SPACE SECURITY INDEX
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SPACE SECURITY INDEX 2013 | EXECUTIVE SUMMARY

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Cover image: Soyuz TMA-07M Spacecraft ISS034-E-010181 (21 Dec. 2012) As the International Space Station and Soyuz TMA-07M spacecraft were making their relative approaches on Dec. 21, one of the Expedition 34 crew members on the orbital outpost captured this photo of the Soyuz. Credit: NASA.

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INTRODUCTION

Space Security Index 2013 is the tenth annual report on developments related to safety, sustainability, and security in outer space, covering the period January-December 2012. It is part of the broader Space Security Index (SSI) project, which aims to improve transparency on space activities and provide a common, comprehensive, objective knowledge base to support the development of national and international policies that contribute to the security and sustainability of outer space.

The definition of space security guiding this report reflects the intent of the 1967 Outer Space Treaty that outer space should remain open for all to use for peaceful purposes now and into the future:

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

The primary consideration in this SSI definition of space security is not the interests of particular national or commercial entities, but the security and sustainability of outer space as an environment that can be used safely and responsibly by all. This broad definition encompasses the security of the unique outer space environment, which includes the physical and operational integrity of manmade objects in space and their ground stations, as well as security on Earth from threats originating in space.

Regular readers will notice a change in the way the information is structured in this report. In previous editions, key developments were organized under eight Chapters—each covering one major aspect of space activity (e.g., civil, commercial, policy, military, etc.). However, given the increasing interdependence, mutual vulnerabilities, and synergies of outer space activities, the decision was made, after consultations with several international space security experts, to reorganize information under four broad Themes, with each divided into various indicators of space security. We trust that this arrangement, as well as reducing repetition, better reflects the close relationship among developments that may have an impact on the security and sustainability of outer space. The structure of the 2013 report is as follows:

» **Theme 1:** Condition of the space environment
  Indicator 1.1: *Orbital debris*
  Indicator 1.2: *Radio frequency (RF) spectrum and orbital positions*
  Indicator 1.3: *Near-Earth Objects*
  Indicator 1.4: *Space weather*
  Indicator 1.5: *Space situational awareness*

» **Theme 2: Access to and use of space by various actors**
Indicator 2.1: *Space-based global utilities*
Indicator 2.2: *Priorities and funding levels in civil space programs*
Indicator 2.3: *International cooperation in space activities*
Indicator 2.4: *Growth in commercial space industry*
Indicator 2.5: *Public-private collaboration on space activities*
Indicator 2.6: *Space-based military systems*

» **Theme 3: Security of space systems**
Indicator 3.1: *Vulnerability of satellite communications, broadcast links, and ground stations*
Indicator 3.2: *Protection of satellites against direct threats*
Indicator 3.3: *Capacity to rebuild space systems and integrate smaller satellites into space operations*
Indicator 3.4: *Earth-based capabilities to attack satellites*
Indicator 3.5: *Space-based negation enabling capabilities*

» **Theme 4: Outer space policies and governance**
Indicator 4.1: *National space policies and laws*
Indicator 4.2: *Multilateral forums for space governance*
Indicator 4.3: *Other initiatives*

It was also decided by members of the SSI Governance Group to add a brief Global Assessment analysis, which will be featured in the full edition of the report. It will provide a broad assessment of the trends, priorities, highlights, breaking points, and dynamics that are shaping current space security discussions.

Until this present edition, each annual report included a brief "Space Security Impact" statement after each indicator of space security. The SSI Governance Group determined that such statements, in isolation, offered an inadequate assessment of outer space security, given the interdependence of space activities. A single, holistic assessment brings together the different ways in which the overall security of outer space is being affected by space activity.

The Global Assessment will be assigned to a different space security expert every year to encourage a range of perspectives. The inaugural essay is by Claire Jolly, senior policy analyst with the International Futures Programme in the Directorate for Science, Technology and Industry of the Organisation for Economic Co-operation and Development (OECD).

The Space Security Index attempts to take stock of all factors that may have an impact on the sustainability of outer space. Critical are such concerns as the threat posed by space debris, the priorities of national civil space programs, the growing importance of the commercial space industry, efforts to develop a robust normative regime for outer space activities, and the militarization and potential weaponization of space.

From search-and-rescue operations to weather forecasting, banking to arms control treaty verification, the world has become increasingly reliant on space applications. The key challenge is to maintain a sustainable outer space domain so that the social and economic benefits derived from it can continue to be enjoyed by present and future generations.

More and more human-created space debris is orbiting the Earth. It is concentrated in the most commonly used parts of Low-Earth Orbit (LEO). In recent years awareness of the space debris problem has grown considerably, largely because various spacecraft have been hit by pieces of debris, intentional debris-generating events have occurred, and satellites have collided with one another. Thus efforts to mitigate the production of new debris through compliance with national and international guidelines are highly important. The future development and deployment of technology to remove debris promise to increase the sustainability of outer space.

