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AN EXTENSION AND NUMERICAL ANALYSIS OF THE HOHMANN SPIRAL TRANSFER

Abstract

This paper investigates the application of a Hohmann Spiral Transfer (HST) in an optimal numerical analysis. The Hohmann Spiral Transfer has previously been defined as a co-planar orbit transfer analogous to the bi-elliptic transfer but incorporating low and high-thrust propulsion and assuming a circular intermediate orbit. The research has previously found that for geostationary satellites incorporating this transfer, a mass saving is possible when considering spacecraft of order 1500kg. The two dimensional case is therefore further developed into a full three dimensional analysis to incorporate the need for an inclination change. This analytical method, with its required simplifications is then developed into a full numerical analysis by allowing the optimisation process to vary the shape of the intermediate orbit. To achieve this, the method adopts locally optimal control laws coupled with optimised weighting constants, which through their application reduce the simulation complexity, to deliver a minimum mass transfer. A comparison against the analytical method is presented and when both are similarly constrained, provides comparable results. The paper first introduces a general method before applying it to two case studies. The two transfers, one starting in a circular orbit and the other in an elliptical orbit, both target a final Geostationary Earth Orbit (GEO). The case studies are based on spacecraft of order 1500kg, which from the previous analysis was found to be the region where a mass saving is possible with current propulsion technology. The transfers deliver a minimum mass transfer within a specified duration of ninety days to satisfy commercial time constraints. It is found that although the analytical analysis provides a reasonable estimation of the transfer, due to the assumptions made, the numerical approach delivers an enhanced solution within the specified mission duration. In addition, the numerical analysis provides the optimal trajectory coupled with the detailed thrust profile which was unavailable with the analytical approach.