NASA Facts

National Aeronautics and
Space Administration

Marshall Space Flight Center
Huntsville, Alabama 35812

Opening the Space Frontier

In-Space Propulsion Technologies
Discovering our Solar System

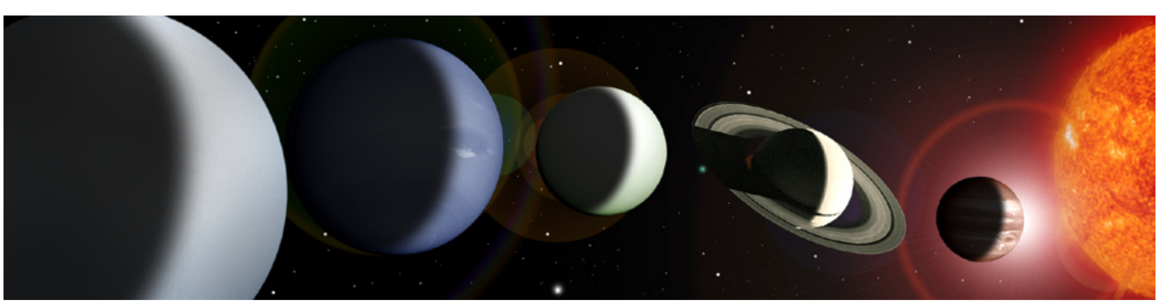
A key challenge facing NASA propulsion researchers is finding a faster and more efficient way of traveling in space. Current propulsion technologies often take years to accomplish deep-space missions—more than six years for NASA's Galileo probe, which launched in October 1989, to reach Jupiter to study the planet and its moons, and 12 years for Voyager 2, which launched in August 1977, to complete its fly by of Jupiter, Saturn, Uranus and Neptune. Today, however, NASA technologists are seeking new means to overcome these obstacles and improve scientific discovery at the destination.

The In-Space Propulsion Technology Program—managed by NASA's Science Mission Directorate in Washington and implemented by the In-Space Propulsion Technology Office at NASA's Marshall Space Flight Center in Huntsville, Ala.—currently is developing alternative propulsion technologies that one day will be used to carry scientific missions to any point in the Solar System—faster than ever before and with greater return on investment. NASA fuels discoveries that make the world smarter, healthier and safer.

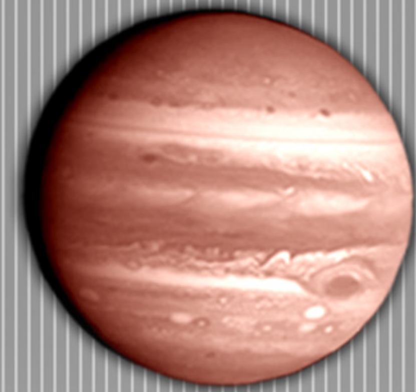
Partnering with researchers in academia, industry and government across America, the project office at the Marshall Center serves as a focal point for technology development and integration. The office is responsible for investigating and developing in-space propulsion technologies that can enable or benefit near-term and mid-term NASA science missions by significantly reducing cost and travel times, and increasing the amount of available capacity for payload.

Center partners include Ames Research Center in Moffett Field, Calif.; Glenn Research Center in Cleveland, Ohio; Jet Propulsion Laboratory in Pasadena, Calif.; Langley Research Center near Hampton, Va.; and White Sands Test Facility in Las Cruces, N.M.

The In-Space Propulsion Technology Program concentrates its efforts in five technology areas: aerocapture technology, next generation electric propulsion, solar sail propulsion, advanced chemical and solar thermal propulsion, and emerging propulsion technologies.



"I had the ambition to not only go farther than man had gone before, but to go as far as it was possible to go."
—Captain Cook (on his voyage to the Pacific in Endeavor.)



