IISL-00-IISL.4.15

# International Regulation of Orbital Debris[1]

**Edward A. Frankle, Esq.**
**General Counsel**
**National Aeronautics and Space Administration**
**Washington, DC[2]**

After several years of relative quiescence, the topic of orbital debris is becoming a major focus of the international space law community. National space agencies are advancing a number of new proposals intended to mitigate the generation of orbital debris by launch vehicles and spacecraft. These proposals have influenced the work of international technical bodies like the Inter-Agency Space Debris Coordination Committee (IADC), composed of experts from national space agencies with large, multifaceted programs. The IADC has labored for the past several years to assess the magnitude of the overall debris problem and devise technical solutions. It has assisted the Scientific and Technical Subcommittee (STSC) of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) and is seeking consensus on recommended guidelines for spacecraft design and operation that could vastly diminish the potential for debris generation. Although there is broad recognition that further technical study is needed, space agencies are already implementing many of the recommended practices.

With the emergence of these embryonic standard practices for debris mitigation, proposals to codify these and other debris mitigation practices into international legal principles are already being made. This paper will discuss the legal and policy background that has encouraged implementation of standard practices for debris avoidance and mitigation by the U.S. Government, the nature of the emerging practices, and ways and means for encouraging states to implement them as quickly as possible.

---



[2] The views expressed herein are those of the author and may not reflect the views of the National Aeronautics and Space Administration or of the United States of America. Invaluable assistance in researching and drafting this paper was provided by E. Jason Steptoe, Associate General Counsel, and Steven A. Mirmina, Attorney-Advisor, of the NASA Office of the General Counsel.

## Background

At the outset, it is essential to clarify that the term "orbital debris" is not synonymous with "space debris." NASA's orbital debris experts use the term broadly, to refer to any human-made object in Earth orbit that no longer serves a useful purpose. The term encompasses non-operational spacecraft, derelict launch vehicle stages, mission-related debris and fragmentation debris. "Space debris" has an even broader and more diffuse meaning. It encompasses a wide range of naturally occurring materials, including all types of meteoroids.

It is also important to understand the current magnitude of the problem; one that is easy to overestimate. In actuality, in the 43 years since humans first began launching objects into space, there have been few instances of damage resulting from orbital debris – either in space or on the surface of the Earth. One recent example occurred in July 1996, when a fragment of an exploded *Ariane* upper stage launched in 1986 collided with a French *CERISE* military satellite launched in 1995.[3] Apart from this instance of known damage resulting from an unintentional space collision of human-made objects, orbital debris has also been blamed for damaging the cockpit windshields of dozens of Space Shuttle missions.[4]

Through STS-96, launched in May 1999, the Shuttle has had to execute eight maneuvers to avoid potential collisions with orbital debris. For example, in January 1996, the Shuttle *Endeavour* was required to alter its course to avoid colliding with an abandoned United States Air Force satellite. In 1997, the Shuttle *Discovery,* with the Hubble Space Telescope (HST) in its payload bay for refurbishment, executed a debris avoidance maneuver to avoid nearby debris from an exploded Pegasus rocket. These incidents show that while the volume of space involved is incredibly vast, the potential for collision is rising with the number of objects in orbit.[5] Further, the need for

[3] *See,* "First Natural Collision of Cataloged Earth Satellites," Orbital Debris Quarterly News, Vol. 1, No. 2, September 1996, NASA Johnson Space Center.

[4] On average, NASA replaces one window after each mission. However, some of these replacements are for meteoroid impacts or other reasons. There was also damage to the speed brakes of the Shuttle Endeavour from an unidentified piece of aluminum. The Long Duration Exposure Facility (LDEF), one of the largest payloads ever deployed by the Space Shuttle and which orbited for nearly six years between 1984-1990, provided the first detailed assessment of small particle debris in Low Earth Orbit (LEO). By exposing samples of materials to the space environment and then returning them to Earth, passive *in situ* measurements of the debris environment are made. Analysis of LDEF's impact–laden surfaces provided NASA a great deal of information regarding the composition of various types of orbital debris and meteoroids, as well as impact cratering, penetration data, and particulate flux estimates in LEO. However, after six years in orbit, there were no major impacts to the LDEF.

