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INTRODUCTION

"Space is in the news more than ever. With both Iran and North Korea developing space programs, and with both the United States and China demonstrating new capabilities to shoot down satellites, international concerns for space security have never been greater. In the Space Security Index, policy makers, journalists, and technical professionals, as well as those just interested in space, have a single reliable resource for information on space security. There is no more comprehensive and up-to-date source of information on developments in space, and the threats to space security."

Hon. Philip E. Coyle
Senior Advisor, Center for Defense Information
Former Assistant Secretary of Defense and Director, Operational Test and Evaluation, US Department of Defense

This is the sixth annual report on trends and developments related to security and outer space, covering the period January to December 2008. It is part of the wider Space Security Index (SSI) project that 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 contribute to space security.

The definition of space security guiding this report is in keeping with the express intent of the 1967 Outer Space Treaty that space should be preserved as a global commons to be used by all for peaceful purposes:

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

This broad definition encompasses the security of space as a particularly unique environment, the security of Earth-originating assets in space, and security from threats originating from space-based assets. The primary consideration in the SSI definition of space security is not the interests of specific national or commercial entities using space, but the security of space as an environment that can be used safely and sustainably by all.

The actions and developments related to space security are assessed according to eight indicators that are organized under three themes:

- The condition of the operating environment
  1) The space environment
  2) Laws, policies, and doctrines
- The type of actors in space and how space is used
  3) Civil space programs and global utilities
  4) Commercial space
  5) Space support for terrestrial military operations
- The status of space-related technology as it pertains to protecting or interfering with space systems, or harming Earth from space

6) Space systems protection
7) Space systems negation
8) Space-based strike capabilities.

Each of the eight indicators is examined in a separate chapter that provides a description of the indicator and its overall impact on space security. A discussion of the prevailing trends associated with that 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.

The physical properties of outer space are distinctly different from the terrestrial environment. Human activities such as debris creation cannot be corrected with technology currently available and debris poses a direct, destructive risk to space assets. Conflicts between states involving space assets could create debris fields that would render important parts of space un-useable. While space activities are a strategic focus for national security interests, the pervasive dual use of space assets for military and civilian purposes contributes to human security by, for example, tracking weather patterns to support agriculture, assisting responses to natural calamities, and monitoring criminal activities and human rights violations.

The annual, systematic assessment undertaken by the Space Security Index makes it increasingly possible to note longer-term trends. For example, the predominance of dual-use space assets means that more states are using space for military and national security purposes. The distinctions between civil, military, and commercial space assets are blurring, creating interdependence and mutual vulnerabilities. The way in which stability is maintained is changing; efforts to adopt new international treaties are being replaced by non-binding, technical approaches to govern outer space. This shift is in part supported by a transition in the way in which space surveillance data is collected and shared. Greater international cooperation supports transparency and confidence in space activities. However, the ongoing development of technology, which better enables the use of space for some purposes and certain actors, may also deny the secure use of space for other legitimate purposes and actors.

Developments captured in the SSI also illustrate the contradictions and complexities intrinsic to outer space activity. The year 2008 marked the tenth anniversary of the International Space Station (ISS). Its success attests to the benefits of international cooperation in space, even while the administration of the ISS was bedeviled by political obstacles that had to be overcome and changing goals of the national civil space programs of participating governments. One of the most significant events of the year was the US destruction of the failed and de-orbiting USA-193 satellite with an interceptor designed for missile defense. It illustrated the ongoing struggle to balance security on Earth and security in space. While the US claimed that the satellite had to

be destroyed before it returned to Earth to avoid potential harm from its dangerous contents, its on-orbit destruction could have resulted in a debris field that would threaten other objects in space.

Space Security 2009 does not provide absolute positive or negative assessments of 2008 outer space activities. Instead, it indicates the range of implications that developments could have on the security of space across the various indicators and highlights the difficult challenges faced by policymakers.

Information contained in *Space Security 2009* is from open sources. 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. But space assets and activities by their very nature are generally in plain view to those with the technical ability to observe them. Increasingly that includes so-called amateurs who make their observations widely available.

Expert participation in the Space Security Index is a key component of the project. The primary research is peer reviewed prior to publication through three processes:

1) The annual Space Security Online Consultation provides insights into the perceptions, concerns, and priorities of space stakeholders around the world, as well as critical feedback on the draft research report.
2) The Space Security Working Group consultation is held each spring for two days to review the text for factual errors, misinterpretations, gaps, and statements about impacts. This meeting also provides an important forum for related policy dialogue on recent outer space developments. (Participants are listed in Annex 1.)
3) Finally, the Advisory Group to the Space Security Index provides its comments on the penultimate draft of the text before publication.