Jupiter

Distance from Earth
390.6 million miles
(628.7 million kilometers)

Temperature
Interior temps may reach 35,000 degrees Fahrenheit
(19,400 degrees Celsius)

Atmosphere
90 percent normal and liquid metallic hydrogen, 10 percent helium, with traces of methane, water and ammonia

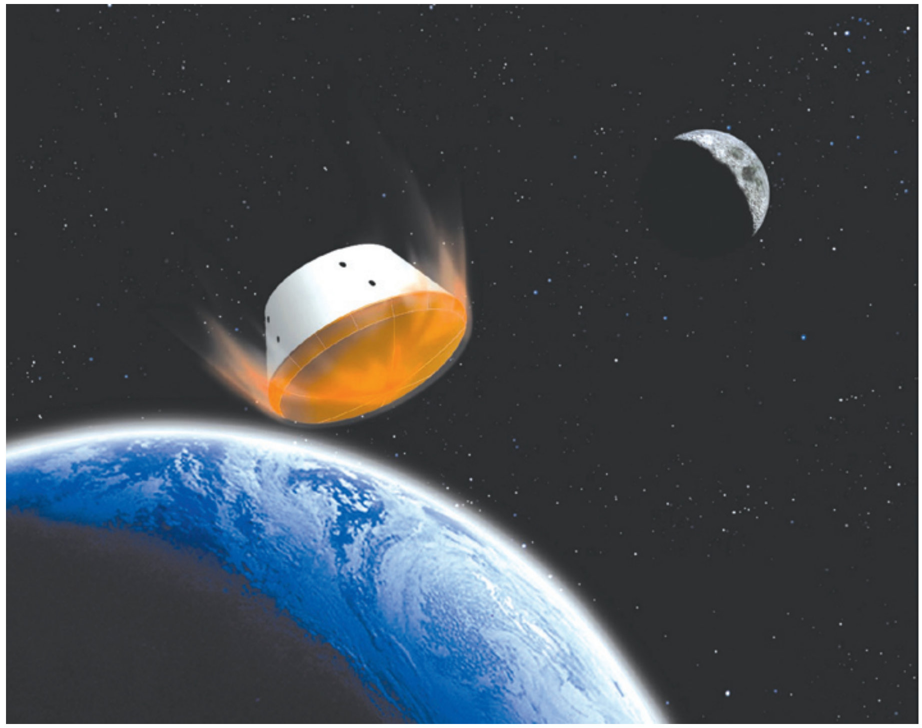
Geology
Gaseous materials density to an inner core 10-15 times the size of Earth

Moons
16 confirmed, 12 uncomfirmed

Rings
A single, faint ring similar to Saturn's in composition

Aerocapture Technology

Aerocapture is part of a family of "aeroassist" technologies under consideration to place spacecraft in long-duration, scientific orbits reducing the need for heavy onboard fuel loads, which historically have inhibited vehicle performance and available capacity for payloads.