[5] As of January 1, 2000, the official U.S. Satellite Catalog listed approximately 8,600 such objects 10 cm or larger; comprised of approximately 40% fragmentation debris, 23% non-operational spacecraft, 18% launch vehicle upper stages and 11% mission-related debris. Only 7.5% of the objects tracked were operational spacecraft. Of even more concern is the estimated 1 million or so pieces of debris that are too small to track. Debris of only 0.04 mm may require replacement of a window of the Space Shuttle; debris measuring 0.1 mm can penetrate an EVA suit; a piece of debris only 0.5 mm in size can penetrate a radiator tube; a 1.0 millimeter fragment of debris may penetrate the reinforced carbon-carbon panels on the leading edge of the Shuttle wings; debris of 3 to 5 millimeters will poke holes in the Shuttle thermal protection system tiles; collision with debris of 5 millimeters or greater would likely penetrate a crew cabin; and any debris fragment between one and ten

debris avoidance techniques rises as we build and inhabit very large space structures such as the International Space Station.

## USG Orbital Debris Mitigation Standard Practices

NASA has been evaluating questions regarding the risks posed by orbital debris since the days of the Gemini program in 1966, leading to the establishment of an orbital debris research program at the Lyndon B. Johnson Space Center (JSC) in the 1970's. In 1981, NASA instituted its first orbital debris mitigation policy, requiring depletion of residual propellants from Delta second stages at the end of mission.[6] NASA's first formal guidance on orbital debris was published in NASA Management Instruction (NMI) 1700.8, "Policy for Limiting Orbital Debris Generation," dated April 5, 1993.[7]

As a result of Recommendation 3 of the 1995 Interagency Report on Orbital Debris,[8] NASA and the Department of Defense (DOD) developed a draft set of U.S. Government Orbital Debris Mitigation Standard Practices based upon the existing NASA Safety Standard 1740.14, entitled "Guidelines and Assessment Procedures for Limiting Orbital Debris" (August 1995). These standard practices have gained wide acceptance within both the U.S. Government and U.S. industry. A dialog between the Government and industry is continuing with the objective of finalizing the standard practices in the near future.[9] As part of this effort, in January 1998, U.S. Government agencies sponsored a workshop in Houston Texas, entitled "U.S. Government Orbital Debris Workshop for Industry," the purpose of which was to provide industry a more complete understanding of the debris mitigation guidelines developed by NASA and DOD.

The following four standard practices serve as the basis on which every U.S. Government mission operates and as the foundation for IADC efforts to establish international guidelines and recommended practices.

1. Programs and projects must assess and limit the amount of debris that they plan to release during normal operations. Any planned release of debris larger than 5 mm in any dimension which will remain on orbit for more than 25 years has to be evaluated and justified.
2. Programs and projects must assess and limit the probability of an accidental explosion both during and after the completion of mission operations. Each program must demonstrate that there is

millimeters could cause serious damage to the Shuttle's payload bay.

[6] *See "The Current State of Orbital Debris Mitigation Standards in the United States,"* by Joseph P. Loftus and Nicholas L. Johnson, published by the American Institute of Aeronautics and Astronautics, IAA-99-IAA.6.5.04 (1999).

[7] NASA Policy Directive 8710.3 (May 29, 1997) supersedes former NASA Management Instruction 1700.8 (April 5, 1993).

[8] The report carries a date of November 1995 but was not publicly released until February 29, 1996.

[9] U.S. Government policy has encouraged NASA and DOD efforts in this area. The 1996 National Space Policy states: "The U.S. will seek to minimize the creation of space debris.... The design and operation of space tests, experiments and systems, will minimize or reduce accumulation of space debris consistent with mission requirements and cost effectiveness." Additionally, the policy commits the U.S. Government to utilize debris mitigation practices and to encourage other nations active in space to similarly adopt such practices. White House Fact Sheet, National Space Policy, September 16, 1996.

no credible failure mode resulting in accidental explosion.

3. Programs and projects also need to assess and limit the probability of operating space systems later becoming a source of debris by collisions with man-made objects or meteoroids. Spacecraft design should limit the probability that collisions with debris smaller than 1 cm diameter will cause loss of control and prevent subsequent disposal after completion of the mission.
4. Programs and projects will plan for cost effective disposal procedures, considering one of three methods: reentry, maneuvering to a storage orbit, or retrieval.