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

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The research for *Space Security 2009* was directed by Jessica West at Project Ploughshares and Dr. Ram Jakhu at the McGill University Institute of Air and Space Law. The research team included:

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The Governance Group for the Space Security Index would like to thank the research team and the many advisors and expert participants who have supported this project. Managing Editor Jessica West has been responsible for the completion of the last three annual SSI publications. She provides the day-to-day guidance and coordination of the project and ensures that the myriad details of the publication come together, and also supports the Governance Group and Advisory Board. In September 2009 Jessica will return to graduate studies. We want to thank her for the contribution she has made to the growth and development of the SSI and wish her much success in her future endeavors. We also want to thank Brian Weeden at Secure World Foundation for providing his time and technical expertise to the project in addition to being part of the research team, and Jonathan McDowell, who has made an increasingly important contribution to the SSI through his dedication and diligence in tracking and interpreting what takes place in outer space.

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The content of *Space Security 2009* does not necessarily reflect the views of the Spacesecurity.org partners: McGill University's Institute of Air and Space Law, Project Ploughshares, the Secure World Foundation, the Simons Centre for Disarmament and Non-Proliferation Research, and the Space Generation Foundation.

While we as the Governance Group for the Space Security Index have benefited immeasurably from the input of the many experts indicated, responsibility for any errors or omissions in this volume finally rests with us.

Dr. Wade Huntley

Dr. Ram Jakhu

Dr. William Marshall

Mr. John Siebert

Dr. Ray Williamson

EXECUTIVE SUMMARY

The Space Environment

TREND 1.1: Growing risk to spacecraft as orbital debris continues to increase — 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 19,000 objects approximately 10 centimeters in diameter or larger. It is estimated that there are over 300,000 objects with a diameter larger than one centimeter, and millions smaller. The annual growth rate of new debris tracked began to decrease in the 1990s, largely due to national debris mitigation efforts, but has accelerated in recent years.

2008 Developments:

- Short-lived debris created by destruction of USA-193 satellite to mitigate risk posed by reentry
- Growth rate of new space debris declines for first time in four years
- Increased risk of spacecraft posed by debris

Space Security Impact

With no major on-orbit fragmentations in 2008, there was minimal additional risk by new debris, but existing debris continues to pose hazards to operational spacecraft, particularly in Low Earth Orbit (LEO). Concerns are also raised by intentional satellite breakups, as well as the ongoing presence in orbit of satellites with a history of severe fragmentation. Although relatively little lasting debris was created, the US destruction of the failed USA-193 satellite prior to its reentry in Earth's atmosphere raises a challenge for space security in which the sustainability of the space environment can potentially conflict with security from threats posed by objects in space.

TREND 1.2: Continued efforts to develop and implement debris mitigation practices — 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 recognition of space debris as a growing threat. Since the mid-1990s, many spacefaring states, including China, Japan, Russia, the US, and the European Space Agency have developed debris mitigation standards, and the United Nations has adopted voluntary guidelines.

2008 Developments:

- International recognition and adoption of UN Debris Mitigation Guidelines
- NASA studies potential value of physically removing debris from orbit

Space Security Impact

Reporting by some states on efforts to implement the Debris Mitigation Guidelines of the UN Committee on the Peaceful Uses of Outer Space (COPUOS) and evidence that some states are factoring the guidelines into decision-making are positive signs that the Mitigation Guidelines are becoming part of state practice. However, responsible actions by a few spacefaring states will not guarantee progress in reducing the creation of space debris. In particular, efforts are needed to make emerging and developing space states aware of the consequences of space debris and their international responsibilities, and to help them develop the technical means to meet those responsibilities. Finally, while the US asserts that it adhered to the guidelines when destroying the de-orbiting USA-193 satellite, it is not clear how other states may engage in similar actions over the long term (see Laws, Policies, and Doctrines).

TREND 1.3: Space surveillance capabilities to support collision avoidance slowly improving — Efforts in the 1980s to create an international space surveillance system to support collision avoidance and debris reentry were unsuccessful, but several states have pursued national systems. The US Space Surveillance Network uses 30 sensors worldwide to monitor over 19,000 space objects in all orbits, but since 2004 has provided limited access to its data, 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. China, the EU, France, Germany, and Japan are all developing independent space surveillance capabilities. Discussions have once again been initiated about the practicalities of sharing such data.

