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KA-X
IN-ORBIT MEASUREMENT OF SPACE DEBRIS AND MICRO METEORITES

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Abstract

In the last years increasing attention of specialists working in space technology has been attracted by the problem of space debris. Up to now many theoretical predictions but not sufficient data about space debris distribution in orbit exist.

KA-X is a low cost space system for the measurement of space debris and micro meteorites in orbit. Ka-X is designed as a small satellite which will be deployed in orbit into a sphere with the diameter of 10 m. KA-X is operating at a 400 km x 1100 km elliptical orbit.

1. Introduction

During the last years increasing attention of specialists working in space technology has been attracted by the problem of space debris.

Due to the extension of life time of spacecrafts the probability of collision with high-speed debris and micro meteorites has increased. This can result in non-fulfillment of the spacecrafts' target tasks. To verify the risk of current space debris and micro meteorites environment and to create a reliable and complete model of space pollution it is necessary to collect as much information as possible on meteorites and space debris distribution.

The existing methods of verification of meteorite and space debris distribution in satellite orbits are not reliable. There are methods of getting information about high-speed particle currents with the help of optical and radiolocational means with the disadvantage of low resolution (the minimal size of the objects observed is approximately 100 mm) (fig.1). At the same time it is know that the quantity of objects in space is increasing with decreasing dimensions (fig. 2).

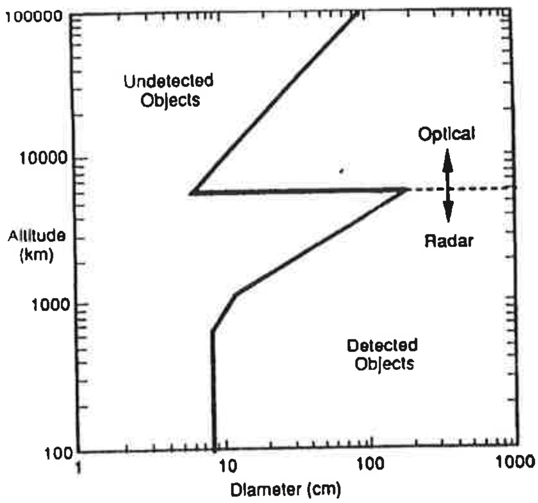
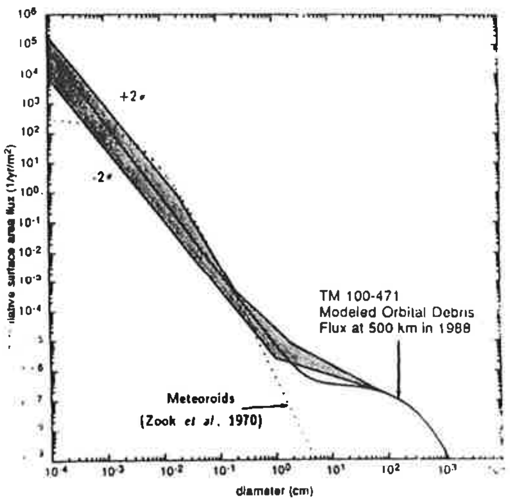


Figure 1. Detection limits of orbiting debris for the operational tracking installations (radar and optical) of USSpaceCom (from Ref. 7)

Figure 1



...re 2. Adopted particulate environment ... for the Space Station altitude according ... 100-471, including uncertainties ... Ref. 7)

Figure 2

2. In Orbit Measurement

That is why the direct measurement of space objects with the help of special facilities should be considered as the most efficient method of getting reliable information on space pollution levels. Such direct measurements were made from 1957 through 1984 with the help of sensors installed on spacecrafts having an insignificant cross section. Moreover, the achieved results were sometimes several orders different from each other. The most interesting data were achieved with the LDEF which was launched in 1984 and returned to Earth in 1990 with the Space Shuttle.

However, such sources of information on space pollution levels are extremely expensive and cannot systematically provide information on the current micro meteorite and space debris situation.

