Paper ID: 21602
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SPACE PROPULSION SYMPOSIUM (C4)
Poster Session (P)

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MISSION DESIGN STUDY OF AN RTG POWERED ION ENGINE EQUIPPED INTERSTELLAR SPACECRAFT

Abstract

In order to better understand the composition and dynamics of the Local Interstellar Medium (LISM), which will allow for more confident travel through interstellar space, a reference mission called the Interstellar Precursor Mission (IPM) is being investigated. The IPM requires a low-mass scientific spacecraft to reach a heliocentric distance of 200 AU in a reasonable amount of time, which by necessity calls for high-energy-trajectory-enabling propulsion architectures. This research explores a variety of unique mission designs for one such architecture, a spacecraft equipped with a Radioisotope Thermoelectric Generator (RTG) powered Ion Engine traveling on a direct solar system escape trajectory, with the goal of determining the relationship between the propulsion system's design and the ensuing escape trajectory. To do this, an orbit simulator was developed which uses a fourth order Runge-Kutta numerical integration method to propagate the thrusting spacecraft's trajectory through time. The initial stored propellant was designed to be completely consumed by the time of engine cut-off (ECO), meaning constant propellant mass flow rates. Simulations were run for engine burn durations of 5, 10 & 15 years, with initial heliocentric velocities (upon leaving the Earth's sphere of influence, corresponding to different launch vehicle capabilities) of 0, 5, 7, 10 & 12 km/sec launched from a circular 1 AU Earth orbit, and with RTG supplied engine powers of 1000, 1500 & 2000 W. A total of 45 simulations were run for the circular 1 AU case, as well as additional comparison simulations for launches from perihelion and aphelion of an elliptical Earth orbit. These simulations yielded many interesting results concerning the total fly-out times to 200 AU, which ranged dramatically from 35 to 140 years depending on the propulsion system settings and orbital initial conditions. The simulations also highlighted the inherent gravitational maneuver inefficiency felt by all low thrust spacecraft, which becomes more apparent under certain conditions. Relations between the initial conditions and the escape trajectories are also shown. Finally, this work also revealed many details about the performance of the spacecraft's propulsion system, including the consequence that increasing the RTG supply power will result in a greater increase of thrust when operating at shorter engine burn durations.