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END-OF-LIFE EXTENSION OF L2 MISSIONS TO NEAR EARTH OBJECTS USING MANIFOLD DYNAMICS.

Abstract

Libration point orbits are becoming an increasingly popular destination for astronomy and solar system science missions. At the end of their nominal mission duration, end-of-life disposal strategies are desired to avoid saturating an attractive and highly perturbed region with uncontrolled spacecraft, and thus discard as well possible undesired trajectories intersecting the Earth or the Moon. Propelantless disposal of spacecraft at L_2 towards the outside region of the solar system has been recently proposed (Soldini et. al., 2014). However, assuming the spacecraft retain certain functionalities and controllability, secondary mission targets that can provide valuable scientific return can be devised. An obvious candidate for these libration point mission extensions would be accessible Near Earth Objects (NEO) in their original orbits. There is an abundance of targets among the NEO population that can be reached at much lower costs than other interplanetary destinations.

Utilising a similar strategy to the one employed to capture Easily Retrievable Objects (Garcia Yarnoz et. al., 2013), but inverted in order to use it for escape, transfer opportunities utilising the hyperbolic unstable manifold departing from libration point orbits around L_2 are here calculated and presented. In fact, the Easily Retrievable Object catalogue represents as well the most affordable targets for this inverted strategy. Due to the much lower masses to be accelerated when compared to asteroid capture (essentially the spacecraft), the cap on the total Δv for such a transfer is raised and a larger number of minor bodies can be accessed at modest costs. In addition, the number of NEO available for this end-of-life extension opportunities is increasing on a daily basis with new observations, and various opportunities are expected to be found any given year.

This paper then focuses on the particular case of JAXA's technology demonstrator mission DESTINY (Kawakatsu et. al., 2013), with the main objective of demonstrating a low-thrust spiraling and lunar swing-by strategy to insert a low-cost mission into an L_2 halo orbit. After the nominal mission duration of 2.5 years, if conditions allow, the spacecraft will leave the halo orbit to other yet undecided destinations. This paper analyses the particular orbit and timeframe of the DESTINY mission to propose NEO targets achievable with the capabilities of the spacecraft. An equivalent end-of-life strategy has been already demonstrated with the transfer of the Chinese probe Chang'e 2 to asteroid Toutatis (Zoua et. al., 2014)