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EFFICIENT MAIN BELT ASTEROID TOUR EXPLOITING SUN-EARTH LIBRATION POINT DEPARTURE

Abstract

The exploration of small bodies and asteroids is a fundamental scientific objective, that helps understanding the origin of the universe and uncover novel celestial mechanics phenomena. In particular, the active asteroids of the Main Asteroid Belt (MAB) are of prominent scientific interest, as their volatiles and ejecta might shed light on the most primordial components on such bodies. Missions to selected targets in the MAB are particularly challenging, due to the phasing problem between the Earth and the target asteroid, as well as the unfavorable orbital inclination of some potential active asteroids, requiring expensive plane change manoeuvres. As a consequence, although attractive, these kind of mission still belong to expensive exploration missions, asking for a large service module class. However, the question of technological feasibility with a small class spacecraft still needs an answer. The paper draws results from recent studies the proponents did, and discusses a mission scenario for a space segment, headed towards the MAB, that benefits of a departure from a Sun-Earth libration point (SEL2). Such scenario derives from the rising number of space mission headed towards SEL2, thus envisaging the possibility of a shared launch for a low-cost MAB mission, greatly reducing the launch cost and the platform mass as well. The departure from SEL2, towards the target asteroids, requires careful mission design and long coasting arcs to obtain an escape trajectory; the study presents the use of resonant Earth-Moon gravity assists, to boost the escape heliocentric velocity, and of a Mars gravity assist to change the plane of the spacecraft. Earth gravity assists are also considered to enable sample return mission scenarios. Different mission profiles are analyzed, focusing on the active MAB bodies, but opening the possibility to visit other targets. The interplanetary trajectories are designed with a low-thrust off the shelf engine, as the high specific impulse benefits spacecraft mass and trajectory flexibility, being able to cope with different mission sequences. The optimization approach is presented, highlighting its operational benefits: splitting the trajectory in a pre- and post- Earth escape phases, two different problems might be solved independently, and then blended in a global optimization approach, thus leaving the analyst a large variety of operational possibilities. In conclusion, it is highlighted how such mission can result beneficial in terms of cost and system complexity, although introducing an added challenge in the trajectory design starting from the SEL points.