All NASA programs in current development will observe the U.S. Government standard practices, or NASA's internal directions, when NASA's are more stringent.[10] But NASA is not the only Federal agency instituting orbital debris avoidance/mitigation measures. In May 1998, the Department of Defense, through its component U.S. Space Command, issued its instruction "Minimization and Mitigation of Space Debris," which established policy and guidance on orbital debris.[11] The National Reconnaissance Office's (NRO) policy on orbital debris[12] ensures that NRO's space operations pose minimal risk to public health and safety. The National Oceanic and Atmospheric Administration (NOAA), which licenses operations of commercial remote sensing satellites, recently issued a regulation requiring licensees to assess and minimize the amount of orbital debris released during the post-mission disposal of its satellite.[13] The Federal Communications Commission (FCC) specifically requires applicants for licenses to submit a casualty risk assessment if planned post-mission disposal of a satellite involves atmospheric re-entry of the spacecraft.[14] The Federal Aviation Administration (FAA) has even suspended the launch license of one commercial satellite operator when it stated it would not comply with its previously approved plan to vent the vehicle's upper stage.[15]

[10] NSS 1740.14 requires that NASA programs include plans for: (1) depleting on-board energy sources after completion of mission; (2) limiting orbit lifetime after mission completion to 25 years or maneuvering to a disposal orbit; (3) limiting the generation of debris associated with normal space operations; (4) limiting the consequences of impact with existing orbital debris or meteoroids; and (5) limiting the risk from space system components surviving reentry as a result of post-mission disposal. Two orbital debris assessment reports are required for NASA programs: one at the Preliminary Design Review and the other 45 days prior to the Critical Design Review. They are reviewed for compliance by the Associate Administrator for Safety and Mission Assurance and by the cognizant program Associate Administrator.

[11] U.S. Space Command Instruction 13-4 (1 May 1998).

[12] NRO Directive 82-6 (6 January 1999).

[13] 15 CFR 960.

[14] The FCC currently addresses concerns regarding orbital debris and satellite systems on a case-by-case basis, under the general "public interest, convenience and necessity" standard in the Communications Act of 1934, as amended. 47 U.S.C. § 151 *et seq.* It intends to commence a rulemaking proceeding proposing to adopt filing requirements for all FCC-licensed satellite services which will explore "orbital debris mitigation issues, including selection of safe flight profiles and operational configurations, and post-mission disposal practices." (Report and Order FCC 00-302, IB Docket No. 99-81, *In the Matter of The Establishment of Policies and Service Rules for the Mobile Satellite Service in the 2 GHz Band,* adopted August 14, 2000, released August 25, 2000)

[15] On December 8, 1997, the FAA suspended the launch license of Orbital Sciences Corporation (OSC) when it declared it would not vent its Hydrazine Auxiliary Propulsion System (HAPS) as it had stated in its license application. After

**Legal Considerations related to Orbital Debris**

1. Liability Convention

a. Requirement for "damage" caused by a "space object"

Neither the Outer Space Treaty,[16] the Liability Convention,[17] the Registration Convention[18] nor any other international instrument defines the terms "orbital debris" or "space debris." The 1972 Liability Convention defines "space object."[19] However, there is no consensus that the term space object includes orbital debris. If the term "space object" does not encompass the full range of objects that may be characterized as orbital debris, then parties suffering damage must look outside the treaties for a remedy. If "space object" does include orbital debris, then treaty provisions may be applicable. For liability to arise, however, a "space object" must cause "damage," a term the Liability Convention limits to physical and direct damage; it does not include indirect or non-physical damage such as pollution of the space environment.[20]

b. Liability based on "fault"

Article II of the Liability Convention provides that liability for damage to objects in outer space is based on fault. Thus, even assuming a piece of orbital debris is a "space object" within the scope of the Liability Convention, for a claim to succeed under the Liability Convention, a State seeking compensation for damage suffered in outer space must prove fault. This requirement will pose several significant legal hurdles to any recovery. First, identification of the object causing the damage and its launching State may be impossible, since the origin of a large number of tracked objects (about 1000) and all of the untracked objects is unknown.

