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A CUBESAT ASTEROID MISSION: DESIGN STUDY AND TRADE-OFFS

Abstract

There is considerable interest in expanding the applicability of cubesat spacecraft into lightweight, low cost missions beyond Low Earth Orbit. A conceptual design was done for a 6-U cubesat for a technology demonstration to demonstrate use of electric propulsion systems on a small satellite platform. The candidate objective was a mission to be launched on the SLS test launch EM-1 to visit a Near-Earth asteroid. Both asteroid fly-by and asteroid rendezvous missions were analyzed. Propulsion systems analyzed included cold-gas thruster systems, Hall and ion thrusters, incorporating either Xenon or Iodine propellant, and an electrospray thruster. The mission takes advantage of the ability of the SLS launch to place it into an initial trajectory of C3=0. Targeting asteroids that fly close to earth minimizes the propulsion required for flyby/rendezvous. The ΔV required is still significant for a 6U cubesat: 400 m/s flyby, 2000 m/s rendezvous for 2001 GP2 (2020 flyby) Many flybys opportunities exist but not all have such low relative velocity to Earth. EM-1 places the vehicle on a trajectory C3 of 0.2 km2/s2 (using a 15 m/s burn and a lunar flyby). The analysis here assumed the mission is ejected from the carrier during the translunar coast, and that the on-board EP system adjusts the lunar fly-by trajectory to take the C3 down to 0). Due to mass constraints, high specific impulse is required, and volume constraints mean the propellant density was also of great importance to the ability to achieve the required ΔV. This improves the relative usefulness of the electrospray salt, with higher propellant density. In order to minimize high pressure tanks and volatiles, the salt electrospray and iodine ion propulsion systems were the optimum designs for the flyby and rendezvous missions respectively combined with a thruster gimbal and wheel system For the candidate flyby mission, with a mission ΔV of about 400 m/s, the mission objectives could be accomplished with a 10W PUC 800s electrospray propulsion system, incorporating a propellant-less cathode and a bellows salt tank. This propulsion system is planned for demonstration on 2015 LEO and 2016 GEO DARPA flights. For the rendezvous mission, at a V of 2000 m/s, the mission could be accomplished with a 50W miniature ion propulsion system running iodine propellant. This propulsion system is not yet demonstrated in space. The conceptual design shows that an asteroid mission is possible using a cubesat platform with high-efficiency electric propulsion.