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FEASIBILITY ANALYSIS OF LARGE-SIZE SPACE DEBRIS DE-ORBITING FROM NEAR-EARTH ORBITS WITH RESPECT TO THE INITIAL MASS OF A FUELLED SC-COLLECTOR

Abstract

Despite of availability of various instruments for dealing with large-size space debris, two main concepts of its de-orbiting to a disposal orbit (DO) can be singled out. Under the first approach, an active spacecraft (SC) transfers between objects and "docs with them" and then their transfers to DOs are effected using thruster de-orbiting kits (TDK). Under the second approach, an object is towed to a DO by an active SC, which executes a transfer to the next object in line from the DO of the previous object. From the point of view of the total V the first de-orbiting variant is much more beneficial both for LEO and GEO. However, the key point in the context of their feasibility is the initial mass of fuelled SC-collector. Under the first de-orbiting variant, in addition to the masses of fuel, of propulsion unit and SC dry mass, one should also take into account total dry masses of all TDKs and fuel in them. As a consequence, in the course of transfers an active SC should carry certain additional mass, which gradually decreases as the next in line object has been de-orbited. Under the second variant, a SC, which operates as a towing vehicle, has to push to a DO an object of several metric tons, which also involves additional fuel consumption. The report analyzes the total mass of a SC-collector versus de-orbiting variants and types of objects (LEO/HEO). For the first de-orbiting variant, we in addition examine the optimal number of TDKs onboard one SC-collector. Calculations show that the first re-orbiting variant is hardly feasible for cleaning GEO protected region. Even 5 TDKs onboard of an active SC makes it to weigh about 5 metric tons, which approaches the limit capabilities of modern heavy launch vehicles for coplanar injection. The second re-orbiting variant is feasible, above all, because a re-orbiting of an object to a DO and return back to GEO requires at most 20 m/s. For low-Earth orbits of existing objects (in the 800-1300 km altitude range), a formation of a DO with 25 years life span requires at least 100 m/s. Hence, the first de-orbiting variant with TDKs is more beneficial. Depending on the type of de-orbited objects (here 5 homogeneous groups can be singled out), the optimal number of onboard TDKs varies from 8 to 12, and the total mass of an SC-collector, from 7 to 12 metric tons.