2008 Developments:

- The US, European Space Agency, and Russia take steps to improve access to independent space surveillance data
- Efforts to better coordinate international space surveillance data increase

Space Security Impact

The various national efforts to improve independent space surveillance capabilities in 2008 are positive for space security because they provide better and redundant tracking of space objects and greater transparency of space activities. However, ongoing challenges to greater cooperation and collaboration include hesitancy to share information on satellites that are deemed sensitive, particularly since space surveillance information can be used to support space negation efforts; and technical difficulties associated with combining information in various formats and from different types of sensors. Consequently, the use of orbital data to adequately support collision avoidance remains limited, but events in 2008 indicate that such use may increase in the near future.

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. Satellite operators spend significant time addressing frequency interference issues, including conflicts such as the disagreement over frequency allocation between the US Global Positioning System, the EU Galileo system, and the Chinese Beidou system. The growth in military bandwidth consumption has also been dramatic: the US military used some 700 megabytes per second of bandwidth during operations in Afghanistan in 2001, 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.

2008 Developments:

- Continued uncertainty regarding future satellite navigation signals
- Efforts to overcome the costs of unintentional signal interference

Space Security Impact

Developments in 2008 further highlight both the scarcity of available slots in the radio frequency spectrum and the challenges with the existing governance mechanisms. In particular, the Chinese plan for Beidou appears to be consistent with current ITU regulations, and efforts to resolve the issue of frequency coordination were complicated by untimely release of technical details about Galileo. Moreover, as military and economic interests drive the growth of competing systems for similar services, additional demands are also made on their related orbits — in this case, highly elliptical orbit. Determining the nature of solutions to satellite signal interference, both accidental and hostile, will continue to be a challenge for the foreseeable future and is a significant deterrent to space security.

Space Laws, Policies, and Doctrines

TREND 2.1: Gradual development of legal framework for outer space activities shifting away from adoption of multilateral treaties — 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 US withdrawal from 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. What began as a focus on multilateral space treaties, however, has transitioned to a focus on what some describe as 'soft law' — referring to a range of non-binding governance tools including principles, resolutions, confidence-building measures, and policy and technical guidelines.

2008 Developments:

- US reiterates its rejection of legally binding approaches to security in space at the UN General Assembly
- US says destruction of failed satellite consistent with the Outer Space Treaty
- European Commission issues draft Code of Conduct for Outer Space Activities
- Implementation issues impede Hague Code of Conduct on Ballistic Missile Proliferation

Space Security Impact

International legal events in 2008 suggest a continued focus on non-binding governance tools, which some refer to as 'soft law', such as transparency and confidence-building measures and codes of conduct. Support for these measures indicates a growing commitment on the part of some leading spacefaring countries to better regulate activities in outer space by codifying generally accepted behaviors. However, the potential risk with this approach is that implementation will be arbitrary and selective, as demonstrated by the ongoing challenges faced by the Hague Code of Conduct, and that de facto international law will be made via the unilateral actions of states, as demonstrated by the US destruction of one of its own satellites. The US action to destroy its satellite and official responses by other governments may stand as precedents for procedures under which the use of force in outer space is legitimized, in the absence of specific treaty law.

TREND 2.2: COPUOS remains active, but the Conference on Disarmament has been unable to agree to an agenda since 1996 — A range of international institutions, such as the UN General Assembly, the UN COPUOS, the International Telecommunication Union (ITU), and the Conference on Disarmament (CD), have been mandated to address issues related to space security. But the CD has been deadlocked without an agreed plan of work since 1996 and there has been no progress on space issues in 30 years, despite efforts to move forward on the Prevention of an Arms Race in Outer Space (PAROS) mandate to develop an instrument relating to the weaponization of space. COPUOS remains active, with a focus on non-binding, technical approaches to security in space.

2008 Developments:

- CD continues without program of work; discusses draft treaty to prevent the weaponization of space
- Continued efforts toward a voluntary rules-based approach to space security

Space Security Impact

Activities surrounding the UN COPUOS in 2008 reinforced the continued focus on non-binding, technical approaches to international governance of outer space noted in Trend 2.1. Despite drawbacks, these are the only mechanisms that are garnering widespread support and leading to improvements in the security of outer space in the face of continued lack of consensus on new treaties in both the UN COPUOS and the CD. However, the increased interaction between these two organizations suggests that addressing security concerns in space more comprehensively may become possible in the future, although the stark division between civil and safety issues and military and weapons issues remains institutionalized.

