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Solar and Hybrid Electric Propulsion Missions to the Outer Solar System

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Abstract

We explore the capability of solar and hybrid solar-nuclear electric propulsion systems to vastly reduce the transit times for robotic missions to Saturn, Neptune and beyond. With a purely solar-electric architecture, the spacecraft performs a slingshot pass close to the Sun and uses the high level of available solar energy to produce a sustained burst of high thrust. Enough kinetic energy is provided during this "sundiver" acceleration maneuver while still within 0.7-1. AU for a payload to reach Jupiter orbit. This study identifies the important parameters in the propulsion system operation (power level, propellant mass, payload release point, distance of closest approach to the Sun), and scan these parameters to understand and optimize the capabilities of the proposed system and mission architecture. The engine's power rating must match the peak power available when the spacecraft is closest to the Sun. The solar array is assumed to be a planar array rather than a concentrator since it will have to operate near the Sun, where concentrators offer a relatively low efficiency increase due to the large solid angle of the Sun. The feasibility of using electric propulsion to provide thrust along the transfer orbit until the transfer orbit reaches >5 AU was also examined. With plausible configurations, a spacecraft can accelerate to 60 kps within 1 AU. In order to stop at Saturn, the spacecraft must retrofire from 1 AU to 5 AU. So far, the best-case Saturn model assumes 30 mT in LEO, and a 5 kps Earth departure velocity from the chemical launch system. The simulation arrives at 1.1×10^6 km from Saturn with a velocity of 3.3 kps. Using chemical SOI, the simulated system delivers an 8.5 mT payload to Saturn orbit in just 4.44 years of transit time. The purely solar powered system will be compared with a solar-nuclear hybrid system to enable extremely deep outer solar system exploration. We will also discuss Uranus, Neptune, Eris, Sedna, and thousand AU simulation results.