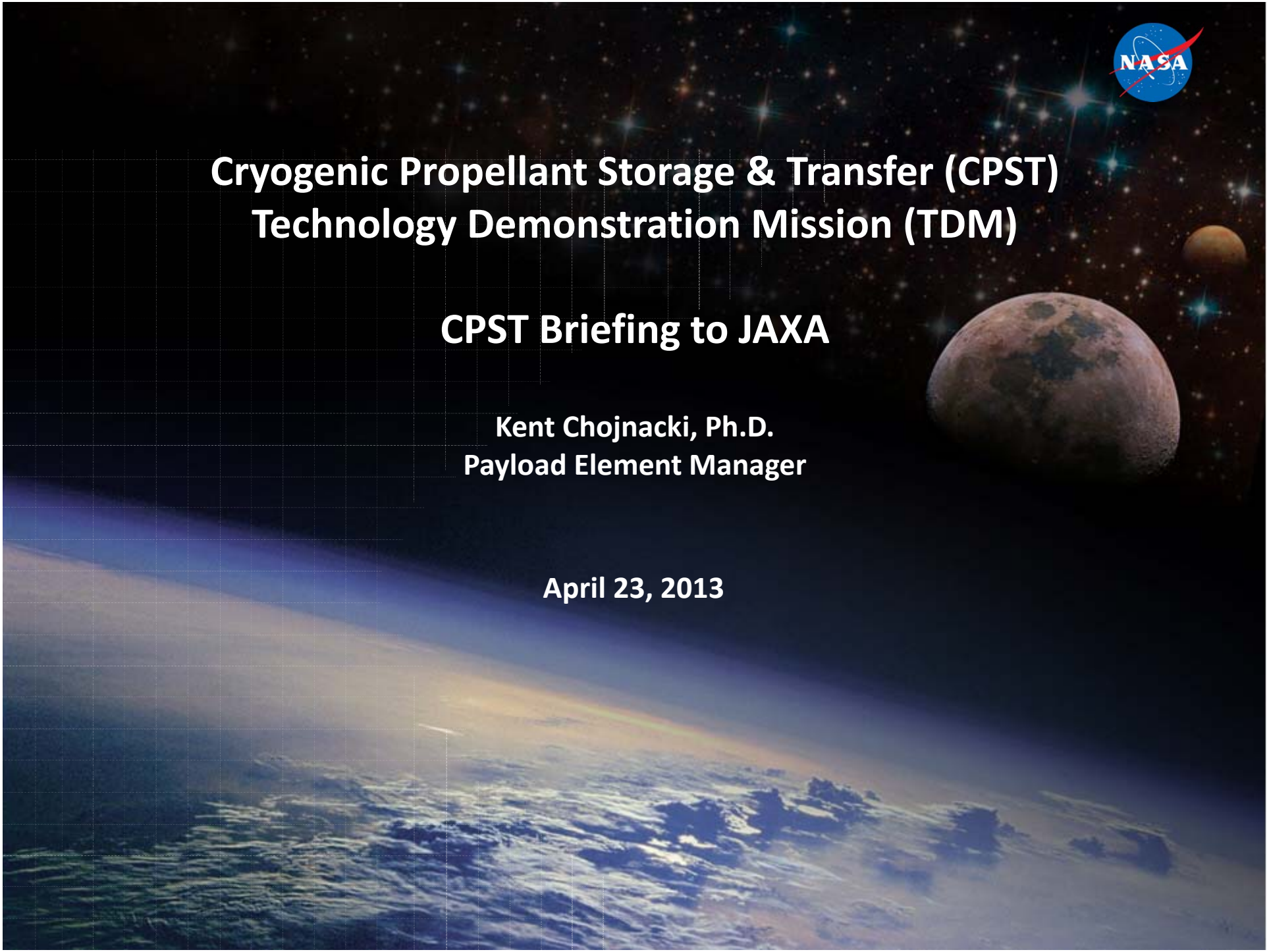

Cryogenic Propellant Storage & Transfer (CPST) Technology Demonstration Mission (TDM)

