NASA SBIR 2008 Phase I Solicitation

X7.01 Cryogenic Storage for Space Exploration Applications

Lead Center: ARC

Participating Center(s): GRC, GSFC, KSC, MSFC

This subtopic includes technologies for long-term cryogenic propellant storage applications in-space, on the lunar surface, and on the Earth. These technologies will impact cryogenic systems for space transportation orbit transfer vehicles, space power systems, spaceports, spacesuits, lunar habitation systems, robotics, in situ propellant systems, and launch site ground operations. Each of these applications has unique performance requirements that need to be met. Innovative concepts are requested for cryogenic insulation systems, fluid system components, and cryogenic conditioning systems.

Long term storage (14 days) of LO_2/ LH_2 cryogenic propellants in low-gravity with minimal propellant loss is required to support space transportation orbit transfer vehicles. The Earth Departure Stage (EDS) and the Altair (Lunar Lander) descent stage require LH_2 and LO_2 storage durations of 14 days in Low Earth Orbit (LEO). Long-term storage (224 days) of LO_2/ LCH_4 cryogenic propellants in low-gravity and reduced gravity with minimal propellant loss is required to support space transportation orbit transfer vehicles. The Altair (Lunar Lander) ascent stage requires LO_2 and LCH_4 storage durations of up to 14 days in LEO and up to an additional 210 days on the lunar surface. Long term storage (224 days) of LO_2 cryogenic propellant on the lunar surface and liquefaction of resource with minimal propellant loss is required to support space power systems, spaceports, spacesuits, lunar habitation systems, robotics, in situ propellant systems. Long term storage (6 months) of LO_2/ LH_2/ LCH_4 cryogenic propellants in 1-g on the surface of the Earth with minimal propellant loss is required to support launch site ground operations. Passive and active thermal control, and pressure control/ thermodynamic venting technologies are sought after.

In-space Storage and Lunar Surface Storage

Passive thermal control serves to limit the heat leak into the cryogenic storage system (LH_2 loss 2 loss 4 loss

Active thermal control combines the passive thermal control technology element with active refrigeration (cryocoolers) to allow storage periods from a few months to years with reduced boil-off losses (LH_2 loss 2 loss 2) cryocoolers of sufficient cooling capacity (20 watts) to eliminate LH_2 boil-off do not exist, and thus the development of 20K cryocoolers is a long-lead technology item. State-of-the-art cryocoolers in the 80K range (LO_2/LCH_4 temperatures) have been developed for cooling sensors and have flown on numerous satellites. However, the integration of these cryocoolers into an active thermal control system for propellant storage of LO_2 and LH_2 is a technology issue. Active thermal control development needs include: flight-type 20K, 20 watt capacity cryocoolers designed for integration into space-based LH_2 storage systems, integrated refrigeration and storage systems, innovative heat exchanger concepts, flight cryocooler to propellant tank integration techniques for large space-based storage systems, distributed cooling shields integrated with MLI, circulator development, development and testing of active cooling techniques for tank penetrations and supports is required.

Pressure control utilizes thermodynamic venting in low-gravity or direct venting in partial gravity to enable selective venting of vapor if necessary (ratio of kilograms of TVS mass per watt of heat removal from $LH_2$2 4 2, LO_2 and LCH_4 to determine the effect of internal tank hardware configuration on fluid mixing.

Earth-based Storage

Passive and active thermal control serves to limit the heat leak into the cryogenic storage system and eliminate cryogen boil-off, but not limited by mass or reliability typically associated with flight systems (LH_2 loss 2 loss 4 loss