Second, the inclusion of a "fault" based regime for determining liability implies

---

negotiations, OSC later agreed to vent the HAPS to reduce risk of explosion on orbit and FAA re-issued the launch license. 14 CFR 415.39 "Safety at End of Launch" requires that:
To obtain safety approval, an applicant must demonstrate for any proposed launch that for all launch vehicle stages or components that reach earth orbit -- (a) There will be no unplanned physical contact between the vehicle or its components and the payload after payload separation; (b) Debris generation will not result from the conversion of energy sources into energy that fragments the vehicle or its components. Energy sources include chemical, pressure, and kinetic energy; and (c) *Stored energy will be removed by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy.* Other equivalent procedures may be approved in the course of the licensing process. (emphasis added)

[16] The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies ("Outer Space Treaty"), entered into force on 10 October 1967.

[17] The Convention on International Liability for Damage Caused by Space Objects ("Liability Convention"), entered into force on September 1, 1972.

[18] The Convention on Registration of Objects Launched into Outer Space ("Registration Convention"), entered into force on September 15, 1976.

[19] "Space object" is defined to include the "component parts of a space object as well as its launch vehicle and parts thereof." Liability Convention, Art. I(d); see also Registration Convention, Art. I(b), (using the same language as the Liability Convention to define "space object."

[20] "Damage" is defined as: "loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations." Liability Convention, Art. I(a).

that there is consensus on the meaning of "fault." "Fault" has significantly different meanings in civil law systems than in common law systems. In civil law, fault is open to interpretation by the courts on a case by case basis. In common law, fault is often equated with negligence, or breach of a duty of care. Thus, in a common law jurisdiction, a State suffering damage will need to prove that the "defendant" State owed it a legal duty, that the duty was breached, and that the breach of this duty was the proximate cause of damage. In the situation of an on-orbit collision, it will be very difficult to determine which State would be "at fault" if a piece of debris strikes an orbiting satellite. An owner of an operational satellite that is struck may well be at fault if it placed the satellite in an orbit where collision is likely or if it failed to maneuver out of the way of an inert piece of debris. Third, since items in orbit move under the inexorable control of gravity and orbital mechanics, it is not at all clear that an eventual collision need be the fault of either party. Thus, the Liability Convention does not create a clear duty of care by which responsibility for damage to an orbiting spacecraft resulting from orbital debris may be assigned.[21]

2. The Registration Convention

Under the Registration Convention, a State that launches a space object into earth orbit or beyond "shall register the space object by means of an entry in an appropriate registry which it shall maintain."[22] Article VI of the Registration Convention requires State Parties that have space monitoring and tracking facilities to respond to requests for assistance in the identification of an object that has caused damage. This requirement for States with tracking services to provide identification of a space object causing damage is the most relevant provision of the Registration Convention for purposes of orbital debris. But the use of the singular term, "space object," and its tie to a "launching," lends credence to an argument that orbital debris – especially the multitude of small pieces that are of most concern – does not easily fit the Registration Convention's definition of "space object." Further, the Registration Convention imposes no affirmative requirement on launching states to inform the U.N. of the breakup or fragmentation of their space objects. Thus, it may be that liability under the Liability Convention for damage caused by orbital debris can only be possible if it is concluded that the term "space object" is not used consistently among the three treaties in which the term appears.

3. The Outer Space Treaty

The Outer Space Treaty itself contains statements that may have application to orbital debris. Article VI declares that "States Parties to the Treaty shall bear

[21] Some commentators who have addressed this issue have proposed that, in place of a regime of fault liability, absolute liability should attach to damage in outer space. They argue that, almost by definition, outer space activities are ultrahazardous and therefore the activity should bear the risk of strict liability, thus shifting the cost of the damage from the injured State to the injuring State. See: Howard A. Baker, Space Debris: Legal and Policy Implications, at 86 (1989) and "Orbital Debris and the Spacefaring Nations: International Law Methods for Prevention and Reduction of Debris, and Liability Regimes for Damage Caused by Debris," P. Limperis, 15 Ariz. J. Int'l & Comp. Law 319, 340 (1998). There are at least two significant problems with this idea. First, it is unclear whether spacefaring nations would agree to the imposition of a strict liability regime for orbital debris, given the complexities of space operations. Second, for reasons noted above, it will not often be clear if a given object was "injured" or if it inflicted the injury by being in the "wrong" orbit, a fact central to assignment of liability.

