METEOROID AND SPACE DEBRIS ACTIVITY IN GOSNIIAS

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ABSTRACT

Accomplishment of the M&D problem in GosNIIAS is discussed. GosNIIAS used the onboard system for monitoring of M&D impacts for many years. There many dedicated protection systems and programs are developed. The unique explosive acceleration system are made and used.

INTRODUCTION

GosNIIAS has been interested in the M&D problem since early 70's. The system for monitoring of meteoroids and space debris (M&D) was mounted on "Salyut"s stations and provided important data on space environment for a long time span. But the real work is only beginning now.

THE M&D MONITORING SYSTEM

The onboard system for monitoring of dust impacts Space Dust Monitoring System (SDMS) was installed and functioned normally for a long time at orbital stations "Salyut –1,2,3,4,6" and "Mir". This set was functioning continuously from 1971 till 2000 (Fif.1). In this time there were recorded over 4000 M&D impacts.
Now a new M&D Monitoring System (MD MS) is developed. It is also based on registration of the penetration rate using special sensors of different thickness and the intermediate board memory. The capacitor sensors with thickness of 3-300 ìm and areas from 100x100 mm^2 to 1000x1000 mm^2 had total mass within 5 kg. The electronic unit (EU) contains up to 40 independent channels. Its dimension is 180x180x150 mm and mass is 4 – 5 kg. The temporal resolution between two successive arrivals was 100 – 200 ìs; information capacity of each channel was as much as 4 KB and could be increased. The MD MS can work in the standby mode and in the routine monitoring mode.
Similar equipment has been installed on the Russian Service Module of ISS.

PROTECTION ACTIVITY

GosNIIAS together with Khrunichev GKNPC was involved in activity on protection of long-term servers "Salyut", "Mir" and the functional cargo "Zarya" of the International Space Station (ISS).

Several types of protective structures have been developed. For example, the protective structure of "Zarya" with total mass below 1260 kg is providing protection of the module with outer area of 180 m^2; i.e. The shield's surface density is 7 kg/m^2. The protection has been tested for high-velocity impacts in Russia and USA. It was shown that this module's design satisfied NASA requirements with PNP level of 0,979.

The development of a shield design takes place using "Techniques of security of safety space vehicle from an operation meteroid and space debris (M&D)"(Fig.3).

This approach presume availability of following things:

- spacecraft design parameter models;

- the near-Earth M&D environment models;

- the high-velocity interaction model validated for single- and multi-layered sheets;

- the set of standardized protective constructions;

- optimization methods for various spacecraft's elements.

There are tested over 10 standardized protective structures (Table 1).

The optimization methods allow to reduce shield's masses by 10-20%.

The available calculation methods were used to evaluate collision risk for over 30 spacecraft, including Earth-orbital stations "Salyut", "Mir", and the cargo module "Zarya" of International Space Station (ISS).

EXPLOSIVE ACCELERATION SETUP

GosNIIAS together with NIIMASH (Mechanical Engineering Research Institute, Dzerzhinsk) and OTP RAN RF (Department of Theoretical Problems of Russian Academy of Sciences) proposes new methods for the new tasks (Fig.2).. The throwing setup up to velocities of 9 – 11 km/s has been developed there. The acceleration is carried out using explosive charge of special shape with mass mere 10.0 kg. The accelerated masses are from 0.1 g to 15 g, and the projectiles may be spherical or cylindrical. The armor sheet cuts off all additional fragments of the setup except gaseous remainders of the buffer.

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The throwing method provides smooth acceleration along all the barrel length using propulsive gases coming from buffer decomposition; the accelerating pressure is much the constant of 1 – 3 GPa. The setup is rather cheap and compact: the barrel length is 200, 400, 800 and 800 mm for velocities 2.5, 5.5 and 11 km /s, respectively.

The setup allows investigating hypervelocity impact on various targets and optimizing protection structures at very important velocity range of 9 – 11 km/s.

Stability of shape and state of projectiles were fixed by means of X-ray pulse installation, as well as by registering shapes and dimensions of the holes in thin barriers. Shape and depth of the craters on thick barriers give additional information on the velocity, mass and integrity of projectiles.

The setup has been refined for a long time in many experimental series. This device was used in about 100 experiments for checking possibility to accelerate spherical and cylindrical projectiles prepared of steel, titanium and aluminum alloys. Velocities from 4.8 km/sec to f V = 10.8 km/sec were reached. Some results of these experiments are given in Table 2.