CPST Briefing to JAXA

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April 23, 2013

CPST Goal and Objectives

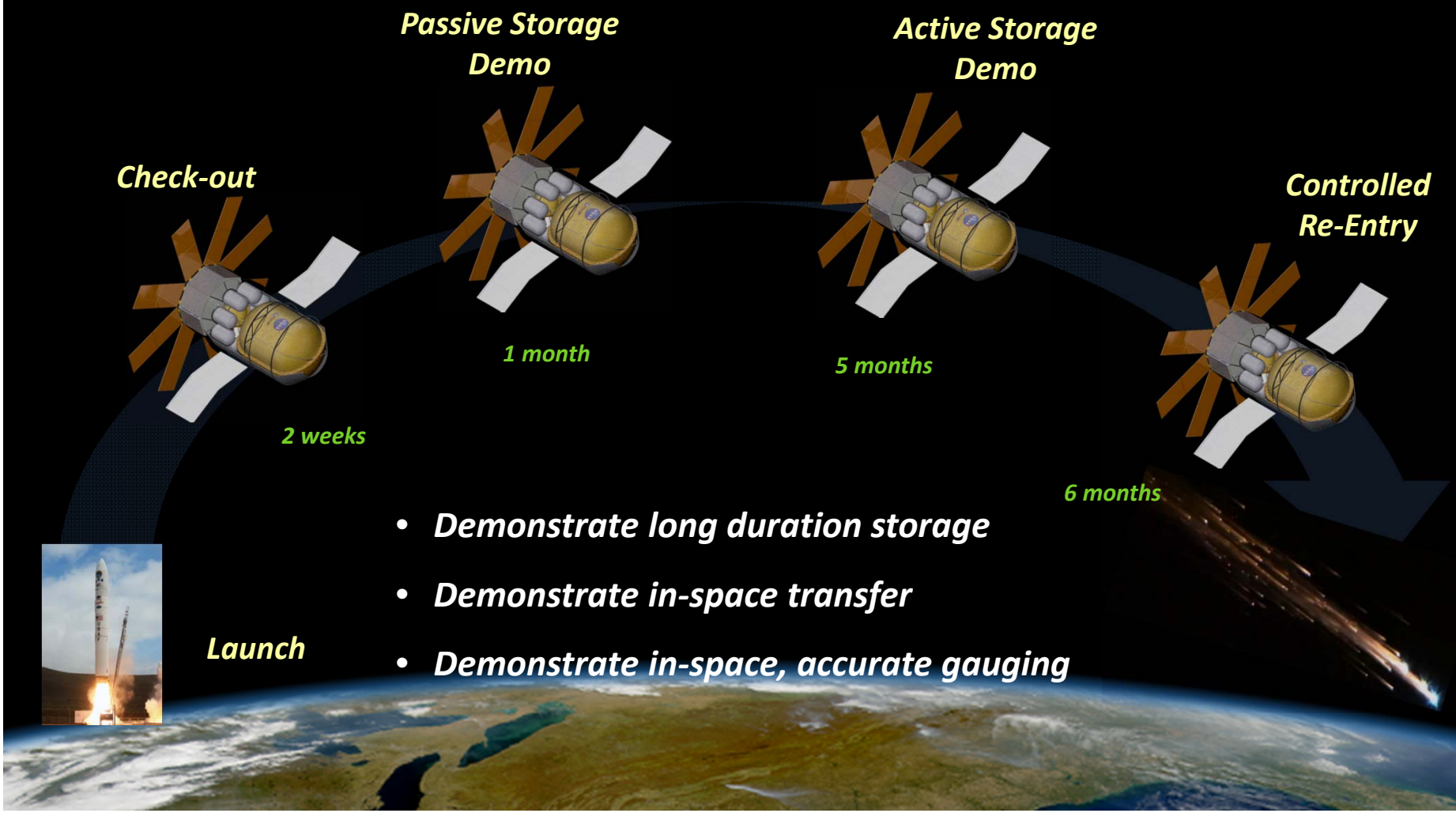
CPST Goal Statement: Advance cryogenic propellant systems technologies for infusion into future extended in-space missions.

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

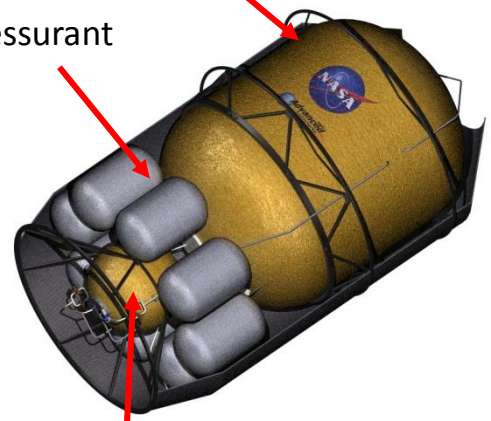
Cryogenic Propellant Storage and Transfer Technology Demonstration Mission

