ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations and Optimisation (2) (5)

Author: Dr. Joan Pau Sanchez Cuartielles
Advanced Space Concept Laboratory, University of Strathclyde, United Kingdom, jpau.sanchez@upc.edu

Dr. Daniel Garcia Yarnoz
Advanced Space Concept Laboratory, University of Strathclyde, United Kingdom,
Daniel.Garcia-Yarnoz@strath.ac.uk
Dr. Elisa Maria Alessi
IFAC-CNR, Italy, em.alessi@ifac.cnr.it
Prof. Colin R. McInnes
University of Strathclyde, United Kingdom, colin.mcinnes@glasgow.ac.uk

GRAVITATIONAL CAPTURE OPPORTUNITIES FOR ASTEROID RETRIEVAL MISSIONS

Abstract

Recently, significant interest has been devoted to the understanding of the minor bodies of the Solar System, including near-Earth and main belt asteroids and comets. NASA, ESA and JAXA have conceived a series of missions to obtain data from such bodies, having in mind that their characterisation not only provides a deeper insight into the Solar System but also represents a technological challenge for space exploration. Advances in both asteroid deflection technologies and dynamical system theory enable new mission concepts, such as asteroid retrieval missions. These envisage a spacecraft reaching a suitable object, attaching itself to the surface and returning it, or a portion of it, to Earth's orbital neighbourhood. The work presented here aims to provide a feasibility assessment of the latter mission concept by defining a set of preliminary mission opportunities. The asteroid retrieval transfers are sought from the continuum of low energy transfers enabled by the dynamics of invariant manifolds. The judicious use of these dynamical features of the Sun-Earth system provides the best opportunity to find extremely low energy Earth transfers for asteroidal material. With the objective to minimise transfer costs, a global search of impulsive transfers connecting the unperturbed asteroid's orbit with the stable manifold phase of the transfer is performed. Seven different design parameters are included in the process; the target retrieved asteroid, the departure time, the insertion time at the stable manifold, the type of equilibrium orbit at which the manifold asymptotically converges, the energy of the manifold, the time at which the manifold arrives at the Earth and a parameter that defines the particular trajectory within the manifold. The stable manifolds used in this process are associated with planar, vertical Lyapunov and halo orbits, computed in the Circular Restricted Three Body problem. As will be seen, vertical and halo orbits provide a natural solution to compensate for the inclination difference between the asteroid and Earth's orbit. Such an optimisation process is a computationally expensive procedure, thus, in order to search for retrieval opportunities among all 9,000 known asteroids, some pruning techniques based on Jacoby constant and Minimum Intersection Orbital Distance will also be discussed. As a final outcome, a series of realistic examples of asteroid retrieval missions will be given, ranging from small technology demonstration missions, to missions delivering material resources to support future human space ventures.