NASA SBIR 2007 Phase I Solicitation

X9.02  Cryogenic Propellant Mass Gauging and Liquid Acquisition for Low Gravity Applications

Lead Center: GRC
Participating Center(s): MSFC

This subtopic includes technologies for applications related to cryogenic propellant management in low gravity. Liquid Acquisition Device (LAD) and Mass Gauging (MG) technologies will principally impact cryogenic systems for Orbital Maneuvering Systems (OMS) and Reaction Control Systems (RCS) for orbit transfer vehicles for in-space transportation applications, and are critical to successful liquid propellant delivery to Orbital Maneuvering Systems (OMS) and Reaction Control Systems (RCS) propulsion system and allowance of smaller propellant tank residuals to assure mission success. Advanced cryogenic technologies are being solicited for all these applications. Proposed technologies should offer enhanced safety, reliability, or economic efficiency over current state-of-the-art, or should feature enabling technologies to allow NASA to meet future space exploration goals.

Technology focus areas are divided as follows: liquid acquisition devices and mass gauging/advanced instrumentation. Innovative concepts are requested for devices that interface with the tank and provide vapor-free liquids for on-orbit propulsion systems, low-gravity mass gauging technologies to enable accurate and reliable measurements of cryogenic liquid mass in low-gravity storage tanks without propellant settling or undue constraints on mission, and cryogen leak detection technologies. Cryogenic propellants such as hydrogen, methane, and oxygen are required for many current and future space missions. Operating efficiency and reliability of these cryogenic systems must be improved considering the launch environment, operations in a space environment, and system life, cost, and safety. This subtopic solicits unique and innovative concepts in the following technologies:

1) Liquid Acquisition:

Providing vapor free cryogenic propellants to in-space propulsion systems at expulsion efficiencies less than 98% without settling the propellants is the objective of the liquid acquisition technology element. Capillary liquid acquisition devices (LADs) are state-of-the-art for toxic propellants, but have not yet been developed for cryogens. Existing cryogenic upper stage main engine restarts use auxiliary thrusters to settle the propellants.
Applications/Technology Maturity: Cryogenic LADs will be required for the LO$_2$/LCH$_4$ version of the OMS/RCS for
the CEV and LSAM and possibly the EDS. LH$_2$ LAD performance represents the primary challenge while LO$_2$ and
LCH$_4$ performance risk is substantially less if the liquids are sub-cooled relative to the propellant tank ullage
pressure.

Development Needs: Liquid acquisition technology needs include investigation of helium solubility and heat
entrapment effects, propellant tank LAD integration, LAD materials selection, analytical performance model
development, and techniques to minimize vaporization inside the LAD channel caused by incident heating through
tank wall/lines and/or changes in tank pressure. CEV, LSAM and possibly the EDS vehicle advanced development
needs include integrated system testing with LH$_2$, LO$_2$ and LCH$_4$ to determine the effect of internal tank hardware
configuration on LAD performance.

2) Mass Gauging/Advanced Instrumentation:

The need for a reliable, accurate method for measuring cryogenic propellant mass without settling the propellants is
the principal objective of the mass gauging technology element.

Applications/Technology Maturity: Applications for cryogenic mass gauging include the EDS, LSAM and the CEV
OMS/RCS. A measurement uncertainty metric of less than 3% of full-tank mass has been established for the
propellant mass measurements for these vehicles.

Development Needs: Methods of determining liquid quantity gauging in propellant tanks in low gravity, high
accuracy differential pressure transducers which can operate submerged in liquid cryogen, and in-space cryogenic
fluid leak detectors.