An Analytic Solution to Fuel-Optimal Reconfiguration of Satellite Formation Flying in the Presence of J_2 Geopotential Disturbance

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Over the past few years there has been a growing interest in satellite formation flying. Originally Hill's equations of relative motion have been used to analyze relative motion between satellites. However, they did not capture the effect of J_2 geopotential disturbance. To resolve this problem, we utilize a set of constant-coefficient, linearized, differential equations of motion given by Schweighart and Sedwick, which include the J_2 effect with very high accuracy. We calculated optimal thrust functions which minimize fuel cost during the reconfiguration of formation of satellites in the presence of the J_2 potential, assuming that the initial/final states in the LVLH frame and transfer time are given. To this end we represented the thrust functions along each axis in a Fourier series and incorporating the constraints at the boundaries, we obtained optimal Fourier coefficients that minimize the fuel cost during the maneuver. The thrust functions composed of these Fourier coefficients can be simply represented in a closed form and no approximation is needed. This analytic solution can be employed in preliminary analysis as a more practical tool.