20th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Post Mission Disposal and Space Debris Removal 2 - SEM (6)

Author: Dr. Victoria Mayorova
Bauman Moscow State Technical University, Russian Federation, victoria.mayorova@gmail.com

Dr. Georgy Shcheglov
Bauman Moscow State Technical University, Russian Federation, h15r@yandex.ru
Dr. Dmitriy Grishko
Bauman Moscow State Technical University, Russian Federation, dim.gr@mail.ru
Mr. Mihail Stognii
Bauman Moscow State Technical University, Russian Federation, mihael199617@yandex.ru
Mr. Sergey Ivanov
Bauman Moscow State Technical University, Russian Federation, isgsial@mail.ru

HYBRID BRAKING SYSTEM FOR LARGE SPACE DEBRIS OBJECTS TO ACCELERATE DEGRADATION OF 25-YEARS DISPOSAL ORBIT

Abstract

According to the current ISO 24113:2019 standard, the lifetime of low disposal orbit must not exceed 25 years. Consequently, this value can be considered as one of the target criteria in promising ADR missions. Previous studies have shown that in 700-1200 km altitude range for R/B disposal the most effective is to equip the active spacecraft (patent RU2695155) with detachable propulsion modules. After capturing an object, such a de-orbiting kit is fixed in its nozzle and further provides its independent removal to the disposal orbit.

The choice of an elliptical disposal orbit (perigee altitude of about 400-450 km) is 1.5 times more advantageous compared to the circular orbit in terms of the required ΔV. However, the apogee of such an orbit of a removed object drops below 700 km only in about 10 years. All this time, the disposal orbit crosses the most populated regions of near-Earth space, increasing risk of collisions and fragmentation. A way out of this situation is the usage of a hybrid scheme for braking the object.

The report investigates the effectiveness of an additional aerodynamic subsystem of the propulsion module, which is deployed after the stage is transferred to a 25-year elliptical disposal orbit. The cross-section area is increased by using several inflatable thin-walled spherical shells, analogous to the "Echo" satellite. To fill the shells one uses supercharging gas left in the displacement delivery system of the propulsion module after the braking impulse. The main advantage of this auxiliary passive technology is the relatively low mass of structures used with a significant increase in surface area, which allows to reduce the lifetime of the disposal orbit to several years. The research covers two different types of stages with masses of 9 and 1.5 tons.

At the next stage we consider the task of finding compromise parameters of the disposal orbit, formed by the braking impulse and evolving due to the passive aerodynamic subsystem. On one hand, the initial disposal orbit should not cross the altitude of 650-700 km, and on the other hand, it should degrade over 25 years. The report presents the results of mass analysis of a propulsion module equipped with a hybrid braking system and finds a reasonable ratio between the propellant mass in the module and the mass of the additional aerodynamic surface. The results obtained allow to reduce the launch mass of the active spacecraft, designed for ADR missions.