Cryogenic Propellant Storage & Transfer (CPST) Technology Demonstration Mission (TDM)

CPST Briefing to JAXA

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CPST Goal and Objectives

**CPST Goal Statement:** Advance cryogenic propellant systems technologies for infusion into future extended in-space missions.

**Objectives**

- (O1) Store cryogenic propellants in a manner that maximizes their availability for use regardless of mission duration
- (O2) Efficiently transfer conditioned cryogenic propellant to an engine or tank situated in a microgravity environment
- (O3) Accurately monitor and gauge cryogenic propellants situated in a microgravity environment
NASA is undertaking a demonstration mission to advance cryogenic propellant storage and transfer technologies that will enable exploration beyond Low-Earth Orbit.

- **Passive Storage Demo**
  - 2 weeks

- **Active Storage Demo**
  - 1 month
  - 5 months

- **Controlled Re-Entry**
  - 6 months

- **Launch**

- **Demonstrate long duration storage**

- **Demonstrate in-space transfer**

- **Demonstrate in-space, accurate gauging**
Cryogenic Propellant Storage and Distribution Functions

Cryogenic Tank Details

- Pressurization
  - Helium
  - Autogenous

- Thermal Control
  - Insulation (launch environments and in-space)
  - Vapor or actively cooled shields
  - Low conductivity/ cooled support structure

- Liquid Acquisition
  - Capillary retention devices

- Pressure Control
  - Zero-g venting (thermodynamic vent and heat exchanger)

- Propellant Transfer
  - To propellant feedline or receiver tank
  - Chill-down/no-vent fill

- Propellant Gauging
  - Settled propellant
  - Inventory (Bookkeeping)
  - Pressure-volume-temperature (PVT)
  - High accuracy micro-g techniques

Hydrogen Storage
Pressurant
Receiver Tank

Spherical or cylindrical tanks

Liquid Propellant

Vent or to vapor cooled shields

Cryogenic Propellant Storage and Distribution Functions
Technologies Recommended for Demonstration on CPST (1 of 2) - Description

• “Thick” Multilayer Insulation (MLI) with Foam Substrate
  – ~60 layer MLI blanket
  – Reduce acreage heat load approximately 2.5 orders of magnitude from state of the art foam only insulation
  – Foam substrate eliminates need for helium shroud purges and reduces ground heat load by factor of 2

• Active Thermal Control (refrigeration using Tube-on-Shield heat collection)
  – Reduce acreage heat load approximately 1 more order of magnitude from MLI with foam substrate

• Low Conductivity Structures (High strength composite struts)
  – Reduce structural heat load by roughly order of magnitude

• Unsettled Pressure Control (Thermodynamic Vent System (TVS), Mixing Pumps)
  – Control pressure within tank by keeping tank thermally mixed (i.e. homogenous)
  – TVS allows efficient venting without settling

• Unsettled Liquid Acquisition Devices (LADs)
  – Remove gas-free liquid from tank without requiring settling burns (reduces RCS system by at least factor of 2)

• Unsettled Transfer Line Chilldown
  – Efficiently cool transfer line, while minimizing mass losses and operational complexities
Technologies Recommended for Demonstration on CPST (2 of 2) - Description

- **Tank Pressurization systems**
  - Provide mechanism to eject liquid during transfer

- **Settled Mass Gauging (Wet/dry sensors)**
  - Ensure method to actively measure liquid level (backup to unsettled mass gauge)
  - Provide method to validate unsettled mass gauge
  - Determine g-level where settled mass gauging breaks down

- **Unsettled Mass Gauging (RF gauging)**
  - Provide method to actively measure liquid level without artificial gravity (reduces RCS system requirements)

- **Unsettled Tank Chilldown**
  - Efficiently cool down receiving tank with minimal mass and operational impacts

- **Operational Transfer Methods**
  - Operationally integrate all phenomena associated with microgravity transfer including achieving high receiver tank fill fractions