NASA SBIR 2014 Phase I Solicitation

H2.04 Nuclear Thermal Propulsion (NTP) Ground Test Technologies

Lead Center: SSC

Participating Center(s): MSFC

A nuclear rocket engine uses a nuclear reactor to heat hydrogen to very high temperatures, which expands through a nozzle to generate thrust. This topic area seeks to develop advanced technology components and system level ground test systems that support Nuclear Thermal Propulsion (NTP) technology development and certification.

Solid core NTP has been identified as an advanced propulsion concept which could provide the fastest trip times with fewer SLS launches than other propulsion concepts for human missions to Mars over a variety of mission years. The current NASA Strategic Space Technology Investment Plan states NTP is a high priority technology needed for future human exploration of Mars. The NTP concept is similar to a liquid chemical propulsion system, except instead of combustion in the thrust chamber, a monopropellant is heated with a fission reactor (heat exchanger) in the thrust chamber. In addition, the engine components and surrounding structures are exposed to a radiation environment formed by the reactor during operation. The NTP had ground testing done between 1955-1973 as part of the Rover and Nuclear Engine for Rocket Vehicle Application (NERVA) programs. The Rover/NERVA ground tested a variety of engine sizes, for a variety of burn durations and start-ups. These ground tests were mostly exhausted in the open air. Information on the NERVA program can be found at (http://history.nasa.gov/SP-4533/Plum%20Brook%20Complete.pdf).

Current regulations require exhaust filtering of any radioactive noble gases and particulates released to stay within the current environmental regulations. The NTP ground testing requires the development of robust materials, advanced instruments and monitoring systems capable of operating in extreme temperature, pressure and radiation environments. This topic area will investigate large scale engine exhaust scrubber technologies and options for integrating it to the NTP engine for ground tests. The NTP engines are pump fed ~15,000-35,000 lbf with a specific impulse goal of 900 seconds (using hydrogen). The NTP primary test requirements can have multiple start-ups (>8) with the longest single burn time ~50 minutes.

This subtopic seeks innovative technologies in the following areas to facilitate NTP ground testing:

- Advanced high-temperature and hydrogen embrittlement resistant materials for use in a hot hydrogen environment (<4400 °F).
- Efficient non-nuclear generation of high temperature, high flowrate hydrogen (<60 lb/sec).
- Devices for measurement of radiation, pressure, temperature and strain in a high temperature and radiation environment.
- Effluent scrubber technologies for efficient filtering and management of high temperature, high flow hydrogen exhausts.
- Innovative refractory materials which use nano-particle additives and/or unconventional non-cement based refractories that can withstand the extreme plume heating environments experienced during rocket propulsion testing.

Specific interests include:

- Filtering of radioactive particles and debris from exhaust stream having an efficiency rating greater than 99.9%.
- Removal of radioactive halogens, noble gases and vapor phase contaminants from a high flow exhaust stream with an efficiency rating greater than 99.5%.
- Applicable Integrated System Health Monitoring and autonomous test operations control systems.
- Modern robotics which can be used to inspect the ground test system exposed to a radiation environment.

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I and show a path towards Phase II hardware/software demonstration with delivery of a demonstration unit or software package for NASA testing at the completion of the Phase II contract.

Phase I Deliverables - Feasibility study, including simulations and measurements, proving the proposed approach to develop a given product (TRL 2-3). Verification matrix of measurements to be performed at the end of Phase II, along with specific quantitative pass-fail ranges for each quantity listed.

Phase II Deliverables - Working engineering model of proposed product, along with full report of component and/or breadboard validation measurements, including populated verification matrix from Phase I (TRL 4-5). Opportunities and plans should also be identified and summarized for potential commercialization.