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LEVERAGING MANEUVERS FOR PLANETARY ESCAPE: STRATEGY FOR A SAMPLE AND RETURN MISSION TO SATURN

Abstract

The ever-increasing number of scientific and Solar System exploration missions has stressed the need for new and effective techniques to deal with the trajectory design in a multi-moon system. To that purpose, v_∞-leveraging (VILT) maneuvers have been largely studied and applied for moon tours design, with particular attention to Saturn and Jupiter systems. Moreover, in the context of the Circular Restricted 3-Body Problem (CR3BP), the combined effects of resonant flybys and small leveraging maneuvers as shown to be an extremely efficient and precise tool to refine the VILT design and reduce even more the propellant consumption cost.

The present work aims to exploit these techniques in the context of Saturn sample and return exploration mission, where moon tours are needed to enter and escape the system. The problem is analyzed using two strategies: first a sequence of VILT is generated with a specifically tailored heuristic optimization. In principle, this step is an extremely large-scale combinatorial optimization problem. However, exploiting prior information on the system and imposing constraints on both the overall tour TOF and the resonance conditions, a methodology to reduce the problem dimension and a reduced size Directed Acyclic Graph (DAG) is constructed. Then, the results of this step are used as an initial guess to generate the corresponding Tisserand – Leveraging Transfers (TILT). The overall procedure is critically tested and then applied in a relevant scenario where an end-to-end transfer from the Earth to Saturn's moon Enceladus is designed. The same approach is then used to design the Earth return trajectory, showing the flexibility of the method.