[22] Registration Convention, Article II(1).

international responsibility for national activities in outer space." Additional language in Article IX would seem to suggest that such responsibility could extend to damage to earth's environment caused by orbital debris. This provision requires State Parties to conduct exploration of outer space, including the moon and other celestial bodies, "so as to avoid their harmful contamination and also adverse changes in the environment of Earth resulting from the introduction of extraterrestrial matter..." However, it would be difficult to interpret this provision as providing a basis for imposing responsibility or liability for orbital debris. First, the provision raises the question of whether Earth's orbits (LEO, MEO, and GEO) are considered "the environment of the Earth." With respect to environmental laws, NASA and the U.S. Government have consistently taken the position that the Earth's environment does not include outer space.[23] Second, it is difficult to argue that by launching man-made items into orbit they become "extraterrestrial matter" of the type that generated the protective regime of Article IX.

**International Discussions**

Despite the lack of a clear international liability regime for orbital debris, NASA and the U.S. Government as a whole have promoted internationally recognized technical standards on orbital debris for application to space activities worldwide.

1. The Inter-Agency Space Debris Coordination Committee (IADC)

In 1993, NASA, the European Space Agency (ESA), the Russian Space Agency (RSA) and several Japanese agencies formed the IADC. The IADC is an informal body with expert, yet limited, participation. Its membership does not include all countries or organizations that develop or launch rockets or all countries or organizations that own or operate satellites.[24] However, the IADC works closely with the Scientific and Technical Subcommittee (STSC) of COPUOS and has made presentations at several STSC meetings.

2. The Committee on the Peaceful Uses of Outer Space/STSC

COPUOS functions through the full Committee and its two subcommittees, the STSC and the Legal Subcommittee (LSC). In 1994, COPUOS added the issue of space debris as a priority agenda item for the STSC, agreeing that consideration of space debris was important and that international cooperation was needed to expand appropriate and affordable strategies to minimize the potential influence of space debris on future space missions. In 1995, the STSC adopted a flexible, multi-year work plan to be followed from 1996 to 1998. The results of the first two stages of the multi-year work plan, to measure and "model" space debris, are contained in the 1996 and 1997 draft reports of the STSC. The 1998 report completed the third stage work plan with results on mitigation. The three combined sections were carried forward and technically amended in 1999. The consolidated report was adopted in the 1999 session of the STSC and published as

[23] *Cf.*, Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, January 4, 1979.

[24] Since that time, membership has expanded to include the Chinese National Space Agency (CNSA), the French National Space Agency (CNES), the British National Space Center (BNSC), the German Aerospace Center (DLR), the Indian Space Research Organization (ISRO), the Italian Space Agency (ASI), and the National Space Agency of Ukraine (NKAU).

a U.N. document.[25] The technical report summarizes the current state of knowledge concerning measurements and modeling of the environment as well as identified orbital debris mitigation measures. It lays a foundation that will help establish a common understanding on the nature and extent of the challenges posed by orbital debris and will serve as the basis for further STSC deliberations on debris issues. This is the beginning, not the end of the STSC's work, however. The STSC agreed to continue to consider orbital debris as an agenda item for the foreseeable future, with a special topic selected for each year.

3. Discussions in the Legal Subcommittee of COPUOS

To date, the topic of orbital debris has been a technical topic only – it is not currently on the LSC agenda. However, recent reports of the STSC reflect the view of several countries that a set of international rules for the launch of spacecraft should be codified, based on current practices of space agencies, in order to reduce the growth of orbital debris.[26] Other nations, including the U.S., have taken the view that LSC discussion of orbital debris was premature and could be counterproductive.[27] Similar concerns exist relative to proposals directing the STSC to develop recommendations to underpin new legal norms for orbital debris.

