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# MISSION ANALYSIS FOR JAXA'S EARTH-MOON LIBRATION-ORBIT CUBESAT

**Abstract**

The Exploration Mission-1 (EM1) is the first test flight of NASA's new Space Launch System. Scheduled for launch in 2018, EM1 will carry the Orion Multi-Purpose Crew Vehicle (MPCV) into a cislunar orbit, together with a secondary payload composed by 13 cubesat. Two of these cubesat are currently proposed by JAXA: EQUULEUS, a 6U Earth-Moon Lagrangian-Point orbiter (in collaboration with the University of Tokyo); and SLSLIM, a 6U Moon lander. This paper presents the mission analysis work for EQUULEUS, while a second paper presents the mission analysis work for SLSLIM. EQUULEUS mission objectives are demonstrating cubesat orbit control techniques within the Sun-Earth-Moon regions; understanding the Earth's radiation environment; characterizing the flux of impacting meteors at the far side of the Moon; and demonstrating future exploration scenarios with a deep-space port at the Lagrange points. Following MPCV disposal, EQUULEUS is separated by the upper stage towards a lunar flyby, which, if not corrected, would result in an Earth escape trajectory. For this reason, after one-day orbit determination a trajectory correction maneuver is performed by the onboard thrusters to pump up the flyby perilune and put the spacecraft into an Moon –return orbit. Exploiting Sun perturbations, multiple

lunar flybys and small trajectory correction maneuvers, EQUULEUS will be finally placed into a libration orbit around the Earth-Moon L2 point. We present the trajectory design process and a few sample trajectories, with the current baseline and the launch window analysis. Several astrodynamics techniques are described, including the search for Lunar-return orbits in the Earth-Sun Circular Restricted Three-Body Problem (first introduced by Lantoine in [1], and further developed by Garcia [2] for EQUULEUS and other applications ); and the design of Libration orbits and low-energy transfers in real ephemeris.

BIBLIOGRAPHY [1] Lantoine and McElrath, "Families of Solar- perturbed Moon-to-Moon transfers," in 24th AAS/AIAA Spaceflight Mechanics Meeting. AAS/AIAA, 2014, AAS 14-471. [2] Garcia et al, "Extended Tisserand graph and multiple lunar swingby design with sun perturbation", 6th International Conference of Astrodynamics tools and Techniques, ICATT conference, 14-17 March 2016, Darmstadt, Germany.