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SOLAR-SAILING TRAJECTORY DESIGN FOR CLOSE-UP NEA OBSERVATIONS MISSION

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ABSTRACT

Near-Earth Asteroids (NEAs) are an extremely valuable resource to study more in depth the origin and evolution of Solar System. At the same time, they constitute a serious danger for the Earth in the not-so-remote case of an impact. In order to mitigate the hazard of a potential impact with the Earth, several techniques have been studied so far and, for the majority of those ones, a good knowledge about the chemical and physical composition of the target object is extremely helpful for the success of the mission. Several survey and mitigation programs have been settled for this purpose, but most of them deal with ground-based observations. A multiple-rendezvous mission with NEAs, with close-up observations, can help the scientific community to improve the overall knowledge about these objects and to support any mitigation strategy. Because of the cost of this kind of mission in terms of delta-V, a solar-sail spacecraft is proposed in this study, in order to take advantage of the propellant-less characteristic of this system. As part of the DLR/ESA Gossamer roadmap, and thus considering the sailcraft based on this technology, the present work is focused on the search of possible sequences of encounters, taking into account the following constraints: the mission time should be about 10 years and at least one Potentially Hazardous Asteroid (PHA) and one object, which takes part of the NASA list of potential NEO target bodies for future human missions (NHATS), should be visited. Because of the huge amount of NEAs, the selection of the candidates for a multiple rendezvous is firstly a combinatorial problem, with more than a billion of possible sequences for only three consecutive encounters: in fact, there are currently more than 11,000 NEAs, of which more than 1,500 are classified as PHAs. Moreover, an optimisation problem should be solved in order to find a feasible solar-sail trajectory for each leg of the sequence. In order to tackle this mixed combinatorial/optimisation problem, the strategy used is divided into two main

steps: a sequence finder by means of heuristic rules and simplified trajectory models, and a subsequent optimisation phase. Preliminary results were presented by the authors in a previous work (Figure 1), demonstrating that this kind of mission is promising. In this paper, we aim to find new sequences by introducing a different approach on the sequence finder algorithm and by reducing the area-to-mass ratio of the solar-sail. A smaller area-to-mass ratio entails either the possibility to carry on more payload or to reduce the sail area, bringing the TRL up. The mission parameters and trajectories of the sequences found are shown and explained.

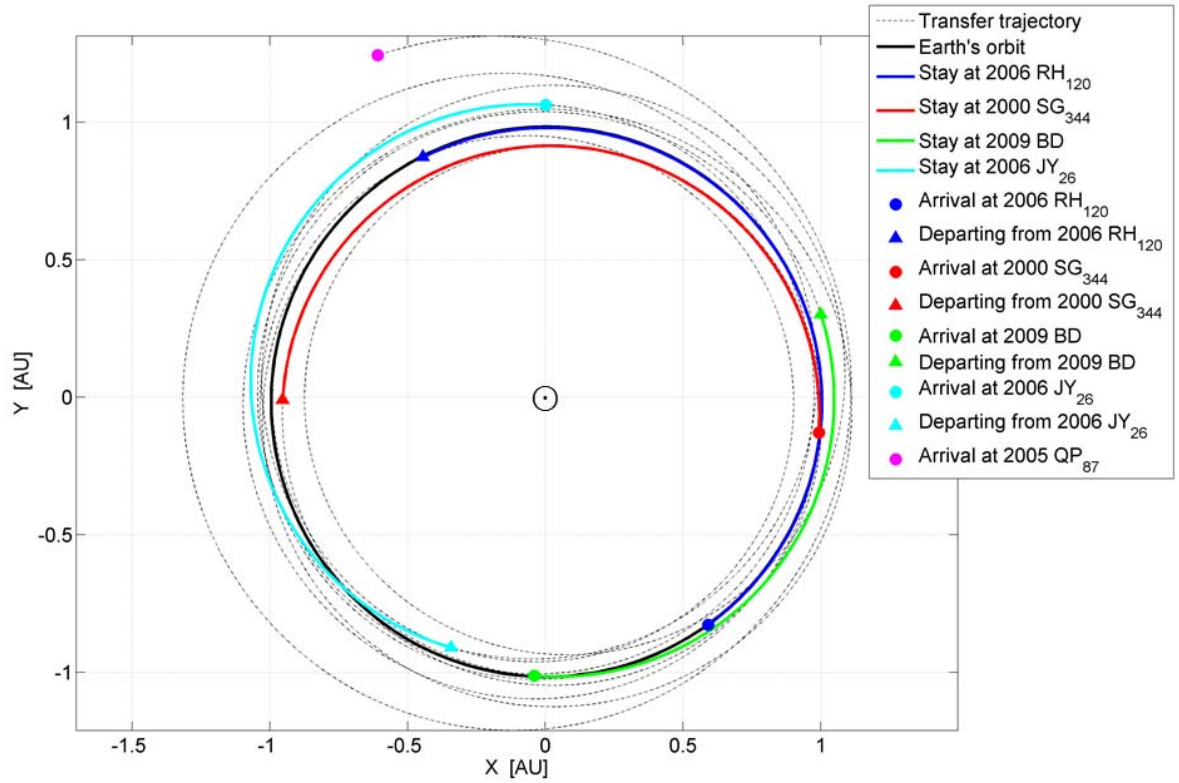

Figure 1. Solar-sail trajectory for a 5 NEAs rendezvous mission.

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