Long-term Cryogenic Propellant Storage for the TOPS Mission

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Motivation
- Liquid Hydrogen (LH2) and Liquid Oxygen (LO2) provide the highest specific impulse of any practical chemical propulsion system. → Highest payload mass fraction.
- NASA is working on several passive, active, and fluid conditioning strategies for long-duration in-space storage of cryogenic propellants.
- Subcooling liquid hydrogen prior to launch will triple the in-space vent-free hold time without adding any significant launched mass.
- TRL increase in launch pad cryogen subcooling heat exchanger hardware.

TOPS Design Study Results
- TOPS that is propelled by LH2+LO2 saves 43% in launched mass over TOPS that is propelled by MMH+NTO.
- TOPS (with the 25% dry mass contingency) can be launched on an Atlas V 551 with a 8% launch mass margin.
- This mission does not close on any Atlas V vehicle if a standard hypergolic propulsion option is used.
- A LH2+LO2 cryogenic propelled TOPS mission could fit comfortably as a New Frontiers mission.
- Confirmed the basic viability and value of the LH2+LO2 cryo propulsion system.
- Provided a much better understanding of how to incorporate this kind of LH2+LO2 cryo propulsion into an actual mission.
- Generated a number of promising approaches for how the cryo propulsion could be further improved in terms of \(I_{sp}\) mass, envelope, thermal control, and required electrical power.
- Efforts are underway to further reduce the TOPS expected dry mass to fit in even smaller launch vehicles without science reduction.

Subcooling Heat Exchanger Development

Experiment Results
Data used to design Subcooling Hardware

Future Work
- LH2+LO2 propulsion system for planetary science missions will significantly enable or enhance many planetary science missions.
- Opens up new opportunities to explore outer planets and their moons by orbiting, landing, and/or sample return, potentially without the necessity of proper planetary alignments for gravity assists.
- Increased science in the near term as well as providing a cost-effective, safe and clean technique for exploration of our solar system.

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