SPACE SECURITY

2008

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EXECUTIVE SUMMARY

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INTRODUCTION

Space Security 2008 is the fifth annual report on trends and developments in space, covering the period January to December 2007. It is part of a wider Space Security Index (SSI) project that facilitates dialog among space experts on space security challenges.

In keeping with the intent expressed in the 1967 Outer Space Treaty that space is a global commons to be used for peaceful purposes, the definition of space security guiding this report is:

The secure and sustainable access to, and use of, space and freedom from space-based threats.

The primary consideration is not the interests or the security of specific actors operating in space, but the security of space as an environment that can be sustained for use by all actors.

The Space Security Index aims to improve transparency with respect to space activities and provide a common, comprehensive knowledge base to support the development of national and international policies that ensure secure space access for all nations. This is critical because outer space is an environment distinctly different from the terrestrial environment, but intimately connected. Human activities such as debris creation require special caution and attention because their impact on space and on Earth can be extreme and far-reaching. Military security on Earth has become intertwined with the security of space assets. Conflicts in space between states can reflect but also aggravate existing tensions. While space activities are a strategic focus for national security, the pervasive dual military and civilian uses of space assets also contribute to global human security by, for example, tracking weather patterns to support agriculture, assisting responses to natural calamities, and interdicting criminal activities and human rights violations. And yet technologies that better enable the use of space for some purposes and actors may deny the secure use of space for other legitimate purposes and actors as technological developments outstrip the existing governance framework for outer space.

Space security is assessed here according to the following eight indicators:

- The space environment
- Space laws, policies and doctrines
- Civil space programs and global utilities
- Commercial space
- Space support for terrestrial military operations
- Space systems protection
- Space systems negation
- Space-based strike systems

Each chapter provides a description of a specific indicator and its impact on space security. A discussion of the prevailing trends associated with each indicator is followed by an overview of key developments throughout the year, and an assessment of their short-term effects on established trends and the broader security of outer space. Longer-term changes can also be observed and noted. For example, a prolonged decline in the annual production of new space debris, described in Trend 1.1 under the Space Environment, has reversed and rates are once again increasing.

Several developments in 2007, captured under different indicators in this volume highlight the contradictions and complexities intrinsic to outer space activity. As described under the space environment indicator in chapter 1, the year 2007 marked the greatest annual increase in space debris, largely attributed to the intercept and destruction of a redundant weather satellite in low Earth orbit by China and the explosion of a failed Russian Briz-M rocket body. Yet 2007 also witnessed the adoption of debris mitigation guidelines by the United Nations, described in chapter 2 on laws, policies and doctrines. Chapter 7 on space support for terrestrial military operations describes the use of missile and anti-missile technologies to threaten space assets and collective security in outer space. Such use sparked renewed efforts to regulate deployments and activities in outer space, as indicated in chapter 2. Despite what may be viewed as growing military tensions in space, 2007 also marked the creation of a "Global Exploration Strategy," described in chapter 3 on civil space programs — a vision produced by the 14 largest national civil space agencies to coordinate future space exploration activities.

Space Security 2008 does not seek to provide an absolutely positive or negative assessment of all outer space activities conducted in 2007. The contradictions and complexities do not allow it. Instead, this volume aims to assess the range of implications that developments could have on the security of space across the various indicators. Such an assessment reflects the real-life challenge faced by policymakers in determining the multiple effects of their potential and actual decisions across the range of indicators.

Expert participation in the Space Security Index is a key component of the project. The primary research is reviewed prior to publication through three processes. The annual Space Security E-Consultation is done online, with comments provided by participants representing all sectors (commercial, military, civil, etc.). This consultation provides invaluable insights into the perceptions, concerns, and priorities of space stakeholders around the world, as well as critical feedback on the research. The Space Security Working Group consultation is held each spring for 2 days and the text is reviewed chapter by chapter for corrections and gaps. The participants are listed in Annex 1. The Working Group meeting also provides an important forum for dialog. Finally, the Advisory Group to the Space Security Index provides its comments in the penultimate step before publication.

Space Security 2008 is based solely on open source information. Great effort is made to ensure a complete and factually accurate description of events, based on a critical appraisal of the available information and consultation with international experts. Strategic and commercial secrecy with respect to space activities inevitably poses a challenge to the comprehensive nature of this report, particularly when reporting on proposed research or future activities. It should be noted, however, that space assets and activities by their very nature are generally in plain view to those with the technology to observe them. Such technology is increasingly available at low cost.

For further information about the Space Security Index, its methodology, project partners, and sponsors, please visit the website **www.spacesecurity.org**. Comments and suggestions to improve the publication are welcome.

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The content of *Space Security 2008* does not necessarily reflect the views of the Spacesecurity.org partners — the McGill University Institute of Air and Space Law, Project Ploughshares, the Secure World Foundation, the Simons Centre for Disarmament and Non-Proliferation Research, the Space Generation Foundation — or The Department of Foreign Affairs and International Trade Canada, or The Government of Canada.

While we as members of the Governance Group for the Space Security Index have benefited greatly from the input of many experts in the development of *Space Security 2008*, responsibility for any errors or omissions in this volume rests with us.

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EXECUTIVE SUMMARY

The Space Environment

Trend 1.1: Growing debris threats to spacecraft as rate of debris production increases — Traveling at speeds of up to 7.8 kilometers per second, space debris poses a significant threat to spacecraft. The number of objects in Earth orbit has increased steadily; today the US Department of Defense (DOD) is using the Space Surveillance Network to track more than 17,300 objects approximately 10 cm or larger. It is estimated that there are over 300,000 objects measuring between 1 and 10 cm in diameter, and billions smaller. The annual growth rate of tracked debris began to decrease in the 1990s, largely due to national debris mitigation efforts, but has been growing again since 2004.

