IAF ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations & Optimization (1) (4)

Author: Dr. Omer Burak Iskender
Nanyang Technological University, Singapore, Republic of, iske0001@e.ntu.edu.sg

Dr. Sangkyun Kim
Kyushu Institute of Technology, Japan, kim.sangkyun571@mail.kyutech.jp
Prof. Keck Voon Ling
Nanyang Technological University, Singapore, Republic of, ekvling@ntu.edu.sg
Prof. Cho Mengu
Kyushu Institute of Technology, Japan, cho@ele.kyutech.jp
Dr. Necmi Cihan Örger
Kyushu Institute of Technology, Japan, orger.necmi-cihan397@mail.kyutech.jp

# LOW-THRUST TRAJECTORY OPTIMIZATION FOR CUBESAT LUNAR MISSION: HORYU-VI

**Abstract**

This paper presents low-thrust trajectory optimization strategy to obtain near circular lunar orbit for cubesats injected in lunar flyby trajectory. The cubesat is assumed to be equipped with uniletarel 4 hall-effect thrusters and released from SLS-2 rocket under Artemis-2 which is the next generation crewed Lunar mission. When the cubesat is released, it gains sufficient energy to escape Earth-Moon system and enters in heliocentric orbit after lunar flyby. Hence we divide the proposed trajectory into three segments. The first segment is to fire the thrusters in the anti-velocity direction to avoid lunar flyby. Second, lunar capture and third, orbit correction. Prior to start of each segment, impulsive-burn trajectory is designed and optimized as a starting point to obtain the nominal finite-burn Earth-Moon transfer trajectory. In addition, the uncertainties on the initial condition and gravitational dynamics as well as the sensor and actuator errors are included in the Monte-Carlo campaign to show the robustness of the design. The optimization problem has the consideration of avoiding repeated Earth flybys therefore Van Allen Belts and satellite constellations, physical thruster constraint, limits on the firing duration. In addition, Fault Detection Isolation and Recovery (FDIR) strategy is included to continue the mission in the event of thruster failure. The formulated constrained nonlinear optimization problem is solved with commercial Sequencial Programming (SQP) solver via MATLAB and verified with the NASA General Mission Analysis Tool (GMAT). The analysis includes the epoch, Earth-Moon-Sun-Jupiter dynamics, Solar Radiation Pressure (SRP) and high-fidelity lunar gravitational model. The results illustrate that low-thrust cubesat HORYU-VI can be insterted into a lunar orbit in 12 months, maintain it's 100km altitude for 6 months and finally change the altitude to 10km; all these in the presence of uncertainty and single thruster failure.