IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IPB)

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THE CAPTURE OF NEAR-EARTH ASTEROIDS IN CLOSE PROXIMITY ORBITS WITH A TWO-SPACECRAFT STRATEGY USING A LINEAR APPROXIMATION

Abstract

Near-Earth asteroids provide numerous opportunities for both space science missions and resource utilisation [Sanchez and McInnes, J Spacecr Rockets, 2011]. The latter could remove the need to lift bulk materials required for future large-scale missions off the Earth and instead source them directly in space. To make these asteroids more accessible for resource extraction, they can in principle be delivered to near-Earth space by asteroid capture missions.

A new strategy has been proposed previously to capture small near-Earth asteroids, using two spacecraft as a 'pitcher' and 'catcher' [Ionescu et al., Acta Astronaut., 2022]. In that strategy, the pitcher spacecraft transfers from asteroid to asteroid and deflects them towards the Earth, while the catcher spacecraft is stationed in high Earth orbit, or at a Lagrange point, and captures the incoming asteroids. The use of fly-bys has also been considered [Ionescu et al., proceedings of AAS/AIAA Astrodynamics Specialist Conference, 2022], where the pitcher would perform either an unpowered or powered fly-by at the Earth. It has been shown that this strategy is able to retrieve more asteroid mass than a conventional one-spacecraft strategy, and often with a shorter mission duration.

This paper will investigate a new approach to the two-spacecraft strategy, focusing on the capture problem for small near-Earth asteroids that have an orbit radius very close to that of Earth. Then, the linear Clohessy-Wiltshire equations can be used to approximate transfers between orbits. Due to the linearisation of the transfers, the computational effort will decrease significantly, therefore the optimisation process can be faster and more expansive. The asteroid orbits are assumed to be equally spaced, and the pitcher is able to transfer from orbit to orbit in order to rendezvous with and deflect a sequence of asteroids. Two scenarios are investigated. The first scenario assumes that there is a continuous flow of asteroids in a volume of space densely populated with small near-Earth asteroids, and the optimum transfer sequence is investigated in order to capture the asteroids. The second scenario considers a volume of space sparsely populated with asteroids, where the pitcher has a sensing horizon in which it can detect asteroids that are nearby. Again, the asteroid sequence is optimised to maximise the retrieved mass. These results, that are obtained using a linearised approximation, can provide insights into optimal operational schemes for the pitcher, which can then be used for designing future multi-spacecraft asteroid capture missions.