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RECONSTRUCTION OF MOTION RELATIVE TO THE CENTER OF MASS OF A LOW-ALTITUDE NANOSATELLITE FROM TRAJECTORY MEASUREMENTS

Abstract

The possibility of indirect restoration of motion relative to the center of mass of a low-altitude nanosatellite of the CubeSa3U standard using trajectory measurements (TLE files) is being investigated. The need to solve such a problem arises if it is not possible to establish radio communication with the nanosatellite after it has been injected into orbit. Therefore, it is important for nanosatellite developers to get at least some idea of the nanosatellite's behavior, which can help determine the cause of the emergency. The study was carried out on the example of the SamSat-218D nanosatellite developed by the Samara University, which was launched into a near-circular orbit with an altitude of 486 km in April 2016 during the first launch campaign from the Vostochny cosmodrome. SamSat-218D is an aerodynamically stabilized nanosatellite of the CubeSa3U standard, for which not only inertial and mass characteristics are known, but also a margin of static stability. The features of the behavior of aerodynamically stabilized nanosatellites in low orbits, due to both the influence of the atmosphere and the design parameters, have been experimentally confirmed: the service life of nanosatellites is shorter, and the angular acceleration created by the aerodynamic moment is much higher compared to satellites with large sizes and masses. The change in the ballistic coefficient of a nanosatellite in time is estimated from the known trajectory measurements and information on the average density of the atmosphere at the points of the trajectory measurements. The ballistic coefficient of the SamSat-218D nanosatellite, which has the shape of a rectangular parallelepiped, depends on the spatial angle of attack and the angle of its own rotation. The ratio of the maximum value of the ballistic coefficient to the minimum value is 4.75. Knowledge of the aerodynamic moment characteristics made it possible to assess the nature of the possible motion relative to the center of mass of the nanosatellite by changing the ballistic coefficient. At the initial stages of the flight, the nanosatellite performed oscillatory motion, which indicated a low value of the angular velocity acquired after exiting the launching device, which confirmed the high characteristics of the launching device. The most probable motion relative to the center of mass of the SamSat-218D nanosatellite is a transitional regime of motion between different equilibrium positions due to the commensurability of aerodynamic and gravitational moments and insignificant angular velocities as it descends in the atmosphere. Over the past 5 years since the launch of the nanosatellite, the satellite's orbital altitude has decreased by almost 70 km, while the atmospheric density provided the satellite's orientation along the orbital velocity, which increases the time of its existence in orbit.