CHAPTER 9

SPACE SECURITY 2006[1]

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INTRODUCTION

The strategic environment of outer space is rapidly evolving. A growing number and diversity of actors are accessing and using space, revenues from its commercial exploitation are growing, satellite services affect daily life all over the world and military space applications are continually expanding. While demonstrating the vital importance of this environment, intensifying space use creates governance challenges including management of space traffic, orbital debris and the distribution of scarce resources such as orbital slots and radio frequencies. It has become clear that technological and political developments are outstripping the existing governance framework for outer space. These governance challenges affecting space security will become increasingly salient as states' dependence on space for national security grows.

For the purposes of this paper, space security is defined as *the secure and sustainable access to and use of space, and freedom from space-based threats*. This definition accepts that space is a global commons, as enshrined in the 1967 Outer Space Treaty (OST), bordering every community on Earth. The concept of space security also embraces a comprehensive understanding of security, encompassing environmental, legal, civil and commercial factors in addition to military ones. Indeed, there cannot be security in space in any meaningful sense if critical space assets are being pelted by orbital debris, if commercial space interests lack the protection of a robust legal regime or if satellites are threatened by space weapons. For space to remain a path to prosperity and a path to peace, these dimensions must be addressed. This paper aims to provide a snapshot of the current state of space security, a vital tool for the space security debate.

Published in *Building the Architecture for Sustainable Space Security—Conference Report, 30–31 March 2006*, United Nations Institute for Disarmament Research (UNIDIR), 2006.

THE SPACE ENVIRONMENT

The danger posed by orbital debris and the distribution of scarce resources such as orbital slots and radio frequencies are key environmental aspects of space security. The number of objects in Earth orbit has increased steadily and there are an estimated 35 million pieces of space debris in orbit as of 2006. Approximately 13,000 orbiting objects large enough to seriously damage or destroy a spacecraft—over 90% of which is space debris—are being tracked. However, the annual growth rate of tracked orbital debris has been decreasing since the early 1990s, due in large part to national space agency debris mitigation efforts. In 2005, the space debris population grew by 2.1%, a modest rate of increase compared with those of recent years.

Recognizing that space debris is a growing threat, many space-faring states, including China, Japan, the Russian Federation and the United States, as well as the European Space Agency (ESA) have developed national debris mitigation standards. In 2005, the Space Debris Working Group of the Scientific and Technical Subcommittee of Committee on the Peaceful Uses of Outer Space (COPUOS) reached agreement that the intentional destruction of *any* orbiting object that could generate "long-lived" orbital debris should be avoided.

In order to mitigate the threat of space debris, space surveillance has been slowly improving. The US Space Surveillance Network and the Russian Space Surveillance System currently provide the most important capabilities. Canada, China, the European Union, France, Germany and Japan are also developing new space surveillance capabilities. In 2005, the United States announced plans for a space situational awareness nano-satellite in geostationary orbit. China established its first Target and Debris Observation and Research Center, while actors in Europe explored the possibility of setting up a space surveillance network by pooling existing ground-based radars and optical telescopes with new assets.

Another environmental concern of expanding satellite applications has been the growing demand for radio frequencies. The number of satellites operating in the 7–8 gigahertz band commonly used by geostationary orbit satellites has been increasing. The growth in military consumption of bandwidth has also been dramatic. Demand for radio spectrum continued to increase in 2005. Radio frequency interference and piracy are also becoming a concern to commercial space actors. In 2005, 1,374 incidents of satellite radio frequency interference were reported, although only 1% of these incidents was intentional.

Furthermore, the space environment is affected by orbital crowding. There are more than 620 operational satellites in orbit at the time of writing: about 46% in low-Earth orbit (LEO), 6% in medium-Earth orbit and slightly more than 47% in geostationary orbit. Increased competition for orbital slot assignments, with greatest demand for geostationary orbit slots where most communications satellites operate, has caused occasional disputes between satellite operators. The International Telecommunications Union has been pursuing internal reforms designed to address slot allocation backlogs and related financial challenges. Demand on orbital slots continued to increase in 2005, with ongoing competition between communication satellite operators and with Iran becoming the forty-fifth state to acquire indirect access to space.

LAWS, POLICIES AND DOCTRINES

Since the signing of the OST in 1967, the international legal framework related to space 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 customary international laws. This legal framework establishes the principle that space should be used for "peaceful purposes" and is not subject to claims of national sovereignty. While there currently exists no ban on the deployment of conventional weapons in space, the OST prohibits the stationing of weapons of mass destruction anywhere in space.