If used to avoid collisions, space situational awareness (SSA) capabilities that track space debris also contribute to space security. Although greater international cooperation to enhance the predictability of space operations would advance space security, the sensitive nature of some information and the small number of leading space actors with advanced tools for surveillance have kept significant data on space activities shrouded in secrecy. But recent developments covered in this report suggest that there is now greater willingness to share SSA data through international partnerships.

The distribution of scarce space resources—including orbital slots and radio frequencies—to spacefaring nations has a direct impact on the ability of actors to access and use space. An increase in the number of space actors, particularly in the communications sector, has created more competition and sometimes friction over the use of orbital slots and frequencies, which have historically been allocated on a first-come, first-served basis.

International instruments that regulate space activities have a direct effect on space security because they establish key parameters for space activities. These include the right of all countries to access space, prohibitions against the national appropriation of space and placing nuclear weapons and weapons of mass destruction in space, and the obligation to ensure that space is used with due regard to the interests of others and for peaceful purposes. International space law can make space more secure by restricting activities that infringe upon the ability of actors to access and use space safely and sustainably, and by limiting space-based threats to national assets in space or on Earth.

While there is widespread international recognition that the existing regulatory framework is insufficient to meet the current challenges facing the outer space domain, the development of an overarching normative regime has been painfully slow. International space actors have been unable to reach consensus on the exact nature of a space security regime, despite having specific alternatives on the table for consideration: both legally binding treaties, such as the Sino-Russian proposed ban on space weapons (known as the PPWT) and politically binding norms of behavior, such as the European Union's proposed International Code of Conduct for Outer Space Activities. The establishment of a Group of Governmental Experts on Space by the UN General Assembly (UNGA) and of the Committee on the Peaceful Uses of Outer Space (COPUOS) Working Group on the Long Term Sustainability of Space Activities, both of which held their first formal meetings in 2012, are seen as positive efforts toward the adoption of agreed transparency and confidence-building measures for space activities.

International cooperation remains central to both civil space programs and global utilities; this interaction affects space security positively by enhancing the transparency of certain civil programs. Collaborative endeavors in civil space programs can help emerging space actors access and use space. International cooperation makes possible complex and expensive projects in space, such as the International Space Station and space exploration.

The role that the commercial space sector plays in the provision of launch, communications, imagery, and manufacturing services and its relationship with government, civil, and military programs make this sector an important determinant of space security. A healthy space industry can lead to decreasing costs for space access and use, and may increase the accessibility of space technology for a wider range of space actors. This can have a positive impact on space security by increasing the number of actors that have a vested interest in the maintenance of space security.

The military space sector is an important driver in the advancement of capabilities to access and use space. It has played a key role in bringing down the cost of space access. Many of today's common space applications, such as satellite-based navigation, were first developed for military use. Space systems have augmented the military capabilities of a number of states by enhancing battlefield awareness, offering precise navigation and targeting support, providing early warning of missile launch, and supporting real-time communications. Furthermore, remote sensing satellites have served as a technical means for nations to verify compliance with international nonproliferation, arms control, and disarmament regimes.

Space capabilities and space-derived information are integrated into the day-to-day military planning of major spacefaring states. Greater military use of space can have a positive effect on space security by raising awareness of mutual vulnerabilities and increasing the collective vested interest in space security. Conversely, the use of space systems to support terrestrial military operations can be detrimental to space security if adversaries, viewing space as a new source of military threat or as critical military infrastructure, develop space system negation capabilities to neutralize the space systems of adversaries. In this sense, the security dynamics of space protection and negation are closely related and space security cannot be divorced from terrestrial security. Under some conditions protective systems can motivate adversaries to develop weapons to overcome them.

The information contained in *Space Security Index 2013* 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. Project partners and sponsors trust that this publication will continue to serve as both a reference source and a tool to aid policy making, with the ultimate goal of enhancing the sustainability of outer space for all users.

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

1) Experts on space security are asked to provide critical feedback on the draft research, which is sent to them electronically.
2) The Space Security Working Group in-person consultation is held each spring for two days to review the draft text for factual errors, misinterpretations, gaps, and misstatements about the impact of various events. This meeting also provides an important forum for related policy dialogue on recent outer space developments.
3) Finally, the Governance Group for the Space Security Index reviews 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 free of any charge in PDF format. Comments and suggestions to improve the project are welcome.

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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.

