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PRELIMINARY STUDY OF THE TRAJECTORY FROM THE EARTH TO THE MOON WITH LOW THRUST FOR THE SMALL SCIENTIFIC SPACECRAFT, DESTINY

Abstract

This study investigates the trajectory design of the small scientific spacecraft, DESTINY (Demonstration and Space Technology for INterplanetary voYage), which aims to be launched by the third Japanese next-generation solid propellant rocket (Epsilon rocket) around 2017 [1]. In the DESTINY mission, the spacecraft will go to the moon by the ion engine from the large ellipse orbit. Afterward, by using the lunar swing-by, the spacecraft will transfer to the periodic orbit in the vicinity of the libration point (Halo orbit) of the Sun- Earth L2 [2]. This study focuses on the transfer trajectories from the Earth to the Moon.

By using the Epsilon rocket, spacecraft is supposed to put into the elliptical orbit of 250 x 24000 km at first. Subsequently the orbital energy is increased by the high specific ion engine to reach the moon. During this phase, the degradation of the solar array panel due to the damage by the radiation of the Van Allen belt should be reduced. Moreover, the apogee altitude with the low use of the ion engine should be increased. Therefore, we have to treat the trajectory design as the multi-objective optimization by changing the launch date/time and the range of the use of ion engine, considering the mission constraints such as the eclipse and the direction of the solar incidence for the thermal control.

From the sensitive analysis, it was found that the launch date/time has a strong effect on the apogee altitude and the transit time of spacecraft in the Van Allen belt. Moreover, we found that it would take about 1.1 years at least to reach the Moon from the initial high elliptical orbit by the constant use of the ion engine except for the time period of the constraints.

Reference [1] DESTINY official web page (in Japanese), URL: https://www.ep.isas.jaxa.jp/destiny [2] M. Nakamiya, and Y. Kawakatsu, “Preliminary Study of the Transfer Trajectory from the Moon to the Halo Orbit for the Small Scientific Spacecraft, DESTINY,” 22nd AAS/AIAA Space Flight Mechanics Meeting, Charleston, SC, January 29 - February 2, 2012.