COllISION OF SPACECRAFT WITH DEBRIS PARTICLES ASSESSMENT

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ABSTRACT *– This paper presents the results of investigations of key problem of collision hazards evaluation: (a) current SD environment, (b) technique for collision probability evaluation, (c) characteristics of the relative flux of SD, (d) account of shape and orientation of typical spacecraft modules, (e) characteristics of the new software for the SD impact hazards evaluation. The test penetration probability calculations are performed; the related results are presented and analyzed.*

KEYWORDS: collisions, cross-sectional are flux, debris, orbital elements, probability of penetration, spatial density, relative velocity, software.

INTRODUCTION

The space debris contamination of the near-earth space (NES) is one of the negative consequences of its practical exploration. This activity gave rise to the generation of a set of rather small-sized space objects, whose study became a new trend in classical astronomy. Further NES exploration is impossible without objective analysis of the current state of contamination, along with its sources and evolution laws. The problem of estimating the possibility of collisions of space debris (SD) is relatively new. Now this problem is being intensively developed. Obviously, in the absence of detailed data on the orbital elements of small-sized objects, the study of the hazard of spacecraft collisions with these objects requires a statistical approach.

Our integrated Space Debris Prediction and Analysis model (SDPA) [1, 2, 3] is a semi analytical stochastic one for the mid- and long-term forecasting of manmade SD larger than 1 mm in size. It is designed for constructing the spatial distributions of density and velocity characteristics, as well as for estimating collision hazard. The aggregate data on SD of various sizes are considered (without joining them to particular contamination sources). The SD characteristics are built on the basis of complex use of accessible measurement information and various a priori data.

In addition to the aforementioned integrated model, an engineering model was developed (SDPA-E) [4], which is similar to the NASA and ESA models [5, 6]. Similarly to these models, the basic initial data files for the engineering model have been prepared on the basis of a large amount of calculations performed by the more complicated model (SDPA). The engineering model is designed for rapid, convenient, and visual presentation of SD characteristics.

CURRENT SPACE DEBRIS ENVIRIOMENT

In accordance with statistical approach to the description of space debris environment, it is characterized by: (a) the dependence of a spatial density on the altitude and latitude of a point, as well as on the size of objects $\rho(h,\varphi,d)$; (b) by statistical distributions of the magnitude $p(V,...)$ and direction of space object velocity $p(A,...)$ in the inertial geocentric coordinate system; (c) the averaged description of contamination sources is applied, which allows one to minimize the number of parameters to be updated from the known experimental data. The longitudinal dependence is not taken into account, as a rule, since the statistical distribution of the ascending node longitude of all SD in the LEO region is close to uniform one. Besides, the developed technique is used the following principles of statistical description of SD motion: (d) the laws of motion are applied to objects considered as the Earth's satellites; (e) the a priori data on disturbing factors are used to a maximum extent.