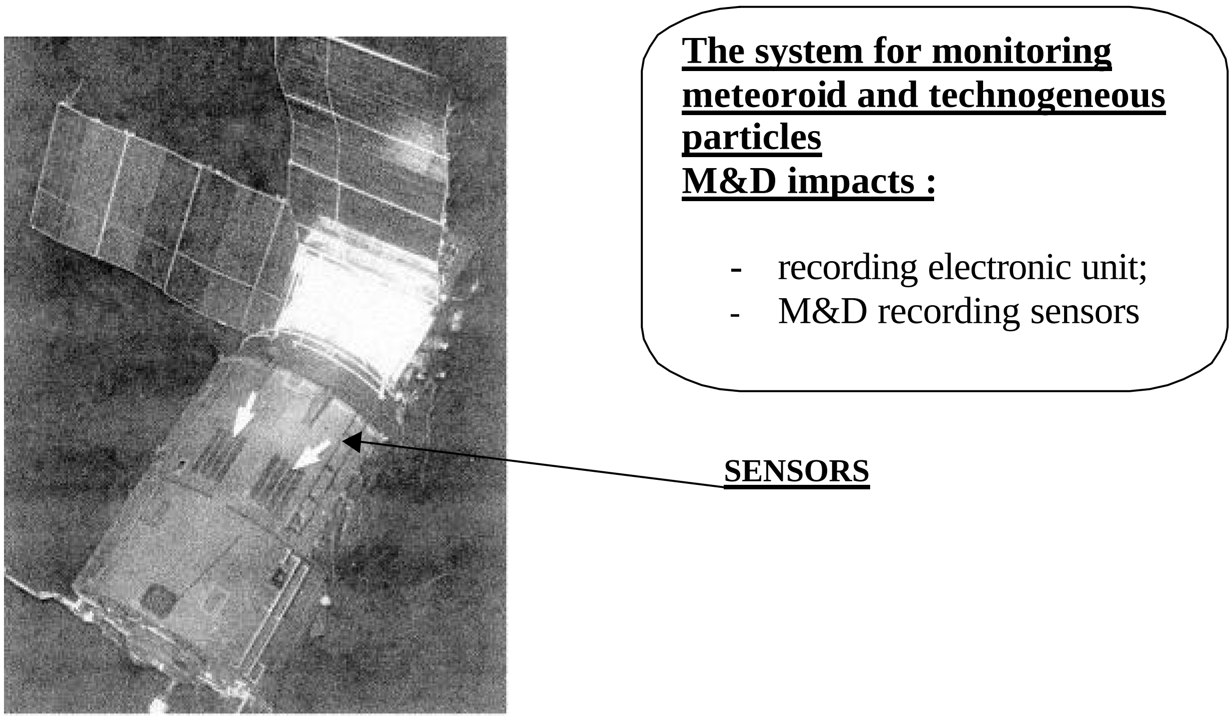
1/1	Thickness of the plating (mm)	The scheme of a protection	Distance up to the plating (mm)	Specific surface mass (kg/m^2)	Ballistic limit d_{cr} , mm at V=3/7km/s	The developer
1	2,5	1,8al + 4Next, 6Kevl	50	11,87	4,4/7,4	NASA
2	3,2	1,27al + 6Next, 6Kevl	100	11,90	5,3/11,6	NASA
3	4	P1,0 + P1,0	100	8,88	5,0/10,5	GKNPC
4	4	2g + P1,0 + P1,0	100	10,75	8,0/12,3	GKNPC
5	1,6	2g + P1,5 + P1,0	100	12,18	6,5/9,0	GKNPC
6	2,4	Protective package # 7	80	7,4	5,8/10,2	GosNIIAS
7	3,0	Protective package # 11	100	7,0	7,0/12,5	GosNIIAS

Table 1. Some tested protection structures.

