Paper ID: 86593
oral

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IP)

Author: Mr. Junji Kikuchi
Japan Aerospace Exploration Agency (JAXA), Japan

Mr. Satoshi Ueda
Japan Aerospace Exploration Agency (JAXA), Japan
Ms. Naomi Murakami
Japan Aerospace Exploration Agency (JAXA), Japan
Mr. Yuki Matsumoto
Japan Aerospace Exploration Agency (JAXA), Japan

ANALYSIS OF TRANSFER TRAJECTORY FROM NRHO TO LUNAR ORBIT OF VARIOUS INCLINATION FOR GATEWAY RELEASE MISSION

Abstract

For the lunar activities starting in the late 2020s, many countries are proposing several lunar landing and orbiting missions. Especially, the construction of the Lunar Navigate Satellite System (LNSS) is scheduled by international collaborations of NASA's LunaNet, ESA's Moonlight, and JAXA's LEAD.

Elliptical Lunar Frozen Orbit (ELFO) is a candidate orbit for LNSS. This ELFO minimizes the control required to maintain the orbit, saving fuel and realizing stable positioning. However, the orbital elements of the ELFO are limited to an inclination angle of around 56°. On the other hand, many lunar landers have been injected into a polar orbit for global access to the lunar surface. Further, the Near Rectilinear Halo Orbit (NRHO), where Gateway will be constructed, is also in a long lunar elliptical polar orbit. Because the inclination angles of these orbits and ELFO are very different, it takes considerable fuel for the LNSS satellites to reach ELFO from other ridesharing spacecraft.

Therefore, the LNSS satellite must be injected into ELFO independently, which poses several problems. To improve positioning performance, LNSS satellites must be injected into ELFO at different phases to compose a constellation. However, it is difficult to launch a rocket frequently for every single LNSS satellite. Further, if the LNSS satellite is to be injected into ELFO on its own, it must make an Lunar Orbit Insertion (LOI) of about 500 m/s. In this case, a large propulsion system is required.

NRHO will have many ridesharing opportunities. However, the transfer trajectory to the lunar orbit of the various inclination has not been actively researched. This paper proposes a transfer method from NRHO to the lunar orbit of desired inclination. In the past, Kikuchi et al. proposed a Perilune Rendezvous Method (PRM) that transitions from Earth to NRHO at low ΔV, utilizing NRHO instability and Earth perturbation.[1] Applying this PRM allows the orbit inclination angle to be controlled.

For example, a low ΔV of less than 250 m/s, half of the LOI, is required for the transition to ELFO. The conditions for ELFO connection are indicated by controlling number of maneuvers and timing. This trajectory would allow LNSS satellites to be released from the Gateway or to rideshare to a spacecraft heading to NRHO. Further, this method can be applied to other lunar landing and orbiting missions that require various orbital inclination angles.

[1]Kikuchi J, et al.(2023).: "Extended Perilune Rendezvous Method for Low Delta-V Transition to NRHO",IAC