2.0 Gbits
Data Downlink:	DSN 19.9 kbps and experimental Ka-band transponder
Propulsion:	100 mN xenon ion thruster, and eight 1 N hydrazine thrusters
Design Life:	2 years
Current Status:	Decommissioned

### Launch

Launch Vehicle:	Delta II 7326
Launch Site:	Cape Canaveral Air Force Station, FL
Date:	October 24, 1998

## Instruments (Stand Alone Experiments)

### Miniature Integrated Camera and Spectrometer (MICAS)

Combined two visible imaging channels with ultraviolet and infrared spectrometers

### Plasma Experiment for Planetary Exploration (PEPE)

An ion and electron spectrometer to measure the solar wind during cruise, the interaction of the solar wind with target bodies during encounters, and the composition of the cometary coma

### Engineering/Experimental Bus Components:

- Solar Electric (xenon ion) Propulsion
- SCARLET™ Solar Concentrator Arrays
- Autonomous Navigation to maneuver payloads
- Small Deep Space Transponder
- Ka-band solid state amplifier at a frequency about four times higher than the standard at the time for deep-space missions
- Beacon Monitor Operations to determine the overall spacecraft health

- Autonomous Remote Agent: An artificial intelligence system to plan and execute spacecraft activities
- Tests of two microelectronics technologies and a mechanical/electronic experiment
- Tests of a high-density power actuation and switching module
- Validated and integrated structure and electronics with the ability to control the temperature all in one device

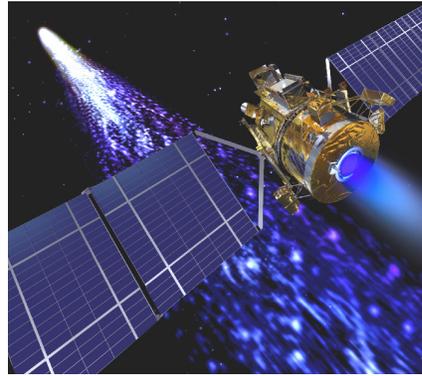
## Mission Partners

### Jet Propulsion Laboratory

Project management, co-development of the spacecraft, payload management, observatory integration, launch operations, mission operations

### Northrop Grumman

Design and manufacture of the spacecraft structure and various subsystems including ground software



Artist's rendering of DS1 approaching a comet



DS1 in final integration at JPL. (NASA photo)