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TRAJECTORY OPTIMIZATION FOR CONSTRAINED SEMI-LOW THRUST ORBIT RAISING: THE VIGORIDE CASE.

Abstract

As the role of private companies in space exploitation is growing sharply, the search for efficient orbit raising systems is thriving, targeting the development of systems able to adapt to different mission scenarios and providing commercial satellite operators suitable solutions for different needs.

In this scenario, Momentus Space is developing an innovative system, called Vigoride, that provides rides from low Earth orbits (LEO) to the target orbits at low cost thanks to a water plasma propulsion engine. Such technology lays midway between low thrust and chemical propulsion, offering fast rides at a lower cost with respect to chemical-propelled system. Nevertheless, it presents two main constraints at system level that need to be taken into account when optimizing the transfer:

- Battery charge/discharge time
- Maximum consecutive thrust time and cool-down time

The above constraints required an ad-hoc optimization approach that allowed tackling the problem effectively by calculating the best thrust profile per orbit. The battery constraint imposes that only a certain percentage of the transfer time can be spent thrusting and that, on the other hand, it can be exploited to save power when less efficient and thrust when most efficient. Also, the thrust level is much larger than a typical low thrust system and therefore the orbit changes rapidly, leading to a much more complex optimization problem due to the high sensitivity or the orbital dynamic to the thrust instability. This paper illustrates the approach adopted to solve the problem, with a linear optimization embedded in a closed-loop control law and a genetic algorithm on top exploited to search the best overall transfer. The presented results show how the problem was solved effectively both in terms of obtained trajectories and computational efficiency, thus allowing for an optimal mission design including system-level constraints.