2007 Developments

- Chinese kinetic satellite intercept creates largest manmade debris field in history
- Trackable space debris population increases by 20.12 percent

Space security impact

The deliberate destruction of a satellite and creation of such a massive debris field at a relatively high altitude in a crowded orbit has a negative impact on space security, increasing the threat of debris collision for operational satellites in low Earth orbit and those launched in the future. Additional unintentional breakups demonstrate that even normal launch activity can further degrade the space environment, even if best practices are applied. Efforts must be made by all space actors to mitigate the threat to space security posed by debris.

Trend 1.2: Increasing awareness of space debris threats and continued efforts to develop guidelines for debris mitigation — Significant on-orbit collisions such as the collision of the French military satellite Cerise with a portion of an Ariane rocket in 1996, and improved tracking abilities have encouraged the cognition of space debris as a growing threat. Since the mid-1990s, many spacefaring states, including China, Japan, Russia, and the US, and the European Space Agency have developed debris mitigation standards.

2007 Developments

- International debris mitigation guidelines adopted
- Better implementation of mitigation guidelines by commercial actors

Space security impact

The approval of voluntary debris mitigation guidelines is a positive step for ensuring the sustainability of the space environment, but the number of breakup events in 2007 (see Trend 1.1) demonstrated that the challenge of space debris will require solutions on multiple fronts. If implemented by all space actors, the debris mitigation guidelines will reduce the chances that future space launches and missions will create additional debris but will not reduce the debris creation from objects already on orbit. The record of implementation was mixed in 2007, with China worsening the problem of debris but commercial operators better managing end-of-life procedures for satellites in GEO. Solutions that help prevent collisions between operational satellites and other objects are still needed, as well as research into potential methods of removing debris from orbit.

Trend 1.3: Space surveillance capabilities to support collision avoidance slowly improving — Efforts to create an international space surveillance system to support collision avoidance and debris re-entry have been unsuccessful, but several states have pursued national systems. The US Space Surveillance Network uses 30 sensors worldwide to monitor over 17,000 space objects in all orbits, but has moderated access to its data since 2004 out of concern for national security. Russia maintains a Space Surveillance System using its early-warning radars and monitors some 5,000 objects (mostly in LEO), but does not widely disseminate data. The EU, Canada, China, France, Germany, and Japan are all developing independent space surveillance capabilities.

2007 Developments

- US focus on improving space situational awareness capabilities continues, but actions are modest
- Worldwide actors continue to develop independent space surveillance capabilities

Space security impact

The international improvement of space surveillance and space situational awareness capabilities in 2007 may have a positive effect on space security by providing improved and redundant tracking of space objects for collision avoidance, as well as greater transparency of space activities. However, the trend toward secretive development of space situational awareness and the continued drive for *independent* space tracking systems indicate a broader mistrust that could reduce space security, particularly as many aspects of these capabilities are enablers for space system negation. In this context, greater transparency may not make actors feel more secure in space, as the growing focus on the space protection/negation elements of space situational awareness demonstrated (see Space Systems Negation Trend 7.1).

Trend 1.4: Growing demand for radio frequency spectrum and orbital slots — Expanding satellite applications are driving demand for limited resources in space, including radio frequencies and orbital slots. More satellites are operating in the frequency bands that are commonly used by GEO satellites and are causing increasing frequency interference. Satellite operators spend about five percent of their time addressing frequency interference issues, including conflicts such as the disagreement over frequency allocation between the US Global Positioning System and the EU Galileo navigational system. The growth in military bandwidth consumption has also been dramatic: the US military used some 700 megabytes per second of bandwidth during Operation Enduring Freedom in 2003, compared to 99 megabytes per second during Operation Desert Storm in 1991. There are more than 800 operational satellites in orbit today: Increased competition for orbital slot assignments, particularly in GEO where most communications satellites operate, has caused occasional disputes between satellite operators. The International Telecommunication Union has been pursuing reforms to address slot allocation backlogs and related financial challenges.

2007 Developments

- Cooperation and conflict over satellite navigation signals
- US efforts to increase military communications bandwidth
- Global efforts to solve spectrum demand issues
- Unintentional radio frequency interference continues

Space security impact

Radio frequency competition, coordination, and interference posed a challenge to space security in 2007, particularly for strategic uses. While international institutions such as the ITU continue to manage competition for space resources, the fact that military operators are outside this arrangement complicates the process, which will only become more difficult as demand from all users increases in the future. Nonetheless, recognition of the issue and progress toward solutions demonstrate the willingness of all space actors to work together on this issue.

Trend 1.5: Increased recognition of the threat from NEO collisions with Earth and progress toward possible solutions — Near Earth objects (NEOs) are asteroids and comets whose orbits bring them in close proximity to the Earth or intersect the Earth's orbit. Over the past decade a growing amount of research started to identify the types of objects that pose threats to Earth and potential mitigation strategies. Mitigation is a difficult challenge due to the extreme mass, velocity, and distance of any impacting NEO, and depends on the amount of warning time. Types of kinetic mitigation methods may include ramming the NEO with a series of kinetic projectiles, and some have advocated the use of nearby explosions of nuclear weapons, which could create additional threats to the environment and stability of outer space.

2007 Developments

- Ongoing debate on mitigation strategies for NEOs

Space security impact

Efforts to address potential threats from NEOs are positive insofar as they make the link between space and the security of Earth. However, some options to mitigate threats, such as the use of nuclear weapons, may have negative repercussions for space security by contributing to environmental hazards and instability. There is a need to further explore this issue with the aim of balancing protection of the Earth from space-based threats with long-term sustainability of the space environment.

