IAF ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations & Optimization (2) (5)

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MISSION DESIGN OF DESTINY+: TOWARD ACTIVE ASTEROID (3200) PHAETHON

Abstract

DESTINY+ (Demonstration and Experiment of Space Technology for INterplanetary voYage, Phaethon fLyby, and dUSt analysis) mission is a candidate for JAXA' Epsilon small-class program to be launched in 2024. The spacecraft will demonstrate advanced technologies that include a highly efficient solar electric propulsion to enable lower cost and higher frequency deep space missions. For the science mission, the spacecraft will perform high-speed flyby observation and explore the asteroid (3200) Phaethon as the nominal mission and several more asteroids as an extra mission. This paper presents the DESTINY+ mission design overview where the spacecraft flies from a geocentric orbit to an interplanetary orbit for multiple asteroid flybys utilizing solar electric propulsion and multiple gravity-assist techniques. We divided the

whole mission into three phases: 1) the spiral orbit-raising phase, 2) the moon swing-by phase, and 3) the interplanetary cruising phase. The first phase starts from geocentric orbit into which the spacecraft is inserted and continues until the spacecraft first flybys the Moon. In the first phase, we solve multi-revolution low-thrust trajectory optimization problems by applying a newly developed multi-objective evolutionary algorithm technique that minimizes flight time and fuel consumption and explores affordable launch windows. The second phase involves multiple Moon's swing-bys to amplify the Earth departure V-infinity. In the second phase, we extensively search multiple lunar swing-by trajectories under the Sun-Earth circular restricted three-body problems. The Moon's swing-bys assisted by solar perturbation enlarge the departure V-infinity up to 1.5 km/s. The third phase performs Phaethon and other asteroids flybys utilizing Earth gravity assists. In the third phase, we solve the global trajectory optimization for multiple asteroid flybys. Finally, we analyze the operational feasibility, including radiation effect analysis, thermal environment analysis, attitude control analysis, and ground station visibility analysis. Finally, we evaluated the robustness of the trajectory and mission planning considering uncertainties such as missed-thrust.