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IMPACT OF MISSION PARAMETERS ON THE PREFERRED VARIANT OF LARGE SPACE DEBRIS TRANSFER TO THE DISPOSAL ORBIT

Abstract

During the last 4 years the first demonstration spaceflights were realized, in which some elements of future ADR missions were practiced. It is economically reasonable to remove several objects by one spacecraft as it is planned, for example, in MRV project (2024). All current projects on cleaning the near-Earth space actually come down to two basic concepts. The first variant assumes that there are detachable propulsion modules onboard an active spacecraft. If the object is captured, such a module is fixed on its surface (most often in a nozzle) and after undocking it gives out a velocity impulse to change the orbit of the object. According to the second variant the spacecraft plays a role of a tug, transferring an object to a disposal orbit by itself. Preliminary analysis has shown that the first variant may be preferable for low orbits, and the second variant – for the vicinity of the geostationary orbit. This report presents the results of calculations, which made it possible to obtain the altitude optimality border for two variants of removal. In addition, it contains a detailed study of the sensitivity of this optimality border to six mission input parameters:

- dry mass of the active spacecraft;
- dry mass of the propulsion module;
- mass of the typical object to be taken away;
- required change in the semi-major axis to transfer the object to the disposal orbit;
- number of detachable modules on board (number of objects, taken away by one spacecraft);
- average value of ΔV for a flight between two objects.

This study used both the requirements of ISO 24113:2019 (for low orbits and GEO) and the ideas of various authors for GNSS altitudes to determine disposal orbit parameters. Varying the dry masses of the spacecraft and the detachable module was carried out on the basis of the design analysis of space systems and their components. The average ΔV values were obtained based on optimal transfer schemes between objects using natural orbital perturbations. The mass of the passive objects varies from 1 to 9 metric tons (R/B and upper stages). The results of the multiparameter analysis show that in most cases the optimality border of disposal variants is located between heights of 5 and 15 thousand kilometers. Special attention in the report is paid to the cases that do not fall in the specified altitude interval.