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ИНСТИТУТ КОСМИЧЕСКИХ ИССЛЕДОВАНИЙ РАН

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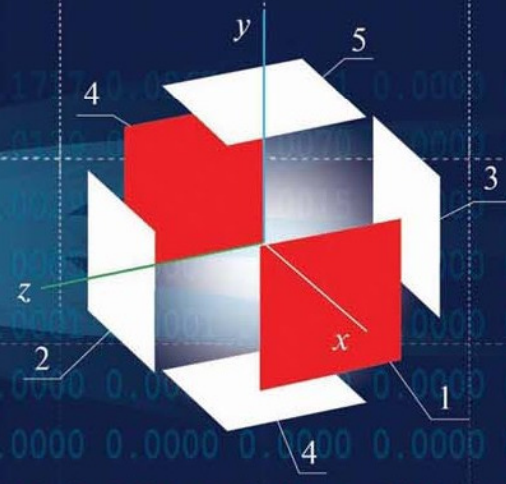
МОДЕЛИРОВАНИЕ КОСМИЧЕСКОГО МУСОРА



МЕХАНИКА, УПРАВЛЕНИЕ И ИНФОРМАТИКА

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MODELING
SPACE
DEBRIS

Nazarenko, A. I., Space debris modeling. M.: IKI RAN, 2013. 216 p.
(Series "Mechanics, Control and Informatics").

The monograph is devoted to systematic description of the techniques, which are used in the modeling of space debris. To solve various space-debris-related application tasks, the author applied a unique approach. The unique approach is based on a statistical description of space debris population and on constructing the transformations of some particular kind of debris' characteristics into the other one.

The monograph includes 15 lectures. Each of lectures considers some specific subject. The first six lectures acquaint the reader with information sources and some known techniques, which are used in space debris modeling. Each of subsequent lectures outlines the techniques of solution of particular application tasks, developed by the author. The task solution algorithms, the examples of software implementation and the results of calculations are presented.

The monograph is intended for research workers, engineers, post-graduate students and students involved in the space debris research.

Keywords: space debris, modeling, application tasks, spatial density, velocity distribution, current state estimation, situation forecast, probability of collisions, mutual collisions, consequences of collisions, objects' reentry time and place.

The preface of the author to the English publication

This monograph is the updated and added version of the author's book "Space debris modeling", published by the Institute of Space Research of the Russian academy of sciences in 2013.

The author introduced into the monograph some corrections, and he also supplemented new chapter "Modeling of sporadic micrometeoroids".

Author would like to be grateful for assistance in the preparation and the translation the presented book to English and publishing this book in English for the international readers around world.

Doctor of technical sciences, professor

/Nazarenko A.I./

Foreword to Russian edition

At the first stages of space exploration it was believed that implementing numerous missions does not have negative ecological effects, at least in the near-earth space (NES). But later it turned out that the technogenous NES contamination became a significant negative factor in space exploration. Study of space debris (SD) became a new direction in the classical astronomy. The further NES exploration is virtually impossible without objective analysis of the current state and sources of space contamination and laws of its evolution. This problem is especially acute for low orbits with altitudes up to 2000 km and geostationary orbits, where technogenous contamination is maximum, and the real danger of mutual collisions of satellites arose. A characteristic feature of monotonously growing technogenous NES contamination is its global and international character.

The problem of preventing hazardous effects of SD formation attracted attention of the world community. Numerous studies have been performed, whose results were published in thousands of articles and in several monographs. The special UN document was devoted to this problem (Technical report on space debris. New York: United Nations Publication, 1999).

The traditional approach to SD studying is deterministic; it is based on determining and forecasting the orbits of particular space debris objects. Orbital parameters of large bodies (larger than about 15...20 cm) have been regularly identified by Space Surveillance Systems (SSS) of Russia and the USA. The catalogs published by SSS contain current estimates of the state vector of each of the objects, which allow forecasting their motion. It is obvious that, in the absence of detailed information about orbital elements of small-size objects, their study requires application of the statistical approach. Characteristics of small-size objects are determined on the basis of special SD models. Therefore, the construction of SD models is associated with the necessity of developing new techniques. These techniques are being intensively developed now.

A characteristic feature of numerous publications on the SD subject is the description of particular results of studying and insufficiently detailed presentation of methodological aspects. Here, in many cases, various methodological approaches are applied to solving particular problems. So, it seems topical to develop and apply some unified approach to solving various applied tasks related to space debris. It is just this issue that is a subject of this monograph.

The unified approach offered by the author is based on statistical SD description and construction of transformations of some SD characteristics into others. Each of monograph's Sections is devoted to consideration of any particular issue. The first six Sections acquaint a reader with information sources and known techniques used in SD modeling. Each of subsequent Sections describes the techniques for solution of particular application tasks. They include the algorithms for solving the tasks, the examples of software implementation and the results of calculations. Subsequent Sections use the materials of previous ones, and they are gradually complicated.

Obtaining the results contained in the monograph was essentially contributed by author's cooperation with his teachers – N. P. Buslenko, M. D. Kislik and P. E. Eliasberg. Their ability of combining theoretical insights with acquiring important application results was an example the author tried to follow.

The solution of problems considered in the monograph would be impossible without permanent many-year support rendered to the author by Yu.P. Gorokhov, N.P. Morozov, G.M. Chernyavskiy and M.V. Yakovlev. A great assistance in solving particular SD modeling-related tasks the author has gained from his colleagues: I.V. Balashov, V.A. Bratchikov, A.G. Klimenko, G.V. Koverga I.L. Menshchikov and I.V. Usovik. The author expresses sincere gratitude to them.

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