Since 1981, the United Nations General Assembly has adopted a resolution on the prevention of an arms race in outer space (PAROS) with near-unanimous support. In 2005, there was a noteworthy shift in the PAROS debate when Israel and the United States voted against the resolution—the first opposition votes in the resolution's history. In 2005, the Russian Federation also tabled a new resolution, inviting states to provide input on measures to promote transparency and confidence building in outer space.

A range of international institutions such as the General Assembly, the COPUOS, the International Telecommunications Union and the Conference on Disarmament (CD) have been mandated to address space security issues. However, the CD has been deadlocked since 1998 and unable to undertake the PAROS mandate to develop an instrument relating to space security and the weaponization of space. An aborted effort was made in 2005 to create four open-ended ad hoc committees under the auspices of the General Assembly First Committee to address the PAROS and other priority issues.

All space-faring states emphasize the importance of cooperation and the peaceful uses of space, including the promotion of national commercial, scientific and technological progress. The United States has recently announced plans for peaceful space exploration of the Moon and Mars, while there is growing interest in manned space programmes. Brazil and India tend to focus on the utility of space cooperation for social and economic development. New space policies were adopted in Europe, China, Japan, Kazakhstan, the Russian Federation and the United States in 2005. The European Commission, for example, unveiled a plan to spend more than US$ 5 billion on "security and space" programmes for 2006–2013 and to double its budget for space-related research programmes.

A growing number of states led by China, the Russian Federation, the United States and key European states are increasingly emphasizing the use of space systems to support national security. This has led several states to view space assets as critical national security infrastructure. US military space doctrine has also begun to focus on the need for "counterspace operations" to prevent adversaries from accessing space. In 2005, actors such as the European Union, India, Israel and Japan continued emphasizing the national security applications of space. The United States is expected to release a new military space directive that, according to certain media reports, would depart from current policy by explicitly calling for development of certain space negation systems.

CIVIL SPACE PROGRAMMES AND GLOBAL UTILITIES

Civil space programmes are a key aspect of space security as they have helped a large number of actors gain access to space. By 2004, 10 actors had demonstrated an independent orbital launch capacity and 44 states had accessed space independently or with the launch services of others. In 2005, China, the Russian Federation and the United States launched 24 civil spacecraft, of which nine were manned, and Iran became the forty-fifth state to launch a satellite.

While there has been growth in the number of states accessing space, civil space programmes have seen changing priorities and funding levels. The general trend in recent years has seen civil space expenditures increase in China and India and decrease in the European Union, Japan, the Russian Federation and the United States. In 2005, most space-faring states, except Japan, experienced modest increases in civil space budgets and these programmes increasingly include security and development applications. Indeed, Algeria, Brazil, Chile, Egypt, India, Malaysia, Nigeria, South Africa and Thailand are all placing a priority on satellites to support social and economic development.

Another aspect of space security has been the steady growth in international cooperation in civil space programmes. International civil space cooperation has played a key role in the proliferation of technical capabilities for states to access space. In 2005 alone, the Russian Federation reached agreements with Brazil, Canada, China, Egypt, India, Indonesia, Iran, Kazakhstan, the Republic of Korea and ESA. The United States established agreements with India, Japan, the Russian Federation and Sweden. ESA, a regional space agency that embodies the benefits of international cooperation, signed agreements with China, India, Morocco, the Russian Federation and Ukraine. Also, eight regional partners formed the Asia Pacific Space Cooperation Organization.

The use of space-based global utilities, including navigation, weather and search-and-rescue systems, has grown substantially since 1995. These systems have spawned space applications that are almost indispensable to the civil, commercial and military sectors as well as most modern economies. China, the European Union, the Russian Federation and the United States have been developing satellite-based navigation capabilities. In 2005, the European Union launched the first of its constellation of Galileo navigation satellites, while India, Israel, Morocco, Saudi Arabia and Ukraine announced their participation in the project. The Russian Federation made plans to cooperate with China and India on the GLONASS satellite navigation system. India also started development of its own separate civilian satellite navigation system called GAGAN.

COMMERCIAL SPACE

The global commercial space sector has seen overall, albeit uneven, growth. The commercial space sector, including manufacturing, launch services, space products and operating insurance, accounted for an estimated US$ 2.1 billion in revenues in 1980 and exceeded US$ 100 billion by 2004. This growth is being driven by the satellite services industry, including telecommunications. In 2005, there were 17 commercial launches, an increase over 2004, and revenues for the year were expected to reach US$ 115 billion. In addition, 20 new commercial satellites were launched in 2005. The general trend to privatize government-owned telecommunications agencies and industry consolidation in the commercial space industry also continued apace.

