30th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Small Spacecraft for Deep-Space Exploration (8)

Author: Mr. Hirotaka Sekine
University of Tokyo, Japan, sekine@space.t.u-tokyo.ac.jp

Dr. Shunichiro Nomura
University of Tokyo, Japan, nomura@space.t.u-tokyo.ac.jp
Dr. Ryohei Takahashi
ArkEdge Space Inc., Japan, takahashi-ryohei@arkedgespace.com
Mr. Vinícius Nery
University of Tokyo, Japan, viniciusfnery@space.t.u-tokyo.ac.jp
Mr. Toshihiro Suzuki
University of Tokyo, Japan, suzuki_t@space.t.u-tokyo.ac.jp
Mr. Riki Nakamura
University of Tokyo, Japan, nakamura@space.t.u-tokyo.ac.jp
Dr. Shintaro Nakajima
Japan Aerospace Exploration Agency (JAXA), Japan, nakajima.shintaro@jaxa.jp
Dr. Yosuke Kawabata
University of Tokyo, Japan, kawabata@space.t.u-tokyo.ac.jp
Mr. Ryota Fuse
University of Tokyo, Japan, fuse@space.t.u-tokyo.ac.jp
Mr. Kota Miyoshi
Japan Aerospace Exploration Agency (JAXA), Japan, miyoshi.kota@jaxa.jp
Mr. Akihiro Ishikawa
University of Tokyo, Japan, ishikawa@space.t.u-tokyo.ac.jp
Dr. Satoshi Ikari
University of Tokyo, Japan, ikari@space.t.u-tokyo.ac.jp
Prof. Ryu Funase
Japan Aerospace Exploration Agency (JAXA), Japan, funase.ryu@jaxa.jp

INITIAL OPERATION RESULTS OF EQUULEUS ADCS: WHEEL UNLOADING STRATEGIES FOR A DEEP SPACE 6U CUBESAT

Abstract

EQUULEUS (EQUilibriUm Lunar-Earth point 6U Spacecraft) is one of ten CubeSats launched by NASA SLS (Space Launch System) in November 2022. The primary mission of this deep space 6U CubeSat, developed by JAXA and the University of Tokyo, is to demonstrate orbit control technology. It is expected to take more than a year to achieve EML2 (the second Earth-Moon Lagrange point) injection while performing multiple lunar swing-bys and orbit control. After reaching EML2, EQUULEUS will continue scientific observations while maintaining a halo orbit. This paper summarizes the initial results of EQUULEUS ADCS operations, specifically focusing on wheel unloading strategies for a 6U CubeSat in deep space. The 6U CubeSat has small-sized reaction wheels and thus limited angular momentum storage capacity, making it essential to effectively manage angular momentum to sustain three-axis attitude control in a deep space where disturbance torque accumulates. The available fuel for angular momentum

management is severely limited due to the size of the spacecraft. This is particularly challenging for EQUULEUS as orbit control is its primary mission, requiring a significant amount of fuel. Furthermore, angular momentum must be strictly managed to guarantee sufficient power generation and maintain spacecraft temperature, even after transitioning from the three-axis control mode to the tumbling mode in case of low battery voltage. Consequently, the EQUULEUS operation efficiently manages angular momentum by utilizing orbit correction control opportunities and SRP (Solar Radiation Pressure). This paper categorizes the angular momentum management method into three phases: 1) Delta-V operation for major orbit changes, 2) TCM (Trajectory Correction Maneuver) operation for minor orbit correction, and 3) cruising. In the Delta-V operation, it is important to continuously perform propulsion operations within a limited time to achieve the mission. Setting an appropriate angular velocity threshold enables the automatic selection of thrusters for unloading while maintaining continuous propulsion system operation. In TCM operations, thruster selection is pre-planned based on the predicted required velocity increment, leading to more robust angular momentum control against uncertain thrust generation. During cruising, utilization of changes in the sun's direction in the body frame enables unloading using SRP. This paper shows the on-orbit results of these methods, and these unloading strategies are applicable for future deep space CubeSat explorations.