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EXECUTIVE SUMMARY

Theme 1:
Condition of the space environment

INDICATOR 1.1: Orbital debris — Space debris poses a significant, constant, and indiscriminate threat to all spacecraft. Most space missions create some space debris, mainly rocket booster stages that are expended and released to drift in space along with bits of hardware. Serious fragmentations are usually caused by energetic events such as explosions. These can be both unintentional, as in the case of unused fuel exploding, or intentional, as in the testing of weapons in space that utilize kinetic energy interceptors. Traveling at speeds of up to 7.8 kilometers (km) per second, even small pieces of space debris can destroy or severely disable a satellite upon impact. The number of objects in Earth orbit has increased steadily.

Today the U.S. Department of Defense (DoD) is using the Space Surveillance Network to catalog more than 16,000 objects approximately 10 centimeters (cm) in diameter or larger. Roughly 23,000 pieces of debris of this size are being tracked, but not cataloged; the U.S. military only catalogs objects with known owners. Experts estimate that there are over 300,000 objects with a diameter larger than one centimeter and several million that are smaller. The annual rate of new tracked debris began to decrease in the 1990s, largely because of national debris mitigation efforts, but accelerated in recent years as a result of events such as the Chinese intentional destruction of one of its satellites in 2007 and the accidental 2009 collision of a U.S. Iridium active satellite and a Russian Cosmos defunct satellite.

The total amount of manmade space debris in orbit is growing each year, concentrated in the orbits where human activities take place. Low Earth Orbit is the most highly congested area, especially the Sun-synchronous region. Some debris in LEO will reenter the Earth's atmosphere and disintegrate quite quickly due to atmospheric drag, but debris in orbits above 600 km will remain a threat for decades and even centuries. There have already been a number of collisions between civil, commercial, and military spacecraft and pieces of space debris. Although a rare occurrence, the reentry of very large debris could also potentially pose a threat on Earth.

2012 Developments

Known space object population

- Cataloged debris population decreases; number of active objects on orbit continues to grow
- U.S. Space Surveillance Network continues to update satellite catalog

Debris-related risks and incidents

- Orbital debris continues to threaten safe space operations of both satellites and the International Space Station
- The risk posed by debris and satellite reentries continued in 2012, but was more actively managed

International awareness of debris problem increases as progress in solutions continues

- Mixed compliance with international debris mitigation guidelines
- International dialogues on debris problem, active debris removal, and other solutions continue in 2012
- Research and development on active debris removal continue in 2012

INDICATOR 1.2: Radio frequency (RF) spectrum and orbital positions — The growing number of spacefaring nations and satellite applications is driving the demand for access to radio frequencies and orbital slots. Issues of interference arise primarily when two spacecraft require the same frequencies at the same time and their fields of view overlap or they are transmitting in close proximity to each other. While interference is not epidemic it is a growing concern for satellite operators, particularly in crowded space segments. More satellites are locating in Geostationary Earth Orbit (GEO), using frequency bands in common and increasing the likelihood of frequency interference.

While crowded orbits can result in signal interference, new technologies are being developed to manage the need for greater frequency usage, allowing more satellites to operate in closer proximity without interference. Satellite builders and operators are coping by developing new technologies and procedures to manage greater frequency usage. For example, frequency hopping, lower power output, digital signal processing, frequency-agile transceivers, and a software-managed spectrum have the potential to significantly improve bandwidth use and alleviate conflicts over bandwidth allocation.

Research has also been conducted on the use of lasers for communications, particularly by the military. Lasers transmit information at very high bit rates and have very tight beams, which could allow for tighter placement of satellites, thus alleviating some of the current congestion and concern about interference. Newer receivers have a higher tolerance for interference than those created decades ago. The 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 (ITU) has been pursuing reforms to address slot allocation backlogs and other related challenges.

2012 Developments

Pressure on the radio frequency spectrum continues to grow

- Growing demand for and crowding of terrestrial RF spectrum with potential impacts on space RF spectrum
- Increased efforts to reduce unintentional radio frequency interference

INDICATOR 1.3: Near-Earth Objects — Near-Earth Objects (NEOs) are asteroids and comets in orbits that bring them into close proximity to the Earth. NEOs are subdivided into Near Earth Asteroids (NEAs) and Near Earth Comets (NECs). Within both groupings are Potentially Hazardous Objects (PHOs), those NEOs whose orbits intersect that of Earth and have a relatively high chance of impacting the Earth itself. As comets represent a very small portion of the overall collision threat in terms of probability, most NEO researchers commonly focus on Potentially Hazardous Asteroids (PHAs). A PHA is defined as an asteroid whose orbit comes within 0.05 astronomical units of the Earth's orbit and has a brightness magnitude greater than 22 (approximately 150 meters in diameter). By the end of 2012 there were 9,448 known NEAs, 857 of which were one km in diameter or larger.

