ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations and Optimization (2) (9)

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LAUNCH WINDOW AND SENSITIVITY ANALYSIS OF AN ASTEROID FLYBY MISSION WITH MINIATURE ION PROPULSION SYSTEM: PROCYON

Abstract

PROCYON (PRoximate Object Close flYby with Optical Navigation) is a mission aimed to demonstrate the technology of a micro spacecraft deep space exploration and proximity flyby to asteroids. The mission is developed by the University of Tokyo in collaboration with JAXA. The spacecraft is scheduled to be launched as a secondary payload in December 2014 with Hayabusa 2 spacecraft.

The trajectory sequence of PROCYON is as follows: 1) electric delta-V gravity assist on an 1:1 Earth resonant orbit, 2) transfer to the target asteroid after the Earth flyby, 3) proximity asteroid flyby using optical navigation, and 4) visit a second asteroid as an extended mission. The mission design of such a small scale spacecraft possesses many challenges: i) the thrust of the miniature ion engine is only 0.3 mN which is three orders of magnitudes less than a typical low-thrust mission; ii) the available propellant mass is only 2 kg which can perform only 9 m/s of Delta-V; iii) requirements on the power and thermal conditions and communication link with the ground station must be satisfied; iv) the thrust direction is constrained due to the solar panel direction pointing to the Sun. Moreover, the launch trajectory for the

spacecraft is restricted by Hayabusa 2's trajectory.

Due to the very low thrust and limited propellant of the mission, it is therefore important to ensure that the mission objective and requirements can still be satisfied under different conditions and parameters. In this paper, we present the results of a broad sensitivity study of PROCYON's trajectory due to various launch dates and mission parameters.

We consider all the mission requirements and formulate the trajectory design as a constrained parameter optimization problem. First, the nominal trajectories are found across a launch window of two weeks. Then we inject different rocket launch errors, duty cycles, initial commission time, and Earth flyby error to generate different conditions for the sensitivity test. These conditions are set as the initial states and input of the optimization algorithm, in which thousands of low-thrust transfer trajectories are calculated for each launch dates. We show that in some cases, the spacecraft is not able reach the Earth after 1 year for the gravity assist which a backup trajectory will be used to visit a secondary asteroid without Earth's flyby. We expect our results to be useful for the mission operation of the world's first deep space mission with a miniature spacecraft.