15th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations (IP)

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SPACE DEBRIS CLOUD EVOLUTION MODELING WITH RESPECT TO MUTUAL COLLISIONS

Abstract

To estimate the contribution of consequences of collision of small-sized objects (SOs) into the current near-Earth space (NES) contamination level, a different approach has been carried out. The main area of investigation is about mutual collisions between the orbital debris particles. During the situation forecasting, the fragmentation model was used, whose parameters were updated based on available data. For cataloged objects, the forecast and real data agree well enough. For smaller-size objects, the results occurred to be unexpected. They testify to the very strong effect of mutual collisions on NES contamination by particles of the size from 1 mm to 5.0 cm. the estimates of a number of objects of mentioned size occurred to be greater an order of magnitude. Space debris smaller than 1 mm in size still have enough energy to cause a fatal damage on a spacecraft, but such tiny debris cannot be followed or tracked from the ground. The focus is on proving two different theories on the matter of debris cloud evolution. The first theory suggested is to separate orbital objects by size, and then calculate the probability of their mutual collisions. Moreover, the amount of energy needed to create new objects has been calculated. Another approach is about implementing the approach of short –term encounters and long-term encounters. We must choose three different random variables as a common basis so that we can meaningfully compute the collision probability. This probability is determined by evaluating a three-dimensional integral over the appropriate region corresponding to the values of the random variables. These approaches have been combined to calculate the collision probability inside the debris cloud. Previous analyses have not considered the effects of satellite appendages, which lead to an underestimation of the long-term space debris population.

This work estimates the total number, size, area-to-mass ratio, and relative velocity of the cataloged fragments; calculates the lifetime and orbital evolution of the fragments and evaluates the short- and long-term hazards they pose in the space environment. How the collision probability depends on the shapes of the colliding objects is analyzed, and results indicate that including shape dependence will increase estimates of collision probability.

Keywords: orbital debris, debris cloud evolution, breakup modeling, cascade effect