NASA Technology Summary

National Aeronautics and
Space Administration

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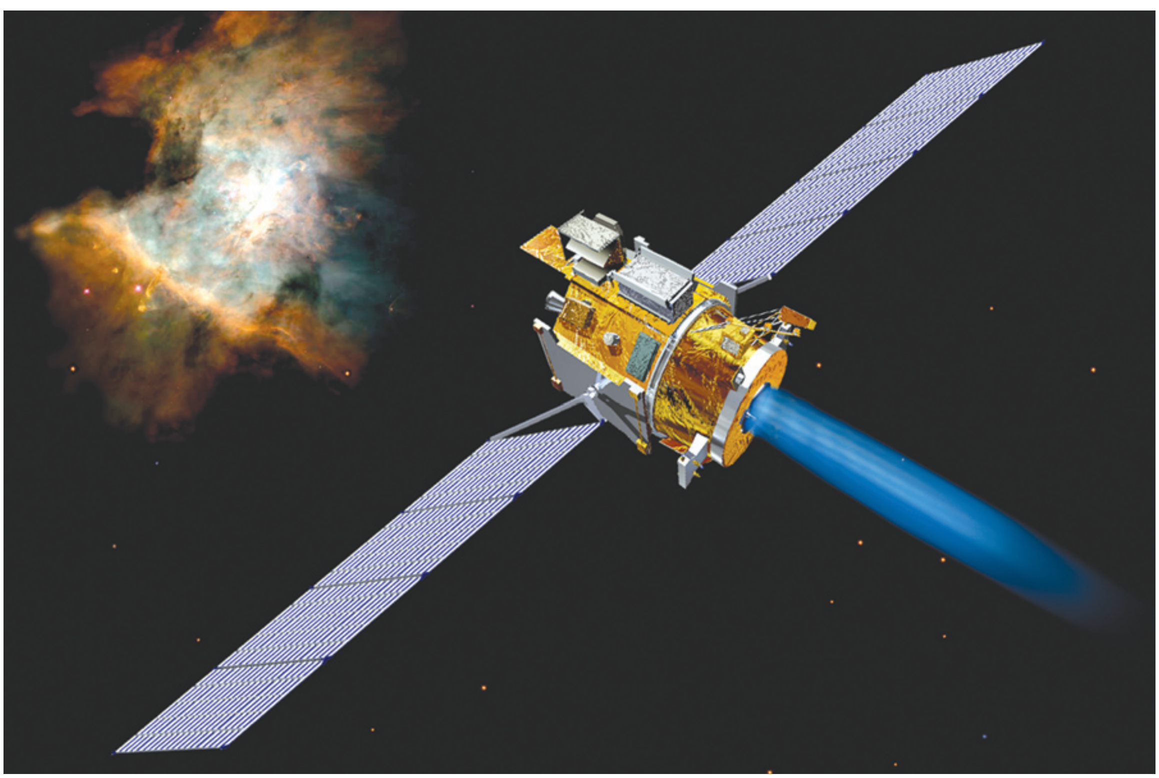
In-Space Propulsion

Ion Propulsion

Ion propulsion—a futuristic technology that for decades catapulted spacecraft through the pages of science fiction novels—is now a reality. An ion engine, developed by NASA and measuring just 12 inches (30 centimeters) in diameter, was the main propulsion source for Deep Space 1, a 20th Century spacecraft that completed—in December 2001 – its primary mission: to validate technologies for 21st century spacecraft.

An ion propulsion system converts spacecraft power into the kinetic energy of an ionized gas jet. As the ionized gas exits the spacecraft, it propels the craft in the opposite direction. An ion engine is fueled by xenon, a colorless, odorless, tasteless and chemically inert gas. The xenon fuel fills a chamber ringed with magnets. When the ion engine is running, electrons emitted from a cathode strike xenon atoms, knocking away an electron orbiting each atom's nucleus and turning it into an ion.

The spacecraft contains a pair of electrically charged metal grids. The force of the electric field generated by the grids exerts a strong, electrostatic pull on the xenon ions, much the way bits of lint are pulled to a pocket comb that has been given a static



electric charge by rubbing it on wool. The xenon ions shoot past the grids at speeds of more than 88,000 mph (146,000 kilometers), continuing out the back of the engine and into space. These exiting ions produce the thrust that propels the spacecraft.

Ion propulsion is 10 times more fuel efficient than on-board chemical propulsion systems. This greater efficiency means less propellant is needed for a mission. In turn, the spacecraft can be smaller and lighter, and launch costs lower.

Deep Space 1 carried 178 pounds (81 kilograms) of xenon propellant, capable of fueling engine operation at one-half throttle for more than 20 months. Ion propulsion increased the craft's speed by 7,900 mph (12,700 kilometers) over the course of the mission.

NASA has studied ion engines since the 1950s. Dr. Harold Kaufman, a technologist at NASA's Glenn Research Center (formerly Lewis Research Center) in Cleveland, Ohio, designed and built the first broad-beam electron-bombardment ion engine in 1959, using mercury as fuel. Suborbital ion engine tests were under way by the early 1960s.

In the early 1990s, NASA identified improved electric propulsion as an enabling in-space propulsion technology for future deep space missions. Glenn Research Center and the Jet Propulsion Laboratory in Pasadena, Calif., partnered on the NASA Solar Electric Power Technology Application Readiness project, or NSTAR. Its purpose: to develop a xenon-fueled ion propulsion system for deep space missions.

Ion engines with extended performance and higher-power, NSTAR-type engines—in the 10-kilowatt and 0.08 pound-thrust range—are candidates for propelling future spacecraft to visit Pluto, the moons of Jupiter and other large bodies in the outer solar system. Low-power (100 to 500 watt) systems also could be used to deliver miniaturized robot spacecraft to visit and study comets, asteroids and other smaller bodies. Laboratory tests to develop high- and low-power, light-weight ion propulsion system components and subsystems are now under way.

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For more information about the Deep Space 1 mission, visit:
http://nmp.jpl.nasa.gov/ds1/

For more information about ion propulsion and other in-space propulsion technology systems, visit:
http://www.nasa.gov
http://www.inspacepropulsion.com

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