1 1	Material and shape	Velocity, V, km/sec	dimensions, mm
1	Steel, sphere	7,7	3,0
2	-“-	6,6	3,0
3	-“-	6,2	3,0
4	-“-	6,2	4,0
5	-“-	8,55	2,0
6	-“-	9,6	2,0
7	-“-	10,0	2,0
8	-“-	10,4	2,0
9	-“-	10,8	2,0
10	Titanium, cylinder	6,0	6x3
11	-“-	6,3	6x4
12	-“-	6,6	6x5
13	-“-	7,2	6x3
14	-“-	7,2	6x3
15	-“-	7,2	6x3
16	-“-	7,5	6x4
17	-“-	7,6	5x3
18	Titanium, cylinder	8,0	6x3
19	-“-	8,4	6x3

1 1	Material and shape	Velocity, V, km/sec	dimensions, **mm**
20	-“-	8,7	6x3
21	Steel, sphere	4,8	4
22	-“-	5,0	3,5
23	-“-	5,1	3,5
24	-“-	5,7	5,0
25	-“-	6,2	4,0
26	-“-	6,6	4,0
27	-“-	6,8	4,0
28		7,2	4,0
29	Titanium, sphere	6,6	5,0
30	-“-	6,6	6,0
31	-“-	6,8	6,0
32	-“-	6,8	6,0
33	-“-	7,5	6,0
33	Aluminum, sphere	2,6	10,0
		4,5	10,0
		5,7	10,0
34		7,5	10,0

Table 2. Experimental data for various projectiles.



The station "Mir" on orbit

Fig. 1. The M&D impact monitoring system.

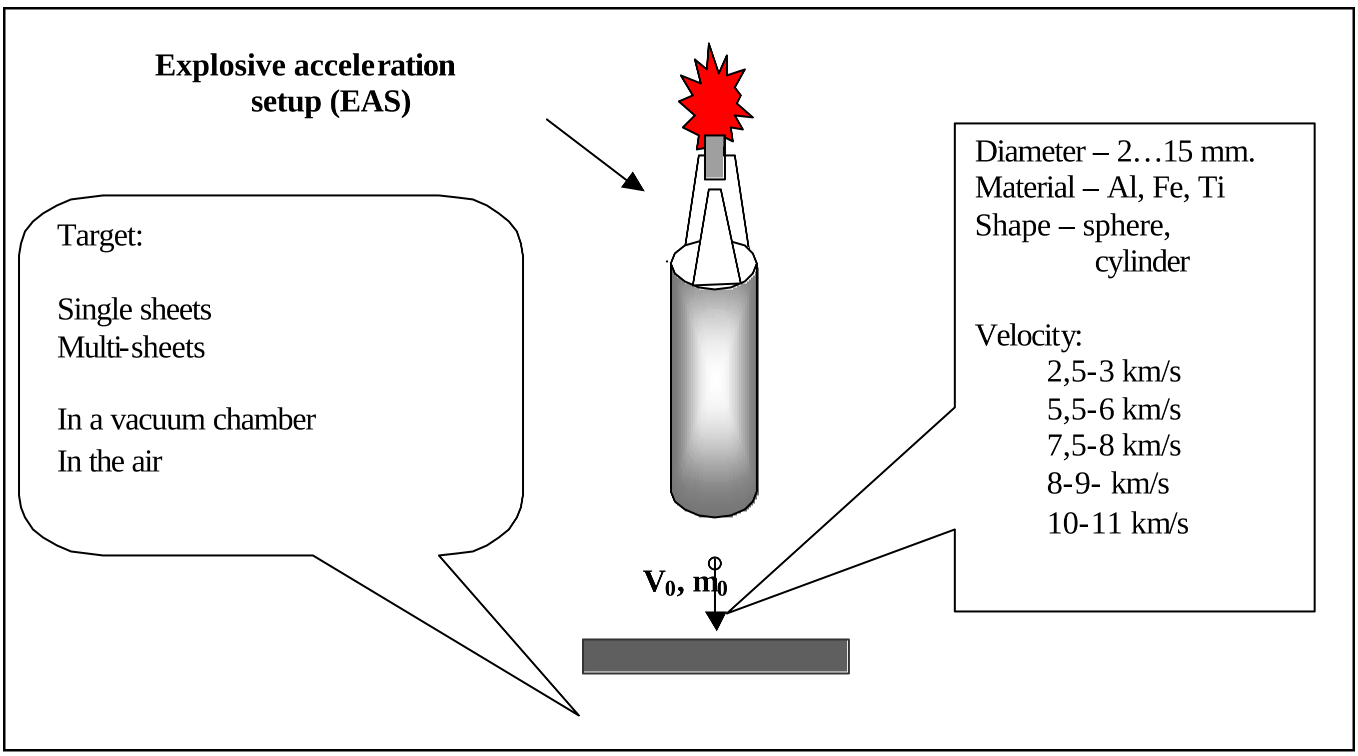


Fig.2. A setup accelerating projectiles up to 9 – 11 km/s.

