Paper ID: 97371
oral

IAF SPACE PROPULSION SYMPOSIUM (C4)
Liquid Propulsion (2) (2)

Author: Dr. Elizabeth Jens
Jet Propulsion Laboratory - California Institute of Technology, United States

Ms. Maggie Stewart
Jet Propulsion Laboratory, United States

DESIGN, DEVELOPMENT AND TESTING OF A SMALL THRUSTER THROTTLE VALVE TO ENABLE LOW-COST MARS LANDED MISSIONS

Abstract

Any spacecraft that is designed to land on a planetary body, such as the moon or Mars, requires a method of slowing itself down as it descends in order to execute a gentle landing. The terminal descent of nearly all lunar and planetary landers to date has been accomplished via rocket engines. Rocket engines that are suitable for landing must involve either a method of throttling across a range of thrust-to-weight ratios or off-pulsing aka Pulse Width Modulation (PWM). The ability to throttle engine thrust enables smaller low-cost landers without complex and expensive propulsion system development required for PWM systems (including propulsion subsystem hot fire testing), more difficult and expensive entry descent and landing algorithms and modeling, increased plume/surface interactions produced by PWM systems, or the mass penalties and loss of landing precision of airbags. This paper describes recent efforts to develop a deep throttling monopropellant engine for precision landing of small payloads on Mars. Such an engine could also be used for future lunar and asteroid belt landers.

The overarching approach for this effort involves designing a new Small Thruster Throttle Valve (STTV) capable of mating to a heritage fixed thrust 300 N class monopropellant engine to produce a throttling engine. Initial efforts have focused on the valve design and performance verification via flow testing. The STTV is designed to achieve a 10:1 throttle range, with flow rates in family with the demonstrated operating limits of the monopropellant engine. The STTV is designed to remain in cavitation across the full throttle range. Cavitation across the valve removes any concerns with potential feed-couple instabilities or flow coupling between different engines in the propulsion system (a key aspect of avoiding the need for a system hot fire test). The valve is also designed to seal closed following touchdown without requiring electrical power to maintain that state. All wetted valve materials are selected for compatibility with hydrazine. The valve is actuated by a custom actuator which utilizes a number of Commercial Off The Shelf (COTS) components including the motor and controller. This paper will focus on the valve design, including closure trades, and will include the results of water flow tests demonstrating valve performance. Future efforts to hot fire test the throttling engine with hydrazine will also be described.