TREND 2.3: 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 in countries such as India and Japan. 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.

2008 Development:

- South Africa approves a National Space Agency with focus on peaceful use

Space Security Impact

States continued to express commitment to international cooperation on the peaceful use of outer space in their civil space policies in 2008. Some peaceful uses of space are increasingly viewed as strategic, however, which could limit opportunities for cooperation and cause political tensions in space, depending on whether states pursue independent or collective measures to achieve the strategic goals set out in their space policies.

TREND 2.4: Growing focus within national policies 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 interfering with US space operations.

2008 Developments:

- Japan issues new space law lifting its ban on national security and military space activities
- China's 2008 White Paper on Defense highlights importance of "informationization"
- France's White Paper on Defense and National Security encompasses overhaul of space strategy
- New approach to space protection in the US may include international interdependence
- Space for security a renewed priority for Europe

Space Security Impact

In 2008 many states continued to emphasize the use of space for national security purposes in policy statements. A positive impact of this trend is increased transparency and clarity of intentions that allow states to better predict the behavior of others in space. However, a parallel trend, in which civilian and commercial space infrastructure is being used for national security purposes, may lead to added vulnerabilities in space if this infrastructure is viewed as a legitimate target during conflict, particularly given the absence of laws governing conflict in space.

Civil Space Programs and Global Utilities

TREND 3.1: Growth in the number of actors with access to space, including dual-use applications — The rate at which new states gain access to space increased dramatically in the past decade. By 2008 9 actors had demonstrated independent orbital launch capacity and 49 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.

2008 Developments:

- Space access continues to increase, with new states gaining satellites and developing space agencies
- Iran, North Korea, Brazil, and South Korea seek direct access to space through launch technology

Space Security Impact

Increased participation in space activities is a positive trend insofar as more actors gain access to space for peaceful purposes, extending the benefits of space applications, science, and security. On the other hand, the growth of space activities also creates challenges for security in space due to increased demand for limited space resources such as orbital slots and radio frequencies, particularly when new activities replicate rather than rely on or enhance the capabilities provided by other states. Because of the ability of space assets and technologies such as launch vehicles to be used for different purposes, the intentions of the many actors in space cannot be known.

TREND 3.2: Changing priorities and funding levels within civil space programs toward large-scale projects — Civil expenditures on space have continued to increase in India and China in recent years, while past decreases in the space budgets of the US, the EU countries, and Russia have begun to reverse. Increasingly, civil space programs include security and development applications. Several states, in particular Brazil, Nigeria, and South Africa, are placing a priority on satellites to support social and economic development. Such dual-use applications as satellite navigation and Earth imaging are a growing focus of almost every civil space program.

2008 Developments:

- NASA focuses on maintaining human access to space as retirement of the Space Shuttle looms
- Space programs in China and India continue to grow, with focus shifting to human spaceflight
- Russia significantly increases the budget for space, primarily to make its Global Navigation Satellite System (GLONASS) viable
- Space agencies continue to focus on robotic missions to the Moon

Space Security Impact

The use of outer space continues to be dominated by a few states, with activities in 2008 demonstrating renewed interest in lunar exploration and human spaceflight. Although developments in 2008 indicate some cooperation on these projects, historical trends indicate that competition may increase if such capabilities become strategic in the future. Nonetheless, it remains to be seen if large-scale projects will gain the necessary investment to come to fruition; only in India, Russia, and possibly China are resources growing significantly. Delays in construction of new human spacecraft in the US may adversely influence space security in the future by limiting human access to space, particularly to the International Space Station (ISS).

TREND 3.3: Continued 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 and Space Shuttle flights to MIR, the Hubble Space Telescope, joint NASA-ESA projects such as Spacelab, and European cooperation with Chinese and Indian lunar probes. The most prominent example of international cooperation is the International Space Station, 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.

2008 Developments:

- Continued international cooperation on space exploration as the International Space Station turns 10
- International cooperation provides access to space for developing countries

Space Security Impact

The continuation in international cooperation in space is a positive development, particularly if it helps to reduce potential tensions over large-scale, national space projects such as human spaceflight and lunar exploration, and enables more states to access the benefits of outer space through shared costs and technologies. Cooperation can also increase transparency of space activities, further reducing potential conflicts in a strategic environment. There is a risk, however, that sensitive military technologies may proliferate, and that greater access to dual-use space-based applications for military purposes may exacerbate regional tensions.

