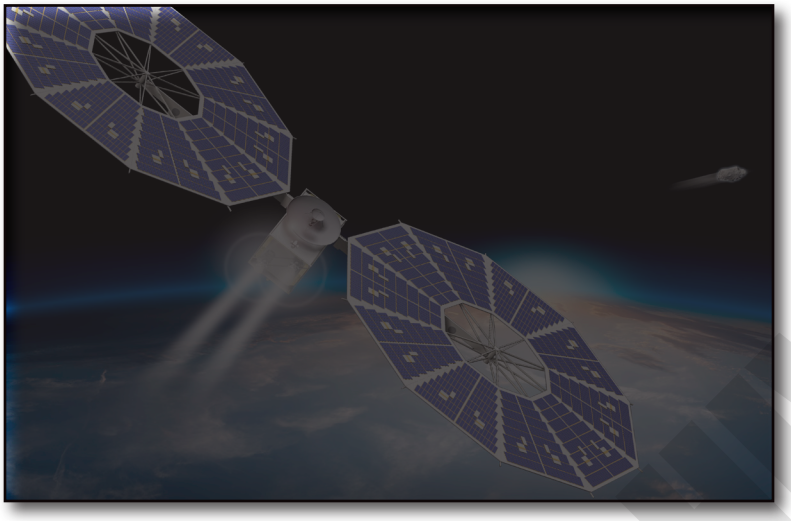
National Aeronautics and
Space Administration

Solar Arrays + Electric Thrusters = More Efficient Space Travel

NASA's Solar Electric Propulsion (SEP) Project is developing critical technologies to enable trips to Mars and asteroids. SEP technologies can also provide commercial benefits.



Artist's concept for an SEP spacecraft.

The Challenge

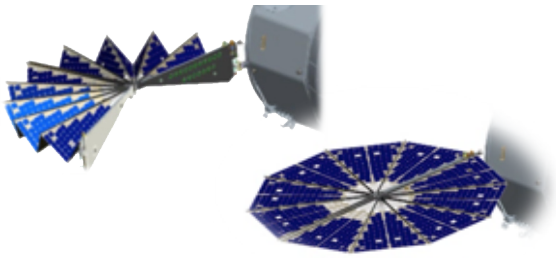
NASA needs to reduce the cost of ambitious exploration missions, and high-power, high-efficiency SEP systems require much less propellant. Our new system, which will use xenon propellant energized by the electric power from solar arrays, will use 10 times less propellant than a chemical propulsion system like the engine on the space shuttles.

- We are developing large solar arrays and high-power thrusters for an SEP system that will fly in space. Compared with current systems, at launch it will weigh 2 times less and use 4 times less storage for the electricity produced, and it will be able to withstand 4 times more radiation.
- Because the spacecraft will weigh much less at launch, fewer heavy launch vehicles will be needed for missions to Mars or near-Earth asteroids, and each launch vehicle will be able to carry more supplies or science instruments. Billions of dollars could be saved.
- The system's 30- to 50-kilowatt (kW) power level will significantly increase SEP capabilities and will make a range of new missions possible.

Large, Flexible Solar Arrays

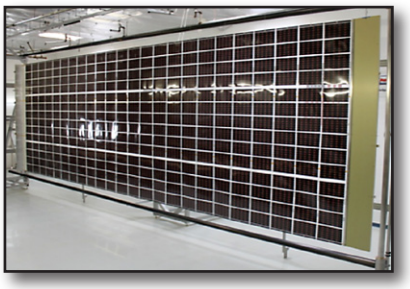
SEP solar arrays must stow into very small, lightweight packages for launch and then unfurl to cover a very large area to capture enough solar energy to produce high levels of electrical power. They also need to be durable so that they can operate for a long time in places like low Earth orbit and the Van Allen radiation belts.

We are building and testing two solar arrays: one that folds out like a fan and one that rolls out like a carpet. Both use lightweight structures and flexible blanket technology.



Above: "MegaFlex" foldout solar array during deployment (left) and fully extended (right). Courtesy ATK Space Systems, Inc.