Space Laws, Policies, and Doctrines

Trend 2.1: Gradual development of legal framework for outer space activities — The international legal framework for outer space establishes the principle that space should be used for "peaceful purposes." Since the signing of the Outer Space Treaty (OST) in 1967, this framework has grown to include the Astronaut Rescue Agreement (1968), the Liability Convention (1972), the Registration Convention (1979), and the Moon Agreement (1979), as well as a range of other international and bilateral agreements and relevant rules of customary international law. The OST prohibits the stationing of nuclear weapons or any other weapons of mass destruction anywhere in space. The termination of the Anti-Ballistic Missile Treaty in 2002 eliminated a longstanding US/USSR-Russia prohibition on space-based conventional weapons, stimulating renewed concerns about the potential for space weaponization.

Since 1981 the UN General Assembly (UNGA) has each year adopted a resolution requesting that states refrain from actions contrary to the peaceful use of outer space and calling for negotiations within the Conference on Disarmament (CD) on a multilateral agreement on the Prevention of an Arms Race in Outer Space (PAROS). Voting patterns have demonstrated near-unanimous support for the PAROS resolution; however, the US and Israel cast the first negative votes in 2005.

2007 Developments

- Chinese satellite destruction raises concerns about the peaceful uses of outer space
- Divisions remain on key space security Resolutions at the UN General Assembly
- Some governments and civil society call for regulatory approaches to space security

Space security impact

Although the Chinese satellite intercept and destruction raised concerns about the peaceful uses of outer space, including secure and sustainable access, it also focused the attention of the international community on the gaps in the current space security legal and regulatory framework. High-level support from government, military, and commercial officials for the increased use of regulatory approaches such as guidelines, rules of the road, and codes of conduct suggest that this might be a viable avenue to enhance the security of outer space in the future. Although significant political divisions remain, efforts in this direction are already being implemented with the adoption of space debris mitigation guidelines in 2007 (see trend 2.2). However, these alternative approaches rely on good-will implementation by states. Moreover, the division on implementation of UN-SPIDER demonstrates that secure and sustainable access to, and use of, space for all requires significant technical and financial support in addition to an enabling legal framework. Overall, developments in 2007 indicate the fragility of space security. Although international commitment to ensure space security now seems stronger, obstacles to meaningful action remain.

Trend 2.2: Progress in COPUOS but the Conference on Disarmament has been unable to agree on an agenda since 1998 — A range of international institutions, such as the UNGA, COPUOS, ITU, and the CD, have been mandated to address issues related to space security. The CD has been deadlocked without an agreed plan of work since 1998, however, and there has been no progress on space issues in 30 years despite efforts to move forward on the PAROS mandate to develop an instrument relating to space security and the weaponization of space.

2007 Developments

- COPUOS addresses the Registration Convention and Space Debris Mitigation Guidelines and charts future role and activities aimed at peaceful uses and sustainability
- Renewed efforts toward resumption of substantive work in the CD

Space security impact

Developments in 2007 demonstrated both the expediency and flexibility of technical, regulatory guidelines to address key threats to the security of outer space, as well as the potential weakness of such an approach to enforce behavior. Moreover, events in COPUOS and the CD suggest that a growing division between states that advocate such technical tools and states that insist on a treaty-based approach to space security could result in blocked progress on all fronts. More generally, however, indications of greater cooperation and support for discussions on space security issues were a positive development for 2007.

Trend 2.3: Spacefaring states' national space policies consistently emphasize international cooperation and the peaceful uses of outer space — All spacefaring states emphasize the importance of cooperation and the peaceful uses of space, but with caveats based on national security concerns. The US has recently announced plans for peaceful space exploration of the Moon and Mars, while there is growing interest in manned space programs. The national space policies of many developing countries, such as Brazil and India, tend to focus on the utility of space cooperation for social and economic development.

2007 Developments

- European Space Policy highlights European independence and civil-military synergies within a context of peaceful uses of outer space
- China's five-year Space Development Plan reaffirms the importance of commercial development and national strength within a context of peaceful uses of outer space
- 14 national space agencies jointly develop framework for coordination of outer space exploration efforts

Space security impact

States continued to express commitment to international cooperation and the peaceful use of outer space in their civil space policies in 2007, demonstrated most strongly by the Global Exploration Strategy. Yet independence in space is also emphasized. The peaceful use of space is increasingly viewed as strategic, which could limit opportunities for cooperation. The impact on space security will depend on whether or not states pursue independent or collective measures to achieve the strategic goals set out in their space policies.

Trend 2.4: Growing focus within national military doctrines on the security uses of outer space — Fueled by the technological revolution in military affairs, the military doctrine of a growing number of actors (led by China, Russia, the US, and key European states) increasingly emphasizes the use of space systems to support national security. Dependence on these systems has led several states to view space assets as critical national security infrastructure. US military space doctrine has focused on the need to ensure US freedom of action in space, through the use, when necessary, of "counterspace operations" that prevent adversaries from accessing space to threaten US interests.

2007 Developments

- Japan considers new space law to permit military use of space
- India continues to consider an Aerospace Command and greater military use of space
- Greater use of space for security purposes considered in Europe

Space security impact

In 2007 states continued to emphasize the use of space for national security purposes through military doctrines and some new programs. A positive impact of this development is an increase in transparency, allowing states to better predict the behavior of others in space, although this is limited to broad goals and objectives. On the other hand, these policies and doctrines also demonstrate a growing concern for the need to protect space assets and capabilities, which may have a positive or negative impact on space security, depending on whether such protection is pursued through passive or aggressive means, collectively or independently.

Civil Space Programs and Global Utilities

Trend 3.1: Growth in the number of actors gaining access to space — The rate at which new states gain access to space increased dramatically in the 1990s. By 2007 10 actors had demonstrated independent orbital launch capacity and 47 states had launched civil satellites, either independently or in collaboration with others. In 2003 China joined Russia and the US as the only space powers with demonstrated manned spaceflight capabilities.