Over the past decade a growing amount of research has identified objects that pose threats to Earth and developed potential mitigation and deflection strategies. The effectiveness of deflection—a difficult process because of the extreme mass, velocity, and distance of any potentially impacting NEO—depends on the amount of warning time. Kinetic deflection methods include ramming the NEO with a series of kinetic projectiles. The increasing international awareness of the potential threat posed by NEOs has prompted discussions at various multilateral forums on the technical and policy challenges related to mitigation. Ongoing technical research is exploring how to mitigate a NEO collision with Earth. The challenge is considerable due to the extreme mass, velocity, and distance of any impacting NEO. Some experts have advocated using nearby explosions of nuclear devices, which could create additional threats to the environment and stability of outer space and would have complex legal and policy implications.

2012 Developments

- Space agencies, amateur observers produce increasingly accurate assessment of NEO population
- International awareness of NEO threat and progress in international response continues

INDICATOR 1.4: Space weather — "Space weather" describes changing environmental conditions in near-Earth space. Explosions on the Sun create storms of radiation, fluctuating magnetic fields, and swarms of energetic particles. These phenomena travel outward through the solar system with a flow of charged particles called solar wind. When they reach Earth they interact in complex ways with Earth's magnetic field.

Some space weather storms can damage satellites and disrupt cell phone communications systems. Space is filled with magnetic fields, which control the motions of charged particles. Geomagnetic storms and more solar ultraviolet emissions heat the Earth's upper atmosphere, causing it to expand, eventually resulting in increased drag. Satellites slow down and change orbit slightly.

As technology has allowed spacecraft components to become smaller, their miniaturized systems have become increasingly vulnerable to solar energetic particles. These particles can often cause physical damage to microchips and change software commands in satellite-borne computers. Another problem for satellite operators is that when a satellite travels through this energized environment electrical discharges can harm and possibly disable spacecraft components.

2012 Developments

- Space weather events continue to affect space operations
- Progress continues on effectively forecasting space weather events

INDICATOR 1.5: Space Situational Awareness — Space Situational Awareness refers to the ability to detect, track, identify, and catalog objects in outer space, such as space debris and active or defunct satellites, as well as observe space weather and monitor spacecraft and payloads for maneuvers and other events. SSA enhances the ability to distinguish space negation attacks from technical failures or environmental disruptions and can thus contribute to stability in space by preventing misunderstandings and false accusations of hostile actions. Increasing the amount of SSA data available to all states can help to increase the transparency and confidence of space activities, which can reinforce the overall stability of the outer space regime.

The Space Surveillance Network (SSN) puts the United States far in advance of the rest of the world in space situational awareness capability. Russia has relatively extensive capabilities in this area; it maintains a Space Surveillance System using early-warning radars and monitors objects (mostly in LEO), although it does not widely disseminate data. China and India have significant satellite tracking, telemetry, and control assets essential to their civil space programs. The EU, Canada, France, Germany, and Japan are all developing space surveillance capabilities for various purposes, although none of these states is close to developing a global system on its own.

Sharing SSA data could benefit all space actors, allowing them to supplement their own data at little if any additional cost. But there is currently no operational global system for space surveillance, in part because of the sensitive nature of surveillance data. Since the 2009 Cosmos-Iridium satellite collision there has been an increased push in the United States to boost conjunction analysis—the ability to accurately predict high-speed collisions between two orbiting objects—and to undertake collaborative agreements with international partners that will allow for an increase in data sharing, As the importance of space situational awareness is acknowledged, more states are pursuing national space surveillance systems and engaging in discussions over international SSA data sharing.

2012 Developments

Capabilities

- The United States continues to invest in and develop its SSA capabilities
- Plans to improve SSA capabilities continue around the world in 2012

SSA sharing

- Efforts continue to increase SSA sharing among various space actors

Theme 2:
Access to and use of space by various actors

INDICATOR 2.1: Space-based global utilities — The use of space-based global utilities has grown substantially over the last decade. Millions of individuals rely on space applications on a daily basis for functions as diverse as weather forecasting, navigation, communications, and search-and-rescue operations. Global utilities are important for space security because they broaden the community of actors that have a direct interest in maintaining space for peaceful uses.

While key global utilities such as the Global Positioning System (GPS) and weather satellites were initially developed by military actors, these systems have grown into space applications that are almost indispensable to the civil and commercial sectors and spawned such equally indispensable applications as weather monitoring and remote sensing. Advanced and developing economies alike depend on these space-based systems. Currently Russia, the United States, the EU, Japan, China, and India have or are developing satellite-based navigation capabilities.