The U.S. has noted in the STSC and other international fora that spacefaring nations are generally behaving responsibly in preventing the creation of space debris. However, an assessment of the effectiveness and pervasiveness of internationally recognized mitigation practices does not exist. Efforts to model and simulate the environment are also needed.[28] It is tempting, especially for lawyers, to seek immediate adoption of formal legal norms to address potential hazards posed by increasing numbers of orbital debris objects. But to do so in an uncertain technical environment in which the potential need to make incremental and frequent adjustments to them will be great, puts at risk the very goals that the legal norms are intended to advance. In short, an evolving factual situation and the existence of numerous unresolved technical issues would not only make achievement of an effective and responsive legal regime unusually difficult, it would also involve COPUOS at an unprecedented level of spacecraft design and operational detail.

**Summary of Legal Status Quo**

The discussion thus far suggests that numerous, fundamental questions about liability for damage caused by orbital debris remain unanswered by the major space treaties. This does not mean, however, that the success of future space activities lies in some yet-to-be-negotiated international treaty. In the past 20 years, the number of countries and organizations launching and operating spacecraft in Earth orbit has increased significantly despite the fact that, in this same timeframe, no new treaties were promulgated and few countries have formally acceded to the ones that do exist.

[25] A/AC.105/720.

[26] *See, e.g.*, A/AC.105/637, "*Report of the Scientific and Technical Subcommittee on the Work of its 33rd session: Committee on the Peaceful Uses of Outer Space*," March 4, 1996, par. 141.

[27] *Id.*, at paragraph 142.

[28] *See*, Statement of the U.S. Delegation to the Legal Subcommittee, February 1999.

Academics and other space law commentators have tended to view orbital debris primarily as an environmental law issue: protection of the Earth's environment from space contamination and protection of the space environment from Earth-generated contamination. It seems, however, that the focus of debate on orbital debris issues is becoming more pragmatic. Rather than seeking broad pronouncements of liability and responsibility from an environmental perspective, spacefaring nations are beginning to examine actual space operations as a means of remedying past problems involving orbital debris. Instead of developing a complex regime of punitive measures to address problems *ex post facto,* the international community appears anxious to encourage orbital debris mitigation at the outset by encouraging compliance with effective design and operations standards.

**The Road Ahead**

In my 12 years as General Counsel of NASA, I have learned that complex questions involving international space law are sometimes answered by technology. Experience also suggests that adopting legal solutions before the scope of the technical problem is understood can lead to unforeseen, if not counterproductive, results.

Every recent analysis of orbital debris has concluded that preventative measures could alleviate future problems.[29] These preventative measures include reliance on emerging technology and establishment of and adherence to standards in spacecraft operational profiles, configurations, design, and post mission conduct.

Although the U.N. may not have the technical expertise to set technical specifications for spacecraft design, other international bodies may be appropriate venues for such discussions: the IADC, for example.

I do not mean to imply that discussions of orbital debris in COPUOS or similar bodies is unnecessary or undesirable. COPUOS was responsible for promulgating every major space law treaty that exists today and continues to monitor adherence to them . The STSC has the experience and credibility necessary to encourage and monitor the adoption of technical standards. The IADC, among other expert international panels, can play a central role by supplying the STSC with updated technical information necessary for the achievement of consensus on meaningful technical standards. But, in the broader view, it should be recognized that promulgation of detailed debris mitigation standards that would directly impact satellite design and operation, would also be qualitatively different from any prior efforts by COPUOS, and should be approached cautiously.

NASA's experience shows that enlightened debris mitigation practices work. But the job is not finished. NASA improves its operating standards as it gains mission experience. The fairly rapid emergence of debris mitigation practice shows that as experience is gained and knowledge increases, standards will change. A legal regime for orbital debris which is precise enough to govern conduct could inadvertently impede the adoption of newer, more effective techniques. Simply put, the knowledge and technological stability needed to create international operational or spacecraft design specifications upon which an effective

[29] Orbital Debris, A Technical Assessment, National Research Council, National Academy Press, 1999.

legal regime could be based does not yet exist.

