SAMPLE

Solar System Missions: NEAR Shoemaker

First Asteroid Landing

Aira Astralis

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Conclusion

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Introduction

Near Earth Asteroid Rendezvous - Shoemaker (NEAR Shoemaker), renamed after its 1996 launch in honor of planetary scientist Eugene Shoemaker, was a robotic space probe built at the Applied Physics Laboratory of Johns Hopkins University for NASA to study the near-Earth asteroid Eros from close orbit over a period of a year. It was the first spacecraft to orbit an asteroid and land on it successfully.

In February 2000, the mission closed in on the asteroid and orbited it.

On February 12, 2001, Shoemaker touched down on the asteroid and was terminated just over two weeks later. The primary scientific objective of NEAR was to return data on the bulk properties, composition, mineralogy, morphology, internal mass distribution, and magnetic field of Eros. Secondary objectives include studies of regolith properties, interactions with the solar wind, possible current activity as indicated by dust or gas, and the asteroid spin state.

This data was used to help understand the characteristics of asteroids in general, their relationship to meteoroids and comets, and the conditions in the early Solar System. To accomplish these goals, the spacecraft was equipped with an X-ray/gamma-ray spectrometer, a near-infrared imaging spectrograph, a multi-spectral camera fitted with a CCD imaging detector, a laser rangefinder, and a magnetometer.

A radio science experiment was also performed using the NEAR tracking system to estimate the gravity field of the asteroid.

The total mass of the instruments was 56 kg (123 lb), requiring 80 watts of power. NEAR was the first robotic space probe built by Johns Hopkins University's Applied Physics Laboratory (APL). A previous plan for the mission was for it to go to 4660 Nereus and do a flyby of 2019 van Albada en route. In January 2000, it would rendezvous with Nereus, but instead of staying, it would visit multiple asteroids and comets.

Some of the choices that were discussed were 2P/Encke, 433 Eros (which became the mission's primary target), 1036 Ganymed, 4 Vesta, and 4015 Wilson-Harrington. The Small-Body Grand Tour was a plan to visit two asteroids and two comets over a decade with the spacecraft. Its declared objective was a year spent orbiting 433 Eros, the near-Earth asteroid that named the mission.

The gamma-ray spectrometer is a NaI scintillator with an active BGO shield.

Chapter 1: The Discovery of NEAR Shoemaker

Initially, the orbit was circular with a radius of 200 km. The orbit radius was brought down in stages to a 50 × 50 km orbit on April 30, 2000, and decreased to 35 × 35 km on July 14, 2000. The orbit was raised over succeeding months to a 200 × 200 km orbit and then slowly decreased and altered to a 35 × 35 km retrograde orbit on December 13, 2000.

The mission ended with a touchdown in Eros's "saddle" region on February 12, 2001. Some scientists claim that the mission's ultimate goal was to link Eros, an asteroidal body, to meteorites recovered on Earth. With sufficient data on chemical composition, a causal link could be established between Eros and other S-type asteroids, and those meteorites believed to be pieces of S-type asteroids (perhaps Eros itself).

Once this connection is established, meteorite material can be studied with large, complex, and evolving equipment, and the results can be extrapolated to bodies in space. NEAR did not prove or disprove this link to the satisfaction of scientists. Between December 1999 and February 2001, NEAR used its gamma-ray spectrometer to detect gamma-ray bursts as part of the InterPlanetary Network.

After launching on a Delta 7925-8 (a Delta II launch vehicle with nine strap-on solid-rocket boosters and a Star 48 (PAM-D) third stage) on February 17, 1996, and exited from Earth orbit, NEAR entered the first part of its cruise phase. NEAR spent most of the cruise phase in a minimal activity "hibernation" state, which ended a few days before the flyby of the 61 km diameter asteroid 253 Mathilde.

On June 27, 1997, NEAR flew by Mathilde within 1200 km at 12:56 UT at 9.93 km/s, returning imaging and other instrument data. The flyby produced over 500 images, covering 60% of Mathilde's surface, as well as gravitational data allowing calculations of Mathilde's dimensions and mass. On July 3, 1997, NEAR executed the first major deep space maneuver, a two-part burn of the main 450 N thruster.

This decreased the velocity by 279 m/s and lowered perihelion from 0.99 AU to 0.95 AU.

The Earth gravity assist swingby occurred on January 23, 1998, at 7:23 UT. The closest approach was 540 km, altering the orbital inclination from 0.5 to 10.2 degrees and the aphelion distance from 2.17 to 1.77 AU, nearly matching those of Eros. Instrumentation was active at this time. The first of four scheduled rendezvous burns was attempted on December 20, 1998, at 22:00

UT. The burn sequence was initiated but immediately aborted.

The spacecraft subsequently entered safe mode and began tumbling.

The spacecraft's thrusters fired thousands of times during the anomaly, which expended 29 kg of propellant, reducing the program's propellant margin to zero. This anomaly almost resulted in the loss of the spacecraft due to a lack of solar orientation and subsequent battery drain. Contact between the spacecraft and mission control could not be established for over 24 hours.

The root cause of this incident has not been determined, but software and operational errors contributed to the severity of the anomaly.

The original mission plan called for the four burns to be followed by an orbit insertion burn on January 10, 1999, but the abort of the first burn and loss of communication made this impossible. A new plan was put into effect in which

NEAR flew by Eros on December 23, 1998, at 18:41:23 UT at a speed of 965 m/s and a distance of 3827 km from the center of mass of Eros.

The camera took images of Eros, data were collected by the near IR spectrograph, and radio tracking was performed during the flyby. A rendezvous maneuver was performed on January 3, 1999, involving a thruster burn to match NEAR's orbital speed to that of Eros. A hydrazine thruster burn took place on January 20 to fine-tune the trajectory. On August 12, a two-minute thruster burn slowed the spacecraft velocity relative to Eros to 300 km/h.

Orbital insertion around Eros occurred on February 14, 2000, at 15:33 UT (10:33 a.m. EST) after NEAR completed a 13-month heliocentric orbit which closely matched the orbit of Eros. A rendezvous maneuver was completed on February 3 at 17:00 UT, slowing the spacecraft from 19.3 to 8.1 m/s relative to Eros. Another maneuver took place on February 8, increasing the relative velocity slightly to 9.9 m/s.

Searches for satellites of Eros took place on January 28 and February 4, and 9; none were found.

The scans were for scientific purposes and to mitigate any possible collision with a satellite. NEAR went into a 321 × 366 km elliptical orbit around Eros on February 14. The orbit was slowly decreased to a 35 km circular polar orbit by July 14. NEAR remained in this orbit for ten days and then was backed out in stages to a 100 km circular orbit by September 5, 2000.

Maneuvers in mid-October led to a flyby of Eros within 5.3 km of the surface at 07:00 UT on October 26. Following the flyby, NEAR moved to a 200 km circular orbit and shifted the orbit from prograde near-polar to a retrograde near-

equatorial orbit. By December 13, 2000, the orbit was shifted back to a circular 35 km low orbit.

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ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.