3. The KA-X Concept

To create an instrument for a systematical collection of information on space pollution at low cost the spacecraft KA-X for research of space environment is being developed by the Samara State Aerospace University in Co-operation with the Central Specialised Design Bureau (Russia), Kayser-Threde GmbH and the Technical University of Munich (Germany).

The objectives of KA-X are:

- measurement of number and parameters of micro meteorites and space debris
- measurement of atmospheric density in the upper atmosphere (250...1100 km)
- estimation of aerodynamic characteristics of space objects.

Every KA-X system consists of a large active main spacecraft and a smaller secondary sphere - passive spacecraft.

The KA-X system is launched piggy back on board the Russian spacecraft Resurs-F1 (fig.3).

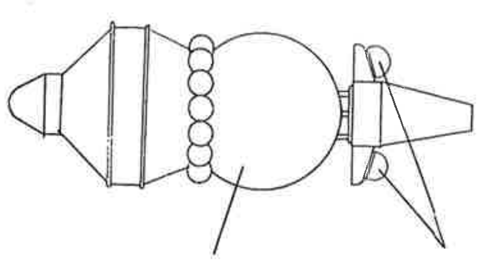


Figure 3

After the orientation of Resurs at an altitude of 400 km KA-X is separated. Using its own motor KA-X enters its operational orbit of 400x1100 kilometers (fig. 4).

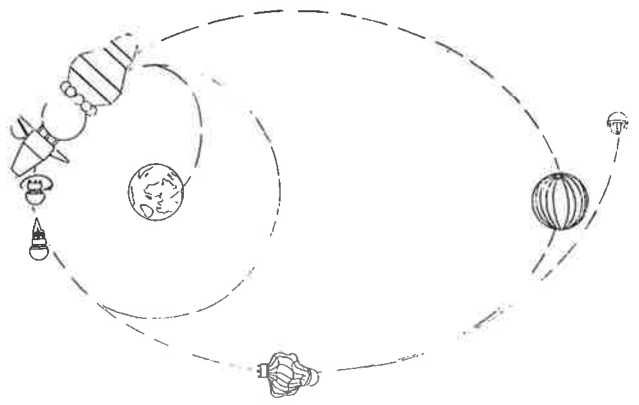


Figure 4

The protection cover is separated and the 10 m in diameter sphere is deployed. The protection cover with the half-sphere film (diameter 0.6 m) is used as passive reference spacecraft (fig. 5). The information on high-speed objects coming from the capacitor and ionic sensors is pre-processed on board KA-X and transmitted to Earth by the telemetry system.

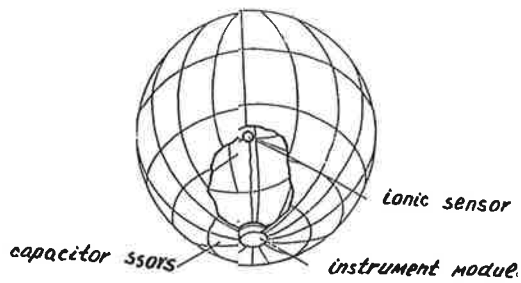
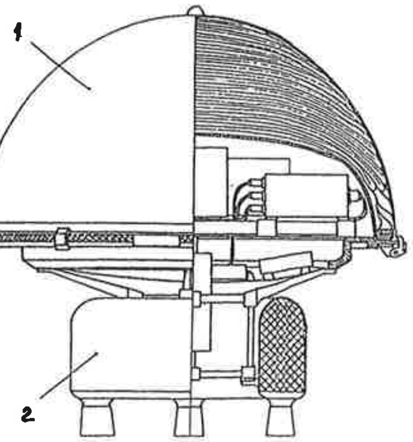


Figure 5

The flight of the two spherical spacecrafts with known ballistic coefficient allows to determine the variations of the upper atmosphere density, using methods which have been developed in previous Pion-spacecraft flights.

At test flight for the demonstration of the deployment of the KA-X spherical structure in low Earth orbit (400 km) is planned to be performed as a first realization step.

Figure 6 shows the design of the KA-X system. Figure 7 shows the operational KA-X configuration. Figure 8 shows the configuration of the passive reference spacecraft.



