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A NOVEL APPROACH TO HYBRID PROPULSION TRANSFERS

Abstract

This paper investigates an orbit transfer concept for a spacecraft with both low and high thrust propulsion systems. The concept is analogous to the high-thrust bi-elliptic transfer. A low-thrust system compared to a conventional high thrust system offers a higher specific impulse implying lower fuel mass consumption; detrimentally however, it has a lower thrust indicating increased transfer time. As such, there is a desire to find the optimal combination of high and low-thrust propulsion to give the best performance for a given set of mission characteristics. Through analytical analysis a detailed parametric trade-space is derived based on specific impulse ratios of the two systems, initial and target orbit radius, transfer time and, most importantly, final mass. It is shown that fuel mass savings of up to 20

A typical bi-elliptic transfer involves three impulses to capture the target orbit; the first impulse occurs at the initial orbit and sends the spacecraft into an elliptical orbit far beyond the target orbit. At the apoapsis a second impulse is applied increasing the orbit energy and initiating the return leg of the elliptical transfer. At the periapsis a third impulse is used to slow the spacecraft and capture into the final orbit. In a similar fashion the hybrid method uses two high-thrust impulses to firstly reach the apoapsis via an elliptical orbit and then to circularise at this radius. Subsequently the low-thrust system is activated and instead of following an elliptical orbit towards the target, a spiral trajectory is used until the final orbit is reached.

Additionally, it was found that the activation point of the low-thrust system can drastically affect the overall propellant mass when only considering transfers smaller than the target orbit. This portion of the results has been identified in prior work, therefore endorsing the validity of the new results within this paper.