THE ORBITAL IMPACT RISK ANALYSIS METHODS. THE COLLO SYSTEM

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ABSTRACT

The used methods to solve typical mathematical and physical problems emerging in the collision risk analysis for spacecraft are given. There is an outline of the COLLO program that allows making risk estimation. The software structure problems are discussed. The confirmation of ballistic limit curve for a tether using observed orbital lifetimes for real space tethered systems are discussed.

1. INTRODUCTION

The code COLLO has been developed for a quite long time. Firstly it was used for estimation of damage risk for Service module in 1997 [1]. The program allowed calculating the mean flow of orbital particles onto generalized cone surface (cone, cylinder, and plane) arbitrarily pointed. The probability of damage for a cylindrical space object was given via its orientation. As it was developed, the code is made into a program system that provides the most important calculations needed for a risk analysis of the even such complex objects as the ISS. The main attention was given to simplicity of this program. Faultlessness of the code manipulations was of great value also. Benchmark test calculations were represented in 1998 [2].

2. THE MATHEMATICAL AND PHYSICAL FEATURES

There are following essential parts of every program for estimation of the risk value: space debris models, meteoroid environment models, ballistic limit equations for various damage modes, algorithm to transform distributions and algorithm to calculate the collision integrals.

Calculations with COLLO program can be done using ORDEM-96. The less important possibility is using the hypothetical space distribution of Na-K droplets that have been speculated from some physical aspects of this problem [4,5,6]. It should be noted that unfortunately there is very poor information about injection conditions of these orbital particulates.

The probability of damage by meteoroids can be calculated using the Grun's model [7].

The accessible ballistic equation set is included only common used [8], and the ballistic limit dependency for tethers obtained in [9] using some simple physical principles. This dependency includes effective dynamic tensile strength of the tether material and the characteristics commonly used for ballistic calculations. This expression can be generalized for the all tether structures using effective strength averaged over the tether's section. The formula was checked calculating the tethers lifetimes in "SEDS-2" and "TiPS" space experiment. The calculated lifetimes seems to be greater then the observed ones [10]. It may be that the expression underestimates the rupture probability for such hard materials as steel. Also we need more tether experiments to do the check more complete.

Orbital distributions transforms into spacecraft frame distributions using ä-transformation [3].

The calculation procedure for collision integrals allows accurate account of different surface shapes and was described earlier, over this algorithm there was putted in operation the Lebeg's integration procedure over the spacecraft's surface. The increasing of computation time pays by serious simplification of the algorithm. If an oncoming particle passes a transparent screen through the additional iterative procedure is used.

3. THE SOFTWARE FEATURES

Because the user set is closed, the program hasn't got even a shell. The common service software is used, but other than shortcomings it has also some advantages.

It was very important that the code arranges user's work in the way to minimize mistakes when data are slated. For this purpose the data are written to the united data base with the subsequent their graphical analysis. Such analysis is required for ballistic limit curves and a spacecraft construction (Fig.1).

Having calculated the obtained results one can have a look on them. The estimated sites are showed on an outline of the spacecraft. The risk level defines a colour of appropriate points (Fig. 2).

So the program structure has the certain view (Fig. 3). It should be noted also, that the geometrical transformations needed for the graphic display are the same things that used in the process of mean flow particles integrations in the calculating algorithm.

CONCLUSION

The COLLO program allows calculating collision risk using known space debris and meteoroid models and ballistic limit equations. It makes allowance for shadowing and transparent screening. The main demands are the space debris model to take into consideration the known sources of orbital particulates, and ballistic limit curves to have clear physical foundations.

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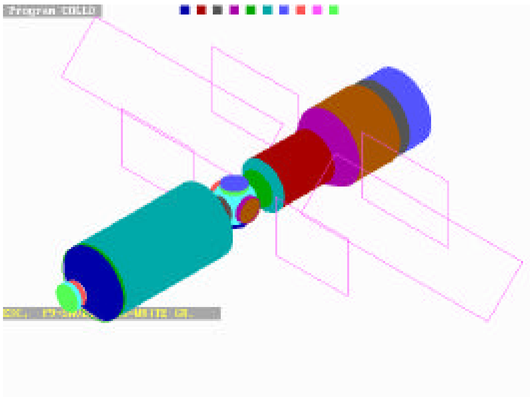

Figure 1. The first ISS module assembly. The solar panel contours are shown.

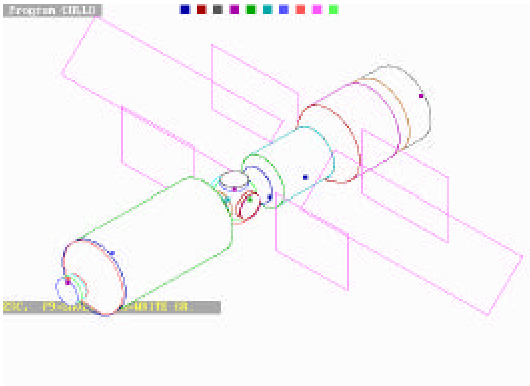

Figure 1. The contour of the first ISS module assembly with calculated points.

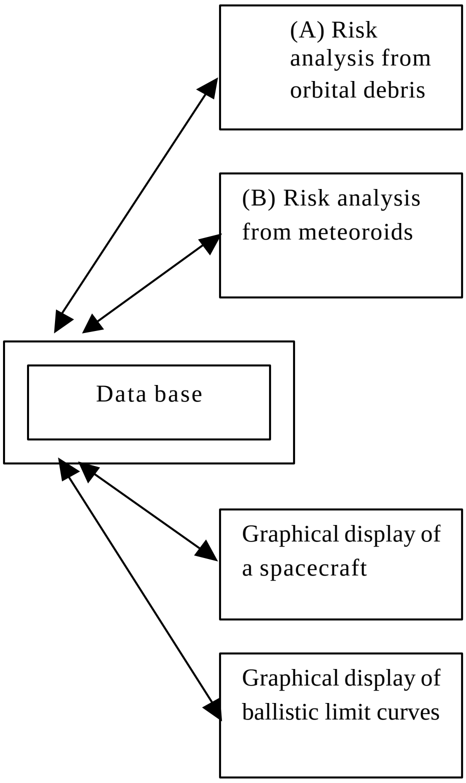

Figure 3. The COLLO's outline.

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