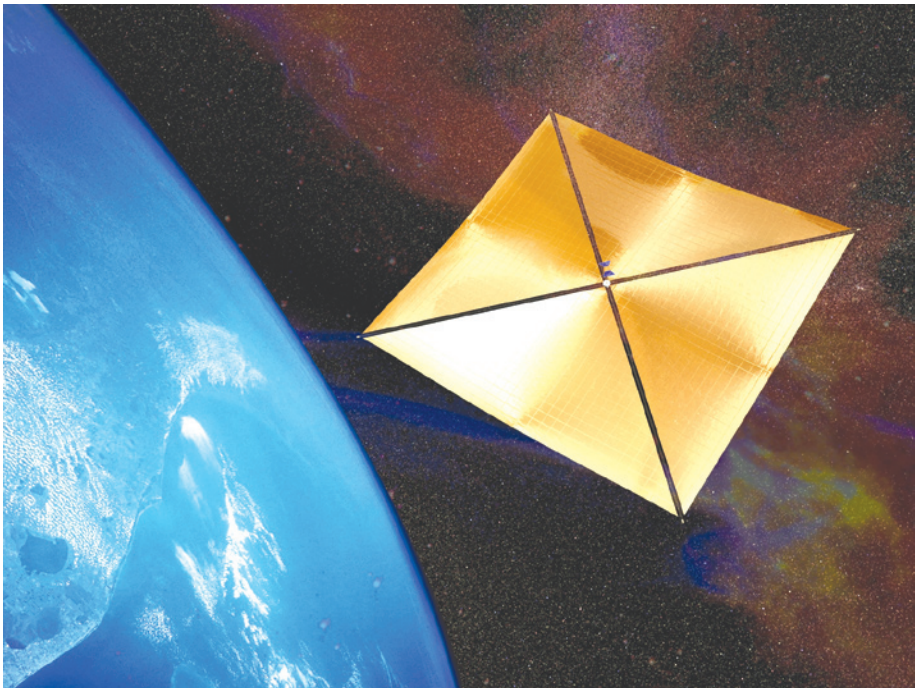
Aerocapture vehicle at Earth orbit

Aerocapture uses a planet's or moon's atmosphere to assist in decelerating an incoming spacecraft in order to accomplish a quick, near-propellantless orbital "capture," or placement of a space vehicle in its proper orbit. The atmosphere's density creates friction, acting as a natural brake to slow down a spacecraft and allowing the craft to enter an elliptical, or oval-shaped, orbit. Small onboard thrusters are then used to raise the craft into its final circular orbit.

This nearly fuel-free method of decelerating a space vehicle could reduce the typical mass of an interplanetary spacecraft by more than half, allowing for a smaller and less expensive launch vehicle, and enabling greater scientific return. The technology also could shorten trip times to outer planets in the Solar System, allow for long-duration orbits and support precise vehicle landings on planets millions of miles from Earth.

Solar Sail Propulsion

Solar sail propulsion uses an inexhaustible natural resource—the Sun—to propel a craft through space. Photons—sunlight—are reflected off giant, reflective sails made of thin, lightweight material. The sails harness the pressure exerted by the photons to provide thrust. This simple, innovative technology is a low-cost, propellantless alternative to conventional chemical rocket propulsion for some types of space missions.



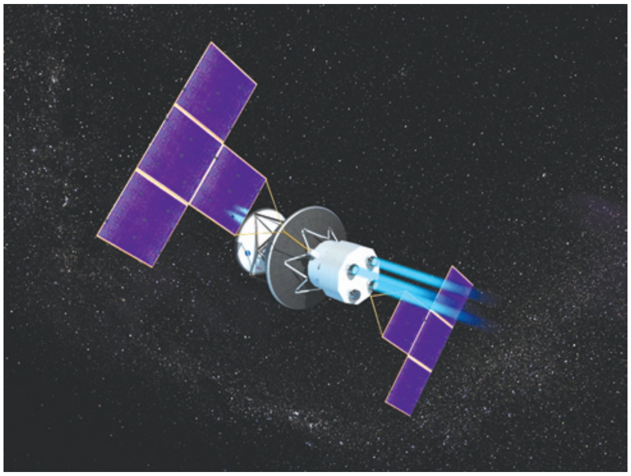
Solar Sail Propulsion at Earth orbit

Because the spacecraft directly uses the Sun's energy to travel through space, there is no engine and no need to carry primary propulsion fuel, thereby reducing payload mass while providing continuous thrust indefinitely. The technology also has no environmental impact on Earth because it obtains its propulsive power from the Sun after leaving the planet.

This propellantless propulsion technology could open up new regions of the Solar System for exploration and science. The technology could also extend the duration of some space missions.

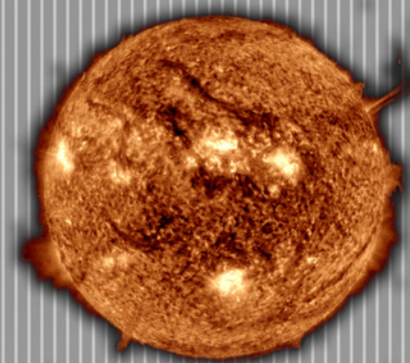
Next Generation Electric Propulsion

NASA's Next Generation Electric Propulsion technology area develops key propulsion elements for solar electric propulsion systems.



Artist's concept of spacecraft propelled by solar electric propulsion using next generation ion thrusters.

The solar electric propulsion systems under development use electrical energy from the Sun to ionize and electrostatically accelerate a propellant to produce thrust. A lightweight alternative to state-of-the-art chemical propulsion, a solar electric spacecraft generates low, sustained thrust for a longer period of time. One such technology NASA has proven in flight is ion propulsion, in which an ion thruster uses electrostatic energy. Ion propulsion powered the



Sun

Distance from Earth
93 million miles
(149.7 million kilometers)

Temperature
Core temperatures reach up to 27 million degrees Fahrenheit (15 million degrees Celsius)

Atmosphere
75 percent hydrogen, 25 percent helium, with 0.1 percent metals made from hydrogen via nuclear fusion; produces huge amounts of energy