NASA's deliberate approach to developing and implementing effective orbital debris mitigation standards is evidently shared by other national space agencies. For example, the Council of the European Space Agency (ESA) passed a resolution defining the agency's objectives in the field of space debris: "to reduce to the maximum possible extent the production of space debris and to promote exchange of information and cooperation with other space operators...."[30] The Japanese Space Agency (NASDA) patterned its standard on orbital debris on the NASA standard NSS1740.14.[31] The Russian "Law on Space" contains a provision prohibiting orbital debris generation.[32] It is also my understanding that France's national space agency, CNES, has developed orbital debris standards, which are not yet in effect.

This is not to say that the international community should do nothing. There exist currently viable alternatives to creating a treaty-like legal framework to govern operational conduct. The goal of the international community should be to encourage compliance with the emerging "rules of the road" as these develop and mature. We should simultaneously encourage other countries to review the national measures such as those taken by the U.S., ESA, Japan, and Russia, since those measures reflect the "lessons learned" since the advent of the Space Age.

A system of widespread, voluntary compliance with technical orbital debris mitigation standards could greatly minimize orbital debris generation, even if those standards were embedded in differing national legal systems. Technical proposals could emanate from the IADC or other groups with a view toward encouraging their adoption and implementation on an ongoing basis in space programs worldwide. As consensus grows on emerging technical practices, technical standards-setting bodies like the IADC could recommend them for adoption. Given the relatively small number of reasonably sophisticated launchers and operators, this approach is likely to be sufficient for the present. Indeed, the COPUOS/STSC could play an important role in reviewing recommended standards and encouraging their adoption within each country's legal framework. However, only after experience with technical standards is gained over time through widespread adoption, can the Legal Subcommittee of COPUOS realistically consider formulating these standards as international principles.

Finally, it is important to note that the important matter of enlightened self-interest is fundamental to any discussion of

[30] ESA/C/LXXXVII/Res. 3, par. II, *Council Resolution on the Agency's policy vis-à-vis the Space Debris issue,* approved on 29 June 1989. ESA is in the process of creating a European Space Debris Safety and Mitigation Standard. It is currently being drawn up by the European inter-agency working group (ASI, BNSC, CNES, DLR, ESA/ESOC) that is based on the CNES standard and ESA Space Debris Mitigation Handbook.

[31] *See* NASDA Standard 18, 28 March 1996. The Space Debris Mitigation Standard defines mitigation measures to be taken at the planning, design and operational phases for launch vehicles and spacecraft in order to minimize generation of orbital debris at launch, on orbit, and at end of life.

[32] "For the purpose of ensuring strategic and ecological safety in the Russian Federation, the following are forbidden: ... harmful pollution of space, leading to unfavorable environmental changes, including intentional destruction of space objects in space." *Russian Federation Law on Space*, Section I, Article 4, Paragraph 2.

orbital debris. Simply put, it is not in the interest of any spacefaring nation to pollute outer space. All countries, including the polluter, would suffer the consequences of such irresponsibility, including greater potential for damage from orbital debris, lack of safe orbital positions for telecommunications satellites, and interference with use of existing satellites.[33]

**Conclusion**

To fully address the actual risks of orbital debris requires a clear appreciation of the orbital debris environment, including debris size, composition, eccentricity, reentry probabilities and other physical characteristics. Without such knowledge, it will be difficult if not risky for the international community to make decisions that could have dramatic implications for national – and commercial – space activities worldwide. More thorough understanding of orbital debris would allow designers of spacecraft to better protect the spacecraft from potential damage and will allow spacefaring nations to implement the most appropriate protective measures (including maneuvering) in a cost effective manner. Research continues to be necessary to characterize the effects of hypervelocity impacts on spacecraft, including research into better scientific models of debris fragmentation as a result of impact.

Although some of the steps that space programs need to take to mitigate the creation of debris are clear, the long term solution to the problem is not. As of now, I am skeptical that a lengthy international debate over legal standards would significantly advance the goal of encouraging spacefaring countries to implement debris mitigation standards. Rather, spacefaring nations should start to take controlled, well-considered steps to mitigate debris creation individually, and collectively be prepared to adopt technological advances that will improve those practices.

[33] One argument that is raised against the imposition of standards is that compliance would increase operational expenses. That argument seems specious. It seems more likely that states sophisticated enough to operate in space will also recognize that increased orbital debris are likely to increase the future costs of space operations due to increased cost of spacecraft design, shielding, maneuvering and even insurance.