NASDA's Activities to the Space Debris

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1. Introduction

Space debris consists of both the meteoroids and the artificial objects such as dead satellites, rockets and their particles, paint flakes or so. Recently, the problem of space debris is regarded as much important because the collision of space debris to manned facilities would be fatal and its probability would increase with the expansion of human activities in space, and also because the probability of collision to the satellites is increasing with extension of their life time and size. From the view point of probability, it is more dangerous in low earth orbits than in the geosynchronous orbit, and the proportion of the artificial objects in space debris has become larger than that of meteoroids, especially in the orbit of space station, 400-500 km high. As for meteoroids, it increases seasonally when the earth passes the heliocentric region where tiny particles are dense. The Perseids meteor stream in August is famous as this example.

The activities to the space debris are categorized as follows.

They are observation of space debris, the incorporation of measures not to generate debris and the protection of live satellites against the collision. The observation is not being conducted routinely in Japan and we depend on U.S. activities for those data. But the latter two activities are being conducted in Japan.

2. Measures in Launch Vehicles

Once the upper stage explodes at a high altitude, a lot of particles scatters in space. The U.S. Delta rockets showed such examples. They were brought into pieces by the explosion of fuel tank because of the residual propellant. To prevent such explosion, NASDA takes the following measures in the second stage of H-I rocket which has been operational in Japan and the H-II rocket which is under development now.

2.1 Blowing down the Residual Propellant in Tanks

There remains propellant of 3% of full load in the second stage tanks at the engine cut off. Though this is blown down through engine chill down lines by opening the valve to space for several hundreds seconds, some amount of propellant may still remain and its evaporation increases the tank pressure. But this pressure is kept below a specified level by the mechanical relief valve to prevent the explosion. (See ①, ② in Fig. 1)

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2.2 Depletion Burning of the Gas Jet Propellant

After the end of mission of the second stage, the residual propellant of gas jets (hydrazine) is depleted by firing the thrusters for about 500 second. (See ⑤ in Fig. 1.)

3. Measures in Satellites

3.1 Deorbiting Geostationary Satellites

To prevent the collision between an operational satellite and a dead satellite in the geosynchronous orbits, NASDA deorbits satellites when they come to the end of life. For example, CS (Communication Satellite) was deorbited into a 400 km higher than geosynchronous orbit in Nov. 1986, with GMS-2 (Geostationary Meteorological Satellite) into 200 km higher orbit in Nov. 1987. NASDA will continue deorbiting in the future if propellant is left in satellites.
Fig. 2. Configuration of JEM and its bumper
3.2 Miscellaneous

NASDA adopts the bolt catcher in ETS-VI (engineering test Satellite), which catches the separation bolts at deploying solar paddle in order that they may not fly away.

4. Measures In JEM

Against space debris, JEM must be as safe as other modules of Space Station. So NASA’s design requirements are adopted to JEM, too. To know the environmental data of space debris is necessary to design JEM, at first. In the orbit of Space Station, space debris is increasing year by year as space activities grow. The safety requirements of JEM should be determined in consideration of such environment. A mathematical model of space debris is made for the design of JEM. For protection of JEM, a bumper system will be used. Some basic experiments have been done to obtain the data concerning characteristics of structure and material for the bumper. However it is difficult to accelerate particles up to the speed of space debris for simulation. The development of test equipment itself is a matter of concern.

The present configuration of JEM bumper is shown in Fig. 2, which is of double barriers of aluminum installed around the external wall of the pressurized module. High speed debris will melt and spread at the collision with the outer barrier and be stopped by the inner barrier. The thermal insulation material between barrier and wall is also effective for protection. Generally speaking, most of collision of space debris happen at the forward area of Space Station, leading to the design impact velocity of 4 km/s. NASA has a plan to make a rail gun for this velocity range. The hyperspeed collision of about 10 km/s is beyond the present equipment and technology. The candidate of material of the bumper is aluminum now. In addition to it we are investigating the feasibility of the organic material like Kevler or the ceramics, too.

5. Conclusion

NASDA’s activities around space debris have been described. Besides that, comprehensive countermeasures will be required against the “Space Pollution” stemming from other sources such as leak of radiant rays from nuclear powered satellites.