Cryogenic Propulsion Systems for Planetary Science Missions. S. Mustafi[1], L. Purves[2], W. Willis[3], C. A. Nixon[4]
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Abstract: Liquid hydrogen (LH2) and liquid oxygen (LO2) cryogenic propellants can dramatically enhance NASA's ability to explore the solar system due to their superior specific impulse capability. Although these cryogenic propellants can be challenging to manage and store, they allow significant mass advantages over traditional hypergolic propulsion systems and are therefore enabling for many planetary science missions. New cryogenic storage techniques such as subcooling and the use of advanced insulation and low thermal conductivity support structures will allow for passive long term storage and use of cryogenic propellants for solar system exploration and hence allow NASA to deliver more payload mass to targets of interest more quickly, launch on smaller and less expensive launch vehicles, or both. These new LH2 and LO2 cryogenic storage technologies and a notional design for a new small 890N LH2 and LO2 engine were implemented in a design study for the Titan Orbiter Polar Surveyor (TOPS) mission and the resulting spacecraft design was able to achieve a 43% launch mass reduction over a TOPS mission, that utilized a traditional hypergolic propulsion system with monomethyl hydrazine (MMH) and nitrogen tetroxide (NTO) propellants. This discussion describes the cryogenic propellant storage design for the TOPS mission and demonstrates how these cryogenic propellants are stored passively for a decade-long Titan mission that requires the cryogenics propellants to be stored for 8.5 years. This cryogenic propulsion system has the potential to significantly benefit any planetary science missions that require high ΔV maneuvers, specially to destinations where solar electric propulsion is challenging to use, such as the ice giants, Uranus and Neptune, that have been identified as targets in the decadal survey.

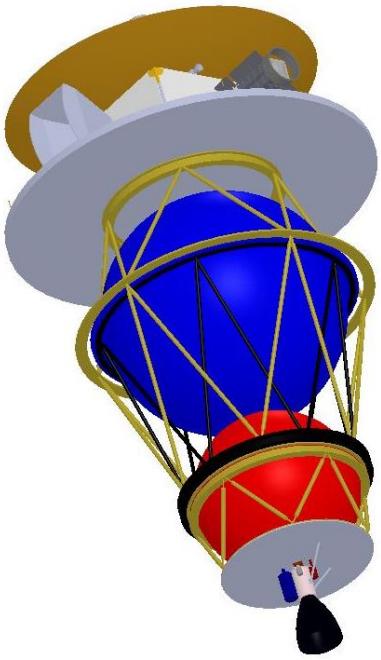

Figure 1: Titan Orbiter Polar Surveyor (TOPS)