Comparison of various approaches for reentry prediction

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A comparative analysis of different methods for satellite reentry prediction was carried out based on the Phobos-Grunt reentry data (11065A and 11065B). A variety of satellite motion models and orbit determination methods were used. Recommendations to increase the accuracy of the reentry task solution are offered.

Preface

In the early space exploration years the necessity arose of determining the lifetime of satellites before their launch, at the designing stage [1]. In subsequent years this problem has attracted specialists' attention in connection with the events of reentry of large-size dangerous satellites, such as Skylab, Cosmos 954, Cosmos 1402, Salyut 7-Cosmos 1686, etc. [2, 3]. The peculiarity of the majority of the satellites' dangerous reentries consists in the lack of communication with satellites and the possibilities of controlling them. Under these conditions, the only source of initial orbital data for solving the task is the results of operations of the Russian and American Space Surveillance Systems (SSS). These systems were built in the interests of the appropriate military agencies. For these reasons the access to the Surveillance Systems' information is rather restricted. Nevertheless, the orbital data on many satellites have been regularly and operatively renewed on the site of the American SSS [4], in the form of the so-called two-line elements (TLEs).

The technique of solution of the considered task is based on the integration of the equations of motion, under known initial data (ID) consisting of the 6-dimensional state and drag parameter estimation vector. Various characteristics are used as a drag parameter. The most popular of them is the ballistic factor estimate (Sb) and the period change under the atmospheric effect per revolution (ΔT).

The feature of the considered task solution is the sensitivity of the results to the accuracy of the initial drag characteristic. The matter is that the satellite lifetime is inversely proportional to the drag characteristic $t_{\text{life}} \approx C/Sb$, where C is some constant [5]. This gives rise to the important dependence for estimating the lifetime determination errors, which are proportional to the lifetime:

$$\delta t_{\text{life}} \approx \frac{\delta Sb}{Sb} \cdot t_{life} . \quad (1)$$

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