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Space Debris: Industry Viewpoint

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Thank you for inviting me to speak to you about the challenging issues associated with space debris. Your willingness and interest in soliciting a perspective on this topic from industry is commendable. I hope that my remarks will provide you with some beneficial insight into the activities of industry which is attempting to use the space environment for the benefit of our global community of nations.

There have been numerous symposia and conferences around the world at which the topic of space debris has been discussed in detail and from differing perspectives. Motorola, an active member of the global space industry since 1958, understands both the business and technical aspects of the space environment. It has presented papers and participated as chairmen of and technical experts on various committees at these symposia and conferences. I would like to first review one of the historical and some of the more recent publications that address space debris. Then I will describe some extraordinary debris mitigation approaches actually employed by Motorola on the IRIDIUM® Program.

Space Debris Issues - Industry and Governmental Developments

I believe that the only published collective recommendation from industry sources on space debris is the 1992 AIAA Special Project on "Orbital Debris Mitigation Techniques: Technical, Legal, and Economic Aspects". In that paper, several actual space debris mitigation techniques were identified as being in use or under consideration by both the United States Government and various private industry organizations. This report mentioned several current and potential debris mitigation techniques associated with the spent upper stages of launch vehicles including:

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1) intentional or guaranteed reentry into the atmosphere,
2) modifications to remove all excess propellants to minimize the risk of on-orbit explosions where reentry cannot be guaranteed,
3) use of separation devices and other launch vehicle design improvements to minimize the release of parts after reaching orbit, and,
4) using various programs to minimize on-orbit collisions including the Collisions On Launch (COLA) program and the Computation of Miss Between Orbits (COMBO) program.

In addition, it identified several operational debris mitigation techniques associated with satellites including, with respect to LEOs, the deorbit and controlled reentry of satellites, and the retrieval or reuse of such spacecraft. With respect to Geostationary (GEO) satellites, the report acknowledges that current techniques seem to focus primarily on maneuvering the spacecraft at its end of life to an orbit higher than the Geostationary orbit.

The National Research Council in the United States began an effort in 1993 to research the topic of space debris from a technical perspective. That effort resulted in the publication last year of an extremely thorough report titled "Orbital Debris - A Technical Assessment". That report set forth several recommendations - many of which can, will and are being implemented by industry on its own. The implementation of other recommendations, however, such as the further cataloging of the debris population at both the LEO and GEO orbits, will need government assistance or access to resources that the government currently controls.

The National Aeronautics and Space Administration (NASA) is in the process of preparing an Orbital Debris Handbook. That handbook, which has not yet been released publicly, is described in a progress report on its status as of last year, as including guidelines around five specific areas. Those areas are:

1) Debris released during normal operations,
2) Debris generated by explosions and intentional breakups,
3) Debris generated by on-orbit collisions during missions operations,
4) Post-mission disposal of space structures, and
5) Risk from reentering debris at post mission disposal.

The progress report on the handbook also indicates that a NASA technical memorandum titled "The Orbital Debris Assessment Reference Manual" will be prepared to provide assistance in developing debris mitigation and assessment efforts. It will allegedly consist of three volumes: Volume I titled "Assessment of Debris Mitigation Procedures": Volume II " Technical Background for Assessing Orbital Debris": Volume III "The Debris Assessment Software User's Guide."

In late February of this year the National Science and Technology Council's committee on Transportation Research and Development finally released it's "Interagency Report on Orbital Debris 1995". That report, which is an update of the

1989 report, suggests several approaches to minimize the continued growth of the space debris problem. It suggests that launch vehicles and spacecraft be designed so that they are "litter-free" (i.e., they not release separation devices or other potential debris once they become orbital.) It also suggests that LEO spacecraft and launch vehicle upper stages be deorbited, or, that all propellants and pressurants be expelled in the event they are not capable of being deorbited. Alternatively, it suggests that LEO satellites be reorbited into a safer orbital location that it describes as a "trash" orbit. This is similar to the approach taken with virtually all Geostationary satellites which are reboosted into higher orbits beyond the Geostationary orbital plane.

Of some intrigue is the suggestion in the report that several space "vacuum cleaners" could be developed to remove certain small and large objects from the low earth orbit areas. The report also suggests the possibility of significant increases in the space debris in LEO orbits due to the proliferation of proposed large LEO constellations. This concern is simply founded upon the large numbers of satellites that are scheduled to be launched to deploy the constellations supporting these programs in the next few years and during the period following their deployment with respect to the maintenance and operation of such constellations by replacing satellites as they approach the end of their useful life. As I will describe later, at least with respect to the IRIDIUM System, we have recognized this risk and undertaken aggressive efforts to significantly reduce the risk of adding to the space debris problem.

