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ANALYSIS OF TECHNOLOGIES FOR ORBIT INSERTION AT SATURN

Abstract

The recent discovery of water vapour plumes at the poles of Enceladus and Europa and other compelling evidence of the existence of subsurface water in the major moons of Uranus has driven the scientific interest and the exploration plans toward these so-called "ocean worlds". In particular, the in situ data provided by Cassini and the observations of HST have revived plans for a return to Saturn. However, a project like Cassini/Huygens is onerous in terms of spacecraft size and mission cost, and one wanders if cheaper and smaller alternatives can exist. In particular, the focus here is on the propellant requirements of the Saturn orbit insertion manoeuvre. In a recent study, the implementation of a gravity assist with Jupiter and an optimal steering law for a propelled arc in the Jupiter-to-Saturn transfer has shown that the arrival hyperbolic excess speed at Saturn can be reduced to 1 km/s or less. This significantly low excess velocity requires an orbit insertion impulse of 150 m/s if the same orbit as Cassini is to be achieved, which is a great feat in comparison with the 622 m/s applied by the latter. This result facilitates the introduction of orbit insertion techniques alternative to propulsion. In this research, we evaluate the performance of gravity assists with Titan along with aero-assisted manoeuvres and electrodynamic tethers. We address the above techniques independently and in combination, with the prime objective of validating their effectiveness in the specified conditions (low relative arrival speed) and, as a second instance, to minimize propellant consumption and maximize payload mass.