X9.03  Cryogenic and Non-Toxic Storable Propellant Space Engines

This solicitation intends to examine a range of key technology options associated with cryogenic and non-toxic storable propellant space engines. Non-toxic engine technology is desired for use in lieu of the toxic but currently operational nitrogen tetroxide and monomethylhydrazine engine technology. Safety concerns with toxic propellants drive mission planners to the use of more costly propulsion modules that are fueled and sealed on the ground. There are also concerns with exhaust residue from toxic systems, which may be carried into habitats for lunar and Mars systems.

The primary mission will be to support lunar ascent/descent reaction control engines and lunar ascent engines. These engines can be compatible with the future use of in situ propellants such as oxygen, methane, and methanol. Key performance parameters:

- Reaction control thruster development is in the 100-500-lbf thrust class with a target vacuum specific impulse of 325-sec. These RCS engines would operate cryogenic liquid-liquid for applications requiring integration with main engine propellants; or would operate gas-gas or gas-storable liquid for small total impulse type applications.

- Ascent engine development is projected to be in the 3,500-6,000-lbf thrust class with a target vacuum specific impulse of 355-sec. The engine shall achieve 90% rated thrust within 0.5 second of the issuance of the Engine ON Command.

Specific technologies of interest to meet proposed engine requirements include:
• Low-mass propellant injectors that provide stable, uniform combustion over a wide range of propellant inlet conditions;

• Combustion chamber designs using high temperature materials, coatings and/or ablatives for combustion chambers, nozzles and nozzle extensions;

• Combustion chamber thermal control technologies such as regenerative, transpiration, swirl or other cooling methods which offer improved performance and adequate chamber life;

• Highly-reliable, long-life, fast-acting cryogenic valves that tolerate high thermal loading due to heat soak-back in low-thrust, pulsing propulsion systems (Thermal Isolation less than 1 Btu/hr) with reduced volume and size is also desirable;

• Highly-reliable, long-life, fast-acting propellant valves for gaseous propellants with reduced power, volume and size.

A key risk related to the use of cryogenic and gaseous propellants such as oxygen and methane are the ability to reliably ignite the propellants in a timely manner. This is of particular importance on ascent engines during abort operations. Recently NASA has been conducting a number of investigations into the ignition characteristics for oxygen and methane, primarily for spark torch systems. NASA continues to be interested in new and innovative methods which may be used as primary or back-up systems. Proposals are also solicited for igniter exciter technologies. In particular, for reaction control systems involving multiple engines that are not all co-located, issues between distributed vs. centralized exciter architectures must be balanced when selecting an exciter design. A "distributed" system refers to an integral exciter at each spark plug, whereas a "centralized" arrangement has at least some exciter components (e.g., DC-DC converter, control electronics, etc.) remotely located (e.g., with other avionics) and shared by multiple engines/spark plugs. Specific technologies of interest include:

• Reliable ignition systems such as spark torch, catalytic, microwave, combustion wave, laser, etc.;

• Exciters to support either capacitive (CDI) or inductive (IDI) discharge ignition types;

• High cycle spark plugs for use with cryogenic and/or gaseous propellants;

• Cryogenic instrumentation such as pressure and temperature sensors that will operate for months/years instead of hours.