Below: "Mega-ROSA" rollout solar array shown stowed (left) and fully extended (right). Courtesy Deployable Space Systems, Inc.



game changing development

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Hall Thrusters

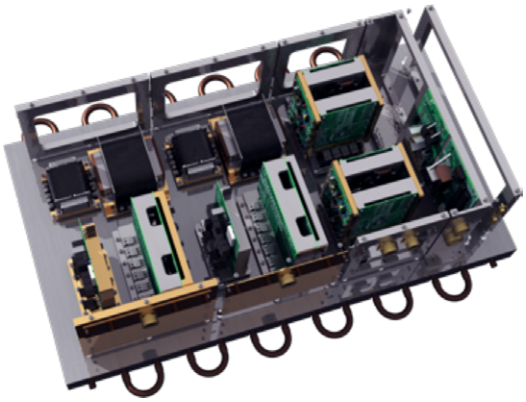
SEP uses electrostatic Hall thrusters instead of a rocket engine with chemical propellant (like liquid hydrogen and oxygen). A Hall thruster uses electricity from solar arrays to emit electrons from an external cathode. Those electrons create ions as they collide with an inert gas like xenon. An electric field accelerates the positively charged ions into an exhaust plume of plasma that races out the back of the thruster and pushes the spacecraft forward. Hall thrusters can rapidly accelerate xenon ions to over 65,000 miles per hour!

Our goal is to develop a 15-kW Hall thruster: 3 times more powerful than current thrusters. Two or three of these thrusters will propel NASA's 30- to 50-kW SEP spacecraft. To achieve this goal, we will use advanced magnetic shielding for the thruster, develop design codes and conduct tests to verify the system's lifetime, and use a long-life, centrally mounted cathode to improve operation.

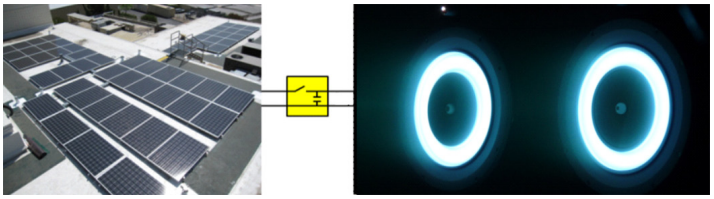
Results from advanced diagnostic tests will guide design and development.

Power Processing

For SEP to work, the electricity from the solar arrays must be conditioned (or adjusted) so that it can be used by the thrusters. We are investigating two new systems for this. They promise to operate at higher temperatures (reducing cooling needs), be more resistant to damage from space radiation, and make high-power electric propulsion systems significantly lighter and less expensive.



Concept for power conditioning.



Rooftop solar arrays feed Hall thrusters at NASA's Jet Propulsion Laboratory Direct Drive Test Bed.

Technology Demonstration Mission

NASA will fly an SEP spacecraft to eliminate risks that cannot be addressed with Earth-based tests. Our goal for the mission is to demonstrate SEP for a high-energy orbit-transfer mission (moving the spacecraft from one orbit to another) that would normally use chemical propulsion.

Future Missions

Future missions could include (1) a robotic SEP spacecraft to redirect an asteroid into lunar orbit for human exploration; (2) a science mission to study how long-duration trips to the Moon and between the Moon and Earth affect living cells; (3) a commercial spacecraft for servicing, repositioning, or extending the lives of communications satellites; and (4) cost-effective robotic and piloted missions to Mars and many other places. Because the thrust levels can be varied as needed, SEP spacecraft will have multiple options in hazardous situations, will be able to reach several destinations in one trip, and will have more launch windows available.

The work on this ambitious project is being conducted under the leadership of the Space Technology Mission Directorate's (STMD) Game Changing Development (GCD) Program. After the technologies have been matured to a sufficient level, GCD's sister organization within STMD, the Technology Demonstration Missions (TDM) Program, will conduct a system-level demonstration.

For more information about GCD, please visit
http://gameon.nasa.gov/
For more information about TDM, please visit
http://www.nasa.gov/mission_pages/tdm/main/

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