TREND 3.4: 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, China, and India are developing satellite-based navigation capabilities. The strategic value of satellite navigation has been underscored by conflicts over use of radio frequencies.

2008 Developments:

- Continued development of independent satellite navigation capabilities
- Global access to remote sensing data improving

Space Security Impact

Ongoing development of space-based global utilities such as satellite navigation systems could 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. However, such a result requires considerable international coordination and cooperation, which have not fully developed due to ongoing disputes over the use of frequency signals, the development of independent capabilities to guarantee service, and a lack of planning for the increased demand on orbits and radio frequencies created by duplicate systems. The growing use of remote sensing data to manage a range of global challenges, including disaster monitoring and response, is positive for space security insofar as it further links the security of Earth to the security of space, expands space applications to include additional users, and encourages international collaboration and cooperation on an important space capability.

Commercial Space

TREND 4.1: Continued overall growth in the global commercial space industry — Commercial space revenues have steadily increased since the industry first started to grow significantly in the mid-1990s. Global commercial space revenues, dominated by satellite services, have been estimated as totaling between $144-billion and $175-billion in 2008. Individual consumers are a growing source of demand for these services, particularly satellite television and personal GPS devices. In recent years Russia has dominated the space launch industry, having the most commercial launches, while US companies have led in the satellite manufacturing sector. However, international competition in both of these sectors is increasing.

2008 Developments:

- Continued industry growth driven by consumer services and a strong satellite replacement market
- Growing international competition from China, India, and Japan
- Growth opportunities for small, low-cost satellites may expand access to space

Space Security Impact

Although the strong commercial launch industry in 2008 was in part due to the ongoing replacement of satellites, continued growth is also seen in satellite services and ground equipment revenues, driven by consumer-oriented 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. Further, individual consumers continue to become more significant stakeholders in space. Growing competition in the commercial launch market may contribute to space security by providing greater access to outer space, although tensions may arise if future demand for space resources such as orbital slots and radio frequencies exceeds supply. Currently, however, the positive gains in the sector's value and ubiquity outweigh the greater friction with respect to supply and demand.

TREND 4.2: Commercial sector supporting increased access to space — Commercial space launches have contributed to cheaper space access. The cost to launch a commercial satellite into GEO has declined from an average of about $40,000/kilogram in 1990 to $26,000/kilogram in 2000, with prices now stabilizing. The commercial space industry is also opening up access to Earth imaging data, which until a few years ago was only available to a select number of governments. Today any individual or organization with access to the Internet can use these services through Google Maps, Google Earth, and Yahoo Maps programs. An embryonic private spaceflight industry continues to emerge, seeking to capitalize on new concepts for advanced, reliable, reusable, and relatively affordable technologies for launch to suborbital trajectories and low Earth orbit.

2008 Developments:

- New launchers entering the market increase capacity, but no indication of further launch cost reductions
- Private human access to space slowly progressing
- Commercial actors continue to expand availability of Earth 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. Moreover, while efforts are being made to support private human access to space, such access may cause 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 Astronaut Rescue Agreement (see Laws, Policies, and Doctrines Trend 2.1). Finally, while the space industry is facilitating greater use of space applications, in particular remote sensing data, there are legitimate fears about the security implications on Earth of widely available imaging data.

TREND 4.3: Government's dependency on the commercial space sector means that subsidies and national security concerns continue to play an important role — The commercial space sector is significantly shaped by national governments with particular security concerns. The 1998 US Space Launch Cost Reduction Act and the 2003 European Guaranteed Access to Space program provide for considerable 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 participation by US companies in international collaborative satellite launch and manufacturing ventures.

2008 Developments:

- Military dependence on commercial space services continues to expand, deepen
- Relationships between governments and commercial sector continue to evolve toward more substantial partnerships
- Ongoing debate over how to apply trade restrictions for security purposes
- Commercial operators engage in space governance

Space Security Impact

The strong relationship between military and commercial uses of space and the security dimensions of many commercial services have complex impacts 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. This could increase overall space security. The focus of the year has been a constant discussion on changes that ought to be brought about in ITAR to increase the commercial competitiveness of the US satellite and launch industries, specifically in the light of the ITAR-free satellites manufactured by Europe for the Chinese market.