Remote sensing satellites are used extensively for a variety of Earth observation (EO) functions, including weather forecasting; surveillance of borders and coastal waters; monitoring of crops, fisheries, and forests; and monitoring of natural disasters such as hurricanes, droughts, floods, volcanic eruptions, earthquakes, tsunamis, and avalanches. Space has also become critical for disaster relief. COSPAS-SARSAT, the International Satellite System for Search and Rescue, was founded by Canada, France, the USSR, and the United States to coordinate satellite-based search-and-rescue. COSPAS-SARSAT is basically a distress alert detection and information distribution system that provides alert and location data to national search-and-rescue authorities worldwide, with no discrimination, independent of country participation in the management of the program. Similarly, in 2006 the UN General Assembly agreed to establish the UN Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER).

Although satellite-based systems can increase the accuracy and reliability of navigation, their simultaneous operation presents significant coordination challenges.

2012 Developments

- Navigation systems of various nations continue to evolve
- Australia develops lightweight Earth observation satellite
- Iran launches Earth observation satellite
- South Africa to launch its first nanosatellite
- Meteosat Third Generation Agreement signed at Ministerial Meeting

INDICATOR 2.2: Priorities and funding levels in civil space programs — Civil space programs can have a positive impact on the security of outer space because they constitute key drivers behind the development of technical capabilities to access and use space, such as those related to the development of space launch vehicles. As the number of space actors able to access space increases, more parties have a direct stake in space sustainability and preservation for peaceful purposes. As well, civil space programs and their technological spinoffs on Earth underscore the vast scientific, commercial, and social benefits of space exploration, thereby increasing global awareness of its importance.

As the social and economic benefits derived from space activities have become more apparent, civil expenditures on space activities have continued to increase in several countries. Virtually all new spacefaring states explicitly place a priority on space-based applications to support social and economic development. Such space applications as satellite navigation and Earth imaging are core elements of almost every existing civil space program. Likewise, Moon exploration continues to be a priority for such established spacefaring states as China, Russia, India, and Japan.

New launch vehicles continue to be developed. Since the cancellation of the Constellation program, the United States has focused on encouraging development of new launchers by the private sector rather than the National Aeronautics and Space Administration (NASA). The China Academy of Launch Vehicle Technology (CALT) is proceeding with development of the Long March-5, the next generation of launch vehicles. Russia continues to develop the new Angara family of space launchers, which are to replace some of the aging Molniya-M launch vehicles currently in service.

2012 Developments
- Changing budgetary allotments in civil space programs
- China conducts first manned mission to Tiangong-1 space station
- Canada renews commitment to International Space Station

INDICATOR 2.3: International cooperation in space activities — Due to the huge costs and technical challenges associated with access to and use of space, international cooperation has been a defining feature of civil space programs throughout the space age. Scientific satellites, in particular, have been cooperative ventures. International cooperation remains a key feature of both civil and global utilities space programs. In particular cooperation enhances the transparency of certain civil programs that could potentially have military purposes.

The most prominent example of international cooperation continues to be the International Space Station (ISS), a collaborative project of NASA, Russian space agency Roscosmos, the European Space Agency (ESA), the Japan Aerospace Exploration Agency (JAXA), and the Canadian Space Agency (CSA). A multinational effort with a focus on scientific research and an estimated cost of over $100-billion to date, the ISS is the largest, most expensive international engineering project ever undertaken.

By allowing states to pool resources and expertise, international civil space cooperation has played a key role in the proliferation of the technical capabilities needed by states to access space. Cooperation agreements on space activities have proven to be especially helpful for emerging spacefaring states that currently lack the technological means for independent space access. Cooperation agreements also enable established spacefaring countries to tackle high-cost, complex missions as collaborative endeavors with international partners.

The high costs and remarkable technical challenges associated with human spaceflight are likely to make collaborative efforts in this area increasingly common. In 2007 the 14 largest space agencies agreed to coordinate future space missions in the document *The Global Exploration Strategy: The Framework for Coordination*, which highlights a shared vision of space exploration, focused on the Moon and Mars. It calls for a voluntary forum to assist coordination and collaboration for sustainable space exploration, although it does not establish a global space program.

2012 Developments

- United States signs data-sharing agreement with Canada; eyes other countries
- China deepens cooperation on space activities with various countries
- European Commission and South Africa Space Agency enter scientific cooperation agreement
- Hungary, Poland, and Romania launch their first satellites
- Russia offers post-mission rehab to ISS astronauts

INDICATOR 2.4: Growth in commercial space industry — The commercial space sector has experienced dramatic growth over the past decade. Companies that own and operate satellites and the ground support centers that control them are experiencing rapidly increasing revenues. Companies that manufacture satellites and ground equipment have also seen significant growth. Such companies include both direct contractors that design and build large systems and vehicles, smaller subcontractors responsible for system components, and software providers. More individual consumers are demanding these services, particularly satellite television and personal GPS devices. From satellite manufacturing and launch services to advanced navigation products and the provision of satellite-based communications, the global commercial space industry is thriving, with estimated annual revenues in excess of $200-billion.

