This subtopic solicits technologies related to cryogenic propellant (such as hydrogen, oxygen, and methane) storage, transfer, and instrumentation to support NASA’s exploration goals. This includes a wide range of applications, scales, and environments consistent with future NASA missions. Specifically, listed in order of NASA’s current priority:

- **Simple mass efficient techniques for vapor cooling of structural skirts (aluminum, stainless, or composites) on large upper stages containing liquid hydrogen and liquid methane (can include para-to-ortho hydrogen catalyst for hydrogen applications).**

- **Lightweight, multifunctional cryogenic insulation systems (including attachment methods) that can survive exposure to the free stream during the launch/ascent environment in addition to high performance (less than 0.5 W/m² with a warm boundary of 220 K) on orbit or <5 W/m² on Mars surface.**

- **Advanced cryogenic spacecraft components including:**
  - Valves (minimum ½” tube size) for low (< 50 psi, Cv > 5, goal of 100+) pressure liquid hydrogen with low internal (~ 1 sccm, goal of < 0.1 sccm) and external (~ 3 sccm, goal of < 0.1 sccm) leakage (> 500 cycles with a goal of 5,000 cycles).
  - Isolation valve/regulation (minimum ½”) for high pressure (>4500 psi) gaseous helium systems (< 70 K fluid, Cv > 2.1) with low internal (~ 1 sccm) and external (~ 3 sccm) leakage (> 500 cycles with a goal of 5,000 cycles).
  - Spherical all-composite 1-2 m diameter propellant tank for Mars application using LO₂/LCH₄; Pressure from 350-1000 psig; Temperature range from ambient to 77 K (LN₂); and Ghe permeability less than 1x10⁻⁴ sccs/m² (at 500 psi, 77 K).

- **Micro-gravity cryogenic pressure control components for thermodynamic vent systems including:**
  - Improved alternatives to state of the art spray bars for using fluid dynamics to collapse the ullage and thoroughly mix a propellant tank in micro-gravity.
  - Low voltage (28 VDC) two-phase flow tolerant mixing pumps of flow rates between 10 and 40 gpm.
  - Novel methods of packaging and manufacture to minimize feedthroughs to the tank and ease of installation into a tank.

- **Innovative concepts for cryogenic fluid instrumentation including:**
  - Fiberoptic and wireless concepts to enable accurate measurement (with minimal sensitivity to electromagnetic interference) of propellant pressures and temperatures in low-gravity storage tanks.
  - Cryogenic pressure transducers (0 – 50 psia typical range, 1% full scale accuracy, 0.5 Hz response) at 20 K.
  - Low power (< 15 W goal) video camera systems for viewing fluid dynamics within a propellant tank (3 – 5 m diameter).

- **Wicking materials or other novel methods/materials of liquid acquisition for use with liquid oxygen, liquid methane, and liquid hydrogen for low temperature heat pipes or tank expulsion.**
Phase I proposals should at a minimum deliver proof of the concept including some sort of testing or physical
demonstration (not just a paper study). Phase II proposals will be expected to provide component validation in a
laboratory environment preferably with a hardware deliverable to NASA.