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Author: Ms. Simeng Huang
Politecnico di Milano, Italy, simeng.huang@polimi.it

Dr. Camilla Colombo
Politecnico di Milano, Italy, camilla.colombo@polimi.it
Dr. Elisa Maria Alessi
IFAC-CNR, Italy, em.alessi@ifac.cnr.it

COMPARATIVE STUDY ON LARGE CONSTELLATION DE-ORBIT STRATEGIES

Abstract

Over the past years, the international interest in large constellations, which are aiming to provide high-speed telecommunication services, is increasingly growing. Many companies, such as OneWeb and SpaceX, have announced the plans to deploy large constellations in Low Earth Orbit (LEO). However, the arise of large constellations, which are composed of hundreds to thousands of satellites, will pose a severe safety threat to the already congested LEO regime. To make the space sustainably usable, large constellations must be properly removed after their end of life. According to the plan of the OneWeb Constellation, low-thrust technology will be used for the orbital transfer phases such as orbit raising and de-orbiting. De-orbiting with low-thrust propulsion is usually achieved via two phases – propulsive phase and non-propulsive phase. That is to say, the spacecraft is actively de-orbited by low-thrust, and then passively re-enters under the natural forces (e.g. atmospheric drag). For the propulsive phase, the common way is lowering the orbital perigee to reach the drag dominated region, which is also the plan of the OneWeb Constellation. For the non-propulsive phase, the traditional way is naturally re-entering under the atmospheric drag. With the development of materials and manufacturing technology, more and more passive de-orbiting devices (e.g. drag and solar sail, and electrodynamic tether) have been used to accelerate the non-propulsive phase. Within past projects funded by the EU commission and ESA, the applicability of solar sails for passive de-orbiting has been demonstrated. This paper will conduct a comparative study for three de-orbit strategies that have application potential for large constellations. The first strategy is lowering the perigee by chemical thrust. The second strategy is lowering the perigee by low-thrust. For these two strategies, once the drag dominated region is reached, the satellite will passively re-enter under the atmospheric drag. The third strategy is reaching a de-orbit corridor by low-thrust. The de-orbit corridor is the resonance due to the Earth's oblateness and solar radiation pressure. And then, driven by the natural perturbations, the eccentricity will be passively increased with the aid of an augmentation device such as solar sail, until the drag dominated region is reached. The comparison will be conducted in a trade-off way from four aspects – fuel consumption, total time to de-orbit, solar sail area-to-mass ratio requirements, constellation coverage performance, for different positions (i.e. semi-major axis and inclination) that the large constellations can be placed.