In addition to orders for satellite fleet replenishment, manufacturers and launch providers are looking to the robust demand for new space-based services to spur new satellite orders. The role that the commercial space sector plays in the provision of launch, communications, imagery, and manufacturing services, as well as its relationship with government, civil, and military programs, make this sector an important determinant of space security. A healthy space industry can lead to decreasing costs for space access and use, and may increase the accessibility of space technology for a wider range of space actors. Increased commercial competition in the research and development of new applications can also lead to the further diversification of capabilities to access and use space.

2012 Developments

Growth in satellite market

- Satellite market continues to expand
- Space X delivers first commercial payload to ISS
- Commercial launch market continues growth

Space tourism

- Virgin Galactic SpaceShipTwo reaches milestone
- Golden Spike Company plans lunar commercial missions
- Actress Sarah Brightman announced as next ISS tourist

Commercial spaceports

- Various commercial spaceports under development

Commercial operators

- Satellite broadband service expands to commercial airlines
- Analysts and industry predict continued satellite industry growth
- Companies announce plans to mine asteroids
- LightSquared files for bankruptcy

INDICATOR 2.5: Public-private collaboration on space activities — The commercial space sector is significantly shaped by the particular security concerns of national governments. There is an increasingly close relationship between governments and the commercial space sector. Various national space policies place great emphasis on maintaining a robust and competitive industrial base and encourage partnerships with the private sector. The space launch and manufacturing sectors rely heavily on government contracts. The retirement of the space shuttle in the United States, for instance, will likely open up new opportunities for the commercial sector to provide launch services for human spaceflight.

Governments function as partners and regulators, while national militaries are increasingly reliant on commercial services. Governments play a central role in commercial space activities by supporting research and development, subsidizing certain space industries, and adopting enabling policies and regulations. Conversely, because space technology is often dual-use, governments have sometimes taken actions, such as the imposition of export controls, which hinder the growth of the commercial market.

There is evidence of increased dialogue between commercial actors and governments on such issues as space traffic management and space situational awareness. National export regulations could gradually be influenced by the growing number of international partnerships formed by the commercial sector.

There are challenges with public-private collaboration on space activities. The growing dependence of certain segments of the commercial space industry on military clients could have an adverse impact on space security by making commercial space assets the potential target of military attacks.

2012 Developments

- United Kingdom provides financial boost to space commercial sector
- European Defence Agency procures commercial bandwidth
- NASA awards contracts, funding to various commercial companies
- United Launch Alliance receives contracts for 11 launches from U.S. Air Force

INDICATOR 2.6: Space-based military systems — The United States has dominated the military space arena since the end of the Cold War and continues to give priority to its military and intelligence programs. Building upon the capabilities of its GPS, the United States began to expand the role of military space systems. They are now integrated into virtually all aspects of military operations: providing indirect strategic support to military forces and enabling the application of military force in near-real-time tactical operations through precision weapons guidance.

Russia maintains the second largest fleet of military satellites. Its early warning, imaging intelligence, communications, and navigation systems were developed during the Cold War. The Chinese government's space program does not maintain a strong separation between civil and military applications. Officially, its space program is dedicated to science and exploration, but as with the programs of many other actors, it is widely believed to provide support to the military.

The Indian National Satellite System is one of the most extensive domestic satellite communications networks in Asia. To enhance its use of GPS, the country has been developing GAGAN, the Indian satellite-based augmentation system. This will be followed by the Indian Regional Navigation Satellite System (IRNSS), which is to provide an independent satellite navigation capability. Although these are civilian-developed and -controlled technologies, they are used by the Indian military for its applications.

States such as Australia, Canada, France, Germany, Japan, Israel, Italy, and Spain have recently been developing multiuse satellites with a wider range of functions. As security becomes a key driver of these space programs, expenditures on multiuse space applications go up. In the absence of dedicated military satellites, many actors use their civilian satellites for military purposes or purchase data and services from civilian satellite operators.

2012 Developments

Military space systems in major spacefaring nations

- The United States continues to update existing space capabilities
- Russia continues to update space capabilities
- China continues deploying space-based military capabilities
- India continues improving its remote sensing satellites

Military and multiuse space capabilities in other countries

- Mexico, Brazil to enhance their telecommunications capabilities
- Iran continues to develop its space capabilities, despite launch failures
- Israel continues to build space capabilities in the past year
- North Korea launches Earth observation satellite

Theme 3: Security of space systems

INDICATOR 3.1: Vulnerability of satellite communications, broadcast links, and ground stations — Satellite ground stations and communications links constitute likely targets for space negation efforts, since they are vulnerable to a range of widely available conventional and electronic weapons. While military satellite ground stations and communications links are generally well protected, civil and commercial assets tend to have fewer protective features. Many commercial space systems have only one operations center and one ground station, making them particularly vulnerable to negation efforts.

