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HYBRID CUBESAT PROPULSION SYSTEM WITH APPLICATION TO A MARS AEROCAPTURE DEMONSTRATION MISSION

Abstract

In recent years there has been increasing interest in utilizing CubeSat technology for exploration missions. Such missions will now require new propulsion development efforts. Most CubeSats are flown as secondary payloads. This introduces additional safety constraints on the propulsion system, particularly with regard to propellant selection. Hybrids are a promising form of propulsion for CubeSats as they have non-toxic propellant options and have lower TNT equivalency than solid motors and liquid bi-propellants engines. Hybrid propulsion systems also enjoy a higher specific impulse than solid rocket motors and monopropellant thrusters, nearly comparable to that of liquid rockets. Hybrid motors are throttle-able, able to be stopped and restarted, and benefit from flexibility in their packaging configuration.

This paper presents a novel hybrid motor propulsion system developed for small spacecraft and designed to fit within a 2U form factor. The propulsion system consists of a main hybrid motor with delta-V capabilities of approximately 30 m/s as well as an Attitude Control System (ACS) for spacecraft de-tumbling and reaction wheel unloading. Different fuel, oxidizer and ACS combinations are compared and evaluated across a number of metrics including Isp performance, storability, and volumetric efficiency. The design is also optimized over the oxidizer to fuel ratio, tank pressure, nozzle area ratio, and combustion chamber pressure. Details of the design methodology are outlined in the paper, including a discussion of the application of a similarity solution analysis to improve design and performance accuracy. Predicted scaling effects on the performance of the main hybrid motor are examined. The final section of the paper is dedicated to a description of the plans for ongoing development of the propulsion system and its application to a Mars aerocapture demonstration mission. A trade study for this mission comparing the final hybrid propulsion system design to a traditional monopropellant system is described.