1 – structure , 2 – solid fuel engine

Figure 6

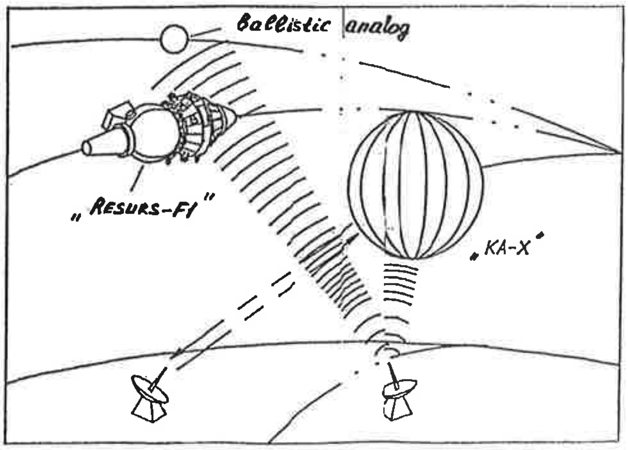


Figure 7

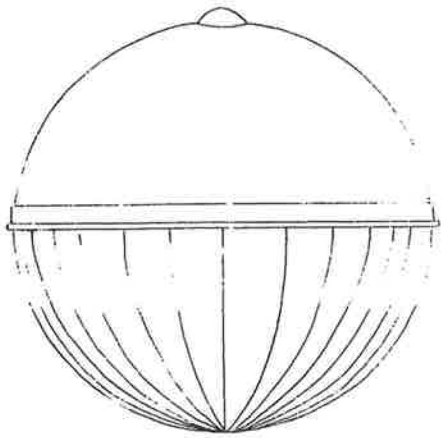


Figure 8

Passive ballistic analog

The measurement area of the 10 m in diameter spherical spacecraft related to the horizontal flux is 153,4 m² (taking into account the spacious distribution of LDEF flight results).

4. Theoretical Predictions

It was already mentioned that different methods for getting information about space pollution levels give different results . We consider that it is not correct to rely only on one method, therefore we estimate the expected efficiency of the KA-X system by different methods. The calculation results of the expected number of collisions per twenty four hours with masses of 10E-9 grams to 10E-7 grams (for a capacitor sensor thickness of 0.2 mm) are shown in table 1.

	Source	Expected number of collisions per 24 hours
1	Kessler (NASA TM - 100471), 1985	
	M_{min} = 10 E -9 gr	F500 = 4039; F1300 = 447,8
	M_{min} = 10 E -7 gr	F500 = 8,776; F1300 = 9,653
2	Comprehensive estimation NASA, 1991	
	M_{min} = 10 E -9 gr	F500 = 420,3
	M_{min} = 10 E -7 gr	F500 = 42,03
3	Grieve et al., 1988	
	M_{min} = 10 E -9 gr	F = 33,33
	M_{min} = 10 E -7 gr	F = 3,333
4	Program EVOLVE NASA JSC, 1990 D > 1 mm	F900 = 0,7690
5	LDEF, 1985 - 1990	
	M_{min} = 1,82 E -7 gr	F = 19,79
	M_{min} = 182 E -4 gr	F = 2,269

Table 1

Figure 9 shows the KA-X functional possibilities.

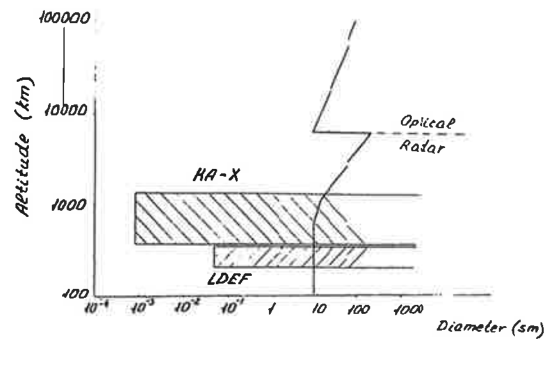


Figure 9