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ANALYSIS OF TECHNOLOGIES FOR SPACECRAFT REMOVAL FROM LOW EARTH ORBITS USING ONBOARD-PRODUCED ELECTROMAGNETIC AND MAGNETIC FIELDS

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The aim of this paper is to analyze the effectiveness of propulsion devices with permanent magnets as an alternative space debris deorbit system for low earth orbits.

The paper considers current problems in the development of methods and means for deorbiting used spacecraft with the help of electromagnetic and magnetic fields produced by different onboard magnetic devices and overviews state-of-the art spacecraft deorbit systems that use an onboard-produced electromagnetic field whose interaction with the incident flow of the ionospheric plasma and the Earth's magnetic field produces an additional drag force, thus deorbiting the spacecraft. The advantages and disadvantages of electromagnetic spacecraft propulsion systems are identified. An alternative method and system are proposed for deorbiting space debris objects using permanent-magnet propulsion devices. A construction diagram of a permanent-magnet device is presented, and an algorithm of its operation is proposed. Magnetic and electromagnetic field shields were analyzed, and the most appropriate shielding material was chosen: a multilayer shield that consists of aluminum, copper, and magnetic layers. A mathematical model of the orbital motion of a spacecraft with the permanent-magnet device was developed. Using SciLab, the deorbit time was calculated for different spacecraft and different altitudes. From the calculated results it was concluded that the effectiveness of the magnet-produced drag force depends on the relation between the spacecraft's inertial characteristics and the permanent magnet volume. It was found that permanent-magnet propulsion devices as deorbit systems are ineffective for large spacecraft heavier than 2 t. This is due to the fact that the increase in the magnet-produced drag force with the permanent magnet volume is not in proportion to the increase in the spacecraft's inertial characteristics with the spacecraft mass. Using these results, the range of effective use of permanent-magnet propulsion device was determined.

Keywords: *permanent magnets, spacecraft, deorbit system, magnetic field, electromagnetic field, electric field, ionospheric plasma flow.*

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