2007 Developments

- Global efforts to increase access to and use of space through development of launch capabilities and institutions
- Microsatellites contribute to increased accessibility of space

Space security impact

Although no new space civil space actors emerged in 2007, nations expanded their civil space capabilities, particularly regarding launch and microsatellite technologies. This is an indicator that space remains accessible for use and exploitation for peaceful purposes. On the other hand, the proliferation of civil space technologies such as launch capabilities also provides more actors with abilities that could potentially be used to threaten access to and use of space by other states. The growing number and diversity of space actors also place increased demand on available space resources and on efforts to coordinate space traffic and implement international legal obligations. In the long term, an increased number of satellites launched into outer space will also add pressure to the problem of space debris.

Trend 3.2: Changing priorities and funding levels within civil space programs — Civil expenditures on space have continued to increase in India and China in recent years, while past decreases in the US, the EU countries, and Russia have begun to rebound. Increasingly, civil space programs include security and development applications. Algeria, Brazil, Chile, Egypt, India, Malaysia, Nigeria, South Africa, and Thailand are all placing a priority on satellites to support social and economic development. Dual-use applications such as satellite navigation and Earth observation are a growing focus of US, European, and Chinese civil space programs.

2007 Developments

- Space budgets grow in India and Russia as focus shifts to large-scale projects
- Use of remote sensing to support sustainable development
- Strong interest in Europe, Russia, US, and India with respect to developing human spacecraft, but efforts progress slowly
- Space agencies continue to focus on the Moon, Mars

Space security impact

Activities in 2007 demonstrated the continuation of a recently renewed interest in large-scale space projects, particularly lunar exploration and human spaceflight. Although developments in 2007 indicate some cooperation on these projects, competition may increase if such capabilities become strategic in the future, as indicated by historical trends. Nonetheless, it remains to be seen if these large-scale projects will gain the necessary investment to come to fruition; only in India, Russia, and possibly China are resources growing significantly. Outer space continues to be dominated by a few states. Delays in construction of new human spacecraft in the US, may adversely influence space security in the future by limiting human access to space, in particular the International Space Station (ISS). Finally, the growing use of remote sensing satellites for sustainable development is drawing more stakeholders into space, and strengthening the relationship between security in space and security on Earth. However, what is essentially the proliferation of dual-use spacecraft may contribute to the expression of regional tensions in space (see Space Support for Terrestrial Military Operations Trend 5.2).

Trend 3.3: Steady growth in international cooperation in civil space programs — International civil space cooperation efforts over the past decades have included the US-USSR Apollo-Soyuz docking of manned modules, Soviet flights to the MIR space station with foreign representatives, the Hubble Space Telescope, and such joint NASA-ESA projects as Skylab. The most prominent example of international cooperation is the ISS, involving 16 states, 56 launches, and an estimated cost of over $100-billion to date. International civil space cooperation has played a key role in the proliferation of technical capabilities for states to access space.

2007 Developments

- International cooperation emerging for Moon/Mars exploration
- International cooperation on the ISS, space science, and launch technology

- US-Chinese cooperation falters

Space security impact

Growing cooperation and collaboration between major and less developed space powers enhance space security by providing partner countries with greater access to space through shared resources and technology. Larger networks of cooperation such as the "Global Exploration Strategy" could also result in greater transparency of space activities, mitigating uncertainties or mistrust that may arise as more countries gain access to space. There is a risk, however, that sensitive military technologies may proliferate. Moreover, as regional cooperation becomes stronger there may be negative geopolitical tensions and rivalries in space — as the tensions between China and the US demonstrate, civil space cooperation is often influenced by strategic concerns. Yet cooperation efforts on the Moon and Mars in 2007 suggest that what is often characterized as a new space race may not in fact become a reality.

Trend 3.4: Continued growth in global utilities as states seek to expand applications and accessibility — The use of space-based global utilities, including navigation, weather, and search-and-rescue systems, has grown substantially over the last decade. These systems have spawned space applications that are almost indispensable to the civil, commercial, and military sectors. Advanced and developing economies alike are heavily dependent on these space-based systems. Currently Russia, the US, the EU, Japan, and India are developing satellite-based navigation capabilities. The strategic value of satellite navigation was underscored by the conflict over frequencies for Galileo and GPS, resolved in 2004.

2007 Developments

- A difficult year for space navigation utilities
- Civil space applications for global monitoring focus on climate change

Space security impact

On the one hand, the growth in global utilities, particularly navigation systems, should have a positive impact on space security by providing redundancy of capabilities and increasing access to space through collaborative efforts, particularly if they are interoperable. Yet ongoing disputes over the use of signals and the development of *independent* capabilities indicate that cooperation is difficult and that this utility remains an important military application subject to potential interference. The growing use of civil space capabilities for climate change monitoring could enhance international commitments to maintain space security by further linking the security of Earth to the security of space.

Commercial Space

Trend 4.1: Continued overall growth in the global commercial space industry — Growth in the commercial space industry is dominated by satellite services, which have tripled in size since 1996, generating revenues estimated between $62.6-billion and $111.14-billion in 2006, or up to 60 percent of the commercial satellite sector's total. Individual consumers are a growing source of demand for these services. Key commercial satellite telecommunications companies include Intelsat, SES Global, Eutelsat, and Telesat Canada. In recent years Russia has dominated the space launch industry with respect to the number of commercial launches, while US companies have led in the satellite manufacturing sector.

