Paper ID: 48520
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IAF SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations - IAF SPACE EXPLORATION SYMPOSIUM (IP)

Author: Mr. Elias Solorzano
Space Flight Laboratory, University of Toronto, Canada

A SOLAR SAIL-BASED MULTI-ASTEROID RENDEZVOUS MISSION FOR TEMPORARY HOVER AND OPERATION OF NANOLANDERS

Abstract

The emerging asteroid mining industry is prompting the need for developing cost-effective interplanetary spacecraft systems to rendezvous with potential asteroids and conduct in-situ resource utilization (ISRU) for the extraction of water and platinum-group metals. As part of the graduate curriculum at the Space Flight Laboratory with the University of Toronto, a team of students developed an innovative small satellite-enabled mission concept to rendezvous with at least 3 Near Earth Objects (NEOs) of ∼0.14 to ∼5 km in diameter in the heliocentric-distance range of 0.5-2.0 AU, and to survey them to determine if they qualify as potential mining sites. To reduce the amount of fuel required for a multi-asteroid rendezvous mission, the spacecraft leverages solar-sail propulsion technology for high ΔV applications such as orbital-raising maneuvers and transit, and implements auxiliary ion-based miniaturized thrusters for leeward-thrust cancellation during hover maneuvers at a local asteroid, enabling the spacecraft to deploy a lander safely and conduct long-duration scientific operations. A Narrow Angle Camera (NAC) and Lidar-based instrument with a signal-to-noise ratio of 20dB are carried on board for astrometry applications in the vicinity of selected NEAs and to support landing-site designation for ISRU. This paper presents in detail the high-level system architecture and operating modes of the spacecraft bus (mothership), its service module (SM), and deployable nano-landers. Furthermore, a detailed description of the mothership internal subsystems at the Preliminary Design Review (PDR) level is also provided. The proposed mission architecture in this paper can have a profound impact in the advancement of low-cost asteroid mining technologies and planetary protection.