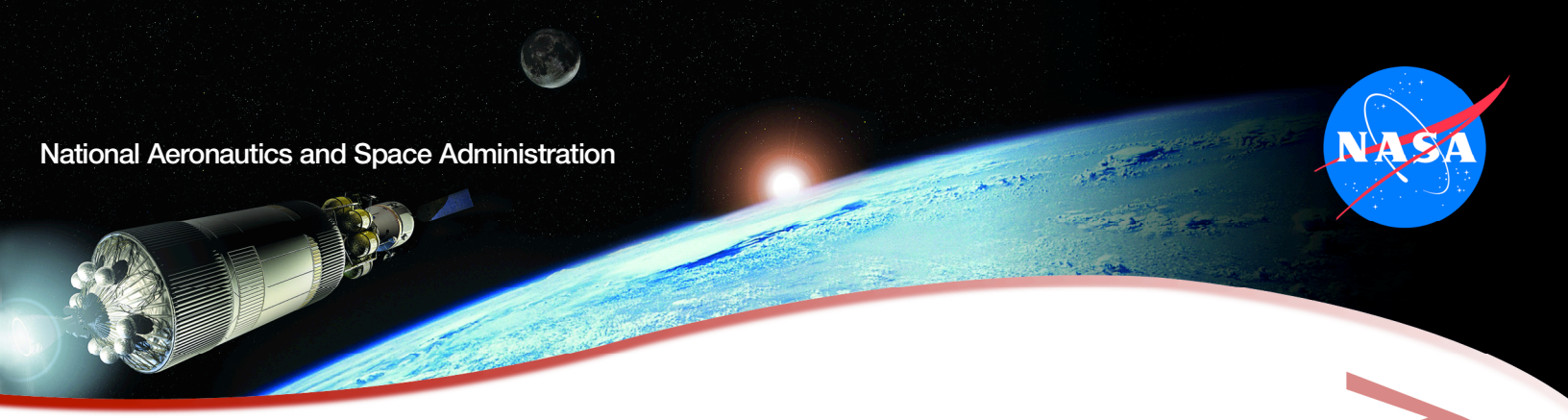
National Aeronautics and Space Administration



Cryo-Propellant Storage

Applying Cryogenic Know-How to Human Spaceflight

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About the Technology

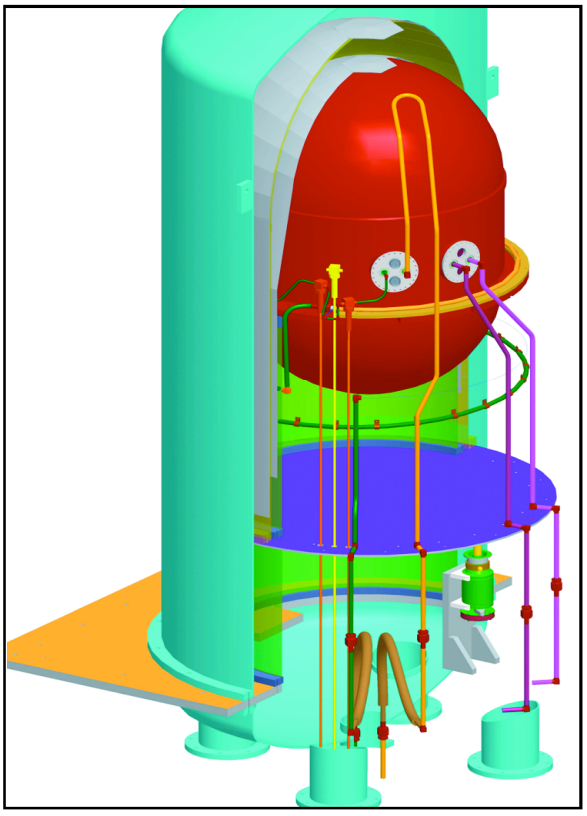
Goddard Space Flight Center's (GSFC) Cryogenic and Fluids Branch is leveraging its unique experience with long-life and dual-cryogen systems to develop the GSFC Cryogenic Fluid Management (CFM) testbed that will demonstrate many of the technologies needed for the long-term storage of cryogenic propellants in space — a capability NASA will need to power its Constellation suite of vehicles and ultimately increase the payload capacity of its transportation system.

Significance of the Technology

Cryogenic fluids, such as liquid oxygen and liquid hydrogen, have been used to propel launch vehicles or orbital-insertion stages for more than 50 years. The higher specific impulse provided by cryogenic propellants allows a greater fraction of a vehicle's initial mass to be devoted to payload. Analyses show, for example, that NASA would realize a 1.3-ton mass advantage if it propels the Orion Crew and Service Module with liquid hydrogen and oxygen.

Currently, however, their use is confined to launch vehicles where hold times are minimal. This is because cryogenic fluids boil off easily. While engineers have developed technologies to reduce boil-off in small scientific payloads, they have not scaled up their designs to the size required for large-vehicle propulsion systems.

The aim of Goddard's development effort is to demonstrate technologies, including active and passive heat-interception systems and efficient pressure-control systems for long-term cryogen storage. Goddard also is working on a thermodynamic subcooling system that may provide a compact method for subcooling cryogenic propellants on the launch pad, leading to months of vent-free cryogenic propellant storage in space. Through design studies, Goddard also aims to show where these cryogenic technologies can provide additional benefit to the Constellation program, including the Ares V Earth Departure Stage, the Altair Lunar Lander modules, the Orion Service Module, and lunar rovers and habitats.



This is an artist's rendering of the fuel-storage system Goddard technologists are developing to protect cryogenics from boil-off.

See reverse side

Cryo

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Benefits of the Technology: At-A-Glance

- Reduce cryogenic propellant boil-off by heat interception using both active and passive methods.
- Deliver months of vent-free cryogenic propellant storage in space by subcooling the cryogenic propellants below their boiling point at atmospheric pressure.
- Scale the technology to accommodate various-sized cryogenic propellant storage tanks.
- Accommodate currently envisioned systems with few or no changes.
- Increase the technology readiness level of important components of the storage and the cryogenic fluid subcooling systems.

Technology Origins

GSFC has extensive expertise in stored cryogen systems for ground and space applications. The Center developed systems for the Cosmic Background Explorer and the Superfluid Helium On-Orbit Transfer (SHOOT) Shuttle demonstration. The SHOOT experiment answered many questions about the behavior of superfluid helium in a microgravity environment and now serves as a starting point for some of the technology development needed to store cryogenic propellants in space. In addition, GSFC has either developed or consulted on virtually every NASA-developed cryogenic scientific payload. GSFC will leverage this expertise to develop liquid hydrogen and oxygen propellant storage tanks as well as launch pad subcooling systems.

The Cosmic Background Explorer used Goddard-developed cryogenic dewars to keep its sensitive instruments cold.

Looking Ahead

Demonstrating technologies needed for boil-off reduction continues under the Center's FY09 Internal Research and Development program. The GSFC Cryogenics and Fluids Branch hopes to continue developing a concept for subcooling cryogenic propellants on the launch pad — a capability that NASA's Exploration Technology Program has identified as a promising means for enhancing Constellation's flexibility.

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