2007 Developments

- Commercial space industry continues to grow, with individual users becoming more important stakeholders
- India and China influence the commercial space industry

Space security impact

Continued growth in the commercial space sector is reflected largely by higher revenues and not necessarily an increase in space activity. However, individual users are becoming more important stakeholders in space as they demand not only more communication services, but also satellite navigation/positioning and remote sensing products. Ongoing growth of the industry suggests that there is overall confidence in the security of space and the ability of both companies and consumers to continue to rely on space resources. Growing competition in the commercial launch market may also contribute to space security by providing greater access to outer space, although tensions may arise if future demand for space resources exceeds supply.

Trend 4.2: Commercial sector supporting increased access to space — Commercial space launches have contributed to cheaper space access. The costs to launch a satellite into GEO have declined from an average of about $40,000/kilogram in 1990 to $26,000/kilogram in 2000, with prices beginning to consolidate. In 2000 payloads could be placed in LEO for as little as $5,000/kilogram. In recent years European and Russian space agencies have been the most active space launch providers. Today's commercial launch providers include Arianespace in Europe, Energiya in Russia, Lockheed Martin in the US, and two international consortia — Sea Launch and International Launch Service. Virgin Galactic and Space Adventures provide private, suborbital human spaceflight.

2007 Developments

- Launch costs remain high in a tight market following launch failures

- Lower insurance rates and new entrants to the launch market may reduce cost of access to space
- Private human suborbital spaceflight expanding, but capabilities limited
- Commercial spaceflight aims for the Moon
- Greater commercial access to high-resolution space imagery

Space security impact

Sustained competition in commercial space launch may slightly reduce the cost of access to space in the near future, but in the absence of revolutionized technologies, there is not likely to be a significant impact on space access. Although the commercial human space flight industry continues to develop, it has yet to deliver sustainable, low-cost launchers. Moreover, while some regulatory efforts are being made to support the prospect of private human access to space, this may cause potential challenges to space security, both in terms of the sustainability of the space environment as well as the applicability of international laws, such as the Outer Space Treaty, which have yet to be revisited by the international community. Finally, while the space industry is facilitating greater use of space applications, in particular remote sensing, there are legitimate fears about the implications for security on Earth (see Trend 4.3 below).

Trend 4.3: Governments both support and regulate the commercial space sector as subsidies and national security concerns continue to play an important role — The commercial space sector is significantly shaped by national governments and security concerns. The 1998 US Space Launch Cost Reduction Act and the 2003 European Guaranteed Access to Space program provide for significant government subsidization of the space launch and manufacturing markets. The US and European space industry also receive important space contracts from government programs. In 1999 the US placed satellite export licensing on the State Department's US Munitions List, bringing satellite product export licensing under the International Traffic in Arms Regulations (ITAR) regime and significantly complicating the way US companies participate in international collaborative satellite launch and manufacturing ventures.

2007 Developments

- Governments and militaries partner with the commercial industry for satellite imaging, communications, and launch services
- Galileo demonstrates the limits to public-private partnerships
- Ongoing efforts to regulate access to commercial satellite imagery
- Private industry joins government in space safety efforts
- Export controls try to balance commercial interests with security concerns

Space security impact

The strong relationship between military and commercial uses of space and the security dimensions of many commercial services has a complex impact on space security. On the one hand, multiple-use spacecraft could become military targets in the future, resulting in an overall decrease in security. Alternatively, the proliferation of dual-use assets in space could make a military attack less useful and, therefore, less likely. Arguably, this could increase overall space security. There are also pros and cons for government users of commercial systems, including greater flexibility and options for using space, but fewer security features to protect this use. The failure of the Galileo partnership, however, demonstrates that the costs and risks of space access and use remain high, and governments must play a key role in ensuring that access. Efforts to regulate access to both commercial space technology and data in 2007 reflected ongoing attempts to balance the benefits of secure access to and use of space against the potential threats it may pose to space security. This balance was better addressed regarding access to commercial imagery in 2007, but striking a balance between these two components of space security will become more complicated if commercial capabilities continue to increase. Finally, the growing interest in the commercial space industry to advance and participate in space governance initiatives is a positive development for space security, since all actors share the same interest in the secure and sustainable access to space.

Space Support for Terrestrial Military Operations

Trend 5.1: US and Russia continue to lead in deploying military space systems — By the end of the Cold War, the US and USSR had developed extensive military space systems designed to provide military attack warning, communications, reconnaissance, surveillance, and intelligence, as well as navigation and weapons guidance applications. By the end of 2007 the US and USSR/Russia had launched more than 3,000 military satellites, while the rest of the world had launched under 100.

The US has dominated the military space arena since the end of the Cold War and currently spends close to $28-billion on military space programs and has approximately 136 operational dedicated military satellites — over half of all military satellites in orbit. Russia is believed to have some 67 dedicated military satellites in orbit. The US is, by all major indicators, the actor most dependent on its space capabilities. As early as 2001 the *Report of the Commission to Assess United States National Security Space Management and Organization* warned that US dependence on space systems made it uniquely vulnerable to a "space Pearl Harbor" and recommended that the US develop enhanced space control (protection and negation) capabilities.

2007 Developments

- US focus on major upgrades to critical systems, but some progress more than others
- US continues to face setbacks on remote sensing programs
- Russia continues to invest in military programs to maintain its space-based capabilities, with focus on revitalizing GLONASS

Space security impact

The US is slowly progressing with modernization of its space systems. The focus is on meeting the bandwidth and secure communications needs of today's military and preventing gaps in next-generation capabilities, both of which are elements of secure and sustainable use of space. Troubles faced by the National Reconnaissance Office, however, demonstrate weaknesses in its abilities to manage complex projects, research and development, and acquisitions, which may continue to hinder major system upgrades. Continued dependence on space assets increases US vulnerability in space, and it is not yet clear if efforts to protect those assets in the future will contribute to or detract from the security of outer space. The Russian focus on revitalizing GLONASS and its aging satellite fleet could also be positive for space security by providing redundancy for the US GPS, more reliable and secure early warning capabilities, and more secure satellite communications.

