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MISSION DESIGN OF THE EQUULEUS AND OMOTENASHI CUBESATS

Abstract

EQUULEUS and OMOTENASHI are two JAXA deep-space Cubesat, that would be launched into cis-lunar orbit by the first test flight of NASA's new Space Launch System. The mission design tasks and related research activities are carried by a team of students at The University of Tokyo and at the Institute of Space and Astronautical Science (JAXA), under the guidance of JAXA and NASA/JPL researchers and engineers. Because of the reduced control capabilities of the Cubesats, the trajectory design of both missions requires the development of special astrodynamics techniques and tools. This paper presents an overview of the challenges and techniques for both projects, together with the current baseline trajectories, compliant with the latest set of initial conditions provided by NASA/MSFC early this year.

EQUULEUS is an Earth-Moon Lagrangian-Point orbiter that would demonstrate Cubesat orbit control techniques within the Sun-Earth-Moon regions; explore the Earth's radiation environment; and characterize the flux of impacting meteors on the far side of the Moon. After separation from the SLS upper

stage, EQUULEUS would execute a maneuver to increase the flyby perilune, and place the spacecraft into a Moon-return orbit. Exploiting Sun perturbations, lunar flybys, and trajectory correction maneuvers, EQUULEUS would be finally captured into a libration orbit around the Earth-Moon L2 point. While trajectories to libration orbits have been studied for many years, EQUULEUS' unique challenges come from (1) the robustness of the trajectory and of the trajectory design to a wide range of launch dates and conditions, which are imposed by the main payload; (2) the low thrust and Δv of its propulsion system; (3) the limited ground-station availability, and its effect on orbit determination errors and operations, especially during early operations and during science operations.

OMOTENASHI is a semi-hard lander that would observe the radiation environment and soil mechanics to reduce the risks of future human exploration. OMOTENASHI would also perform a trajectory correction maneuver after separation from the upper stage to target a landing site over the near side of the Moon. A solid rocket would be used to slow down the spacecraft to almost a stop, followed by a free fall to the ground. OMOTENASHI is a very ambitious mission for many subsystems, including mission design: since de-orbiting and landing maneuvers are executed in one burn, there is little room to correct errors, and the trajectory is designed to minimize the sensitivities to the uncertainties and increase the probability of success.