The vulnerability of civil and commercial space systems raises security concerns, since a number of military space actors are becoming increasingly dependent on commercial space assets for a variety of applications. Satellite communications links require specific electronic protective measures to safeguard their utility. Although unclassified information on these capabilities is difficult to obtain, it can be assumed that most space actors are able to take advantage of simple but reasonably robust electronic protective measures. Sophisticated electronic protective measures were traditionally unique to the military communications systems of technologically advanced states, but they are slowly being expanded to commercial satellites.

While many actors employ passive electronic protection capabilities, such as shielding and directional antennas, more advanced measures, such as burst transmissions, are generally confined to military systems and the capabilities of more technically advanced states. Because the vast majority of space assets depend on cyber networks, the link between cyberspace and outer space constitutes a critical vulnerability. Satellite communications links require specific electronic protective measures to safeguard their utility.

2012 Developments

- United States begins enforcement of ban on distribution of personal GPS jamming equipment
- High Integrity Global Positioning System (HIGPS) capability prepares for full operational deployment
- Eutelsat to field test anti-jamming capability
- Chairman of the Joint Chiefs of Staff recommends establishment of United States Cyber Command (USCYBERCOM) as a unified command

INDICATOR 3.2: Protection of satellites against direct threats — Direct interference with satellites by conventional, nuclear, or directed energy weapons is much more difficult to defend against than attacks against ground stations. The primary source of protection for satellites stems from the difficulties associated with launching an attack of conventional weapons into and through the space environment to specific locations. Passive satellite protective measures include system redundancy and interoperability, which have become characteristics of satellite navigation systems.

While no hostile anti-satellite (ASAT) attacks have been carried out, recent incidents, such as the 2007 ASAT test in which China destroyed one of its own satellites and the 2008 U.S. destruction of USA-193 using a modified SM-3 missile, testify to the availability and effectiveness of missiles to destroy an adversary's satellite. Space-based surveillance systems, such as the Space Tracking and Surveillance System (STSS) and Space Fence, enhance the ability to detect potential negation efforts.

It is almost impossible to provide a physical hardening of satellites that protects them from conventional weapons, such as kinetic hit-to-kill, explosive, or pellet clouds. Directed energy weapons can make use of a ground-based laser directed at a satellite to temporarily dazzle or disrupt sensitive optics. Optical imaging systems on a remote sensing satellite or other sensors, such as the infrared Earth sensors that are part of the attitude control system of most satellites, would be most susceptible to laser interference. Since the attacker must be in the line of sight of the target, opportunities for attack are limited to the available territory below the satellite.

Dispersing capabilities to a number of satellite operations can be used as a protective measure. Dispersion through the use of a constellation both increases the number of targets that must be negated and increases system survivability. Redundancy in satellite design and operations also offers a number of protective advantages. Since onsite repairs in space are not cost effective, some satellites employ redundant electronic systems to avoid single-point failures.

2012 Developments

- U.S. Air Force delays decision to deploy disaggregated satellite missions

INDICATOR 3.3: Capacity to rebuild space systems and integrate smaller satellites into space operations — The ability to rapidly rebuild space systems after an attack could reduce vulnerabilities in space. The capabilities to refit space systems by launching new satellites into orbit in a timely manner to replace satellites damaged or destroyed by an attack are critical resilience measures. Multiple programs show the prioritization of, and progress in, new technologies that can be integrated quickly into space operations. Smaller, less expensive spacecraft that may be fractionated or distributed on hosts can improve continuity of capability and enhance security through redundancy and rapid replacement of assets. While these characteristics may make attack against space assets less attractive, they can also make assets more difficult to track, and so inhibit transparency. Although the United States and Russia are developing elements of responsive space systems, no state has perfected this capability.

A key U.S. responsive launch initiative is the Falcon program developed by Space Exploration Technologies (SpaceX), which consists of launch vehicles capable of rapidly placing payloads into LEO and GEO. Organized under NASA's Commercial Orbital Transportation Services (COTS) program, the Falcon 9 uses less expensive components and systems than traditional rockets, including nine kerosene/liquid-oxygen-burning Merlin engines. Similarly, the development of fractionated architectures is meant to provide system redundancy and increase assurance of continued operation of critical space infrastructures.

