IAF ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations & Optimization (1) (4)

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MULTI-OBJECTIVE OPTIMIZATION FOR LOW THRUST SPIRAL TRAJECTORY OF DESTINY+

Abstract

DESTINY$^+$ (Demonstration and Experiment of Space Technology for INterplanetary voYage, Phaethon fLyby and dUSt analysis) is a small-sized high-performance deep space vehicle proposed at ISAS/JAXA. DESTINY$^+$ is launched by the Epsilon rocket into a highly elliptical orbit around Earth and spiral up its orbit to Moon by the solar electric propulsion (SEP) system. After several Moon swing-bys, DESTINY$^+$ escape from Earth sphere of influence and transfer to asteroid 3200 Phaehton for flyby observation. During the spiral phase to Moon by low thrust transfer, it is important to minimize the time of flight (TOF), fuel consumption, eclipse duration, and the effect of the radiation belt. Though the thrust level of SEP is low, its fuel consumption rate is less than one-tenth than conventional chemical propulsion, and it requires long flight time, but consumes less fuel. However, it is difficult to obtain thrust control profiles to minimize multiple indices such as TOF, fuel consumption mass, and eclipse time. Therefore, we applied a newly developed Multi-Objective Evolutionary Algorithm (MOEA) to obtain an optimal thrust control strategy and an affordable launch window.The numerical results show that the launch window is limited if the upper limit of the eclipse duration is set. The numerical results also show that to minimize the effect of radiation belt, the continuous thrust is effective until the spacecraft is over the radiation belt. To apply the optimal control to an actual spacecraft, it investigates a method to realize control gradually rotating its attitude during spiral orbit rising phase, and evaluates its effect of orbit change between the optimal control and actual adaptable control.Finally, we evaluate the robustness of the trajectory planning in case of SEP failure.