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TSAT: DEMONSTRATING ATTITUDE CONTROL AND ORBIT MANEUVERS WITH ELECTROSPRAY MICROTHRUSTERS

Abstract

Propulsion technology has been identified as a key development area for increasingly capable CubeSats. This paper describes a demonstration mission for electrospray microthrusters developed in MIT's Space Propulsion Lab. The key feature of this system is that it can perform both attitude control and orbit maneuvers with the same set of thrusters, significantly increasing available payload volume. The propulsion system is based on the extraction and acceleration of heavy molecular ions using strong electric fields at the interface between the propellant (low vapor pressure ionic liquid) and vacuum. The process of field evaporation to produce the charged particles does not require any appreciable volume for ionization. Furthermore, the propellant does not need to be pressurized and flows exclusively by capillarity forces. The lack of valves, pipes, pumps and pressurization enables very compact designs, compatible with CubeSat limitations and requirements. The thrusters combine attitude control and orbit maintenance into a single actuator set with very high specific impulse. Furthermore, the small I-bit of the thrusters provides fine control in both attitude and orbit position. TSat, a 1U technology demonstration mission, will validate the performance of iEPS (ion Electrospray Propulsion System) on-orbit and also demonstrate combined 3-axis control and delta-V capability. The thrusters are currently TRL 5. The full TSat system is expected to reach TRL 7 by summer 2014. This paper describes the TSat vacuum testing, flight system architecture, concept of operations, control algorithms, thruster validation metrics, high voltage thruster electronics and software architecture.

TSat ground vacuum testing is enabled by a custom-designed magnetically-levitated balance for CubeSats. The balance frame allows for a complete characterization of thruster performance in vacuum through thruster-controlled slew maneuvers about one axis. This test facility also allows characterization of the performance of iEPS thrusters for high precision attitude control down to the arc-second range. The flight model will expand upon the ground vacuum tests by performing simple attitude control tests on-orbit as well as orbit adjustments and maintenance. Direct measurement of thruster voltages and currents as well as gyro, magnetometer, sun sensor, and GPS measurements will be used to assess thruster performance as well as control algorithm performance. The TSat technology demonstration will serve as a precursor to further formation flight and constellation missions that utilize the iEPS propulsion suite.