Accounting for about one-third of the 60–70 annual space launches, the commercial space sector has played a role in the decreasing cost of space access. The costs to launch a satellite into geostationary orbit have declined from an average of about US$ 40,000/kilogram in 1990 to US$ 26,000/kilogram in 2000, with prices still falling. The European and Russian space agencies are the most active space launch providers. With the launch of Mojave Aerospace Ventures' SpaceShipOne in 2004, the private sector entered the suborbital manned spaceflight sector. Nonetheless, demand for commercial launchers stayed flat in 2005 as the United States continued to lose market share to Europe and the Russian Federation. Japan successfully tested a new launcher and China announced its imminent return to commercial space launch. More than 20 companies are developing a reusable suborbital launch vehicle for space tourism.

Government subsidies and national security concerns continue to play an important role in the commercial space sector. Governments significantly subsidize the space launch and manufacturing markets, including insurance costs. The European and US space industries also receive important space contracts from government sources. However, government administered export controls such as the Missile Technology Control Regime and the US International Traffic in Arms Regulations (ITAR) regime can complicate participation in international collaborative satellite launch and manufacturing ventures. In 2005, the US Department of Defense remained the world's largest commercial space client. At the same time, commercial space actors such as the International Space Business Council cited ITAR as the "industry's most serious issue". As a result of high insurance premiums, a number of commercial space actors have stopped insuring their in-orbit assets and/or purchased spare satellites.

SPACE SUPPORT FOR TERRESTRIAL MILITARY OPERATIONS

Space played a critical role in ensuring strategic stability during the Cold War. As a result of the revolution in military affairs, space is increasingly supporting tactical terrestrial military operations. The Russian Federation and the United States lead in developing military space systems to provide military attack warning, communications, reconnaissance, surveillance, intelligence, navigation, and weapons guidance. The United States spends roughly 95% of all global military space expenditures and has approximately 135 operational, military-related satellites—over half of all the military satellites in orbit. The Russian Federation is believed to have some 85 dedicated military and 18 multipurpose satellites in orbit. The United States is, by all major indicators, the actor most dependent on its space capabilities. In 2005, 19 dedicated military space satellites were launched. The Russian Federation and the United States launched six and seven military satellites, respectively. However, 2005 also saw significant cutbacks to a number of US military space programmes and the Russian Federation experienced three failed launches and the loss of two military satellites.

Declining costs for space access and the proliferation of technology are enabling more states to develop and deploy their own military satellites using the launch capabilities and manufacturing services of others, including the commercial sector. European Union states have developed a range of military space systems. France, Germany, Italy and Spain jointly fund the Helios 1 military observation satellite system. France, Germany and Italy are planning to launch six low-orbit imagery intelligence systems to replace the Helios series by 2008. The United Kingdom maintains a constellation of three dual-use Skynet 4 communications satellites. France operates four signal intelligence satellites. The European Union Galileo satellite navigation programme, initiated in 1999, will have an inherent dual-use capability. In 2005, France continued development of the most advanced and diversified independent military space capabilities in Europe with the launch of the Syracuse 3A military communications satellite and ongoing work on the Spirale early-warning and Melchior military communications satellites.

Spain launched the XTAR-EUR communications satellite, and the United Kingdom launched a dual-use imagery micro-satellite called TopSat.

Asia is increasingly becoming the arena of military space rivalry. China provides military communications through its DFH series satellite and has deployed a pair of Beidou navigation satellites to ensure its navigational capability. China also maintains three ZY series satellites for tactical reconnaissance and surveillance functions, has deployed three military reconnaissance satellites and is believed to be purchasing additional commercial satellite imagery from the Russian Federation to meet its intelligence needs. Japan operates the commercial Superbird satellite, which provides military communications, and has two reconnaissance satellites. India maintains its Technology Experimental Satellite and a naval satellite, both of which provide military reconnaissance capabilities. In cooperation with a French company, Thailand will soon produce its first intelligence and defence satellite. In 2005, China launched the Beijing-1 (Tsingshua-1) Earth observation micro-satellite amid speculation that China's continued participation in the Galileo navigation system might eventually be used to improve the accuracy of its missiles. Taiwan announced plans to launch a Follow-On RSS reconnaissance satellite. In an effort to improve satellite images of the Democratic People's Republic of Korea's nuclear and missile facilities, Japan began research in 2005 on scaling down the size of reconnaissance satellites to enhance their manoeuvrability. Pakistan began construction of a remote sensing satellite.

