CHAPTER 5

SPACE DEBRIS: NEXT STEPS[1]

Theresa Hitchens

No one with a stake in the future of outer space would dispute the fact that near-Earth orbit has become increasingly populated with man-made junk. Space debris is the inevitable consequence of the global uses of space—every single space launch will create some amount and form of debris, just as every kind of public transport on Earth creates some amount and form of pollution. Most space scientists and operators have long recognized that pollution in space, like pollution on Earth, is dangerous. But, as with environmental problems on Earth, there remain challenges to characterizing the exact nature of the debris problem, as well as disagreements about the gravity of the situation and how best to address it. One thing that is certain is that failure to stem the creation of space debris will undercut the security of all assets in space, increasing the likelihood of collisions and possible conflict over liability for them.

The official catalogue of space objects kept by the US Air Force's Space Surveillance Network (SSN) contains about 9,000 objects, but the Air Force also tracks approximately 4,000 other objects whose origins and exact orbits are not yet confirmed. Although there is no unclassified, publicly available data on exactly how many operational satellites are orbiting at any one time,[2] US officials say that only about 6% of those 13,000 objects being watched are working satellites or spacecraft, such as the International Space Station. The rest is debris.[3]

Worse yet, the debris now tracked represents only a small fraction of the junk in orbit. Most space debris is smaller than 10cm—too small to be verifiably detected and followed with current technology.[4] Space scientists estimate that there are more than 100,000 objects between 1cm and 10cm in size—that is, larger than a marble—and perhaps trillions of pieces that are smaller yet.[5] Space debris is concentrated in the two orbits that are most

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useful for human space operations: Low Earth Orbit (LEO) is defined as between the ceiling of the Earth's atmosphere from around 100km to 1,000–2,000km in altitude; Geosynchronous Orbit (GEO) is roughly 36,000km above the Earth and where satellites essentially remain stationary over one spot on the ground.

Space debris is dangerous because of its potential to collide with and damage satellites and/or spacecraft. Even tiny pieces of debris such as paint flecks measured in millimetres can cause destruction. Debris is so dangerous because objects in orbit move at extremely high speeds—about 10km per second in LEO[6]—thus relative velocities and the energy generated at impact can be very high. In fact, NASA must replace one or two Space Shuttle windows after each mission as a result of damage by small pieces of debris.[7] "We get hit regularly on the shuttle", Joseph Loftus, then assistant director of engineering for NASA's Space and Life Science Directorate, as quoted by *space.com* in September 2000, noting that, as of that time, more than 80 shuttle windows had been replaced because of debris impacts.[8]

Debris can also be a danger to people and things on the ground, as some space junk in LEO will eventually de-orbit, pass through the atmosphere and land. Although such landfalls are rare, they do happen when very large space objects de-orbit. For example, large pieces of Skylab fell over Western Australia in July 1979; in April 2000, pieces of a Delta 2 second stage rocket fell over Cape Town, South Africa.[9] Debris—as well as the ever-increasing population of active spacecraft and satellites—can further interfere with astronomical observations by creating a form of light pollution (just like satellites or spacecraft, debris pieces can reflect sunlight and clutter efforts at sky mapping). Light pollution is not only a problem for civil astronomy, but also for military efforts at space surveillance, since tracking and monitoring space objects relies in large part on optical telescopes.

In yet another parallel with pollution on Earth, it is much easier to prevent space debris than to clean it up. Indeed, currently there are no technologies that can reliably "clean up" space junk put up in decades past. Unfortunately, although preventing the creation of debris might be simpler than removal, it is not easy since it would require operators to incorporate special design features into their spacecraft or satellites. Nonetheless, many space-faring nations and commercial interests have woken up to the need

for debris mitigation caused by concerns that if nothing is done now, certain highly useful orbital planes might no longer be safe for satellites and spacecraft.[10] For example, the International Space Station is moved at least four times a year to avoid debris collisions.[11] Certainly, with the high costs of launching and maintaining satellites—not to mention the costs of insuring them—commercial firms have no desire to see space become more cluttered with potentially damaging debris.

Many of the major space-faring powers (including the European Space Agency, France, Japan, the Russian Federation and the United States) have put regulatory standards into place aimed at limiting the creation of debris from government-sponsored space operations; and other nations (such as China and India) are working to put into place similar "good practices". The various debris mitigation standards now in place are similar, including limiting the amount of debris produced from normal operations, such as throwaway orbital stages or components; burning off fuel at the end of a satellite's mission life; and removing non-operational spacecraft and rocket stages from orbit, either by de-orbiting objects in LEO (over a certain time) or boosting them up and out of the way into a so-called "graveyard" orbit for objects in GEO.[12]

However, these national efforts vary in scope and in application—some, for example, contain exemptions that allow waivers if a certain mitigation practice is deemed too expensive. Moreover, some space-faring powers still have not completely embraced the idea of mitigation practices, concerned that added costs might hamper their ability to develop competitive space industries.