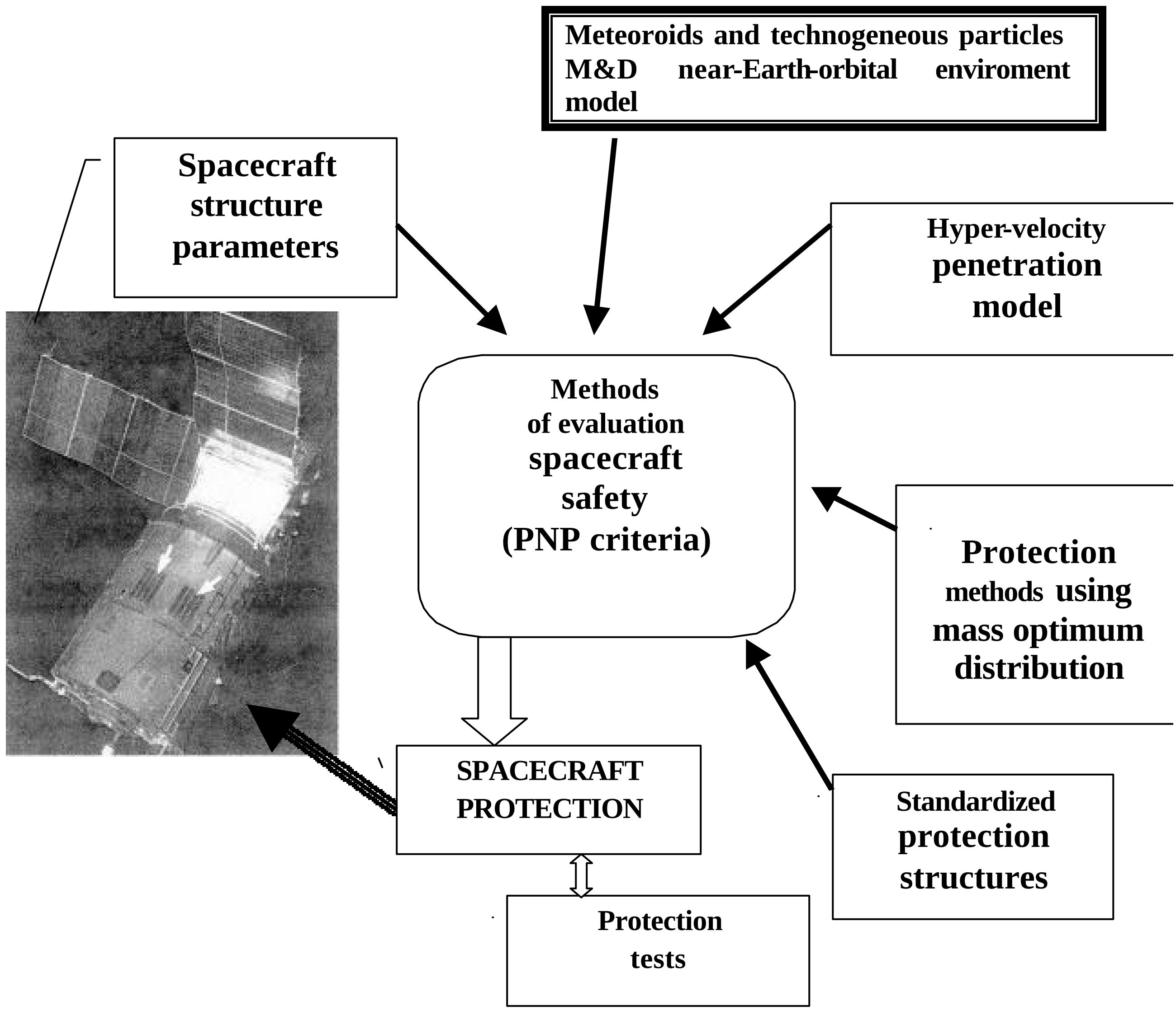


Fig. 2. Protection approach and risk analysis

CONCLUSION

The protection of spacecraft is complicated technical problem and includes many new tasks. Solving this problem the space technique is raised to a new level of safety and carefulness. It is very important to provide consistent continuous progress in this direction. In this paper there were signed the most important nowadays things: observing, hypervelocity impact and protection. We hope that our programme are interesting for the space community and will be supported.