NASA SBIR 2017 Phase I Solicitation

S3.02 Propulsion Systems for Robotic Science Missions

Lead Center: GRC

Participating Center(s): JPL, MSFC

Technology Area: TA2 In-Space Propulsion Technologies

The Science Mission Directorate (SMD) needs spacecraft with more demanding propulsive performance and flexibility for more ambitious missions requiring high duty cycles, more challenging environmental conditions, and extended operation. Planetary spacecraft need the ability to rendezvous with, orbit, and conduct in-situ exploration of planets, moons, and other small bodies in the solar system (http://solarsystem.nasa.gov/multimedia/download-detail.cfm?DL_ID=742). Future spacecraft and constellations of spacecraft will have high-precision propulsion requirements, usually in volume- and power-limited envelopes. Also recently precise propulsion systems have been incorporated into disturbance reduction systems to demonstrate that a solid body can float freely in space completely undisturbed in order to explore the gravitational universe. However, technology limits to propulsion system life still exist which can ultimately limit mission duration for more ambitious follow-on formation flying applications.

This subtopic seeks innovations to meet SMD propulsion in chemical and electric propulsion systems related to sample return missions to Mars, small bodies (like asteroids, comets, and Near-Earth Objects), outer planet moons, and Venus. Additional electric propulsion technology innovations are also sought to enable low cost systems for Discovery class missions, and low-power, nuclear electric propulsion (NEP) missions. Roadmaps for propulsion technologies can be found from the National Research Council (http://www.nap.edu/openbook.php?record_id=13354&page=168) and NASA's Office of the Chief Technologist (http://www.nasa.gov/pdf/501329main_TA02-InSpaceProp-DRAFT-Nov2010-A.pdf).

Proposals should show an understanding of the state of the art, how their technology is superior, and of one or more relevant science needs. The proposals should provide a feasible plan to fully develop a technology and infuse it into a NASA program. In addressing technology requirements, proposers should identify potential mission applications and quantify the expected advancement over state-of-the-art alternatives.

Advanced Electric Propulsion Components

Towards that end, this solicitation seeks to mature and demonstrate iodine electric propulsion technologies. Iodine propellant has two key advantages over the state-of-the-art (SOA) xenon propellant: (i) increased storage density and (ii) reduced storage pressure. These key advantages permit iodine propulsion systems with conformal storage tanks, reduced structural mass, and reduced volume compared with the SOA xenon, while retaining similar thrust, specific impulse, and thruster efficiency.

This subtopic seeks proposals that mature iodine propulsion technologies, including:

- Iodine compatible Hall Effect Thruster cathodes with lifetimes greater than 10,000 hours.
- Robust and electrically efficient iodine storage and delivery system architectures (scalable 5 kg to 100 kg iodine):
    - Numerical modeling to guide system design and CONOPS, predicting power consumption, iodine mobility, thermal transport, sublimation rate, condensation, clogging, recovery time post-anomalies, etc.
    - Design and analysis of innovative iodine feed system architectures.
    - Experimental demonstration of promising feed system architectures under conditions of long-term iodine storage and dynamic thermal environments.
- Compact low-power iodine compatible feed system technologies, including high accuracy pressure sensors (<1 atm full scale), propellant flow control valves, latch valves, heaters, etc.
    - Feed system technologies utilizing innovative iodine resistant materials and coating.
    - Experimental and numerical demonstration of component operation in dynamic simulated mission environments.

This subtopic also seeks proposals that explore uses of technologies that will provide superior performance in for high specific impulse/low mass electric propulsion systems at low cost. These technologies include:

- Thruster components including, but not limited to, advanced cathodes, rf devices, advanced grids, lower-cost components enabled by novel manufacturing techniques.
- Any long-life, electric propulsion technology between 1 to 10 kW/thruster that would enable a low-power nuclear electric propulsion system based on a kilopower nuclear reactor.

Secondary Payload Propulsion

The secondary payload market shows significant promise to enable low cost science missions. Launch vehicle providers, like SLS, are considering a large number of secondary payload opportunities. The majority of these satellite missions flown are often selected for concept or component demonstration activities as the primary objectives. Opportunities are anticipated to select future satellite missions based on application goals (i.e., science return). However, several technology limitations prevent high value science from low-cost spacecraft, such as post deployment propulsion capabilities, Additionally, propulsion systems often place constraints on handling, storage, operations, etc. that may limit secondary payload consideration. It is desired to have a wide range of Delta-V capability to provide 100-1000s of m/s.

Specifically, proposals are sought for:

- Chemical and/or electric propulsion systems with green/non-toxic propellants.

- Improved operational life over SOA propulsion systems.

In addressing technology requirements, proposers should identify potential mission applications and quantify the expected advancement over state-of-the-art alternatives.

Solar/Electric Sail Propulsion

This subtopic seeks sail propulsion innovations in three areas for future robotic science and exploration missions:

- Large solar sail propulsion systems with at least 1000 square meters of deployed surface area for small (<150 kg) spacecraft to enable multiple Heliophysics missions of interest.
- Electric sail propulsion systems capable of achieving at least 1 mm/sec2 characteristic acceleration to support Heliophysics missions of interest and rapid outer solar system exploration.
- Electrodynamic tether/sail propulsion systems capable generating from the Lorentz Force delta-V sufficient to de-orbit from altitudes up to 2,000 km and to maintain a small (< 500 kg) spacecraft in LEO at altitudes up to 400 km for 5 years enabling Earth ionospheric and plasmasphere investigations.

Design solutions must demonstrate high deployment reliability and predictability with minimum mass and launch volume and maximum strength, stiffness, stability, and durability.

Innovations are sought in the following areas:

- Novel design, packaging, and deployment concepts.
- Lightweight, compact components including booms, substrates, and mechanisms.
- Validated modeling, analysis, and simulation techniques.
- Ground and in-space test methods.
- High-fidelity, functioning laboratory models.

Note: Cubesat propulsion technologies have been moved to a new STMD subtopic: Z8.01 - Small Spacecraft Propulsion Systems.