Another problem is that not all space operations or operators are "national" in nature. Indeed, there are a growing number of international consortia launching and operating commercial satellites. One company, SeaLaunch, launches from ocean platforms and thus technically does not necessarily work within any nation's "territory". The global nature of the industry not only has resulted in debate about which nation state is responsible for licensing multinationals—not to mention which state bears liability under the Liability Convention—but also, even more generally, the international community continues to argue about what the term "launching state" actually means. In this way, space is very much like the high seas, where regulating shipping has been complicated by the ease at which shady operators "change flags".

Armel Kerrest, a French specialist in international law, wrote:

> The problem is that, by nature, outer space activities are international, they take place in an international space, involve international consortia, may be located in international domain (etc.). Moreover, mitigating space debris creation is very expensive, when private activities are concerned, there is good reasons [*sic*] to think that, given the competition, some entrepreneurs will try to avoid those measures by conducting their activities under a more favorable law. Doing so, they will get a great competitive advantage. It is already the case for sea activity; why should it be any different for outer space?[13]

In an attempt to "internationalize" an approach to debris mitigation, the United Nations and the Inter-Agency Space Debris Coordination Committee (IADC) are attempting to develop coordinated, international debris mitigation guidelines. Space debris has been on the agenda of the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) since 1994, with COPUOS issuing the Technical Report on Space Debris (A/AC.105/720) in 1999.

The IADC comprises the space agencies from China, France, Germany, India, Italy, Japan, the Russian Federation, Ukraine, the United Kingdom and the United States, plus the European Space Agency (ESA). It was established in 1993 as an information exchange group. In 2001, COPUOS asked the IADC to develop and submit a set of voluntary international guidelines that might eventually be adopted by COPUOS and the United Nations at large. On 29 November 2002, the IADC submitted the guidelines to COPUOS, for consideration at the committee's 17–28 February 2003 session in Vienna, Austria. It was originally expected that COPOUS would endorse the guidelines in 2004; however, several nations—particularly India, which has been somewhat sceptical of the international efforts at mitigation, and the Russian Federation—have submitted comments asking for changes that require renewed IADC discussions. As both the IADC and COPUOS work on the basis of unanimity, some compromises will need to be found. Officials now are hoping that the IADC guidelines can be agreed at the next meeting of the COPUOS Science and Technical Subcommittee in 2005.[14]

The IADC guidelines ask nations to limit debris released during normal space operations, minimize the potential for on-orbit break-ups, undertake post-mission disposal and prevent collisions. In addition, the IADC

recommends that a space debris mitigation plan be put together for each space project, and asks nations to voluntarily report—beginning in 2005—on mitigation efforts.[15]

However, the guidelines are voluntary, and thus include no legally binding requirements for those who adopt them. The guidelines do not recommend how nations should implement and enforce them, nor do they suggest how nations should integrate them into their current processes for approving space launches. Therefore, some experts worry that the IADC measures will simply not be enough.

For example, only about one-third of space operators now regularly boost dead spacecraft in GEO to a graveyard orbit at least 300km higher for disposal, according to Walter Flury, director of the space debris programme at ESA.[16] Only 22 of 58 non-functioning satellites in GEO were put into graveyard orbits between 1997 and 2000, according to research by ESA's European Space Operations Centre.[17]

What is the key reason for non-compliance with best practices? Costs. For example, GEO boosting could cost a company "hundreds of millions of dollars in lost revenue", according to a story in the *Edmonton Journal*.[18] While most debris mitigation measures are not extraordinarily expensive if included during a satellite's design, the small profit margins afforded to space launch firms and the competitive global market mean that achieving compliance with voluntary guidelines might be difficult.

"It is unlikely that voluntary application of mitigation measures will solve the space debris problem", Flury said, "Just think about the commercial sector of space activities with its competitive character."[19]

So what should be done? A number of actions could be taken by the international community to build upon and improve the IADC effort:

- COPUOS should adopt the IADC guidelines as soon as possible, followed by a UN resolution to enshrine them. Further, as part of the agreement to follow the guidelines, each signatory should pledge not to use launch services of countries or companies that do no comply with the guidelines. Signatories should also agree to share technology needed to enable the guidelines to be followed, with a special emphasis on helping developing nations defray costs.

