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Author: Mr. Ryusuke Harada
Japan Aerospace Exploration Agency (JAXA), Japan

Dr. Satomi Kawamoto
Japan Aerospace Exploration Agency (JAXA), Japan
Mr. Nobuaki Nagaoka
JAXA, Japan
Prof. Toshiya Hanada
Kyushu University, Japan

THE IMPACT ASSESSMENT OF ACCIDENTAL EXPLOSIONS OF LARGE CONSTELLATIONS ON LOW EARTH ORBIT ENVIRONMENT

Abstract

Currently, several commercial companies plan to build global communication infrastructures by using large constellations (LCs). Some of them has already started to deploy spacecraft in low earth orbit (LEO), and their service is available in some area. An LC consists of hundreds to thousands of 100 – 300 kg satellites with an altitude of 300 – 1300 km replaced every year during the constellation lifetime. Because of the large number of spacecraft, the LC has great impacts on LEO once inserted in orbit. JAXA's previous work availed the long-term stability and short-term safety for an LC deployed by varying their altitude and number of spacecraft. When LC's altitude is lower, the impacts appear shortly and the long-term effect may be acceptable. However, an unstable self-cascading effect occurs when LCs are inserted into higher orbits. These results were shown through numerical simulations assuming accidental collisions but no explosions. Since an great number of fragments are generated once an explosion occurred, the impacts of LC's explosions will affect enormously on LEO environment. This study aims to assess the impact of accidental explosions in an LC on LEO and reveal the relativeness of explosion rate, number of spacecraft, operational altitude, and post-mission disposal (PMD) success rate of LC. The environmental impacts are evaluated from the point of views such as the effective number of objects, the number of conjunctions, and the cumulative collision probability including small size of debris. The effects of explosions in an LC are evaluated in comparison to the result of no explosion case. An LC is deployed in higher orbits and lower orbits varying number of spacecraft aiming to reveal the difference of behaviors depending on altitudes. When continuous explosions happened at higher altitudes during the constellation lifetime, the new debris will accumulate in orbits and boost the effect of unstable self-cascading. On the other hand, newly generated debris by explosions in lower altitudes will cause secondary impacts such as collisions with LEO objects because of the high population in its altitude, and the number of conjunctions with debris larger than 10 cm or collisions with small debris will greatly increase. The explosion rate would be a parameter with 0.001 as a benchmark. The upper limits of the explosion rate corresponding to LC's characteristics such as operational altitude, number of spacecraft, and PMD success rate is also discussed.