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STATISTICAL RESEARCH OF THE NANOSATELLITE RELATIVE MOTION AFTER SEPARATION FROM THE ROCKET CARRIER UPPER STAGE

Abstract

This paper is dedicated to the problem of upper stages use for a nanosatellite low-cost orbiting as a piggy back launch (for example, the rocket "Soyuz"). Upper stages after separation of the primary payload make uncontrollable flight and become space debris. Reliable data on angular velocities the stage obtained are not available, because it was not expected their use. Statistical modeling of the primary payload separation process allowed to calculate estimates of the angular velocity projections, which obtains the upper stage (for the upper stage of the rocket carrier "Soyuz" their range is +/ – 2.5 deg/s). These data allowed to formulate a new task to provide the safe separation of the secondary payload (nanosatellite) from the upper stage for which the orientation of the longitudinal axis is described by a probabilistic model. In this problem, when the motion at low orbits due to the large differences between ballistic coefficients of upper stage and nanosatellite, the atmospheric drag can occur dangerous for two flight turns after the separation. Preliminary analysis confirmed the relevance of this problem and need choose the initial conditions of separation (time delay and the separation velocity of the nanosatellite) for guaranteeing of safe motion both nanosatellite and upper stage. There was obtained the analytical equations for the distribution laws of the nanosatellite separation velocity components in the random orientation of the upper stage longitudinal axis conditions. These equations are allowed to estimate the probability of the nanosatellite hit in a dangerous area around the upper stage. The results obtained analytically are coincided with the results of the numerical simulation. Their were made the estimations of the probability of possible dangerous approaches occurrence for Soyuz orbital stage (insertion orbit – heights in perigee 190 km, in apogee 240 km) and formed the recommendations for dangerous approaches prevention. The acceptable parameters of the nanosatellite separation with the random nature of the upper stage orientation were obtained. The separation velocity should be from 1 m/s till 1.5 m/s, and the time delay of the nanosatellite separation after the primary payload separation should be from 5 s till 20 s. The method of choice of separation parameters from non-oriented platform can use for piggy back launching not only for Soyuz upper stage but for other rockets. The reported study was partially supported by Russian Fund for Basic Research, research project No. 13-08-97015- r$_V olgaregion_a$.