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FROM HYPERBOLIC ARRIVAL TO A CYCLER OF THE INNER LARGE MOONS OF SATURN

Abstract

Since the discovery of geyser-like jets of water vapor and ice particles from an underground ocean beneath its icy crust, Enceladus has become a promising lead in our search for worlds where life could exist. Following the observations of the Cassini spacecraft, Mimas, Tethys and Dione have also gained the attention of the scientific community with questions regarding their age, formation and habitability. This has led to numerous plans for follow-up missions for the in-situ exploration of these moons of Saturn on behalf of scientists and leading space agencies. Previous and current contributions have proposed a lunar cycler of the Inner Large Moons (ILMs, i.e., Mimas, Enceladus, Tethys, Dione) in which the scientific observations of individual bodies are carried out from low-energy orbits of circular restricted three-body problems (CR3BPs) with Saturn and the moons as primaries. Such orbits are built on heteroclinic and homoclinic connections of Lyapunov and Halo orbits of the equilibrium points L1 and L2 of each system, whereas the connecting legs of the cycler (i.e., the trajectories that depart a moon and approach another moon in the system) link states belonging to invariant manifolds of periodic orbits of consecutive Saturn-moon CR3BPs. The present investigation addresses the design of the connection between the hyperbolic arrival from an interplanetary trajectory and the cycler itself. The interplanetary transfer, which was dealt with in a previous contribution, uses a combination of planetary gravity assists and low-thrust propulsion to minimize the hyperbolic excess velocity at Saturn (1 km/s). Here we propose a sequence of gravity assists with Titan, Rhea and the ILMs themselves to further decrease the energy of the spacecraft and approach the scientific targets with a suitable relative speed to initiate the cycler, thus minimizing the use of fuel. In this way, we complete a mission scenario that starts from Earth's departure, reaches Saturn, approaches the ILMs and carries out a complete observation tour of these objects.