The report contains many other recommendations including the establishment of government and industry design guidelines on orbital debris and further international cooperation and discussion on this topic. Rather than commenting on any of the specific recommendations contained in this newly released report, I would simply suggest that, to the extent discussions on this topic are continued further in this forum or others, that you seek the input from all available industry sources in order to both understand the technical issues associated with this matter and to facilitate a practical solution that will be beneficial for us all. In the event the establishment of national or international standards on space debris mitigation is pursued, it is essential that some consideration be given to the ability of industry to conform to such standards on a prospective basis. A phased approach which gradually implements any such standards over a period of time would be much more readily embraced by industry and could be implemented much more effectively. To assist in your analysis of this topic further, let me describe for you a specific program now being developed by industry.

Space Debris Mitigation Efforts on the IRIDIUM Program

For the past six years I have been deeply involved in the development of the business and programmatic arrangements of one of the world's most ambitious space programs - the IRIDIUM Communication System being developed by Motorola. IRIDIUM is one of a number of low earth orbit (LEO) satellite-based telecommunications systems announced by industry and is expected to begin commercial service in 1998.

As you are probably all well aware, the issue of orbital debris is particularly significant for LEO satellites due to the thousands of individual pieces of debris located at that altitude. This is particularly significant for the IRIDIUM Communication System which will utilize 66 satellites in a constellation of six orbital planes at an altitude of approximately 780 km. In addition to the 66 satellites, roughly six spare satellites will be in orbit slightly below the orbit of the constellation. I'd like to share with you some of the specific orbital debris mitigation strategies that we are employing in the IRIDIUM program.

Early in the development phases of the IRIDIUM program, Motorola decided that it would implement a state-of-the-art orbital debris mitigation philosophy. Initially this concept required the selection of orbits which minimized the collision hazard for all the spacecraft in the constellation. For example, small adjustments were made to inclination and argument of latitude to create spacing distances between spacecraft of greater than 100 km at the North and South Pole.

Motorola also inserted a specific requirement in its design level space segment specifications which requires the implementation of debris mitigation approaches by all of our suppliers, including our launch service suppliers. The following is a sample of the wording contained in the specifications:

> "Subsequent to deployment of all of the IRIDIUM Space Vehicles, the launch vehicle upper stage must perform a deorbit maneuver placing the upper stage in a decay orbit."
>
> "Design analysis shall also be performed to demonstrate that the launch vehicle or related hardware does not generate any debris on orbit in excess of the limitations specified in the IRIDIUM Space Segment Specification."

We sought out experts knowledgeable about specific hazardous components such as the nickel-hydrogen batteries. As a result of the advice of the noted Russian scientist, Boris Tsenter, we modified the nickel-hydrogen battery design and incorporated key procedural recommendations into our operations plan.

Perhaps the most visible and widely acclaimed aspect of the debris mitigation practices implemented for the IRIDIUM system is the end-of-life deboosting of the spacecraft. This space debris mitigation mandate required us to include additional mass and fuel to accommodate the deboosting maneuvers associated with placing the spacecraft in a decay orbit that would ultimately result in its reentry into the atmosphere.

Recently we began discussions with Orbital Sciences Corporation regarding its ORBCOMM constellation of satellites that it is beginning to deploy which will occupy orbits close to the orbits of the IRIDIUM satellites. These discussions are on-going and we expect to engage in discussions with all members of industry and governments who would find benefit from sharing orbital data to insure to the maximum extent possible that on-orbit collisions are avoided.

These debris mitigation approaches, taken as a system requirement for a 66 satellite constellation, are unique. Nonetheless, they can be implemented on many satellite programs. Our experiences on the IRIDIUM program have demonstrated that there are several factors, however, that must be considered before any specific approach to debris mitigation is implemented effectively.

As you know, the development time and effort associated with current space-based activities extends over many years before the first satellite is ever launched. During that time significant design and production tradeoffs are evaluated by the engineering and operations staffs in their efforts to develop a spacecraft that performs the essential mission functions as efficiently as practical. During that time several interfaces with the launch vehicles that may launch the spacecraft are also designed.

A formal space debris mitigation philosophy and approach should, therefore, be adopted at the earliest point in the spacecraft development cycle to attain the maximum ability to implement practical debris mitigation approaches. Where such debris mitigation philosophies are not considered until later in the development cycle, the ability to implement such approaches is significantly reduced due to the costs and time associated with redesigning the spacecraft and launch vehicles.

In summary, I hope it is rather clear that, where active debris mitigation philosophies are incorporated in the early development efforts of new spacecraft and launch vehicle systems, significant and effective debris mitigation techniques can be employed in those systems at an acceptable cost. Further research into other debris mitigating techniques is being pursued by industry and should be implemented at appropriate times in the future. Finally, continued assistance from government and discussions between industry, government and academia will serve to increase the chances of implementing better and practical approaches to minimizing the space debris problem that we face today. However, it is not a problem that any one business enterprise or country can hope to solve on its own - it will require international communication and commitment to adopt those policies that can minimize the space debris dilemma for us all.

Thank you for your time and your attention.

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