Trend 5.2: More actors developing military space capabilities — Regional tensions are a significant driver of military space acquisitions. Declining costs for space access and the proliferation of space technology are enabling more states to develop and deploy their own military satellites via the launch capabilities and manufacturing services of others, including the commercial sector.

China provides military communications through its DFH series satellite, and has deployed a pair of Beidou navigation satellites to ensure access to navigational capability. China also maintains three ZY series satellites in LEO for tactical reconnaissance and surveillance functions, has deployed three military reconnaissance satellites, and is believed to be purchasing additional commercial satellite imagery from Russia to meet its intelligence needs.

EU states have developed a range of military space systems. France, Germany, Italy, Spain, Belgium, and Greece jointly use the Helios-1 military optical observation satellite system in LEO, which provides images with a one-meter resolution. France, Germany, and Spain have also developed a range of radar reconnaissance and communications capabilities and France is developing a missile early-warning system. The UK maintains a constellation of three dual-use Skynet 4 communications satellites in GEO. The joint EU-European Space Agency Galileo satellite navigation program, initiated in 1999, is intended to operate for civil and commercial purposes, but will have an inherent dual-use capability.

Israel operates a dual-use Eros A imagery system as well as the military reconnaissance and surveillance Ofeq-5 system. India's civil space agency maintains its Technology Experimental Satellite for remote sensing, but it also provides military reconnaissance capabilities. Japan operates the commercial Superbird satellite for military communications and has four "information gathering" remote sensing satellites — two optical and two radar. Thailand operates a military communications satellite and is developing its first intelligence and defense satellite.

2007 Developments

- Europe developing a range of integrated military capabilities, both dedicated and dual-use
- China investing to achieve self-reliance in space
- Focus on remote sensing capabilities in the Middle East and Asia
- Canada to use dual-use satellite to monitor the Arctic, develop military support capabilities
- Potential use of space for military purposes in Nigeria

Space security impact

The continued drive for more states to develop and deploy both dedicated military and dual-use space systems was reflected in 2007 along with a growing emergence of strategic partnerships. While an increase in the use of space for military purposes demonstrates the continued accessibility of the space environment and greater access to space technologies, states continue to operate and develop their space programs with considerable secrecy, reducing transparency of space operations. There are indications that these developments are affecting perceptions of security on Earth; how this in turns affects the security of space will depend on how states react to perceived threats from and in space. As more states become dependent on space systems for military operations and national security, mutual vulnerability may provide incentives to enhance the security of outer space or to develop capabilities to quickly negate space systems. The growing diversity of space systems for global navigation and positioning and communications may enhance the security of space operations by providing redundancy, particularly if they are interoperational.

Space Systems Protection

Trend 6.1: US and Russia lead in general capability to detect rocket launches, while US leads in the development of advanced technologies to detect direct attacks on satellites — The ability to distinguish space negation attacks from technical failures or environmental disruptions is critical to maintaining international stability in space. Early warning also enables defensive responses, but the type of protection available may be limited. Only the US and Russia can reliably detect rocket launches. US Defense Support Program satellites provide early warning of conventional and nuclear ballistic missile attacks; Russia began rebuilding its aging system in 2001 by upgrading its Oko series satellites. France is developing two missile-launch early-warning satellites — Spirale-1 and -2. Most actors have a basic capability to detect a ground-based electronic attack, such as jamming, by sensing an interference signal or by noticing a loss of communications. It is very difficult to obtain advance warning of directed energy attacks that move at the speed of light.

2007 Developments

- Russia upgrades its early-warning systems, but results are limited
- US early-warning upgrade efforts continue to face challenges, but also some success
- US focus on space situational awareness
- Global development of space surveillance capabilities

Space security impact

As space actors seek to improve their launch detection and space surveillance capabilities, space security could be enhanced through greater transparency of space activities, more accurate threat detection, and greater redundancy, which can support protective responses and overall confidence. The benefits of space surveillance could be increased with data sharing among different actors. Yet the continued drive for independent space tracking systems indicate broader mistrust that could reduce space security, particularly as many aspects of these capabilities are enablers for space system negation. In this context, as demonstrated by the US focus on the space protection/negation elements of space situational awareness, greater transparency may not make actors feel more secure in space.

Trend 6.2: The protection of satellite ground stations is a concern, while the protection of satellite communications links is poor but improving — Many space systems lack protection from attacks on ground stations and communications links. The vast majority of commercial space systems have only one operations center and one ground station, leaving them vulnerable to negation efforts. While many actors employ passive electronic protection capabilities, such as shielding and directional antennas, more advanced measures, such as burst transmissions, are generally unique to military systems and the capabilities of more technically advanced states. China and the US have been aggressively pursuing a variety of anti-jamming capabilities.

2007 Developments

- Slow but steady progress on laser satellite communication links but technological challenges remain
- US RADIRS Unit becomes operational
- Renewed focus on protecting commercial satellites

Space security impact

Developments in 2007 had a mixed impact on space security. While some progress has been made toward securing ground to satellites communications through the use of laser links, progress remains slow due to major technological challenges and communication links remain vulnerable. In the meantime, a greater ability by the US to identify and respond to sources of interference might enhance the security of some systems, but efforts to better protect commercial satellites will only be effective if market incentives are in place.

Trend 6.3 Protection of satellites against some direct threats is improving but remains limited — The primary source of protection for satellites comes from the difficulties associated with launching an attack into space. Satellite protection measures also include system redundancy and interoperability, which has become characteristic of satellite navigation systems. Most key US, European, and Russian military satellites are hardened against the effects of a high-altitude nuclear detonation. Nonetheless, if an actor has the ability to overcome these natural defenses, there are few options available for physically protecting a satellite against a direct attack. Consequently, initiatives to prevent the proliferation and use of negation capabilities covered in the chapters on Laws, Policies and Doctrines and Commercial Space are also critical for protection, as is the achievement of collective space security as defined by the Space Security Index.

