# NASA Seeks Industry's Concepts for Solar Electric Propulsion for Deep Space Exploration Mission-2 near the moon

NASA is leading the next steps into deep space near the moon, where astronauts will build and begin testing the systems needed for challenging missions to deep space destinations including Mars. The area of space near the moon offers a true deep space environment to gain experience for human missions that push farther into the solar system, access the lunar surface for robotic missions but with the ability to return to Earth if needed in days rather than weeks or months.

The agency published a Request For Information (RFI) July 17 to capture the U.S. industry's current capabilities and plans for spacecraft concepts that potentially could be advanced to provide power and advanced solar electric propulsion (SEP) to NASA's deep space gateway concept. Solar electric propulsion typically refers to the combination of solar cells and ion drive for propelling a spacecraft through outer space. This technology has been studied by NASA and is considered promising. The main concept is a nexus of Solar panels on spacecraft and ion thruster.

NASA is examining a lunar-orbiting, crew-tended spaceport concept that would serve as a gateway to deep space. In addition to the power propulsion element, the gateway would include a habitat to extend Orion crew time, a docking capability, and would be serviceable by logistics modules to enable research and replenishment for deep space transport infrastructure.

NASA is in the early stages of acquisition planning with the goal of developing a flight unit payload to launch on the agency's second integrated mission of the Space Launch System rocket and Orion spacecraft.

"Through the RFI, we hope to better understand industry's current state-of-the-art and potential future capabilities for deep space power and propulsion," said Michele Gates, director of the Power Propulsion Element at NASA Headquarters in Washington. "With the upcoming BAA, we will fund industry-led studies to identify the most urgent areas for focus over the next several years, for the benefit of human spaceflight, as well as commercial applications."

One of the Technology Area (TA) of NASA's Mars roadmaps is In-Space Propulsion Technologies that addresses the development of higher-power electric propulsion, nuclear thermal propulsion, and cryogenic chemical propulsion. Improvements derived from technology candidates within this TA will decrease transit times, increase payload mass, provide safer spacecraft, and decrease costs.

## Deep Space Gateway and Deep Space Transport

Under a program dubbed Deep Space Gateway, agency officials said they still plan to use the lunar orbit as a staging platform to build and test the infrastructure and the systems needed to send astronauts to Mars. But instead of breaking off a chunk of asteroid and dragging it to the moon, NASA's new plan calls for building an orbiting spaceport that could have even more uses.

The second phase of missions will confirm that the agency's capabilities built for humans can perform long duration

missions beyond the moon. For those destinations farther into the solar system, including Mars, NASA envisions a deep space transport spacecraft.

This spacecraft would be a reusable vehicle that uses electric and chemical propulsion and would be specifically designed for crewed missions to destinations such as Mars. The transport would take crew out to their destination, return them back to the gateway, where it can be serviced and sent out again. The transport would take full advantage of the large volumes and mass that can be launched by the SLS rocket, as well as advanced exploration technologies being developed now and demonstrated on the ground and aboard the International Space Station.

## NASA to fly ion thruster on Mars orbiter

An ion thruster is a form of electric propulsion used for spacecraft propulsion. It creates thrust by accelerating ions with electricity. As the ionised particles escape from the aircraft, they generate a force moving in the other direction. Power supplies for ion thrusters are usually electric solar panels, but at sufficiently large distances from the sun, nuclear power is used.

Michael Patterson, senior technologist for NASA's In-Space Propulsion Technologies Program compared ion and chemical propulsion with "Tortoise and the Hare". "The hare is a chemical propulsion system and a mission where you might fire the main engine for 30 minutes or an hour and then for most of the mission you coast." "With electric propulsion, it's like the tortoise, in that you go very slow in the initial spacecraft velocity but you continuously thrust over a very long duration – many thousands of hours – and then the

spacecraft ends up picking up a very large delta to velocity.”

The NASA Glenn Research Center has been a leader in ion propulsion technology development since the late 1950s, the NASA Solar Technology Application Readiness (NSTAR) ion propulsion system enabled the Deep Space 1 mission, the first spacecraft propelled primarily by ion propulsion, to travel over 163 million miles and make flybys of the asteroid Braille and the comet Borelly.

NASA Glenn recently awarded a contract to Aerojet Rocketdyne to fabricate two NEXT flight systems (thrusters and power processors) for use on a future NASA science mission. In addition to flying the NEXT system on NASA science missions, NASA plans to take the NEXT technology to higher power and thrust-to-power so that it can be used for a broad range of commercial, NASA, and defense applications.

## NASA Works to Improve Solar Electric Propulsion for Deep Space Exploration

NASA has selected Aerojet Rocketdyne, Inc. of Redmond, Washington, to design and develop an advanced electric propulsion system that will significantly advance the nation’s commercial space capabilities, and enable deep space exploration missions, including the robotic portion of NASA’s Asteroid Redirect Mission (ARM) and its Journey to Mars.