Space Support for Terrestrial Military Operations

TREND 5.1: US and Russia continue to lead in deploying military space systems — Estimated at $29-billion, almost half of all global spending on space is for defense-related programs that provide military attack warning, communications, weather forecasting, reconnaissance, surveillance, and intelligence, as well as navigation and weapons guidance applications. The US spends 95 percent of this amount, but spending on military space programs is increasing in other countries around the world. At the end of 2008 there were over 150 operational dedicated military satellites worldwide, with the US operating approximately 76, and Russia approximately 36.

2008 Developments:

- US faces increased demands for military satellite capabilities as it struggles to upgrade its systems
- Russia increases investment in GLONASS again, pursues other high-priority upgrades

Space Security Impact

Despite ongoing acquisition challenges in providing next-generation space capabilities for its military and intelligence communities, the US maintains the most capable and robust systems, which are one indication of secure and sustainable access to and use of space. While ongoing dependence on space systems for security makes the US particularly vulnerable in space, efforts are being made to mitigate this risk through the use of commercial capabilities and smaller satellites that can be launched quickly. Russian space efforts and funding are focused on finishing the GLONASS program and upgrading early warning capabilities, both of which could be positive for security in space by providing redundancy for US GPS and greater stability through more reliable early-warning data.

TREND 5.2: More states developing military and dual-use space capabilities — During the Cold War, states allied with either the US or the USSR benefited from their capabilities. Traditionally, military satellites outside of the US and Russia have been almost exclusively intended for telecommunications and imagery intelligence. Recently, however, states such as China, France, Germany, Japan, Israel, Italy, and Spain have been developing satellites with a wider range of functions. Security is a key driver of established government space programs, pushing spending higher. However, in the absence of dedicated military satellites, many actors use their

civilian satellites for military purposes or purchase data and services from other satellite operators. While individual European states have pursued independent, national space capabilities for military support, in a unique twist, they also share many of these capabilities among European partners.

2008 Developments:

- European states continue to cooperate on military space projects
- The Council of the European Space Agency endorses military use of its dual-use space projects
- China continues to launch potential dual-use spacecraft
- India and Israel cooperate on space
- Japan plans new military uses of space
- Canada continues to develop dual-use space capabilities

Space Security Impact

The drive for more states to develop and deploy both dedicated military and dual-use space systems demonstrates the continued accessibility of the space environment and greater access to space technologies. In general, these systems are being developed independently of one another and, while in theory some, such as satellite navigation, could be interoperable to enhance security, such cooperation is not the rule. However, Europe is emerging as the one region where space-based capabilities are being developed cooperatively, thus providing access to more states and redundancy of capabilities. As more states become dependent on space systems for military operations and national security, greater vulnerability may provide incentives to enhance the security of outer space or to develop capabilities to quickly negate space systems. At the same time, increasing reliance on dual-use spacecraft will make intentions difficult to determine.

Space Systems Protection

TREND 6.1: US and Russia lead in ability to detect rocket launches, while US leads in development of 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. The US Defense Support Program provides 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 experimental 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.

2008 Developments:

- US and Russia continue to upgrade early warning systems, and Japan considers developing a national early warning capability
- US pursues on-orbit warning and attack detection capabilities to enable defensive responses
- Improvements in access to independent space surveillance data, and ongoing discussions about options to share such data

Space Security Impact

Efforts to improve missile early warning capabilities in the US and Russia contribute to space security by maintaining the foundation of capabilities to monitor compliance with international controls on missile and nuclear technology developments that could be used to threaten objects in space (see Space Systems Negation), and to warn of impending threats. Thus the loss of the US sensor to detect nuclear blasts weakens an important protection measure, while the potential for early warning capabilities to be developed by additional actors is a positive measure that could increase the robustness of these efforts. US interest in developing local, on-orbit capabilities to warn of possible attacks or detect interference with a satellite can enhance protection of specific space systems by enabling defensive responses and possibly deterring attempts to interfere with those satellites. More broadly these capabilities could contribute to increased stability if they were able to identify the source of interference and if it were intentional, accidental, or environmental. It is noted, however, that on-orbit surveillance and warning can potentially facilitate aggressive counteractions in space, which could be destabilizing and spiral into conflict.

TREND 6.2: Efforts to protect satellite communications links but ground stations remain vulnerable — Many space systems lack protection from determined attacks on ground stations and communications links. Because the vast majority of commercial space systems have only one operations center and one ground station, they are 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. Laser communications still have the best potential to reduce vulnerabilities of satellite communications links, but are proving difficult to implement.