NASA is undertaking a demonstration mission to advance cryogenic propellant storage and transfer technologies that will enable exploration beyond Low-Earth Orbit



- *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

Vent or to vapor cooled shields

STRUT

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

Spherical or cylindrical tanks

Liquid Propellant

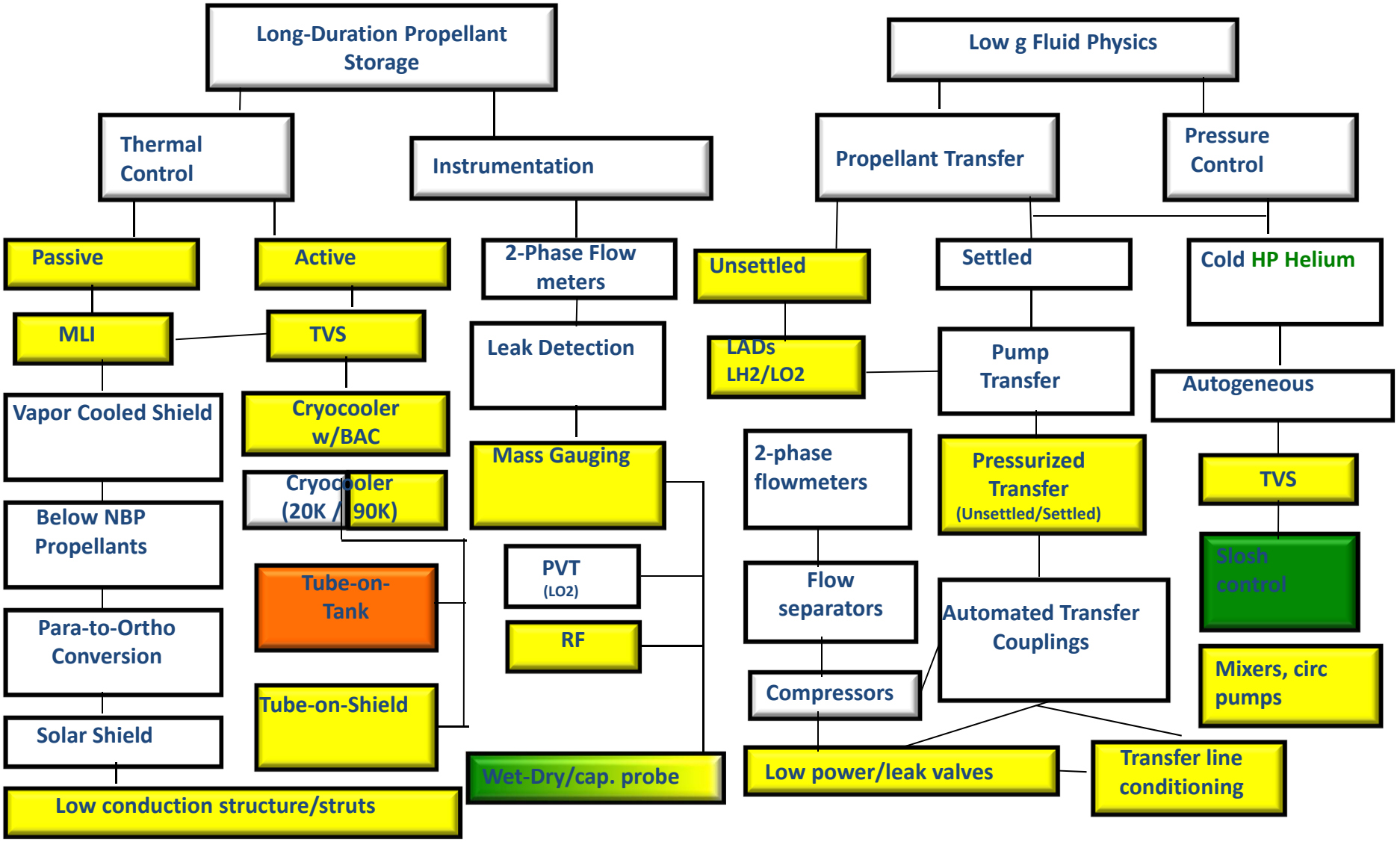
Liquid Acquisition
- Capillary retention devices

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

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

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

In-Space Cryogenic Fluid Management Technology Trade Space



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