Geology
Huge ball of hot gas and nuclear reactions; center of Solar System, where planets, moons, asteroids, comets, meteroids, and other rock and gas orbit

Moons
61

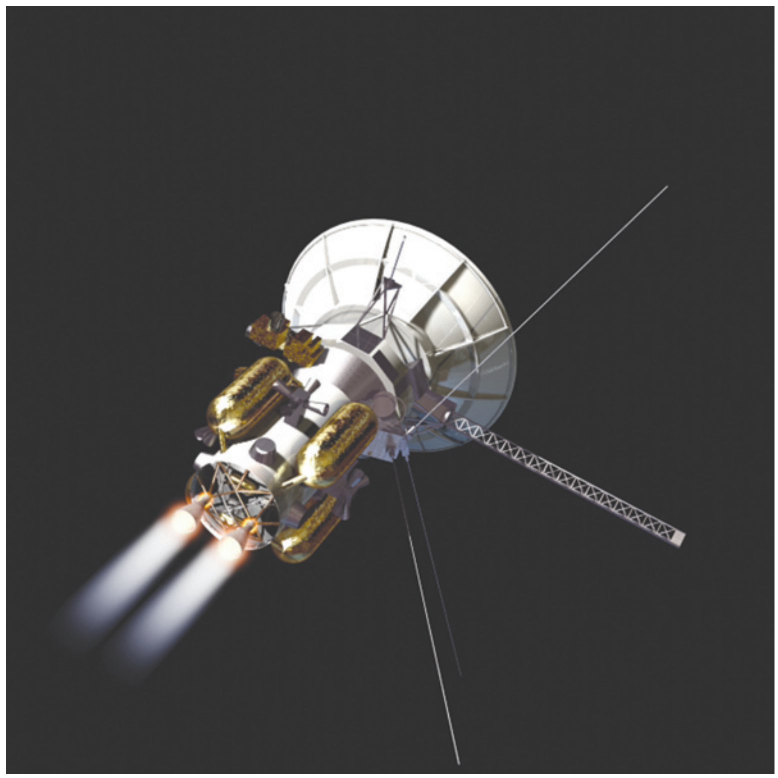
Rings
None

Deep Space 1 technology demonstrator, which flew by Comet Borrelly in September 2001. The mission was completed in December 2001.

Solar electric-powered spacecraft—less hampered by the mass limitations of conventional chemical systems—can travel faster, carry heavier payloads and accomplish broader mission objectives than traditional deep-space probes. Shorter trip times plus reduced spacecraft mass could mean lower operational costs and a less expensive launch vehicle.

Advanced Chemical & Solar Thermal Propulsion

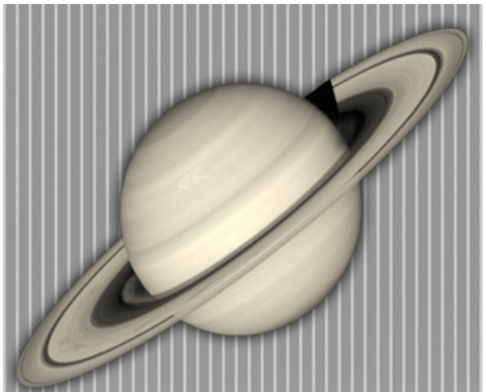
Advanced chemical propulsion technologies offer solutions for improving rocket propulsion for in-space applications. NASA researchers are investigating advanced reformulations of conventional chemical fuels and studying the combustion properties of new propellants to decrease propulsion system mass and increase payload mass.



Artist concept of spacecraft powered by advanced chemical propulsion

Advanced chemical propulsion technologies can provide near-term, cost-effective ways for future spacecraft to explore the space frontier. Advanced chemical systems could make use of new technology developments such as cryogenic propellant—extremely low-temperature propellant—for extended missions. They also could make use of lightweight storage components and deliver higher specific impulse, or total thrust achieved per amount of fuel burned, and ease the demands placed on aerobraking.

Advanced chemical propulsion is an attractive technology option for improved transportation of payloads in space because the systems generate a tremendous amount of thrust, necessary to overcome the gravitational effects of a planet or other satellite.