2007 Developments

- US continues to pursue space-based satellite protection

Space security impact

The development of autonomous on-orbit servicing satellites and nanosatellites for local space surveillance has the potential to improve space security for the actors employing those technologies by providing better on-orbit threat identification and response options to protect the space-based components of satellite systems. However, the basic technologies involved are also applicable for spacecraft negation and raise questions about the implications of more active space-based protection systems for the security of other actors in space. The overall impact on space security will depend greatly on how the relevant technologies are used and how transparent the usage is. Moreover, space-based protection capabilities themselves could be defeated by a determined attacker.

Trend 6.4: US leads in developing of capabilities to rapidly rebuild space systems following direct attacks on satellites — The ability to rapidly rebuild space systems after an attack could reduce vulnerabilities in space and increase the ability to recover from an attack. Although the US and Russia are developing various elements of responsive space systems, no state currently has this capability. The key US responsive launch initiative is the Falcon program, which seeks to develop a rocket capable of placing 100-1,000 kilograms into LEO within 24 hours. It includes the AirLaunch LLC QuickReach air-launch rocket and the SpaceX Falcon-1.

2007 Developments

- US increases efforts for Operationally Responsive Space (ORS)
- Canada considers responsive space
- Small and nanosatellite research may contribute to passive protection

Space security impact

Whether efforts on more responsive space launch and flexible deployment of microsatellites will enhance the secure use of space systems remains unclear. The formal definition of the US ORS concept and the continued development of small satellites and launch vehicles are steps toward a rapid replacement capability, but an operational ORS capacity remains fairly distant. Further studies are also needed to determine the survivability of small satellites against potential threats. Nonetheless, the use of small and relatively low-cost satellites for a greater range of applications potentially allows actors to replace outdated, malfunctioned, or attacked satellites more often and quickly. Constellations of smaller satellites can also provide enhanced protection through redundancy, but because they are difficult to detect and track, transparency of and confidence in space activities could be reduced.

Space Systems Negation

Trend 7.1 Proliferation of capabilities to attack ground stations and communications links — Ground segments and communications links remain the most vulnerable components of space systems, susceptible to attack by conventional military means, computer hacking, and electronic jamming. A number of incidents of intentional jamming of communications satellites have been reported in recent years. Iraq's acquisition of GPS-jamming equipment for use against US GPS-guided munitions during Operation Iraqi Freedom in 2003 suggested that jamming capabilities are proliferating. The US leads in developing doctrines and advanced technologies to temporarily negate space systems by disrupting or denying access to satellite communications, and has deployed a mobile system to disrupt satellite communications without inflicting permanent damage to the satellite.

2007 Developments

- Tamil Tigers illegally broadcast radio and television on Intelsat signals
- Mysterious jamming incidents demonstrate continued ease of jamming satellite communications
- Intrusion of secure computer networks in China, UK, Germany, France, and the US
- US and China upgrade capabilities for cyber attacks, jamming

Space security impact

Incidents of both deliberate and unintentional satellite interference in 2007 demonstrate the vulnerability of satellite communications and computer networks to external attacks. Moreover, the significant security and financial costs that result from interference show the debilitating effect that relatively low-cost, low-technology threats can have on the security of space operations. Facilitating and dispersing authorization for attacks could also create greater instability. It should be noted, however, that interference with satellite communications and ground stations is generally temporary and reversible and is less provocative and escalatory than other types of space system negation.

Trend 7.2 US leads in the development of space situational awareness capabilities to support space negation — Space surveillance capabilities for debris monitoring and transparency can also support satellite tracking for space negation purposes. The US and Russia maintain the most extensive space surveillance capabilities and the US has explicitly linked its development of enhanced space surveillance systems to efforts to enable offensive counterspace operations. China and India also have satellite tracking, telemetry, and control assets essential to their civil space programs. Canada, France, Germany, and Japan are actively expanding their ground-based space surveillance capabilities.

2007 Developments

- Space surveillance capabilities highlight vulnerability of satellites to detection
- Orbital Express satellite demonstrates automated approach using Space Situational Awareness data

Space security impact

Space surveillance can support both protection and negation activities. Efforts to develop and enhance space surveillance systems can have a positive impact on space security by increasing the ability of actors to safely operate in space, enhancing transparency of outer space activities, and providing a redundancy of capabilities. But the potential for such capabilities to support deliberate attacks against satellites and other space objects is demonstrated through the centrality of space surveillance in identifying foreign satellites, space control efforts, and close proximity operations, depending on the extent to which the capability were integrated into military command systems. Transparency in the collection and use of space surveillance data would enhance its positive contribution to the security of outer space.

Trend 7.3 Ongoing proliferation of ground-based capabilities to attack satellites — The development of ground-based ASAT weapons employing conventional, nuclear, and directed energy capabilities dates back to the Cold War when a variety of US and USSR programs were initiated. Since then technologies have proliferated. The capability to launch a payload into space to coincide with the passage of a satellite in orbit is a basic requirement for conventional satellite negation systems. Some 28 states have demonstrated suborbital launch capability and, of those, 10 have orbital launch capability. As many as 30 states may have low-power lasers to degrade unhardened satellite sensors. The US and China lead in the development of more advanced ground-based kinetic-kill systems with the capability to directly attack satellites. Both have deployed advanced missile and laser programs, which have inherent satellite negation capabilities in LEO.

