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FUEL-MINIMUM FUEL-AVERAGE CONTROL ALGORITHM FOR LARGE CONSTELLATION CONFIGURATION MAINTENANCE BASED ON PERTURBATION COMPENSATION METHOD

Abstract

In the recent years, many large constellations are being or to be deployed in Low Earth Orbit (LEO), to provide high-speed telecommunication services for the global Earth. Under the complex perturbations in LEO regime, the constellation configuration will deviate from the nominal one and has to be maintained frequently; in other words, the relative drifts between satellites have to be eliminated. In this work, we develop a fuel-minimum fuel-average control algorithm for large constellation configuration maintenance, using the perturbation compensation method. The idea of this method is to slightly offset the mean orbital elements of satellites, so that the linear part of the drift can by compensated by the long-term perturbed motion caused by the element offsets. Firstly, we propose a concept of constellation-relative drift, to make the fuel consumption of satellites even. For a j-th constellation satellite, the constellation-relative drift is defined as the absolute drift of that satellite subtracted from the average absolute drifts of all constellation satellites. Then, we perform a Taylor expansion in power of the element offsets for the drift rates, considering the Earth oblateness perturbation and the luni-solar perturbation, the two dominant perturbations in LEO regime; by integrating the expanded drift rates in time, we are able to derive a matrix equation composed of the element offsets, the drifts, and the influence of the element offsets on the drift rates. However, the solution to this equation, i.e., the element offsets, is not unique. In order to solve this problem, we first employ the matrix analysis theory to derive the solution space, and then build-up a quadratic index that evaluates the total fuel consumption of all satellites and the difference between the fuel consumption of each satellite with respect to the average fuel consumption of all satellites. Finally, according to the first-order necessary condition for local optimality, the optimal element offsets, which minimises the quadratic index, can be obtained.