Israel operates a dual-use Eros-A imagery system as well as the military reconnaissance and surveillance Ofeq-5 system. In 2005, Israel announced its intention to launch the Ofeq-7 and TechSAR surveillance and reconnaissance satellites. The Middle East also saw a proliferation of military space capabilities with the launch of Iran's Sina-1 satellite, which, although officially civil, has been claimed to have dual-use remote sensing functions. And in North America, Canada announced its intention to launch a radar surveillance satellite called RADARSAT-2.

SPACE SYSTEMS PROTECTION

Space systems protection involves detecting, withstanding and recovering from attacks on the ground and space-based segments of a space system. The Russian Federation and the United States lead in general capabilities to detect rocket launches, while the United States leads in the development of advanced technologies to detect direct attacks on satellites. US Defense Support Program satellites provide early warning of conventional or nuclear ballistic missile-based attacks and it is also developing capabilities to detect in-orbit attacks on satellites. The Russian Federation began rebuilding its ageing missile launch warning system in 2001. France is due to launch two missile-launch early-warning satellites in 2008. 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. Directed energy attacks move at the speed of light, making advance warning very difficult to obtain. The United States maintained its lead in space situational awareness capabilities in 2005, announcing plans for the Space Surveillance Telescope and the Deep View radar of the Autonomous Nanosatellite Guardian for Evaluating Local Space (ANGELS) programme.

The most vulnerable segment of a space system is often the ground segment, where many systems lack protection from attacks. The protection of satellite communications links is also generally poor but improving. While many actors employ passive electronic protection capabilities, such as shielding and directional antennas, more advanced measures, such as burst transmissions, are exclusive to the military systems of more technically advanced states. China and the United States have been aggressively pursuing a variety of jamming protection capabilities. In 2005, the United States successfully tested the GPX airborne pseudo-satellite, employing an unmanned aerial vehicle to boost power of GPS satellite signals and overcome jammers.

The protection of satellites against some direct threats is improving, largely through radiation hardening, system redundancy and greater use of higher orbits. China and Japan are developing navigation satellites that will increase the global redundancy of such critical systems. The European Union and the United States have agreed to make their navigation systems interoperable. Increasingly, states are placing military satellites into higher orbits, where they are less vulnerable to attacks than in LEO. Most key European, Russian and US military satellites are already hardened against the effects of a high-altitude nuclear detonation. In 2005, the United States achieved improved radiation hardened microchips and began research to characterize the radiation environment in medium-Earth orbit in order to make better use of this environment. The United States is reportedly developing a stealth satellite with the ability to evade detection by the terrestrial space surveillance systems of other actors.

In addition, the Russian Federation and the United States lead in capabilities to rapidly rebuild space systems following a direct attack on satellites. The concept of so called responsive lift was pursued by Lockheed Martin and SpaceX through research and development of low-cost launch vehicles. The Russian Federation, for its part, continued research on air-launched responsive lift capabilities.

SPACE SYSTEMS NEGATION

The negation of ground- or space-based segments of a space system can be achieved by electronic, conventional, nuclear and directed energy means. There has been a proliferation of capabilities to attack ground stations and communications links of space system. These remain the most vulnerable components of space systems, susceptible to attack by conventional military means, computer hacking and electronic jamming. In 2005, Libya and Iran sponsored the jamming of satellite communications and China continued to be a major target of satellite jamming.

The United States leads in the development of space situational awareness capabilities that could support space negation and, along with the Russian Federation, maintains the most extensive space surveillance capabilities. China and India also have satellite tracking, telemetry and control assets essential to their civil space programmes. Canada, France, Germany and Japan are all actively expanding their ground-based space surveillance capabilities. While this technology enhances transparency and enables space collision avoidance, it can also provide capabilities for targeting satellites and space negation. The United States increased its lead in space situational awareness technologies in 2005 with research and development into ANGELS and the Deep View radar. Some actors in Europe have begun discussions on the option of pooling existing space surveillance capabilities as well as developing additional independent capabilities of their own in order to be less reliant on US data.

Ground-based capabilities and precursor technologies to attack satellites are becoming more widespread. A variety of US and USSR/Russian programmes during the Cold War and into the 1990s sought to develop ground-based anti-satellite (ASAT) weapons. 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: 28 states have demonstrated suborbital launch capability; of those, 10 have orbital launch capability. As many as 30 states may already have the capability to use low-power lasers to degrade unhardened satellite sensors. The United States leads in the development of more advanced ground-based kinetic kill systems with the capability to directly attack satellites. It has deployed components for a ground-based ballistic missile defence system and is developing an airborne laser system, both of which have inherent LEO satellite negation capabilities.

