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ANALYSIS AND OPTIMIZATION OF A NETWORK OF ORBITAL STATIONS FOR MOMENTUM EXCHANGE TRANSFERS

Abstract

Space stations in Earth orbit can be coordinated in a network to host other space missions and reduce drastically the need of propellant-based propulsion. This work models and studies the orbital dynamics of a network of stations which can perform capture and release payload operations up to a limit relative velocity, thereby imparting a ΔV that allows them to reach the next station propellantlessly. If the mass of the stations is comparably higher to that of payloads, the ascending transport operations are supported by the orbital energy and momentum of the stations. The network can restore its momentum by descending payloads if the traffic of out-faring and in-faring payloads is balanced, thus behaving as an accumulator for orbital energy.

Through an iterative procedure, simultaneous payloads operations can be simulated in a programming environment. A model incorporating the payload transfer operations, an orbital propagator and a targeting scheme is capable of reproducing the functioning of the network, thus obtaining useful data on the degradation inflicted to the stations among other operational information.

A network design procedure is proposed based on the maximum allowable relative velocity between payloads and stations. With applicable safety factors and design margins, the scheme can produce networks that improve the distribution of the degradation imposed on each station of the network upon mission execution, spreading the induced perturbations more evenly.

Lastly, a scheme to optimize the capture/release schedule is established to minimize the perturbation to the orbital parameters of the stations for a given mission profile. Results measure the performance of a network under two example mission profiles. For the proposed case study, the optimizer algorithm successfully finds the appropriate timing of operations in order to fulfill the relative velocity constraint and attain an 8% improvement in the selected cost function.