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APPROACH STRATEGIES FOR INSERTING INTO ENCELADUS SCIENCE ORBIT CONFIGURATIONS

Abstract

Saturn's moon Enceladus is an exciting destination for future exploration missions thanks to the discovery of organic-rich geysers on its South pole region by the Cassini spacecraft. In particular, a spacecraft orbiting around or in the vicinity of Enceladus would be able to obtain valuable measurements to assess the moon's ability to sustain simple life forms. Options for science orbits with a variety of geometric and observational properties have been proposed in the literature for this type of mission, including include near-circular orbits, highly elliptic inclined orbits, near rectilinear halo orbits (NRHOs), and heteroclinic connections between more distant halo orbits. Generally, one or more impulsive maneuvers are required to insert into these orbits from a Saturn-centric approach trajectory. In order to fully characterize these orbits' suitability for future missions, these insertion costs must be computed for each configuration. These requirements can significantly impact overall mission cost and time constraints.

For individual orbit configurations, methods have been developed in the literature to efficiently compute these insertion costs, including V-infinity leveraging maneuvers, Tisserand-Poincare graphs, and low energy approach trajectories along periodic orbit manifolds. However, not all methods are usable with each type of science orbit, and no thorough evaluation of the best strategy to reach the various proposed Enceladus science orbit configurations has been conducted. In this work, we will provide a consistent comparison of the insertion and approach costs (i.e., Delta-V and time-of-flight) required to enter into each type of science orbit. For all orbit types, we will compute approach trajectories using the Saturn-Enceladus circular restricted three-body problem, in order to establish a consistent dynamic model. Appropriate methodologies for each family of orbits will be identified and analyzed - for example, not all orbit types have useful manifolds along which they can be approached. In addition, the use of intermediate orbits such as halo orbits to act as staging orbits to access the useful lower-altitude science orbits will be investigated.

This work will provide a thorough analysis of the accessibility of the various options for Enceladus science orbits that can serve as a baseline for future mission designs. The strategies detailed in this work will also be applicable to exploration missions around other outer planet moons.