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ARCHITECTURE STUDY FOR IN-ORBIT LONG TERM CRYOGENIC STORAGE TO SUPPORT SPACE EXPLORATION

Abstract

The space community is currently focusing on defining mission architectures able to perform multiple interplanetary missions to support deep space exploration. In particular, placing orbital propellant depots in strategic locations in space would allow to increase the useful mass transferred.
The design of the propellant depot depends greatly on the propellant storage time and the thermal environment it experiences. Furthermore, different propellants are being considered for use, including hydrolox and methalox. For both, efficient boil-off reduction strategies are fundamental. The aim of this work is to evaluate different depot architectures for different thermal environments and mission durations from a couple of days up to several years.

The approach taken in this work consisted in the development of a propellant depot sizing model that allows determining the effect of different thermal control design options for varying mission duration, thermal environments, propellant combinations and depot configurations. The model allows for taking into account both passive and active cooling methods. The latter include, amongst others, vapour cooled shields and cryocoolers. The model also allows for a varying multi-nodal thermal analysis to estimate boil-off rates for the different designs. Main objective for the studies is to identify the architecture that is most mass efficient.

Preliminary results show that mass efficient designs can be achieved with only passive insulation for mission durations below one year, while for longer times active measures are proven to be better.
Moreover, while hydrolox still represents the best solution thanks to its higher specific impulse compared to other mixtures, methalox has shown promising results for long term storage thanks to its less strict storage temperature requirements and would represent a valid starting point for future research. Recommendations regarding thermal management of in space propellant transfer will be also given.