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Author: Prof. Maisa Terra
Instituto Tecnológico de Aeronáutica (ITA), Brazil, maisa@ita.br

Dr. Antonio Almeida Prado
INPE, Brazil, prado@dem.inpe.br

CONTRIBUTIONS OF VENUS SWING-BY MANEUVER IN EARTH-MARS TRANSFERS

Abstract

Interplanetary transfer design is challenging given the high complexity involving many-body effects, primarys orbit geometry, elevated cost, suitable time window for departure and return, and transfer time, among other issues [1]. Specially, short-time interplanetary transport based on the exploitation of hyperbolic invariant manifolds associated to the collinear equilibria of the Restricted Three-Body Problem (R3BP) requires additional costs, given that pseudo-heteroclinic connections are not available, except for a few cases, such as, Jupiter-Saturn and Uranus-Neptune systems [2]. Given that, many contributions have explored distinct strategies and techniques to seek suitable interplanetary transfer solutions with affordable costs and reasonable time.

In this paper we investigate Earth-Mars transfer exploring distinct mathematical modeling approaches in order to seek interesting solutions for a round trip to Mars, either direct or via Venus flyby. In the first analysis, transfers are computed exploring the natural dynamics of the Sun-Jupiter system in the context of the R3BP framework. Earth and Mars are considered as point masses with no gravity. However, the eccentricities of their orbits are taken into account. In a second approach, a gravity assist by Venus is included in order to provide a shorter time window for a trip back to Earth, and therefore decrease the total flight time on a round trip. To define good initial guesses for this numerical procedure, an initial classical Lambert problem algorithm provides solutions both for the Earth-Venus leg and the Venus-Mars leg. Besides that, a swing-by maneuver is computed inside the Venus's sphere of influence. These initial guesses are refined to provide solutions of the Sun-Jupiter system dynamics. We compute both solutions for minimum cost and for minimum total flight time, exploring the influence of Venus flyby. We present our results and compare them with other solutions of literature. Finally, we discuss the multiparametric dependence of optimal solutions and suggest possible applications and extensions of our analyzes.

[1] Striepe, S.A. and Braun, R.D., Effects of a Venus Swingby Periapsis Burn During an Earth-Mars Trajectory, The Journal of the Astronautical Sciences 39 (3) 299-312, 1991.

[2] Ren, Y., Masdemont,J.J., Gómez, G., Fantino, E., Two Mechanisms of Natural Transport in the Solar System, Communications in Nonlinear Science and Numerical Simulation 17 (2) 844-853, 2012.