2007 Developments

- China tests direct ascent missile against own satellite, triggers protective response
- US continues development of ballistic missile defense systems and considers use against a de-orbiting satellite
- Ballistic missile defense efforts in Japan, India may lay the foundation for potential ground-based ASAT capabilities
- Ongoing development of high energy lasers

Space security impact

The Chinese satellite intercept in January 2007 ended a 20-year pause in known ASAT testing and demonstrated a current capability to destroy LEO satellites. The successful destruction of FY-1C and the debris cloud created are both negative developments in space security, compounded by a potential spiral of capabilities and tests — indicated by US anti-ballistic missile activities — as well as other protective responses. The continued development of high energy lasers combined with adaptive optics could have a negative impact on space security as it has the potential to cause permanent damage to a satellite. The same technologies could also be applied to satellite tracking and identification. The development of theater-level ABM capabilities by the various actors, although not a direct threat to space objects, is cause for concern, because most of the necessary technologies, such as target detection, tracking, homing, command and control networks, and boosters, are also applicable to ASAT roles.

Trend 7.4: Increasing access to space-based negation-enabling capabilities — Space-based negation efforts require sophisticated capabilities, such as precision on-orbit maneuverability and space tracking. Many of these capabilities have dual-use potential. For example, microsatellites provide an inexpensive option for many space applications, but could be modified to serve as kinetic-kill vehicles. The US leads in the development of most of these enabling capabilities, although none appear to be integrated into dedicated space-based negation systems.

2007 Developments

- US and European states testing space-based technologies with potential negation capabilities

Space security impact

The emergence of advanced space-based capabilities is likely to complicate space security because of the range of passive protection and more active negation functions that they can serve, with the line between these types of activities unclear. These technologies could be used to enhance knowledge of local space and gather information on other, potentially hostile, satellites or to support on-orbit servicing of satellites to extend their lifespans or recover from negation efforts. But all of the capabilities described have clear space negation applications. Currently, however, these programs are still experimental and their funding levels are relatively low. The more immediate consequence is the challenge posed by not knowing what the threats are, largely because of the secrecy of many technology programs.

Space-Based Strike Systems

Trend 8.1: While no space-based strike systems have been tested or deployed, the US continues to consider a space-based interceptor for its missile defense system — Although the US and USSR developed and tested ground-based and airborne ASAT systems between the 1960s and 1980s, there has not yet been any deployment of space-to-Earth or space-to-missile strike systems. Under the Strategic Defense Initiative in the 1980s, the US invested several billion dollars in the development of a space-based interceptor concept called Brilliant Pebbles, and tested targeting and propulsion components required for such a system. The US and USSR were both developing directed energy strike systems in the 1980s, although today these programs have largely been halted.

2007 Developments

- NFIRE successfully tests sensor system in space for missile defense
- Multiple Kill Vehicle received boost in FY08 budget allocation
- Congress cuts funding for Space Test Bed

Space security impact

The ongoing absence of space-based strike systems and infrastructure continued to support the security of outer space in 2007. While precursor technology development continued through the NFIRE test and MKV program, restraint exercised by US policymakers is positive and indicates concern for space security and the challenge of balancing terrestrial missile defense requirements with the need to maintain freedom from space-based threats.

Trend 8.2: A growing number of countries are developing more advanced space-based strike-enabling technologies through other civil, commercial, and military programs — The majority of advanced, space-based strike enabling technologies are dual-use and are developed through other civil, commercial, or military space programs. While there is no evidence to suggest that states pursuing these enabling technologies intend to use them for space-based strike purposes, such development does bring these actors technologically closer to this capability. For example, China, India, and Israel are developing precision attitude control and large deployable optics for civil space telescope missions. There are also five states in addition to the European Union that are developing independent, high-precision satellite navigation capabilities. China, India, and the EU are developing Earth reentry capabilities that provide a basis for the more advanced technologies required for the delivery of mass-to-target weapons from space to the Earth.

2007 Developments

- Prompt Global Strike program authorized by the US Congress
- Report outlines the potential costs to deploy space-based weapons
- Upgrades in US global missile tracking and warning
- The US, Europe, China, and Russia continue research and development of global positioning systems
- Continued progress in air-based laser technology

Space security impact

Space-based weapons designed to strike terrestrial targets will require sophisticated technological developments that, at present, few spacefaring states seem able to exploit. The development of dual-use capabilities that also provide enabling technologies for space-based strike systems continued in 2007, although there is no evidence that states are developing such capabilities for strike purposes. Nonetheless, the potential for space-to-Earth strike systems will continue to pose a challenge to the international community as advanced space-based technologies continue to be developed. While some enabling technologies for space-based strike are specific to that purpose and include significant technology barriers, many are advanced technologies associated with other space applications and have been developed for a variety of purposes by several different actors; this means that if one actor were to pursue a space-based strike capability, others could follow.

"The Space Security Index is one of the finest examples of a comprehensive approach to space security, and a most positive contribution by civil society on a topic of such momentous importance."

Johannes C. Landman
Netherlands Ambassador for Multilateral Disarmament, Arms Control and Non-Proliferation, Permanent Representative to the Conference on Disarmament, Geneva

"The Space Security Index is a unique and exceptional annual endeavor to provide the global community with significant information concerning security in outer space. By addressing all of the relevant sectors that influence space security, the Index is an invaluable reference document for all space professionals."

Colonel Philip A. Meek
Judge Advocate, United States Air Force, (Ret.), and former Associate General Counsel (International Affairs), Department of the Air Force

"No one source is more valuable than the Space Security Index to learn about the present state of space activities. Space is critical to protect the Earth's environment and to improve life for all of humanity. For the present and future generations, we must preserve outer space as the source of security and wealth. The first step is to read *Space Security 2008*."

Dr. Setsuko Aoki
Professor, of International Law, Faculty of Policy Management, Keio University

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Ambassador Thomas Graham, Jr.
Former Special Assistant to the President for Arms Control, Nonproliferation and Disarmament

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