Paper ID: 9358
oral
student

SPACE SYSTEMS SYMPOSIUM (D1)
Enabling Technologies for Space Systems (2)

Author: Mr. Patrick R. Chai
National Institute of Aerospace/Georgia Institute of Technology, United States, patrick.chai@gatech.edu

Dr. Alan Wilhite
National Institute of Aerospace/Georgia Institute of Technology, United States, wilhite@nianet.org

CRYOGENIC THERMAL MANAGEMENT OF AN ORBITAL PROPELLANT DEPOT

Abstract

In order to make long duration human space exploration feasible, significant advances must be made to overcome current technology limitations. In any manned mission architecture, upwards of seventy percent of all payload delivered to orbit is propellant and propellant mass fraction dominates almost all segments of any mission due to the current limitation in propulsion technology. To mitigate this, the use of an orbital propellant depot has been extensively studied. NASA's Office of the Chief Technologist identifies cryogenic thermal management enabling long-term on-orbit storage as the biggest game changing technology development for reduction of mass required in orbit. In this paper, a thermal model of an orbital propellant depot is used to examine the effects of passive and active thermal management strategies. Results show that an all passive thermal management strategy results in significant boil-off for both hydrogen and oxygen. At current launch vehicle prices, these boil-offs equate to millions of dollars lost per month. Zero boil-off of propellant is achievable with the use of active cryocoolers; however, the cooling power required to produce zero-boil-off is an order of magnitude higher than current state-of-the-art cryocoolers. This study shows a zero-boil-off cryocooler power requirement of 70 watts at 90 K for oxygen, and 90 watts at 20 K for hydrogen for a representative Near Earth Object mission. Significant research and development effort is required to advance the state-of-the-arts of in-space cryogenic thermal management to enable long duration human space exploration.