NEXT GENERATION SPACE SECURITY CHALLENGES

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INTRODUCTION

As the sustainable use of outer space becomes increasingly critical to security issues on Earth, including national, international, human, environmental and economic security, policy leaders must act to ensure that this environment remains safe and usable for the next generation. In order to do so, it is necessary to understand the types of challenges that will face the international community in outer space in the near future.

The following analysis of next-generation space security challenges is based on research contained in the Space Security Index series of publications. The Space Security Index provides an annual assessment of the status of space security based on objective and evidence-based analysis to promote transparency and confidence in space activities, and to support the development of policies that ensure secure access to space for all.[1]

The definition of space security developed by the Space Security Index is the secure and sustainable access to space and freedom from space-based threats. This is very much an environmental approach to space security that has as its goal the common security of all actors in the space environment. Because outer space is a particular, and particularly sensitive, environment, it presents unique governance challenges to the international community. Based on current trends, the most significant challenges in the future will involve:

- sustainability of the operating environment;
- the increase in space actors; and
- the proliferation of space technologies.

These types of challenges are interconnected and in many ways reinforce one another, demanding a holistic approach to managing the security of outer space.

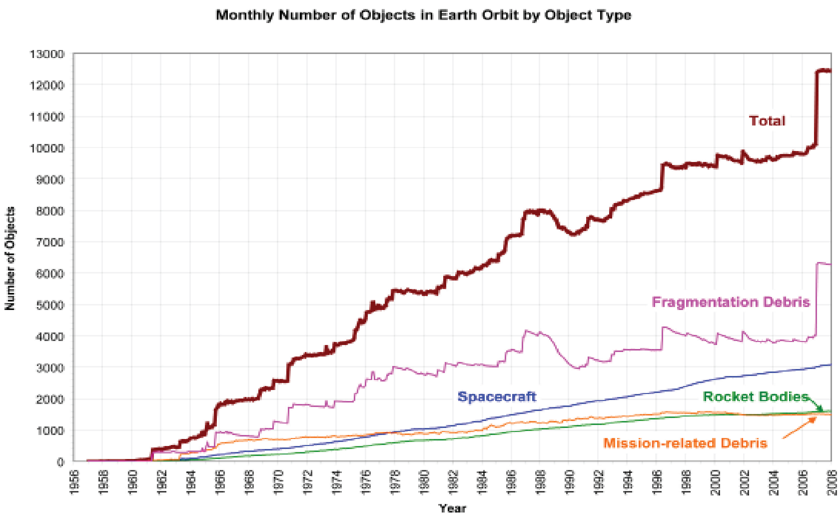
Published in *Security in Space: The Next Generation—Conference Report, 31 March–1 April 2008*, United Nations Institute for Disarmament Research (UNIDIR), 2008.

OPERATING IN OUTER SPACE: THE CHALLENGE OF DEBRIS

Space debris poses a serious challenge to operating in the space environment because it is largely unavoidable (particularly in popular orbits), it is indiscriminate and it is long term. Prevention is currently the only form of mitigation available.

The challenge of space debris is particularly highlighted by events in 2007, which produced one of the largest yearly increases in space debris ever (see Chart 1). Most of this debris was caused by the intentional destruction of an obsolete Chinese weather satellite, Fengyun-1C, by a kinetic intercept vehicle on 11 January 2008. As of 1 February 2008, 2,317 pieces of debris from the event were identified and catalogued by the US Space Surveillance Network (SSN).[2] It is estimated that some 150,000 pieces of debris to small to be tracked were generated.[3] As a result of this event, the amount of debris in low Earth orbit has increased by approximately 20%, raising the number of close approaches to operational satellites. According to the US Air Force, the number of close approaches to the approximately 400 operational US satellites has doubled to almost 200 per week,[4] although the definition of a close approach is not clear.

Chart 1. Growth in on-orbit population by category



This is a summary of all objects in Earth orbit officially catalogued by the US Space Surveillance Network. "Fragmentation debris" includes satellite break-up debris and anomalous event debris while "mission-related debris" includes all objects dispensed, separated or released as part of the planned mission.

