Paper ID: 86587
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

TRAJECTORY DESIGN OF NRHO TRANSFER WITH CONTINUOUS LAUNCH WINDOW FOR LOGISTICS RESUPPLY MISSION TO GATEWAY

Abstract

As a post-ISS mission, the construction of Gateway in lunar orbit is planned, and a cargo supply mission to Gateway is also being considered by JAXA. NRHO is a candidate orbit for Gateway, and several methods for the transfer trajectory from Earth are being researched. However, an intermediate trajectory between In-Direct Transfer (IDT) for manned flight missions and the Weak Stability Boundary (WSB) trajectory has not been actively studied.

The launch window is a major challenge facing a cargo transport mission to Gateway. NRHO has a 9:2 monthly resonance, averaging nine revolutions every two months. Because the spacecraft can reach to the NRHO at the limited phase position, there is a short launch window by IDT. Therefore, the launch delay causes a long standby period, resulting in inefficient cargo transport. On the other hand, because the WSB requires the transfer period more than 100 days. This is not suitable for the cargo transport.

In 2022, the perilune rendezvous method (PRM) was discovered to transfer future supplies by NRHO to Gateway.[1] In this method, a deceleration maneuver during a lunar swing-by inserts a spacecraft into an elliptical lunar orbit. The spacecraft can then enter the NRHO with a small velocity increment by waiting for when the Moon's orbital plane coincides with the NRHO. Most of the ΔV is in the direction of the velocity vector, so this method is highly ΔV efficient. Further, the spacecraft can be injected into NRHO more accurately than IDT because positional error can be absorbed in the lunar orbit.

This research aims to extend PRM to provide a daily launch window to Gateway. The PRM can control the transition period to NRHO by extending the semi-major axis in the lunar orbit. This characteristic gives us a continuous launch window. Compared to IDT, PRM could also maximize the cargo volume and accommodate rocket launch delays. In this paper, the relationship between the transition period and the total ΔV is clarified. Basically, the longer the transition period, the lower the total ΔV amount. This database can contribute to greatly expanding the options for the logistics missions. Moreover, the total ΔV with the trajectory correction maneuver considers several errors is revealed. Finally, the injection accuracy into NRHO is discussed.

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