NASA Technology Summary

National Aeronautics and
Space Administration

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## In-Space Propulsion

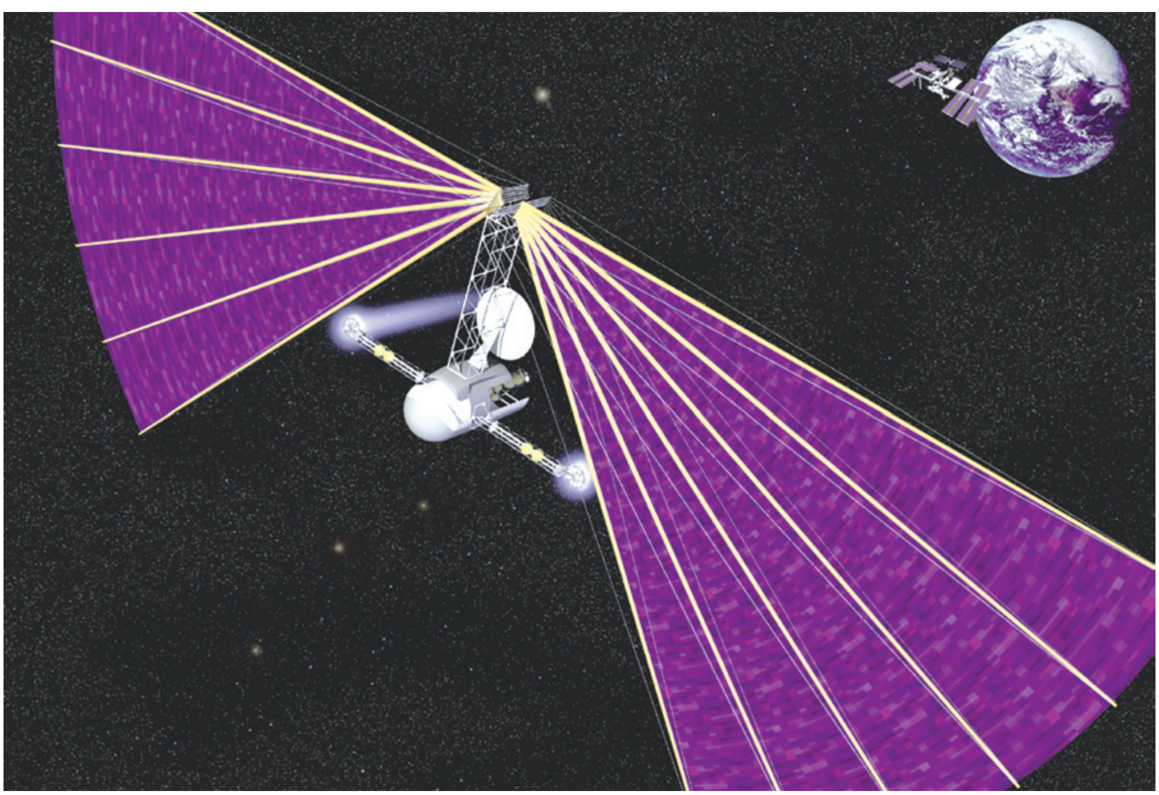
# Solar Electric Propulsion

In the early 1990s, NASA identified electric propulsion as a key in-space propulsion technology for possible future deep space missions and began developing and testing various electric propulsion technologies. Intended to reduce fuel mass, decrease travel times and permit larger payloads, electric propulsion technologies may be one of the keys to our continued exploration of Earth's neighboring worlds.

Electric propulsion technologies generate thrust via electrical energy derived from a solar source, such as solar arrays, which convert solar radiation to electrical power.

This energy is used to accelerate an on-board propellant by one of three processes:

- Electrostatic: accelerating a propellant by applying a force to a charged particle in an electric field
- Electromagnetic: using a current to induce a magnetic field to accelerate propellant
- Electrothermal: accelerating a propellant by electrically heating and expanding it through a nozzle



Among the more mature solar electric propulsion technologies typically considered for in-space use in Earth orbit and beyond are:

- Hall thrusters
- Ion thrusters
- Pulsed plasma thrusters
- Arcjet thrusters
- Resistojets

The NASA Solar Technology Application Readiness (NSTAR) thruster was the first ion thruster used for primary propulsion on Deep Space 1, NASA's successful ion propulsion demonstrator launched in October 1998. Deep Space 1 cruised the Solar System up to 158 million miles (254 million kilometers) from Earth, testing in-space hardware and electric propulsion capabilities. It encountered Comet Borrelly near the completion of its mission in December 2001.

Spacecraft powered by typical electric propulsion systems may eject propellant at up to 20 times the speed of conventional chemical systems, delivering a much higher specific impulse, or the amount of thrust obtained for the weight of fuel burned. Electric-based systems also require far less propellant mass than a state-of-art, chemical-propellant craft.

Another benefit of electric propulsion is that deep-space missions would no longer be constrained by narrow and rare launch window opportunities dictated by planetary alignment. Traditionally, chemical-propelled spacecraft move from planet to planet as they travel, using "gravity-assist" maneuvers in each world's orbit to increase their own velocity and "sling-shot" toward their final destination. A mission to Neptune or Pluto using electric propulsion, for example, could make straight for its intended target, rather than "touring" other planets to help boost its velocity as it travels.

NASA's Solar Electric Propulsion team includes researchers from Glenn Research Center in Cleveland; the Jet Propulsion Laboratory in Pasadena, Calif.; Marshall Space Flight Center in Huntsville, Ala.; and leading-edge partners in other government agencies, industry and academia. The Marshall Center implements the In-Space Propulsion Technology Program, which is managed by the Science Mission Directorate in Washington. NASA fuels discoveries that make the world smarter, healthier and safer.

For more information about NASA In-Space Propulsion Technology systems, visit:
**http://www.nasa.gov**
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