2008 Developments:

- Plans for US Cyber Command evolve; NATO opens Co-operative Cyber Defense Center
- US focuses on improved security of existing communications links, while efforts to develop future laser links continue, but face both technical and budgetary challenges

Space Security Impact

Efforts to secure the network safety of critical infrastructure, which includes satellite command and control stations, reflects the interdependence of security in space with other terrestrial security issues and the complexity of defending against potential threats. These efforts are positive insofar as they reduce the number and severity of network attacks; encourage international cooperation, currently limited to NATO members; and enable governments to keep pace with innovations in cyber attacks. Laser communication technologies continue to offer the promise of better protection for ground-to-satellite communications, which is one of the most prevalent sources of attacks on space system. But progress remains slow and is currently focused on satellite-to-satellite transmissions. Efforts to improve the security of both computer networks and communications links demonstrate the spiral effect of protection-negation dynamics in space, where capabilities to improve one lead actors to improve the other.

TREND 6.3: Protection of satellites against some direct threats is improving but remains limited — The primary source of protection for satellites stems from the difficulties associated with launching an attack into space. Passive satellite protection measures also include system redundancy and interoperability, which have 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, physically protecting a satellite from a direct kinetic attack remains difficult.

2008 Developments:

- US, Canada, and Sweden experiment with formation flying, which could support dispersion techniques to reduce the vulnerability of satellite systems
- US pursues technology enablers for on-orbit repair

Space Security Impact

Capabilities that would enable actors to disperse the function of a single large satellite into a cluster of smaller satellites are progressing and would contribute to security in space by reducing the vulnerability of space-based components, which would no longer rely on a single spacecraft. However, other security challenges, such as the ability to safely manage traffic in space, could increase. While enabling technologies to repair damaged spacecraft on-orbit through new propulsion, maneuvering, docking, and grappling capabilities is progressing, it remains a longer-term potential. As capabilities to protect satellites on-orbit become more active, however, there is a potential for them to be used against non-cooperative spacecraft. The long-term impact on space security will depend greatly on how technologies are used and how transparent usage is. Moreover, space-based protection capabilities could still be defeated by a determined actor, raising the potential for a spiral of protection and negation capabilities in space.

TREND 6.4: Efforts to develop capacity to rapidly rebuild space systems following direct attacks, but no operational capabilities — The ability to rapidly rebuild space systems after an attack could reduce vulnerabilities in space. Although the US and Russia are developing 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 to 1,000 kilograms into LEO within 24 hours. It includes funding for the the AirLaunch LLC QuickReach rocket, which came to an end in 2008, and the SpaceX Falcon-1.

2008 Developments:

- US, China, and France developing more capable microsatellites and rapid launch technologies

Space Security Impact

The ability to quickly launch new satellite systems, reconstitute damaged or failed components, or upgrade existing capabilities contributes to space security by reducing the vulnerability of space systems to environmental threats and natural degradation of capabilities and deterring potential attacks on space components. When combined with microsatellite constellations that can replace a single satellite (Trend 6.3), the longevity of the constellation is increased immeasurably. Relatively inexpensive systems are being developed to launch smaller satellites. As with most space technology, however, they could be used for other purposes, including the covert launch of space-based anti-satellite systems.

Space Systems Negation

TREND 7.1: Capabilities to attack ground stations and communications links are widely spread — Ground segments, including command and control systems and communications links, remain the most vulnerable components of space systems, susceptible to attack by conventional military means, computer hacking, and electronic jamming. Several incidents of intentional jamming of communications satellites have been reported in recent years. Iraq's acquisition of GPS-jamming equipment 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.

2008 Developments:

- US and China pursuing cyber attack capabilities
- States are vulnerable to cyber attacks by individuals

Space Security Impact

Although cyber attacks in 2008 did not appear to target space systems, they nonetheless represent a growing threat to space security as capabilities to launch them are spreading and improving, in what is becoming a protection-negation spiral (see Space Systems Protection Trend 6.2). For now, cyber attacks are less damaging than kinetic or other physical attacks, since they are generally temporary and reversible. They can, however, seriously disrupt a nation's ability to respond to a more damaging attack, and so should not be taken lightly. Because there have been few known past events, data on the impact of cyber attacks is scarce and the full impact of such a breach is unknown. Moreover, because individuals, often anonymous, as well as states can interfere with this facet of space security, the consequences could be both more complex and destabilizing.

TREND 7.2: US leads in the development of space surveillance capabilities that can support 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. France, Germany, Japan, and Europe are developing independnet space surveillance capabilities.

