OPTIMIZATION OF THE INTERFACE BETWEEN SPACE DEBRIS ENVIRONMENT MODELS AND DAMAGE PREDICTION TOOLS

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ABSTRACT

The problem of determining the composition and discreteness of the initial data for damage prediction tools, ensuring computation time minimization under limitation on errors of penetration probability (PP) estimates, is considered in this report. The investigations are carried out on the basis of application of the software, in which the construction of space debris environment characteristics is combined with PP calculation.

The results of PP estimation are presented depending on the composition and discreteness of the initial data representation. As a result, the recommendations for the optimal form of the initial data representation are worked out.

1. INTRODUCTION

Fig. 1 shows schematically the link between the SDPA environment model and damage prediction tool (SDPA-PP).

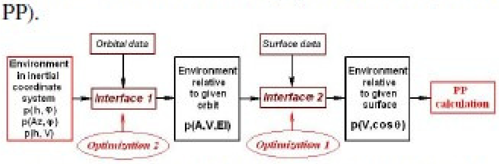

Figure 1. Scheme of the link between environment model and damage prediction tool.

Three types of space debris environment models are used in the SDPA-PP software for calculating the probability of space debris penetration through SC walls:

1. In the inertial coordinate system;
2. Relative to the given orbit;
3. Relative to the given surface.

The SD environment in the inertial coordinate system, used in our model, includes the following characteristics:

1. The subdivision of SD sizes into ranges (8 for LEO and 9 for GEO). Fragment of this subdivision is presented in the table below.

2. The spatial density $\rho(h,\varphi)_j$ depending on the altitude and latitude of a point as well as on the SD size (d_j, d_{j+1}).

3. Two-dimensional statistical distributions of the tangential/radial velocity vector component as a function of altitude of a point ($p(h,V_\tau)_j$ / $p(h,V_r)_j$) for each range of SD size.

4. Statistical distributions of velocity directions ($p(Az,\varphi)_j$) of approaching (i. e. flying up to SC) SD particles for various latitudes.

5. Statistical distribution of particle's density ($p(\rho_p)_j$) for each range of SD size.

№ of range	1	2	3	4	5	6	7
d_j, d_{j+1}, cm	0.1-0.25	0.25-0.5	0.5-1.0	1.0-2.5	2.5-5.0	5.0-10	10-25

The blocks "*Interface 1*" and "*Interface 2*" carry out transformation of one type of SD environment into another. In the final analysis, their content depends on the technique of penetration probability calculation.

2. THE TECHNIQUE OF A PP EVALUATION

The principles of our technique are stated in a series of our publications (Nazarenko, 2000, 2001, 2003) rather adequately. The known ballistic limit equations for the critical particle size (d_c) as a function of wall design parameters, SD size, collision velocity direction, as well as particles density, are used here (Cour-Palais, 1982, Christiansen, 1998). These equations (the so-called ballistic curves) are as follows:

$$d_c = f\left(V, cos(\theta), \rho_p, t_b, S, t_w, \rho_w\right). \qquad (1)$$

The following designations are applied here: V is the relative velocity of a particle, θ (teta) is the angle between the relative velocity and perpendicular to the surface, ρ_p is the density of a particle, t_b is the thickness of an external wall layer (bumper or shield), S is the distance between a bumper and a wall, t_w is the thickness of a wall as such, ρ_w is the wall material density.

Consider some elementary platform dS on the SC surface. Its orientation, characterized by some angles α and β, is assumed to be known. This elementary platform collides with particles of various size (d) and various densities (ρ_p) approaching with various velocities (V) and under various angles ($cos(\theta)$). The statistical approach is applied to estimate the penetration