- Member States of the United Nations should be encouraged to develop national legislation on space activities to incorporate the IADC guidelines into processes for launching and operating satellites.
- The COPUOS Legal Subcommittee, with the IADC, should begin work to develop recommendations to harmonize national regulations regarding debris mitigation practices and licensing processes standard to a specific minimum degree that could be put into place in 5 to 10 years time.
- The International Organization for Standardization (ISO) should continue its work with IADC (under ISO/TC20/SC14 7th Working Group) to develop underpinning engineering methods for implementation of the guidelines, including looking at the most cost-effective methods for achieving them.
- Recognizing that ISO standardization could take many years, United Nations Members States should in the near-term be encouraged to develop national standards for applying the IADC guidelines—for example, NASA already has such standards for applying the US mitigation guidelines—as a minimum approach to debris mitigation.
- The COPUOS Legal Subcommittee should be tasked with developing, by 2014, international legal standards for debris mitigation to be applied to all space operators under an international treaty that eventually could be negotiated under the auspices of the United Nations.
- Consideration should be given to how the Liability Convention might be amended with new provisions aimed at creating penalties for space operators whose failure to accept or comply with the internationally recognized debris mitigation guidelines results in debris creation or collisions.
- The international community needs to continue to develop better debris tracking technologies, methods and networks in order to improve collision prediction. In particular, there is a need to develop capabilities other than the US Space Surveillance Network to provide continuity of data to the international community and transparency. COPUOS should establish a working group to consult with amateur space tracking networks, such as SeeSat, to explore the feasibility of an open, publicly available space surveillance network and database.

Obviously, some of these suggested measures (particularly those that involve trying to create legal international standards) are likely to be controversial and time consuming to develop and implement. However,

this is all the more reason for beginning efforts at the national level now. Ultimately, though, it must be recognized that outer space—like the Earth's atmosphere—is a global resource that must be protected by all if it is to be preserved for the benefit of all.

Notes

1 This presentation is drawn from a larger monograph on "Future Space: Charting a Secure Course", to be published by the author under a generous grant from the Carnegie Corporation of New York.

2 E-mail exchange with a National Aeronautics and Space Administration (NASA) official, February 2003.

3 Nicholas L. Johnson, chief scientist and programme manager, NASA Orbital Debris Program Office, Johnson Space Center, Houston, Texas, "Space Debris, Its Causes and Management", presentation to Congress in Washington, DC, sponsored by Representative Adam Schiff, Democrat from California, and organized by the Monterey Institute of International Studies, 24 July 2002; updated data provided by a NASA official.

4 National Research Council, 1995, *Orbital Debris: A Technical Assessment*, Washington, DC, National Academy Press, pp. 34–37.

5 Johnson, op. cit.; updated data provided by a NASA official.

6 National Research Council, 1995, *Orbital Debris: A Technical Assessment*, Washington, DC, National Academy Press, p. 4.

7 Johnson, op. cit.; updated data provided by a NASA official.

8 Maia Weinstock, Orbiting Junk Continues to Threaten International Space Station, 5 September 2002, *space.com*, at <www.space.com/scineceastronomy/planetearth/space_junk_000901.html>.

9 Leonard David, Holy Hunks of Junk, It's Raining Boosters!, 10 May 2000, *space.com*, at <www.space.com/news/raining_boosters) 000510.html>.

10 Daniel Gonzales, 1999, *The Changing Role of the U.S. Military in Space*, RAND Project Air Force, Santa Monica, p. 47.

11 Orbital Debris Threatens Future Space Journeys, *China Daily,* 26 November 2003, at <www.1.chinadaily.com.cn/en/doc/2003-11/26/content_284869.htm>.

12 *Inter-Agency Space Debris Coordination Committee Space Debris Mitigation Guidelines*, New York, United Nations, 29 November 2002

(A/AC.105/C.1/L.260); Office of Safety and Mission Assurance, 1995, *NASA Safety Standard: Guidelines and Assessment Procedures for Limiting Orbital Debris*, Washington, DC, NASA (NSS 1740.14) at <orbitaldebris.jsc.nasa.gov/mitigate/safteystandard.html>.

13 Armel Kerrest, *Space Debris, Remarks on Current Legal Issues*, presented at the Third European Conference on Space Debris, Darmstadt, 19–21 March 2001, ESA SP-473, vol. 2, p. 869, October 2001, at <fraise.univ-brest.fr/~kerrest/IDEI/debris-Darmstadt.pdf>.

14 E-mail exchange with an official involved in the IADC and COPUOS discussions, 5 March 2004.

15 *Inter-Agency Space Debris Coordination Committee Space Debris Mitigation Guidelines*, 2002, op. cit., section 5.2, p. 8.

16 Written answers to questions from the author to Walter Flury, director of the space debris programme at ESA, Paris, 24 July 2003.

17 *Garbage Mountains in Orbit*, ESA news release, Paris, 23 March 2001.

18 Andrew C. Revkin, Highway Patrol: Outer Limits: The final frontier is becoming cluttered with garbage and satellites. Scientists are trying to set some ground rules for controlling pollution and traffic in space, *Edmonton Journal*, 2 March 2003, D9.

19 Flury, op. cit.