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ORBIT CONTROL OF ASTEROIDS IN LIBRATION POINT ORBITS FOR RESOURCE EXPLOITATION

Abstract

Recent studies have suggested that near-Earth asteroids (NEAs) could be harvested and exploited for resources. It is in fact well known that some NEAs are potentially full of strategic resources for in-space utilization (e.g., future in-orbit construction of space components) or even precious metals that may find interest in terrestrial commodity markets. Harvesting asteroids will without doubt be costly; however more and more space companies have shown interest in this idea, as the benefit might overcome the cost in a not so far future. A scenario which was investigated in the last few years consists of modifying the NEA's orbit such as to capture it into a libration orbit of the Sun-Earth system – Halo, planar or vertical Lyapunov. The asteroid's motion may then remain indefinitely on a periodic orbit near a libration point, which is relatively accessible from Earth, or alternatively transferred to other regions of the cislunar space (e.g., Moon orbit). The intrinsic risk of this scenario is the possibility to divert the asteroid's trajectory in a way that it could impact the Earth. It is in fact well known that these orbits are unstable, with some of their manifolds departing towards the Earth. This paper therefore aims to provide a more accurate account of the towing manoeuvre required to place an asteroid on a libration point orbit near the Sun-Earth L2 point. We provide an assessment of the control requirements in terms of propellant, thrust magnitude and steering in order to safely tow an asteroid to the Earth's vicinity. The paper investigates the optimal control of the towing spacecraft during two distinct phases: firstly, at Earth approach, when the asteroid is still far but slowly approaching the Earth following a stable invariant manifold trajectory; secondly, after the insertion into a target libration orbit, as station keeping is still necessary in order to keep the asteroid from drifting away and causing any potential concern for the Earth. By means of a Monte-Carlo analysis, we quantify the control margins necessary to ensure that the asteroid does not divert irreparably on a different trajectory, and hence becomes a risk for the Earth. In addition, a range of potentially useful target orbits near the libration points are analysed in terms of station-keeping costs and safety. This analysis will thus determine the amount of time the asteroid can be controlled on the orbit, for a given propellant mass and propulsion subsystem characteristics.