Paper ID: 13916
oral
student

ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (1) (6)

Author: Ms. Neus Lladó
Elecnor Deimos, Spain

Prof. Josep J. Masdemont
Universitat Politecnica de Catalunya (UPC), Spain
Prof. Gerard Gomez
University of Barcelona, Spain
Dr. Yuan Ren
York University, Canada

CAPTURING SMALL ASTEROIDS INTO SUN-EARTH LAGRANGIAN POINTS FOR MINING PURPOSES

Abstract

The aim of this paper is to study the capture of small Near Earth Objects (NEOs) into the Sun-Earth L1 or L2 using low-thrust propulsion for mining or science purposes. As it is well-known, the vicinity of these points is inside a net of dynamical channels suitable for the transport in the Earth-Moon neighborhood, hence different final destinations from here could be considered. Asteroids with very small mass and not representing a potential hazard have to be considered.

In a fist step of our study a pruning of asteroids that cannot be moved by low-thrust capability is made. As initial database, we have considered NEOs with stellar magnitude bigger than 28, which are the smallest available. A 10-years backward propagation of the trajectory from the Earth for different NEO masses has been done in order to identify suitable candidates. For this purpose we use the Gauss planetary equations to study the most effective direction of thrust in order to change semi-major axis, eccentricity or inclination. Three different bounds depending on the orbital element optimized have been found. NEOs inside these ranges are labeled as possible candidates for transfer to the vicinity of the Sun-Earth L1 or L2 with low-thrust propulsion.

In a second step we optimize the transfer trajectory of the selected asteroids to the L1 or L2 vicinity. To find optimal solutions a direct method has been implemented. Two cases are considered: optimization of transfer time and fuel consumption. In the first one, the thruster is always working, while in the second approach coast arcs can also appear. A Runge-Kutta parallel shooting method based on the sparse nonlinear solver IPOPT has been chosen to solve the problem.

In a first approximation, the problem has been modeled as a Two-body problem in an heliocentric ecliptic coordinate system. The initial seed is a low-thrust trajectory with fixed amount of thrust parallel to the velocity. In a second phase, this problem is optimized fixing the thrust or giving a range for it. Each trajectory is studied in detail, taking into account the trade-off problem of minimizing transfer time and fuel consumption. A refinement of trajectories in more realistic models such as RTBP or full ephemeris equations is also addressed.

Finally, a list of the capable asteroids to get captured by a low-thrust engine comparing the optimized variables of the different models will be made in order to select the best candidates.