Advances in Liquid Hydrogen Storage Workshop

Date: August 18, 2021; 11 am – 4 pm (EDT)

Location: Virtual (Webex)

Objectives: This half-day webinar will cover US Department of Energy (DOE) liquid hydrogen (LH_2) related initiatives and outlook and introduce recent advancements in large-scale LH_2 storage technologies and projects at NASA, including integration of active refrigeration systems, high performance insulation, and the construction of a next-generation 4700 m^3 (1.25M gallon) LH_2 sphere at Kennedy Space Center (KSC).

Agenda:

- **11:00 am. Introduction; DOE Perspectives (Ned Stetson, DOE)** — 30 min.

- **11:30 am. Historical Overview of LH_2 Operations at KSC (Robert Johnson, NASA-KSC)** — 30 min.

  A summary will be presented of construction and operations of the LH_2 storage and vehicle servicing systems at the historic Launch Complex 39 pads A and B. These systems supported the Apollo and Shuttle Programs, and are being prepared to support the Artemis Program, returning humans to the surface of the moon.

- **12:00 noon. Break** — 15 min.

- **12:15 pm. LH_2 Storage and Handling Demonstrations Using Active Refrigeration (Adam Swanger, NASA-KSC)** — 60 min.

  Pioneered at NASA Kennedy Space Center, Integrated Refrigeration and Storage (IRAS) is a means of achieving zero loss LH_2 storage & transfer. It has been proven on tank scales up to 125 m^3 by the Ground Operations Demonstration Unit for Liquid Hydrogen (GODU-LH_2) project and was infused into the design of the new 4700 m^3 LH_2 tank at KSC.

- **1:15 pm. Lunch** — 30 min.

- **1:45 pm. The New LH_2 Sphere (James Fesmire, NASA-KSC)** — 60 min.

  At 4700 m^3 (1.25M gallons) capacity, the new LH_2 sphere currently under construction at Launch Complex 39B at KSC will be the largest LH_2 storage vessel in the world when it is fully commissioned in 2022. Built to support NASA's Space Launch System rocket, the new tank also includes two new energy-efficient technologies: a glass bubble insulation system in lieu of traditional perlite, and an IRAS heat exchanger for controlled storage capability.

- **2:45 pm. Break** — 15 min.

- **3:00 pm. Economics of Energy-Efficient, Large-Scale LH_2 Storage Using IRAS & Glass Bubble Insulation (Adam Swanger & James Fesmire, NASA-KSC)** — 30 min.

  A simple economic analysis of IRAS and glass bubble insulation implementation will be presented for various LH_2 tank sizes and levels of thermal performance.

- **3:30 pm. Panel Discussion and Q&A: Path Forward and Wrap-Up (DOE & NASA)** — 30 min.

  Possible topics for discussion: Potential NASA/DOE/Industry collaborations; LH_2 liquefaction and distribution; LH_2 densification; codes and standards.

  Panel Participants: Ned Stetson (DOE), Adam Swanger (NASA KSC), Robert Johnson (NASA KSC), James Fesmire (NASA KSC), Peter Ferland (NASA KSC), Michael Meyer (NASA NESC), Jeffrey Feller (NASA NESC), John Barclay (PNNL), and Ian Richardson (Washington State University).