2008 Development:

- US space surveillance and tracking data enable destruction of a failed satellite, as global efforts to improve access to such data continue

Space Security Impact

Space surveillance capabilities can be used to both enhance and degrade security in outer space, but activities in 2008 seemed to favor positive impacts (see Space Environment Trend 1.3 and Space Systems Protection Trend 6.1). The US engagement of a de-orbiting satellite in 2008 demonstrates the applicability of surveillance data to negation, but also the fact that such capabilities are used far more extensively to support civil space efforts such as human spaceflight, mitigate the risk of collision with debris, and manage space traffic. Nonetheless, the potential for independent space surveillance capabilities to support deliberate attacks against satellites and other space objects, demonstrated through the centrality of space surveillance in identifying foreign satellites, space control efforts, and close proximity operations, is one of the obstacles preventing access to the more precise data that is needed for some of the more protection-oriented functions listed above.

TREND 7.3: Ongoing proliferation of ground-based capabilities to attack satellites — The development of ground-based anti-satellite 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 to more than 30 states. 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 that could enable a rudimentary attack in space 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, China, and Russia lead in the development of more advanced ground-based kinetic-kill systems that have the capability to directly attack satellites. They have access to advanced laser programs, which have inherent satellite negation capabilities in LEO.

2008 Developments:

- US reconfigures anti-missile system to destroy a failed satellite as it de-orbits
- Ongoing efforts to improve missile technology globally may enable anti-satellite capabilities
- US laser program for missile defense continues, but feasibility not proven

Space Security Impact

The US engagement of the de-orbiting USA-193 satellite demonstrates the ability to reconfigure an interceptor missile, even if only for a one-time event, for use against a satellite, raising the prospect of greater insecurity in space as more actors research and develop anti-missile systems. Increased global interest in missile and anti-missile capabilities has an uncertain effect on the security of outer space. While it is potentially threatening and destabilizing and could trigger an arms race targeting space, some assess it as a valuable deterrent against the use of force in space because it creates mutual vulnerabilities. The development of high-energy lasers can have the same uncertain impact, but this uncertainty is aggravated by the fact that lasers can be used in a wide range of space activities, including tracking objects in space, and they can be much more easily used covertly or without warning.

TREND 7.4: Increased 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 or aid in targeting for other 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.

2008 Developments:

- A broad range of dual-purpose space-based technologies continue to be developed
- US weapons technology programs developing proximity and maneuverability capabilities

Space Security Impact

The duality of many of the technologies outlined here is clear from their presence in both Space Systems Protection and Space Systems Negation chapters. While microsatellites were initially created to protect space systems, much of their development has been in a range between passive protection and active negation. The largest danger is in the capacity to conduct proximity maneuvers, since the size of such satellites implies that they are difficult to detect and track. However, these capabilities are still very much under development, and the ability of one satellite to approach an uncooperative satellite without notice to conduct an offensive operation is still several years away.

Space-Based Strike Capabilities

TREND 8.1: While no space-based strike systems have been tested or deployed, the US continues to develop technologies behind space-based interceptors 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 space-based directed energy strike systems in the 1980s, although today these programs have largely been halted.

2008 Developments:

- Funding cut for US Space Test Bed, but feasibility study approved
- Experimental missile defense satellite conducts second successful test of rocket sensor technology
- Multiple Kill Vehicle contract awarded

Space Security Impact

The absence of space-based strike systems and infrastructure continued to support the security of outer space in 2008. While precursor technology development continued in the Near-Field Infrared Experiment Test and the Multiple Kill Vehicle program, restraint by US policymakers is positive and indicates concern for space security and the challenges of balancing terrestrial missile defense requirements with the need to maintain freedom from space-based threats.

TREND 8.2: More countries are developing advanced space-based strike-enabling technologies through civil, commercial, and military programs — The majority of advanced, space-based strike enabling technologies are dual-use and are developed through 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. Five states in addition to the European Union 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.

2008 Developments:

- US Prompt Global Strike program continues to develop, but its long-term implications are unclear
- Key actors continue to develop a range of space-based strike enabling capabilities

Space Security Impact

Space-based weapons designed to strike terrestrial targets will require sophisticated technological developments that, at present, few spacefaring states seem able or willing to exploit. The development of dual-use capabilities that also provide enabling technologies for space-based strike systems continued in 2008, 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 discrete 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. If one actor were to pursue a space-based strike capability, others could follow.

2009

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