X10.02 Critical Technologies for In-Space Application of Nuclear Thermal Propulsion

Lead Center: GRC

Participating Center(s): MSFC, SSC

NASA is interested in the development of critical technologies for first in-space applications of solid core nuclear thermal propulsion (NTP) systems for use in a variety of future exploration missions. For short, round trip, human missions to Mars, NTP systems may be enabling. It can potentially also help reduce launch mass or increase payload delivery for cargo and crewed missions to the Moon and other destinations. The first anticipated in-space application of solid core NTP systems could occur in the time frame of 2025 to 2030 and could be based on a high-thrust/high-Isp (~850 - 950s) NTP system that uses a fission reactor with U-235 fuel as its source of thermal energy. During the short primary propulsion maneuvers of a typical conceptual mission, large quantities of thermal power (100s of MWt) would be produced within the NTP system and removed using LH₂ propellant that is pumped through the engine's reactor core. The superheated hydrogen gas is then exhausted out the engine's nozzle to generate thrust. Recent NASA studies have shown that small engines (~15-25 klbf), used individually or in clusters, could support a broad range of mission types. Representative ranges of engine performance include: 1) hydrogen exhaust temperatures ~2500-2900 K; 2) propellant flow rates ~7-13 kg/s; 3) chamber pressures ~500 -1500 psi ; and 4) nozzle expansion area ratio ~200:1-500:1.

Proposals are sought to further improve safety, performance, reliability, and life factors as well as reduce projected weight and costs for the first in-space NTP systems, subsystems, and components beyond that in previously achieved ground test systems. Proposals are solicited in the following key technology/concept areas:

- High temperature, radiation tolerant instrumentation and avionics for engine health monitoring. Non-invasive designs for measuring neutron flux (outside of reactor), chamber temperature, operating pressure, and H₂ propellant flow rates over wide range of temperatures are desired;
- Long-life, lightweight, reliable hydrogen turbopump designs and technologies;
- Lightweight, long-life, high heat flux thrust chambers, regenerative-cooled nozzles and radiation-cooled skirt extensions that are compatible with hot hydrogen;
- Radiation tolerant materials compatible with above engine subsystem applications and operating environments;
- High temperature, low-to-moderate burn-up carbon- and ceramic-metallic (cermet)-based nuclear fuels for
use in NTR and BNTR engines;

- Improved chemical vapor deposition (CVD)/coating techniques for heritage "Rover/NERVA" type carbon-based fuels that reduce and/or prevent cracking, fuel element erosion via H₂ attack, and release of fission product gases into the engine’s H₂ exhaust stream;

- Mass-optimum neutron and gamma radiation shielding materials and designs that minimize exposure/damage to key engine components and subsystems (e.g., LH₂ turbopumps) and provide radiation protection for the crew; and

- Dual-use shielding materials and designs that also provide habitat protection against galactic cosmic rays and solar flares are also encouraged.

Note that any associated NTP simplified test approaches, power systems, and thermal management/heat rejection systems technologies should be submitted to subtopic areas X10.01, X10.03, and X10.04, respectively.