Source: National Aeronautics and Space Administration, Orbital Debris Quarterly News, *vol. 12, no. 1, January 2008, <http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv12i1.pdf>.*

In addition to the Chinese satellite intercept, there were several other incidents during 2007 that contributed to the worst year ever for new debris creation. These events are summarized in Table 1.

Table 1. 2007 debris event summary

Parent object	State	Date	Estimated number of pieces*	Catalogued number of pieces**	Lifespan of pieces
FY-1C	China	11 January	2,600	2,300	long
Beidou	China	2 February	70–100	0	long
Aux Motor	Russia	14 February	60+	0	long
CBERS-1	China/Brazil	18 February	100	66	short
Briz-M	Russia	19 February	1,000+	0	long
H2-A	Japan	28 July	14	14	short
UARS	United States	10 November	4	4	short
Delta IV	United States	11 November	25+	0	short

* *according to the US SSN*
** *as of 1 February 2008*
Data compiled from the public satellite catalogue Space Track, *<www.space-track.org>.*

While steps are currently being taken to mitigate the production of new space debris, including the adoption of debris mitigation guidelines by the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS) in June 2007, these are non-binding guidelines that Member

States have pledged to implement within national licensing or other applicable mechanisms “to the greatest extent feasible”. The threat of rising debris levels will continue to be posed through growth in the number of space actors and space missions in the future, the potential use of kinetic-force technologies against objects in space, and the process of debris collision and fragmentation that occurs naturally in the space environment.

OPERATING IN OUTER SPACE: LIMITED MONITORING

Space surveillance capabilities are vital to the mitigation of environmental hazards such as space debris, as well for creating greater transparency and confidence in space activities. There is no international space surveillance mechanism or catalogue of objects, but several states have developed discrete capabilities. The United States possesses the most advanced surveillance system, which tracks over 17,000 objects larger than 10cm in diameter. Russia maintains a space surveillance capacity through its early-warning radars, and France and Germany have national capabilities through the Grande Réseau Adapté à la Veille Spatiale system and the Forschungsgesellschaft für Angewandte Naturwissenschaften Tracking and Imaging Radar, respectively. Canada, China, Japan, Ukraine and the United Kingdom are all developing independent space surveillance capabilities. Details of these systems as indicated through public sources are given in Table 2.

The capabilities that have been developed to date are limited in terms of the size of objects that can be observed in outer space at different altitudes, and in terms of the international availability of the data. The next generation will require both better space situational awareness capabilities, and better sharing. This is due both to the inevitable growth of space debris, as well as the need for greater transparency of space activities, which are naturally marked by a degree of uncertainty. This uncertainty increases risks to space security as more actors with more advanced capabilities enter outer space, challenging both abilities to monitor space traffic, and potentially creating an environment of fear and mistrust.

Table 2. Worldwide space situational awareness capabilities

Actor	Optical sensors	Radar sensors	Orbital sensors	Global coverage	Central tasking	Catalogue	Public data
Amateur observers	■			□	□	□	■
Bolivia*	■						
Canada	■						
China	■	■					
European Union	■	■		(□)	(□)	(□)	
France	■	■					
Georgia*	■						
Germany		■					
Japan	■	■					
India	■						
Norway		■					
Russia	■	■				□	
South Africa	■						
Spain*	■						
Switzerland	■						
Tajikistan*	■						
Ukraine	■						
United Kingdom	■	■					
United States	■	■	□	□	■	■	□
Uzbekistan*	■						

