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ENHANCING PLANETARY EXPLORATION BY USING HYBRID PROPULSION TRANSFERS

Abstract

Low-energy transfers, or weak stability boundary transfers, are achieved with impulsive v's that intrinsically involve chemical propulsion. Low-thrust propulsion represents a viable option to attain further reductions of the propellant mass fraction. However, with low-thrust propulsion only, the transfer time increases excessively. In addition, in the case of Earth-Moon transfers, low-thrust propulsion is not likely used to reach the Sun-Earth equilibrium points region; this makes the interior transfer through Earth-Moon L1 the only feasible solution in these cases (e.g., as in SMART-1).

An appealing option to improve the performances of low-energy transfers without increasing the transfer time is represented by the so-called "low-energy, low-thrust transfers" or "hybrid propulsion transfers". The concept of hybrid propulsion transfer has been first observed in 2008, and it has been assessed in a number of more recent works. The transfer is hybrid as both chemical and SEP are used on the same platform. Nevertheless, it is worth stressing that while the duration of SEP is long (tens or hundreds of days), the chemical propulsion is used only to achieve the first translunar injection.

This work analyzes special Earth-Moon transfers that make use of both chemical and solar electric propulsion. A first high-thrust, low-Isp impulse is used to place the spacecraft into an exterior-like low-energy transfer to the Moon, possibly performing a lunar gravity assist. The subsequent use of low-thrust, high-Isp propulsion makes it possible to perform a lunar ballistic capture leading to a final, low-altitude orbit about the Moon. We show through comparison that hybrid propulsion transfers outperform both the chemical transfers (Hohmann, interior, and exterior) and the fully solar electric propulsion transfers (SMART-1-like) in terms of propellant consumption. Hints at system level are given to assess the applicability of such transfers to real scenarios.