Harnessing the Sun’s Gravity for LEO to GEO Transfers

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The geosynchronous orbit (GEO) belt is in incredibly high demand, yet it requires a considerable amount of fuel to reach. Common launch sites for GEO satellites include Guiana Space Centre, Kennedy Space Center and Baikonur Cosmodrome. Without dog-leg maneuvers, the minimum inclination that may be reached are 5, 28.5 and 51° respectively. Therefore, for high latitude launch sites, a large part of the fuel budget is allocated for inclination changes (Δi). To minimize this additional cost, several strategies have been developed in the past, such as two-burn strategies where the Δi is optimally distributed over the two burns, three-burn bi-elliptic or supersynchronous transfers where the Δi is performed at high altitudes, etc.

In [1], a new strategy is proposed where the Δi and periapsis raise (Δrp) from LEO to GEO is performed by third-body perturbations from the Sun. Transfers starting at a 51° inclined orbit have been found that require only 2.5% more ΔV than transfers from 28.5°. Hence, this technology facilitates flexibility in launch site selection to go to GEO. Such transfers depart LEO after an in-plane impulse in the velocity-direction to reach the required transfer orbit eccentricity and arrive back at periapsis at GEO altitude with the right inclination, after which another in-plane impulse in the anti-velocity direction re-circularises the orbit. Assuming the initial rp and i are fixed, the design variables are time of year of launch, initial transfer eccentricity (e), argument of periapsis (ω) and longitude of ascending node (Ω). Every permutation of those four design variables result in different realizations for final rp and final i. Given the size of the state space, and the sensitive maps between design variables and final rp and i values, navigating the state space is not trivial.

In this paper, a robust way to find transfers for any time of year and initial orbit inclination is developed. For each time of year, with resolution one day, the combination of initial values, navigating the state space is not trivial.

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Fig. 1. Example Δrp contour

Fig. 2. Final results

References