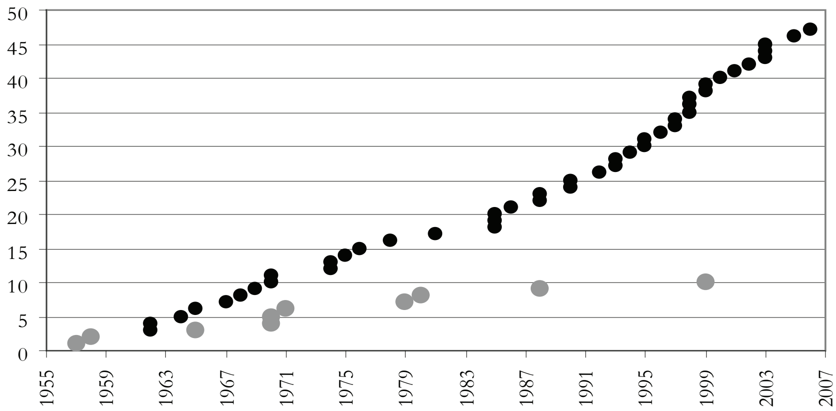
Key: ■ = full capability; □ = some capability; (□) = under development
** part of the International Scientific Optical Network*

Source: analysis by Brian Weeden, technical consultant, Secure World Foundation.

INCREASE IN SPACE ACTORS

Linked to the operational challenges of the space environment are the number and diversity of space actors, which continue to grow as the social, economic and security benefits that space access provides are sought. Chart 2 indicates the growing number of national actors accessing outer space.

Chart 2. Growth in the number of national actors accessing space



● = *first independent launch*
● = *deployment of first satellite*

Source: Jonathan's Space Report, "Satellite Catalogue and Launch Catalogue", <http://planet4589.org/space/log/satcat.txt>; Encyclopedia Austronautica, "Chronology 2004", <http://www.astronautix.com/chrono/20041.htm>.

Not only are more national actors gaining access to outer space, particularly developing countries, but new private actors with a range of interests are also emerging. As companies such as SpaceX and Bigelow Aerospace seek to revolutionize access to outer space by drastically reducing costs and providing access to private individuals, the number and type of users of outer space will continue to grow. Even among traditional civil, military, and commercial space actors, the use of outer space is both growing and diversifying. In 2007, the number of satellites launched by each actor was on par with one another at roughly 35 spacecraft each, and there is a notable overlap of users for different spacecraft, blurring this standard classification of space actors.

Increasingly, the growing number and diversity of actors in outer space will strain both the availability of resources and the current international legal and regulatory regime for outer space. Both radio frequencies and orbital slots, the building blocks of operating in outer space, are limited resources, currently managed by the International Telecommunications Union (ITU). The distribution of these resources on a first-come, first-served basis may be contentious in the future, with one concern being the growing military use of space resources, which is not regulated by the ITU. Moreover, the current legal regime is based extensively on the premise of states as actors, which has already generated some challenges regarding registration and liability issues, but will prove more problematic in the future as private actors increasingly access outer space. The need for a set of common and consistent rules and procedures for operating in outer space, or a system of space traffic management that includes all actors, will also become more apparent in the future as the use of outer space increases.

Finally, as space access spreads, so does access to and development of space technologies, some of which could be used to threaten the security of space operations.

PROLIFERATION OF SPACE TECHNOLOGIES: GROUND-BASED CAPABILITIES

One of the greatest technological challenges to the security of outer space in the future will continue to come from ground-based capabilities, particularly the horizontal and vertical proliferation of missile technologies. For example, medium- and long-range ballistic missiles can be modified to threaten space objects in low Earth orbit, as demonstrated by the Chinese missile intercept on 11 January 2007. Similarly, the spread of anti-ballistic missile defences is also of concern due to the potential of use against space objects, illustrated by the intercept of US-193 with a modified Standard Missile 3 used by the Aegis Ballistic Missile Defense System on 21 February 2008. Not only can longer range missiles and anti-missile systems directly threaten spacecraft in low orbits, but they also pose a risk to the operating environment through the creation of debris.

Although the spread of missile and anti-missile capabilities is predominantly driven by security concerns on Earth and not necessarily linked to space capabilities, it has the potential to threaten the security of space operations. Managing this threat in the future will require initiatives not only aimed at enhancing the security of outer space, but also to address the driving security concerns on Earth.

