The forecast of near-Earth space contamination for 200 years and the Kessler Syndrome

A.I. Nazarenko

Abstract. The paper presents the results of application of the last version of the SDPA (Space Debris Prediction and Analysis) model for forecasting the human-produced contamination of the low Earth orbit area with accounting for mutual collisions of catalogued objects. The forecasting term is 200 years. It is shown that this source of formation of small-sized space debris is essential already now. The conclusion is drawn that the *irreversible growth of human-produced contamination of space has turned from a hypothesis (the Kessler syndrome) to reality: it already began.*

Previous works. At the end of 90-ties the SDPA model [1] was updated in the interests of performing the long-term forecast of the LEO contamination level. The feature of these studies consists in the fact that the main attention here was given to development of the technique of accounting for the consequences of mutual collisions. The results of these investigations were published in a series of papers [2 - 13] and in the monograph [11]. They have also been submitted at the Science and Technological Subcommittee of the UN Committee on Peaceful Use of Space [4].

Consider the principles of the technique *of accounting for mutual collisions of space objects (SOs).* The correct solution of this problem is an extremely difficult task. The main difficulties are caused by the probabilistic character of the problem, by the dependence of collisions' probability and conditions on a great number of factors, whose characteristics vary in time, as well as by the absence of an authentic model of estimating the collision consequences.

To estimate the number of collisions *(N)* of a spherical-shaped spacecraft, having the cross section area *F*, with small-sized space debris particles, the following differential equation is used:

$$\frac{dN}{dt} = F \cdot \rho(t) \cdot \overline{V}_{rel}(t). \qquad (1)$$

Here $\rho(t)$- is the density of particles, $\overline{V}_{rel}(t)$ is the average collision velocity. Functions $\rho(t)$ and $\overline{V}_{rel}(t)$ in the right-hand part can greatly vary within the limits of