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DYNAMIC PROXIMITY OPERATIONS: USING SWARMS OF ROBOTIC SPACECRAFT FOR IN-SPACE MANUFACTURING

Abstract

With the emergence of the space servicing sector, along with the return of manned missions beyond low earth orbit, there is an increased need for quick, efficient, and most of all, safe Rendezvous and Proximity Operations (RPO). More than that, the next big step forward may be manufacturing in space, which will involve swarms of small satellites cooperating in close proximity to each other, all subjected to the same laws of orbital mechanics. Currently, there is a lack of knowledge about how to safely operate a swarm of spacecraft in close quarters in a dynamically changing environment (i.e., a "space construction site"), without creating a high risk of collision and potential debris creation.

To do this, a methodology was developed using genetic algorithms. These algorithms are designed to swarm architecture with a stable, recurring, and efficient set of trajectories. This can be done for a swarm of N spacecraft, taking into account gravitational perturbations, to obtain trajectories that are recurring over a set amount of time. In addition, this methodology takes into account the dynamic nature of a "space construction site", where the size, shape, and spin of the reference body is changing. This involves altering the trajectories over time to take into account these changes to the system, while also minimizing the delta-V costs of these maneuvers.

This paper will describe the swarm architecture methodology proposed, as well as its merits, drawbacks, and optimal use cases. It will also investigate the resulting trajectories from this genetic algorithm methodology and compare them to those resulting from traditional orbital determination schemes.