Saturn

Distance from Earth
795.2 million miles
(1.27 billion kilometers)

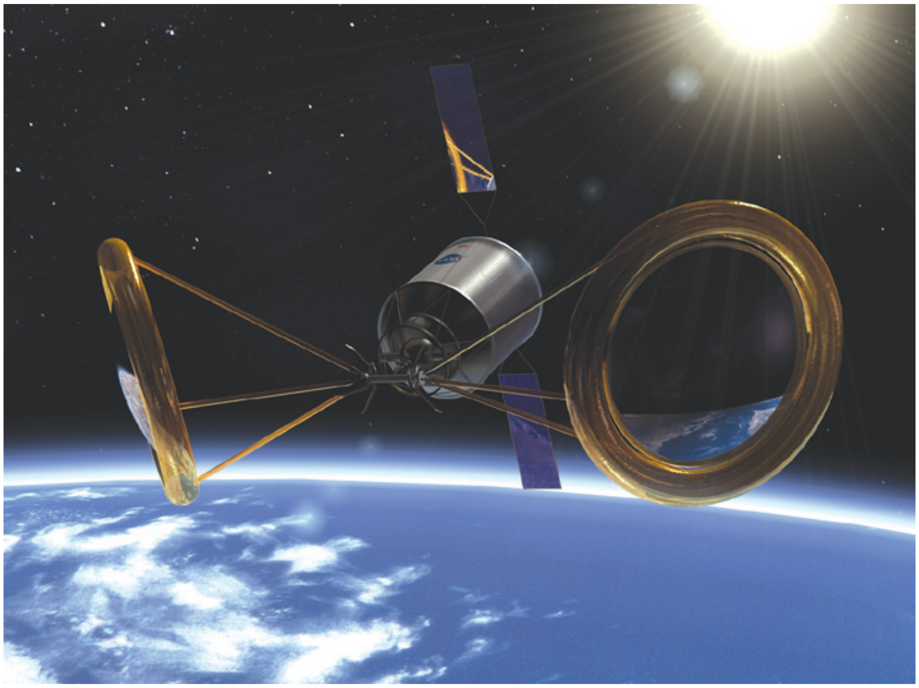
Temperature
Interior temps reach 21,000 degrees Fahrenheit (11,600 degrees Celsius)

Atmosphere
Approximately 75 percent hydrogen and 25 percent helium, with traces of water, methane and ammonia

Geology
Gaseous surface above liquid-metallic hydrogen layers, molecular hydrogen layers and a rocky core

Moons
18 confirmed, 12 unconfirmed

Rings
Trademark rings are composed of water, ice, and icy rock particles



Solar thermal propulsion at Earth orbit

Solar thermal propulsion provides a fuel-efficient, low-cost alternative to conventional chemical propulsion systems for some mission applications.

A solar thermal-powered spacecraft captures solar energy with inflatable concentrator mirrors that focus sunlight inside a high-temperature engine cavity to heat propellant. Because solar thermal propulsion requires only one propellant gas in combination with sunlight to boost a payload from a low orbit to a high one, the system increases payload space previously allocated to fuel storage.

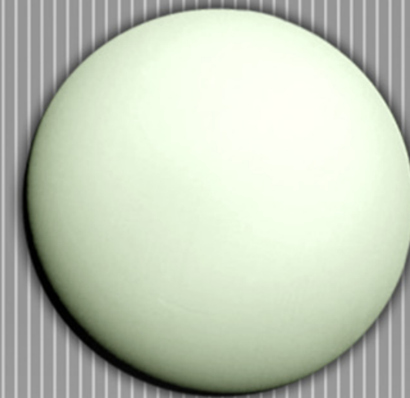
Solar Thermal Propulsion systems are candidates for interplanetary travel—inner Solar System missions from the Sun to Mars—and automated exploration.

Emerging Propulsion Technologies

The In-Space Propulsion Technology Program actively identifies and evaluates innovative candidate technologies for development. These innovative concepts under research are the responsibility of the Emerging Propulsion Technologies project area. Ultra-light solar sails and pulsed plasma thrusters are some of the many possible concepts that fall into this technology area. One technology presently being investigated utilizes a very long cable, or tether, in space.

Tether technology promises to be a propellantless propulsion system that could dramatically reduce the cost of raising and maintaining the orbits of spacecrafts, including those destined for deep space.

