NASA SBIR 2016 Phase I Solicitation

H2.01 LOX/Methane In-Space Propulsion

Lead Center: GRC

Participating Center(s): JSC, MSFC

NASA is developing high thrust in-space chemical propulsion capabilities to enable human and robotic missions into the proving ground (Mars and beyond). Successful proposals are sought for focused investments on key technologies and design concepts that may transform the path for future exploration of Mars, while providing component and system-level cost and mass savings. In-space propulsion is defined as the development and demonstration of technologies for ascent, orbit transfer, pulsing attitude/reaction control (RCS), and descent engines.

The goal of this subtopic is to examine novel technology options that include the use of additive manufacturing or other low cost processes which save mass and/or cost compared to current state-of-the-art (SOA) technologies and fabrication methods. Technologies of interest for operation with liquid oxygen and methane specifically are sought.

Proposers shall show how their technology works and provide the following:

- Assessment of SOA with the key performance parameters (KPP) of their choosing (such as performance, mass, response time, etc.), including specifics which may be referenced in backup material - provide SOA for each major technology element in the proposal.
- Address the outstanding technology performance being promised and the degree to which the concept is new, different, and important. Particularly how the technology and/or fabrication technique proposed saves cost and/or mass is desired.
- Provide quantitative assertions (e.g., x% improvement of y, z kg of mass savings, xx% in cost savings, etc.) to the advancement over the SOA.

Phase I Deliverables - Research to identify and evaluate candidate technology applications to demonstrate the technical feasibility and show a path towards a demonstration. Bench or lab-level demonstrations are desirable. The technology concept at the end of Phase I should be at a TRL of 4 to 5.

Phase II Deliverables - Emphasis should be placed on developing and demonstrating the technology under simulated mission conditions. The proposal shall outline a path showing how the technology could be developed into mission-worthy systems. The contract should deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract. The technology concept at the end of Phase II should be at a TRL of 5 to 6.

For reference, current anticipated performance goals for liquid oxygen/liquid methane systems are:

- Reaction control thruster development in the 100-800 lbf thrust class. The reaction control engines would operate cryogenic liquid-liquid for applications requiring integration with main engine propellants; or would operate gas-gas or gas-liquid for small total impulse type applications. RCEs operating on liquid cryogenic propellant(s) should be able to tolerate operation for limited duty cycles with gaseous or saturated propellants of varying quality. Integrated RCS (IRCS) capability desired (common propellant tanks for RCS and main engines).
- Descent pump-fed engine development with 50,000 lbf thrust and a minimum vacuum specific impulse of 360-sec. The propulsion system should be capable of stable throttling to 5:1 (20% power). Space survival time of greater than 3 years.
- Ascent pump-fed engine development with 25,000 lbf thrust and a minimum vacuum specific impulse of 360-sec. The propulsion system should be capable of stable throttling to 5:1 (20% power). Space survival time of greater than 4 years.
- Integrated Propulsion and Feed System technologies, such as for integrated reaction control systems (RCS). This would include thermal conditioning features, self-pressurization/re-pressurization control, and system isolation control.

For reference, some specific propulsion technologies of interest are included below. In all cases – interest in using additive manufacturing or novel fabrication methods to save cost and mass are desired to achieve the specific component objectives identified below:

- Injector concepts with throttle range greater than 4:1 while maintaining stable combustion over the range of operation and inlet conditions and meeting performance goals at full throttle condition.
- Regenerative cooled combustion chamber technologies which offer improved performance, especially at sub-critical or trans-critical conditions, and provide adequate chamber life. This includes methods for addressing differential boiling within regenerative channels and/or start up transients (gas/gas, to two-phase, to high-quality liquid/liquid) for both fuel and oxidizer circuits.
- Turbopump technologies specific to liquid methane that are lightweight with a long shelf life that can meet deep-throttle requirements, including small durable high speed turbines, high speed lightweight electric direct current (DC) motor driven pumps, high fatigue life impellers, zero net positive suction head (NPSH) inducers, low leakage seals, and long life in-situ propellant fed bearings.
- Engine valves with a focus on light-weight (at the system level, considering supporting pneumatics, batteries, etc.), fast-acting, low-leakage throttle valves, which meet the following performance considerations: Maintain consistent mixture ratio (MR) over the throttle range, 50% (minimum) force margin, cold and warm operations, easily chilled in, with leakage in the 10^{-4} to 10^{-6} standard cubic centimeters per second (SCCS) range (gaseous phase oxygen and methane).