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TEMPORARILY CAPTURED ORBITERS: ENERGY CONSIDERATIONS FOR RENDEZVOUS MISSIONS

Abstract

Temporarily Captured Orbiters (*TCO*s) are likely the ideal candidates, amongst the Near-Earth Asteroids (*NEA*s), for in-situ identification, redirection or even capture missions, due to their proximity and low ΔV requirements. These celestial bodies, also referred to as *minimoons*, are small asteroids, with a 1m diameter on average, that enter the Earth-Moon system (EMS) for a short period of time, before escaping the system or impacting Earth. There have been only two discovered TCOs to date, namely, 2006 RH120 and 2020 CD3. Therefore, the few existing studies on their population are primarily based on simulations, which have shown that at any time there should be at least one TCO orbiting Earth. Such simulations create a database of synthetic TCOs by propagating the orbit of a population of hypothetical NEAs, with pre-assumed orbital elements, under multi-body gravitational dynamics for a given period of time. Despite such efforts, a clear understanding of the orbital characteristics of such bodies is yet to be obtained for proper mission designs.

This paper presents several key results that provide more insight into the formation of TCOs, as well as energy considerations for proper planning of a rendezvous mission with a TCO, using the latest estimates of a population of nearly 20000 synthetic TCOs. First, regions of space are studied where TCOs exhibit low specific energy with respect to various observation locations, including Sun-Earth and Earth-Moon liberation points, through a sensitivity analysis using Monte-Carlo simulations. Next, through investigating the orbital elements of pre-capture TCOs, those elements that affect the inclination of orbital plane during capture period are identified, in order to devise a mechanism for predicting low ΔV TCOs. A key question to also answer is why the majority of TCOs exhibit a retrograde orbit around Earth. Further, the effects of the Moon on temporary captures into the EMS are examined, specifically as to whether the presence of the Moon explains the variability in the non-dimensional Sun-Earth Jacobi constants of the synthetic TCO population. Finally, the paper investigates certain Temporarily Captured Flybys (*TCF*s) that can also be suitable candidates for rendezvous and possibly capture or redirection missions, due to their long stay in the EMS.