“Through this contract, NASA will be developing advanced electric propulsion elements for initial spaceflight applications, which will pave the way for an advanced solar

electric propulsion demonstration mission by the end of the decade," said Steve Jurczyk, associate administrator of NASA's Space Technology Mission Directorate (STMD) in Washington. "Development of this technology will advance our future in-space transportation capability for a variety of NASA deep space human and robotic exploration missions, as well as private commercial space missions."

Aerojet Rocketdyne will oversee the development and delivery of an integrated electric propulsion system consisting of a thruster, power processing unit (PPU), low-pressure xenon flow controller, and electrical harness. NASA has developed and tested a prototype thruster and PPU that the company can use as a reference design.

The company will construct, test and deliver an engineering development unit for testing and evaluation in preparation for producing the follow-on flight units. During the option period of the contract, if exercised, the company will develop, verify and deliver four integrated flight units – the electric propulsion units that will fly in space. The work being performed under this contract will be led by a team of NASA Glenn Research Center engineers, with additional technical support by Jet Propulsion Laboratory (JPL) engineers.

The first operational test of an electric propulsion system in space was Glenn's Space Electric Rocket Test 1, which flew on July 20, 1964. Since then, NASA has increasingly relied on solar electric propulsion for long-duration, deep-space robotic science and exploration missions to multiple destinations, the most recent being NASA's Dawn mission. The Dawn mission, managed by JPL, surveyed the giant asteroid Vesta and the protoplanet, Ceres, between 2011 and 2015.

The advanced electric propulsion system is the next step in NASA’s Solar Electric Propulsion (SEP) project, which is developing critical technologies to extend the range and capabilities of ambitious new science and exploration missions. ARM, NASA’s mission to capture an asteroid boulder and place it in orbit around the moon in the mid-2020s, will test the largest and most advanced SEP system ever utilized for space missions.

## NASA’s First Launch of SLS and Orion

NASA is hard at work building the Orion spacecraft, Space Launch System (SLS) rocket and the ground systems needed to send astronauts into deep space. The agency is developing the core capabilities needed to enable the journey to Mars.

Orion’s first flight atop the SLS will not have humans aboard, but it paves the way for future missions with astronauts. During this flight, currently designated Exploration Mission-1 (EM-1), the spacecraft will travel thousands of miles beyond the moon over the course of about a three-week mission. It will launch on the most powerful rocket in the world and fly farther than any spacecraft built for humans has ever flown. Orion will stay in space longer than any ship for astronauts has done without docking to a space station and return home faster and hotter than ever before.

This first exploration mission will allow NASA to use the lunar vicinity as a proving ground to test technologies farther from Earth, and demonstrate it can get to a stable orbit in the area of space near the moon in order to support sending humans to deep space, including for the Asteroid Redirect Mission. NASA and its partners will use this proving ground to practice deep-space operations with decreasing

reliance on the Earth and gaining the experience and systems necessary to make the journey to Mars a reality.

## Request for Information (RFI)

The Power and Propulsion Element (PPE) is the first planned element in the Deep Space Gateway (DSG) concept and would launch as a co-manifested payload with the Orion crewed vehicle on the Space Launch System (SLS) on Exploration Mission-2.

This NextSTEP Appendix C, targeted for release in the August 2017 timeframe, will seek proposals for areas necessitating further study for this specific application of advanced solar electric propulsion (SEP). Studies are anticipated to be brief (3-4 month duration) with succinct products to assist in the development of the PPE concept and approach.

Studies intend to address key drivers for PPE development such as but not limited to potential approaches to: meeting the intent of human rating requirements; concept and layout development; attitude control; propulsive maneuverability; power generation; power interface standards; power transfer to other Gateway Elements; hosting multiple International Docking System Standard (IDSS) compatible docking systems; batteries/eclipse duration; 15 year lifetime; communications; avionics, assembly integration and test approaches; extensibility; accommodations of potential (international or domestic partner provided) hardware such as robotic fixtures, science and technology utilization and other possible elements; and options for cost share/cost contributions.

NASA may also request assessment of impact of acquiring high power, high throughput SEP strings as part of the commercial bus, rather than through a Government Furnished Equipment

route.

## PPE Reference Capability Descriptions

- The PPE will have a minimum operational lifetime of 15 years in cis-lunar space.
- The PPE will be capable of transferring up to 24kW of electrical power to the external hardware.
- The PPE will be capable of providing orbit transfers for a stack of TBD mass with a center of gravity of TBD.
- The PPE will be capable of providing orbit maintenance for a stack of TBD mass with a center of gravity of TBD.
- The PPE will have 2,000 kg-class tank Xenon capacity
- The PPE will be compatible with the SLS vehicle co-manifested launch loads on the Exploration Mission -2 (EM-2) flight.

### References and resources also include:


https://www.nasa.gov/press-release/nasa-works-to-improve-solar-electric-propulsion-for-deep-space-exploration

https://www.nasa.gov/feature/nasa-power-propulsion-rfi

https://www.fbo.gov/index?tab=documents&tabmode=form&subtab=core&tabid=5b75177986f2eee65643cc9068919a35

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