In 2005, the China and the United States continued to work on directed energy technologies. The United States is pursuing lighter, smaller and more durable solid state laser designs. The existing American Starfire Optical Range was fitted with a sodium beacon laser with possible ASAT applications. Research in China continued on laser frequencies and adaptive optics, which can help to maintain laser beam quality over long distances. Though not a dedicated programme, this basic research could eventually support ground-based and airborne ASATs. In 2005, more advanced work on ground-based kinetic kill weapons was also conducted in China, the Russian Federation, the United Kingdom and the United States. The US conventional kinetic energy ASAT programme was awarded a contract to develop three advanced kill-vehicles. The United States continued to develop its Ground-based Midcourse Defense system and the Russian Federation upgraded the A-135 anti-ballistic missile system. China, the United Kingdom and the European Aeronautic Defence and Space Company conducted basic research into kinetic kill-vehicles for missile defence. Such kinetic kill interceptors could serve as ASATs.

Although less developed, there has also been a proliferation of space-based negation-enabling capabilities. Space-based negation would require sophisticated capabilities such as precision in-orbit manoeuvrability and space tracking, capabilities that have dual-use potential. The United States leads in the development of most of these enabling capabilities, though none appears to be integrated into dedicated space-based negation systems and enabling capabilities continued to proliferate in 2005. The US XSS-11 and DART micro-satellites demonstrated dual-use rendezvous and surveillance capabilities. Both Japan and the United States conducted asteroid interception missions in 2005, which used key negation-enabling capabilities such as tracking, firing and monitoring. Robotic technologies for on-orbit servicing such as the Robotic Components Verification on ISS (ROKVISS) system were demonstrated on the International Space Station. The Defense Advanced Research Projects Agency (DARPA) expressed interest in developing capacity for in-orbit servicing, repair and orbit manipulation using space robotics. Finally, China, Europe and the United States conducted research, development and testing of homing sensors that could be used for a range of space systems negation applications.

SPACE-BASED STRIKE WEAPONS

Although the former Soviet Union and the United States developed and tested ground-based and airborne ASAT systems between the 1960s and 1990s, there has not yet been any deployment of space-to-Earth or space-to-missile space-based strike weapons (SBSW) systems. Under the Strategic Defense Initiative in the 1980s, the United States invested several billion dollars in the development of a space-based interceptor (SBI) concept called Brilliant Pebbles. The former Soviet Union and the United States directed energy programmes of the 1980s for SBSW systems have largely been halted. The US Near Field Infrared Experiment (NFIRE), originally due for launch in 2006, was to be the first fully integrated SBSW spacecraft with a sensor platform and kinetic kill-vehicle. In 2005, the Missile Defense Agency (MDA) removed the “kill-vehicle” portion of the planned NFIRE test saying it posed a risk of technical failure. Further MDA plans include the deployment of a test-bed of three to six integrated SBIs by 2011–2012.

Although no SBSW have been deployed, a growing number of actors are developing SBSW precursor technologies outside of SBSW programmes. The majority of SBSW prerequisite technologies are dual use. They are not related to dedicated SBSW programmes, but are sought through other civil, commercial or military space programmes. While there is no evidence to suggest that states pursuing these enabling technologies intend to use them for SBSW systems, their development does bring these actors technologically closer to such a capability. Both the number of such technologies being pursued in non-SBSW programmes and the number of actors doing so are increasing: 32 states have developed or are developing independent high-precision satellite navigation capabilities. Since 1994, nine states have deployed a first small or micro-satellite—a key SBI precursor technology. China and the European Union are developing re-entry technologies that are also required for the delivery of mass-to-target weapons from space to Earth.

In 2005, Europe, China, the Russian Federation and the United States maintained research and development on re-entry technologies relevant to potential orbital bombardment systems. Upgrades were made in 2005 to the Russian and US global missile tracking and warning systems—foundational technologies for any future space-based missile interceptor. While lagging far behind the Russian Federation and the United States on missile tracking, China conducted basic research on how to obtain greater missile-tracking precision and real-time accuracy. China, the European Union, India, the Russian Federation and the United States continued research and development on global positioning systems, a precursor technology of use in certain SBSW systems.

Note

1 This article is based on a longer study of space security entitled "Space Security 2006"; the full report can be accessed at <www.spacesecurity.org/SSI2006.pdf>. The members of the Spacesecurity.org research consortium include the Cypress Fund for Peace and Security, the Institute of Air and Space Law at McGill University, the International Security Research and Outreach Programme of Foreign Affairs and International Trade Canada, Project Ploughshares, the Simons Centre for Disarmament and Non-Proliferation Research at the University of British Colombia and the Space Generation Foundation.