The Momentum-eXchange/Electrodynamic Reboost tether or MXER tether may be a viable alternative to conventional chemical propulsion (upper stages). MXER could provide a reusable in-space infrastructure for high-thrust and high-efficiency spacecraft propulsion.



Uranus

Distance from Earth
1.69 billion miles
(2.72 billion kilometers)

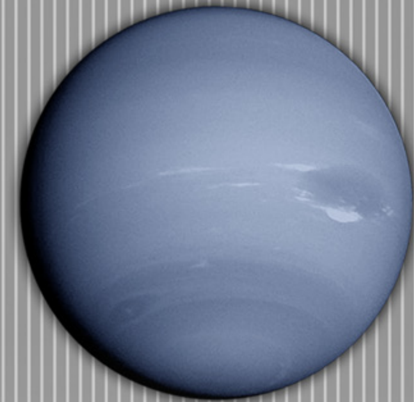
Temperature
-350 degrees Fahrenheit
(-212 degrees Celsius)

Atmosphere
83 percent hydrogen, 15 percent helium, 2 percent methane

Geology
Primarily rock and ice; helium/hydrogen core

Moons
21

Rings
11 faint rings



Neptune

Distance from Earth
2.71 billion miles
(4.35 billion kilometers)

Temperature
-350 degrees Fahrenheit
(-212 degrees Celsius)

Atmosphere
Hydrogen, helium and methane levels similar to Uranus; fastest atmospheric winds in the solar system, exceeding 1,500 mph (2,414 kilometers per hour)

Geology
Gaseous outer surface; core of rock, ice and liquid hydrogen

Moons
8

Rings
Four faint, dark rings

Proposed tether technology at Earth orbit

A MXER tether system is an innovative combination of technologies designed to help propel satellites from Low Earth orbit to higher energy orbits, such as to the Moon, Mars and beyond. The system consists of a long, strong cable -- approximately 100 to 150 kilometers long (62 to 93 miles) -- rotating in an elliptical orbit around Earth. Like a catapult, one end of the tether catches payloads in low Earth orbit. As it rotates, the tether accelerates the payloads to higher velocities and then throws them into higher-energy orbits.

Once the payload is released, the momentum given to it from the tether is restored using electrodynamic forces to push against the Earth's magnetic field. By using solar power to drive ionospheric current through the tether and create thrust, the tether can reboost itself, or increase its energy and raise its orbit, without using propellant.

More about In-Space Propulsion

"There is nothing so far removed from us to be beyond our reach, or so far hidden that we cannot discover it." — Rene Descartes

The mission of NASA's In-Space Propulsion Technology Program and the technologies being researched and developed under its charter is threefold: to enable science at new destinations; to significantly reduce the time and cost required for spacecraft to reach their destinations; and to allow mission planners to shift their focus from the difficulty of the journey to the science challenges at the destination.

All these technologies play a part in the efforts of the In-Space Program to develop advanced propulsion systems that will revolutionize NASA's interplanetary science mission goals.

Research in these technology areas is being done by the In-Space Propulsion Technology Program, which is managed by NASA's Science Mission Directorate in Washington and implemented by the In-Space Propulsion Technology Office at the Marshall Space Flight Center in Huntsville, Ala. The program's objective is to develop in-space propulsion technologies that can enable or benefit near and mid-term NASA space science missions by significantly reducing cost, mass and travel times.

To find out more about the planned missions of NASA's Science Mission Directorate and the Marshall Center's In-Space Propulsion Technology Office, visit:

http://www.nasa.gov
http://www.inspacepropulsion.com

Marshall Space Flight Center Media Relations Department
http://www.msfc.nasa.gov/news

Pluto

Distance from Earth
3.58 billion miles

Temperature
-373 degrees Fahrenheit

Atmosphere
Indications of heavy nitrogen, with some carbon monoxide and methane; entire atmosphere may freeze solid except when closest to Sun

Geology
Studies suggest 70 percent rock, 30 percent water ice containing nitrogen, methane, ethane, and carbon monoxide

Moons
1 (Charon)

Rings
Note: For 20 years out of every 240, Pluto's orbit brings it closer to the Sun than Neptune. This phenomenon last occurred between February 1979 and February 1999. It will start again in 2219.

Explore. Discover. Understand.

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