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INITIAL GUESSES FOR CISLUNAR LOW-THRUST TRANSFERS

Abstract

In the coming years the Lunar Gateway and satellite networks around the Moon will most likely become a reality. To efficiently establish and supply these architectures, electrically propelled space tugs on cislunar low-thrust trajectories could be utilized. To improve the computation time of these transfers, especially in the early mission design phases with changing spacecraft configurations, innovative approaches are required. This paper describes a method to create a database of initial guesses for cislunar low-thrust transfers and rapidly obtains a feasible solution for a cycler concept. For this purpose, the Q-Law, a Lyapunov feedback control law, and an ant colony optimizer were used to generate fuel-to-flight time optimized Pareto fronts for various orbit transfers, specific impulses, and thrust to mass ratios. All calculations were performed within the circular restricted three-body problem and considered eclipses. Several trajectories were inserted into a high-fidelity environment to quantify the influences of perturbations induced by the Sun and the oblateness of the Earth. In the next step, the Pareto fronts were fitted by an analytical function to derive the coefficients presented in the paper. Using generic interpolation methods, a cislunar, low-thrust cycler concept was designed and evaluated. The results indicate that feasible transfer approximations for specific missions can be derived from the Pareto front fits. The transfer epochs were selected to ensure favorable eclipsing conditions. This is crucial since occultations have a significant influence on the transfer time and/or fuel required for the transfer. Finally, this paper looks at the potential next steps including operational constraints, for example the maximum spacecraft slew rates.