ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation & Control (3) (5)

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A STUDY ON GUIDANCE LOGIC FOR FINITE-TIME MANEUVER IN CISLUNAR ORBIT

Abstract

This study addresses a new guidance logic which is utilized for finite-time orbital maneuvers in cislunar orbits. This study is motivated by international discussion regarding design architecture of future space stations in cislunar orbits. According to the Global Exploration Roadmap, a concept of new space station in the lunar vicinity is proposed. It is expected that resupply missions to new cislunar stations are required.

Whitley and Martinez [1] researched transfer cost to Near Rectilinear Orbit (NRO) of Earth-Moon system. NRO is a candidate of the orbits in which new cislunar station is located. According to identified mission sequence, orbital maneuvers with large delta-V are required including powered lunar flyby to have a spacecraft injected into target NRO. The maximum size of delta-V is about 250 m/s which is significantly larger than the size of delta-V required in rendezvous missions to the International Space Station (ISS) in the Low Earth Orbit (LEO). Although further trajectory optimization reduces the size of delta-V, a spacecraft for cislunar resupply mission needs to be designed to have a ca-pability to execute large orbital maneuvers with limited thrust force of spacecraft's own main engines.

In case of LEO mission, Yamanaka and Nobori [2] proposed a guidance logic which is suitable for large orbital maneuvers such as re-entry maneuver from LEO. This practical logic was implemented in onboard software of Japanese resupply spacecraft a.k.a. the HTV as a part of guidance function. In cislunar orbits, we must consider unique conditions of orbital dynamics dominated by the features of the multibody problem. In addition, required delta-V for single finite-time orbital maneuver in cislunar mission is about 7 or 8 times larger than those required for LEO mission. Therefore, a new guidance logic for finite-time orbital maneuvers which achieves precise execution accuracy even with unique gravitational environment needs to be developed.

This paper presents evaluation results of cislunar gravitational effect which affects maneuver accuracy, followed by proposed guidance logic which is suitable for finite-time orbital maneuvers in cislunar orbit. Finally, Simulation results are presented to prove efficiency of proposed logic.

Reference:

[1] Whitley, R., and Martinez, R., "Options for Staging Orbits in Cislunar Space", Proceedings of 2016 IEEE Aerospace Conference, 10.1109/AERO.2016.7500635, March 2016, Big Sky, MT, U.S.A.

[2] Yamanaka, K., and Nobori, H., "New velocity increment cut-off guidance algorithm for long duration maneuvers", Guidance, Navigation, and Control Conference, AIAA-97-3710, 1997, New Orleans, LA, U.S.A.