NASA SBIR 2011 Phase I Solicitation

X2 Propulsion

Human Exploration requires advances in propulsion for transport to the moon, Mars, and beyond. A major thrust of this research and development activity will be related to space launch and in-space propulsion technologies. These efforts will include earth-to-orbit propulsion, in-space chemical propulsion, in-space nuclear propulsion, and in-space electric propulsion development and demonstrations. NASA is interested in making propulsion systems more capable and less expensive. NASA is interested in technologies for advanced in-space propulsion systems to support exploration, reduce travel time, reduce acquisition costs, and reduce operational costs.

Subtopics

X2.01 Low Cost Heavy Lift Propulsion

Lead Center: MSFC

Participating Center(s): GRC, KSC

Heavy lift launch vehicles envisioned for exploration beyond LEO will require large first stage propulsion systems. Total thrust at lift-off in will probably exceed 6 million pounds. There are available, in-production, practical propulsion options for such a vehicle. However, the cost for outfitting the booster with the required propulsion systems is in the hundreds of millions of dollars (2011 $). This cost severely limits what missions NASA can perform. Low cost design concepts and manufacturing techniques are needed to make future exploration affordable.

Objectives include:

Development of propulsion concepts whose cost is less than 50% of currently available heavy-lift propulsion options but with similar performance (i.e., reduced parts count, increased robustness to allow less expensive manufacturing techniques, less complex parts to maximize vendor competition, maximization of common parts, etc.) - both solid and liquid options are desired.

Development and demonstration of low-cost manufacturing techniques (i.e., use of rapid prototype techniques for metallic parts, application of nano-technology for manufacturing of near net shape manufacturing, etc.).

X2.02 High Thrust In-Space Propulsion

Lead Center: GRC

Participating Center(s): JSC, MSFC

This solicitation intends to examine a range of key technology options associated with cryogenic, non-toxic storable, and solid core nuclear thermal propulsion (NTP) systems for use in future exploration missions. Non-toxic engine technology, including new mono and bi-propellants, is desired for use in lieu of the currently operational NTO/MMH engine technology. Handling and safety concerns with toxic chemical propellants can lead to more costly propulsion systems. For future short round trip missions to Mars, NTP systems using nuclear fission reactors may be enabling by helping to reduce launch mass to reasonable values and by also increasing the payload delivered for Mars exploration missions. Non-toxic and cryogenic engine technologies could range from pump fed or pressure fed reaction control engines of 25-1000 lbf up to 60,000 lbf primary propulsion engines. Pump fed NTP engines in the 15,000-25,000 lbf class, used individually or in clusters, would be used for primary propulsion.

Specific technologies of interest to meet proposed engine requirements include:

- Non-toxic bipropellant or monopropellants that meet performance targets (as indicated by high specific impulse and high specific impulse density) while improving safety and reducing handling operations as compared to current state-of-the-art storable propellants.
- High temperature, low burn-up carbide- and ceramic-metallic (cermet)-based nuclear fuels with improved coatings and /or claddings to maximize hydrogen propellant heating and to reduce fission product gas release into the engine's hydrogen exhaust stream.
- Low-mass propellant injectors that provide stable, uniform combustion over a wide range of propellant inlet temperature and pressure conditions.
- High temperature materials, coatings and/or ablatives or injectors, combustion chambers, nozzles, and nozzle extensions.
- High temperature and cryogenic radiation tolerant instrumentation and avionics for engine health monitoring. Non-invasive designs for measuring neutron flux (outside of reactor), chamber temperature, operating pressure, and liquid hydrogen propellant flow rates over wide range of temperatures are desired. Sensors need to operate for months/years instead of hours.
- Combustion chamber thermal control technologies such as regenerative, transpiration, swirl or other cooling methods, which offer improved performance and adequate chamber life.
- Long life, lightweight, reliable turbopump designs and technologies include seals, bearing and fluid system components. Hydrogen technologies are of particular interest.
- Highly-reliable, long-life, fast-acting propellant valves that tolerate long duration space mission environments with reduced volume, mass, and power requirements is also desirable.

- Radiation tolerant materials compatible with above engine subsystem applications and operating environments.

Note to Proposer: Subtopic S3.04 under the Science Mission Directorate also addresses in-space propulsion. Proposals more aligned with science mission requirements should be proposed in S3.04.

X2.03 Electric Propulsion Systems

Lead Center: GRC

Participating Center(s): JPL, MSFC

The goal of this subtopic is to develop innovative technologies for high-power (100 kW to MW-class) electric propulsion systems. High-power (high-thrust) electric propulsion may enable dramatic mass and cost savings for lunar and Mars cargo missions, including Earth escape and near-Earth space maneuvers. At very high power levels, electric propulsion may enable piloted exploration missions as well. Improved performance of propulsion systems that are integrated with associated power and thermal management systems and that exhibit minimal adverse spacecraft-thruster interaction effects are of interest. Innovations are sought that increase system efficiency, increase system and/or component life, increase system and/or component durability, reduce system and/or component mass, reduce system complexity, reduce development issues, or provide other definable benefits. Desired specific impulses range from a value of 2000 s for Earth-orbit transfers to over 6000 s for planetary missions. System efficiencies in excess of 50% and system lifetimes of at least 5 years (total impulse > 1 x 107 N-sec) are desired. Specific technologies of interest in addressing these challenges include:

- Long-life, high-current cathodes (100,000 hours).
- Electric propulsion designs employing alternate fuels (ISRU, more storable).
- Electrode thermal management technologies.
- Innovative plasma neutralization concepts.
- Metal propellant management systems and components, and cathodes.
- Low-mass, high-efficiency power electronics for RF and DC discharges.
- Lightweight, low-cost, high-efficiency power processing units (PPUs).
- PPUs that accept variable input voltages of greater than 200V and vary by a factor of 2-to-1.
- Direct drive power processing units.
- Low-voltage, high-temperature wire for electromagnets.
- High-temperature permanent magnets and/or electromagnets.
- Application of advanced materials for electrodes and wiring.

- Highly accurate propellant control devices/schemes.
- Miniature propellant flow meters.
- Lightweight, long-life storage systems for krypton and/or hydrogen.
- Fast-acting, very long-life valves and switches for pulsed inductive thrusters.
- Superconducting magnets.
- Lightweight thrust vector control for high-power thrusters.
- Fast-starting cathodes.
- Propellantless cathodes.
- High temperature electronics for power processing units.

Note to Proposer: Subtopic S3.04 under the Science Mission Directorate also addresses in-space propulsion. Proposals more aligned with science mission requirements should be proposed in S3.04.