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SCIENTIFIC MISSION TO A SOLAR POLAR ORBIT USING SOLAR SAIL PROPULSION

Abstract

Solar sail propelled missions to a polar orbit of the Sun offer unique science opportunities. Previous proposals have recommended the use of a 2-phase transfer to reach a solar polar orbit, however a 3-phase transfer has since been shown to offer a significant reduction in the transfer time at the expense of higher thermal stresses. The 3-phase transfer involves spiralling in close to the Sun, performing a rapid inclination increase, and spiralling back out to the final target orbit. A general perturbation solution for such a transfer has been defined which offers significant advantages over the numerically optimised solutions currently available. The insights provided by this analytical solution are used here to rapidly generate a holistic understanding of the mission architecture options available and hence how the mission and system design could be traded. A number of potential science missions are identified which could benefit uniquely from the use of such an orbit. These require that a solar latitude of 60 be achieved within 5 years before proceeding to a true polar orbit. A comparison between the use of the 2- and 3-phase transfer options identify that in real terms, the 3-phase transfer will reach a polar orbit approximately 1 year ahead of the 2-phase transfer. In addition, the increased efficiency of the transfer would allow for an increase in the allowable payload mass; with up to an extra 33kg payload potential predicted. Further work should allow for the mission and system design to be traded; for example to investigate the implications of increased thermal system mass (due to a reduction in the minimum solar approach distance) against reduced transfer time or sail size.