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Microgravity Experiments from Sub-Orbital to Orbital Platforms (3)

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THE REDUCED GRAVITY CRYOGENIC TRANSFER PROJECT

Abstract

Abstract Title: The Reduced Gravity Cryogenic Transfer Project Author: Jason Hartwig

The transfer of cryogenic propellants has never been demonstrated in a reduced or microgravity environment in a mass-efficient manner. Advanced cryogenic transfer technologies in microgravity will enable many future architectures, including Lunar or Martian ascent or descent stages, upper stages, and aggregation/fuel depots. Efficient cryogenic fluid transfer methods will reduce the transfer time or amount of propellant consumed for chilldown of transfer line hardware and tanks, and most importantly, will ensure successful engine restart or fill of a customer receiver tank (depot). The purpose of the Reduced Gravity Cryogenic Transfer (RGCT) project is to enable three of the six transfer technologies: line chilldown, tank chilldown, and tank fill/transfer in a reduced gravity environment. RGCT has three project elements: (1) ground and reduced gravity line chilldown tests, (2) ground and reduced gravity tank chilldown and fill tests, and (3) numerical model development and validation.

First, an existing liquid nitrogen (LN2) based parabolic flight rig used is being upgraded to investigate the performance benefits of coating the transfer lines as well as the mass savings in using intermittent

pulse flows on the chilldown process. 1-g transfer line chilldown data will also be gathered on long tubes (¿4 m) with variable parameters such as tube thickness, tube length, flow rate, flow direction, coating thickness, and valve duty cycle. Second, NASA is designing, ground testing, and flight testing a LN2-based cryogenic tank-to-tank transfer rig to explore microgravity sensitivities encountered during tank transfer in a reduced gravity environment. The rig is designed to vary the liquid injection method, valve cycling, inlet conditions, and flow rate for tank chilldown and tank fill. The receiver tank will be fully instrumented, including high speed cameras to image flow patterns during chill and fill. Third, RGCT will produce a set of numerical design, sizing, and scaling transfer models and will develop and implement new boiling and droplet heat and mass transfer subroutines into lumped node tank chilldown models, perform validation of lumped node tank chilldown models to historical data, predict tank chilldown and fill performance for larger architectures, and perform pretest predictions and post-test comparison of flight tests. This paper will provide a description of the ongoing design and modeling, and a status of hardware and testing developments for both line chilldown and tank chilldown and fill to date.