PROLIFERATION OF SPACE TECHNOLOGIES: SPACE-BASED CAPABILITIES

Another technological source of insecurity in the future is likely to come from the research and development of advanced, space-based technologies that could threaten secure and sustainable use of outer space. Examples of such technologies include, but are not limited to, microsatellite and smaller spacecraft capabilities, manoeuvrability and docking capabilities, and laser communication. These technologies are not by their nature threatening, and none are currently linked to dedicated anti-satellite systems, but they have the potential to serve a variety of purposes that can be difficult to verify once based in outer space. Not only could these technologies be used to physically threaten satellites, but due to their dual-use abilities, they can cause perceptions and *misperceptions* of insecurity in outer space, which can lead to very real consequences. The challenge for the future will be to create systems or mechanisms of verification, trust and transparency, particularly in light of the growing number and diversity of actors in outer space and the current obstacles to reliable monitoring of that environment. Otherwise it will be difficult to verify the purpose of space-based capabilities and to keep perceptual sources of insecurity and consequent reactions from spiralling out of control.

PROLIFERATION OF SPACE TECHNOLOGIES: SPACE-TO-EARTH STRIKE

There are currently no space-to-Earth strike capabilities. The United States continues to explore advanced technologies that could enable such a capability through programmes such as the Near Field Infrared Experiment and other missile defence initiatives, but there are no currently no programmes or policies in place to pursue such a capability. Nonetheless, the potential for space-to-Earth strike systems will continue to pose a challenge to the international community in the future, particularly as advanced space-based technologies continue to be developed, which may lead to hedging strategies. Moreover, while some enabling technologies for space-based strike are discrete and include significant technological barriers, many are advanced technologies associated with other space applications and have been developed for a variety of purposes by several different actors (see Table 3).

This means that if one actor were to pursue a space-based strike capability, others could follow. The dynamic nature of space technology makes it difficult to control or to dominate, allowing for an escalation of capabilities in outer space. Like the risks posed by the ground-based and space-based systems discussed above, the challenge of space-based strike is not simply one of technology spread, but is inherently linked to transparency, confidence and unresolved security issues both in outer space and on Earth.

SPACE SECURITY: NEXT-GENERATION RESPONSES

Analysis of current trends in space security indicates that the challenges of tomorrow will have behavioural, perceptual, organizational and technological roots. Moreover, these challenges are interconnected and in many ways serve to reinforce one another, and they are deeply entrenched in other security issues on Earth.

These characteristics suggest that a variety of tools will be needed that will also work together to create broad security in outer space, and also address related security challenges on Earth, such as missile and ballistic missile defence, and nuclear capabilities. Current proposals for space security address a range of these challenges together, but not independently. It is important to consider the relationships between them and how they might work with one another to create a holistic governance regime for outer space. The question to be answered is not which tool is most needed, most practical or most attainable, but what can be done today to address each of these challenges in the future. This is a question of political will.

Table 3. Advanced space-based warfare enabling capabilities

Capability	Conventional			Nuclear	Directed energy	
	Interceptors	Hypervelocity rod bundle	Munitions delivery	Munitions delivery	Lasers	Neutral particle beams
Precision positional maneuverability	■	■	■	■		
High-g thrusters	■					
Large Δ*v* thrusters	■	■	■	■		
Global positioning	■	■	■	■	■	■
Missile homing sensors	■				■	
Global missile tracking	▲				▲	▲
Global missile early warning	▲				▲	▲
Launch-on-demand	■	■	■	■	■	■
Microsatellite construction	■					
High-power laser systems					■	
High-power generation					■	■
Large-aperture deployable optics					■	
Precision attitude control					■	■
Precision re-entry technology		■	■	■		
Nuclear weapons				■		

Key: ■ *= required;* ▲ *= needed but not necessarily on the primary craft(s)*

Notes

[1] This research has been made possible through a partnership with the Secure World Foundation and support from the Government of Canada.

[2] Data compiled from Space Track, at <www.space-track.org>.

[3] Orbital Debris Quarterly of the NASA Orbital Debris Program Office, available at <http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv12i1.pdf>.

[4] Kevin Whitelaw, "The problem of space debris", *U.S. News & World Report*, 4 December 2007.