



## NASA SBIR 2016 Phase I Solicitation

### H2.03 High Power Electric Propulsion

Lead Center: GRC

Participating Center(s): JPL, MSFC

The goal of this subtopic is to develop innovative, high-power (>100-kW) electric propulsion systems. High-power solar or nuclear electric propulsion may enable dramatic mass and cost savings for lunar and Mars cargo missions, including Earth escape and near-Earth space maneuvers, at power levels that enable a wide range of exploration missions. Innovations and advancements leading to improvements in the end-to-end performance of high power electric propulsion systems are of interest. Methods are sought to increase overall system efficiency; improve system and/or component life or durability; reduce system and/or component mass, complexity, and development issues; or provide other definable benefits. In general, thruster systems providing total impulse values greater than  $10^7$  N-sec are desired. Specific impulse values of interest range from a minimum of 1500-sec for Earth-orbit transfers to over 6000-sec for planetary missions.

Advanced high-power concepts that provide quantifiable benefits over state-of-the-art electric propulsion systems are to be developed. Key figures of merit include: thrust density (to decrease thruster footprint), thruster efficiency (>60%), lifetime (>10's khrs), reliability, and scalability. A practical and affordable method of performing relevant ground testing should be discussed, taking into account the pumping capabilities of state-of-the-art vacuum facilities. The proposed propulsion system should be mindful of the development of an efficient, low specific mass power processing unit, with an emphasis on reducing complexity and cost. Specific technologies of interest include but are not limited to:

- Nesting/clustering moderately powered thrusters to reach a desired total throughput: This component development can include: an assessment of system performance and plasma plume interactions, a thermal characterization of the system, and an assessment of the system lifetime during multi-thruster operation. The impact of multi-thruster operation on the power processing unit and feed system performance should also be addressed.
- High-current electromagnetic accelerators that directly addresses thruster efficiency and lifetime. This component development can include an investigation of electrode geometries, thermal management designs, and material selection to mitigate electrode erosion, the major lifetime limiter. Innovative, high efficiency power processor architectures/convertors for high-amperage thrusters that can be evolved into space flight hardware and survive thermal and radiation environments are desired.
- Scalable, high-perveance gridded ion engines with thrust densities that significantly exceed the current state-of-the-art ( $\sim 3$  N/m<sup>2</sup> for the NEXT ion engine). This component development can include the development of novel designs of the discharge chamber and ion optics for maximizing anode current and beam extraction capability, respectively.
- Long-life hollow cathode technologies for use with high-power electrostatic engines. The cathodes should be tested in a relevant environment (e.g., comparable magnetic field environment) and provide sufficient current densities for high-power thruster operation.
- Components for inductively pulsed plasma thrusters, in particular highly accurate flow controllers and fast

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acting valves; and solid state switches capable of high current (MA), high repetition rate (up to 1-kHz), long life (? 10<sup>9</sup> pulses) operation. High-voltage converters for pulsed power applications with a high-efficiency, low-complexity architecture that can be evolved into space flight hardware and survive thermal and radiation environments are desired.

- Advanced manufacturing methods for the fabrication of high power thruster components and associated systems; of particular interest is additive manufacturing for complex geometries, which may include: ceramic insulators, ion optics, and magnetic poles. Figures of merit include lower cost, rapid turnaround, and material and structural integrity comparable to or better than components or systems produced using current fabrication methods.

Proposals addressing advanced technology concepts should include a realistic and well-defined roadmap defining critical technology development milestones leading to an eventual flight system. Sub-scale, proof-of-concept experiments are highly desired for the Phase I effort. In addressing technology requirements, proposers should identify candidate thruster systems and potential mission applications that would benefit from the proposed technology.