2012 Developments

- ATK awarded DARPA Phoenix contract
- NASA's Robotic Refueling Mission and CSA's Dextre perform second satellite servicing task from ISS
- Initial Operational Capability declared for Operationally Responsive Space (ORS)-1 satellite
- Deployment of smallsats on the rise

INDICATOR 3.4: Earth-based capabilities to attack satellites — Some spacefaring nations possess the means to inflict intentional damage on an adversary's space assets. Ground-based anti-satellite weapons employing conventional, nuclear, and directed energy capabilities date back to the Cold War, but no hostile use of them has been recorded. Conventional anti-satellite weapons include precision-guided kinetic-intercept vehicles, conventional explosives, and specialized systems designed to spread lethal clouds of metal pellets in the orbital path of a targeted satellite.

A space launch vehicle with a nuclear weapon would be capable of producing a High Altitude Nuclear Detonation (HAND), causing widespread and immediate electronic damage to satellites, combined with the long-term effects of false radiation belts, which would have an adverse impact on many satellites. The application of some destructive space negation capabilities, such as kinetic-intercept vehicles, would also generate space debris that could potentially inflict widespread damage on other space systems and undermine the sustainability of outer space.

Security concerns about the development of negation capabilities are compounded by the fact that many key space capabilities are dual-use. For example, space launchers are required for many anti-satellite systems; microsatellites offer great advantages as space-based kinetic-intercept vehicles; and space surveillance capabilities can support both space debris collision avoidance strategies and targeting for weapons.

The United States, China, and Russia lead in the development of more advanced ground-based kinetic-kill systems that are able to directly attack satellites. Recent incidents involving the use of ASATs against their own satellites (China in 2007 and the United States in 2008) underscore the detrimental effect that such systems have for space security. Such use not only aggravates the space debris problem, but contributes to a climate of mistrust among spacefaring nations.

2012 Developments

- Jamming incidents and capabilities proliferate
- Missile systems pursued by various countries
- Directed energy weapons continue to be developed

INDICATOR 3.5: Space-based negation enabling capabilities — Deploying space-based ASATs—using kinetic-kill, directed energy, or conventional explosive techniques—would require enabling technologies somewhat more advanced than the fundamental requirements for orbital launch. Space-based negation efforts require sophisticated capabilities, such as precision on-orbit maneuverability and space tracking.

While microsatellites, maneuverability, and other autonomous proximity operations are essential building blocks for a space-based negation system, they have dual-use potential and are also advantageous for a variety of civil, commercial, and non-negation military programs. For example, microsatellites provide an inexpensive option for many space applications, but could be modified to serve as kinetic-kill vehicles or offer targeting assistance for other kinetic-kill vehicles. Space-based weapons targeting satellites with conventional explosives could potentially employ microsatellites to maneuver near a satellite and explode within close range. Microsatellites are relatively inexpensive to develop and launch and have a long lifespan; their intended purpose is difficult to determine until detonation.

On-orbit servicing is also a key research priority for several civil space programs and supporting commercial companies. While some nations have developed these technologies, there is no evidence that they have integrated on-orbit servicing into a dedicated space-based negation system.

2012 Developments

- Orbital rendezvous and docking capabilities continue to be pursued

Theme 4: Outer Space policies and governance

INDICATOR 4.1: National space policies and laws — The development of national space policies that delineate the principles and objectives of space actors with respect to access to and use of space has been conducive to greater transparency and predictability of space activities. National civil, commercial, and military space actors all operate according to these policies. Most spacefaring states explicitly support the principles of peaceful and equitable use of space, and emphasize space activities that promote national socioeconomic, scientific, and technological goals. Virtually all space actors underscore the importance of international cooperation in their space policies; several developing nations have been able to access space because of such cooperation.

However, the military doctrines of a growing number of states emphasize the use of space systems to support national security. Major space powers and emerging spacefaring nations increasingly view space assets such as multiuse space systems as integral elements of their national security infrastructure. As well, more states have come to view their national space industries as fundamental drivers and components of their space policies.

Bilateral cooperation agreements on space activities are increasingly common among spacefaring actors. A number of nations, including the United Kingdom, Germany, Australia, and the United States, have made innovation and development of industrial space sectors a key priority of their national space strategies.

2012 Developments

- U.K. Space Agency publishes its Civil Space Strategy
- Japan eases restrictions on military space development
- States in the United States enact legislation on spaceflight liability
- U.S. DoD Space Policy Directive and Defense Strategic Guidance issued
- United States eases export controls on some satellites and related components

INDICATOR 4.2: Multilateral forums for space governance — International institutions including the First Committee of the UN General Assembly, the UN Committee on the Peaceful Uses of Outer Space, the International Telecommunication Union, and the Conference on Disarmament (CD) constitute the key multilateral forums in which issues related to space security are addressed.

The UN General Assembly created COPUOS in 1958 to review the scope of international cooperation in the peaceful uses of outer space, develop relevant UN programs, encourage research and information exchanges on outer space matters, and study legal problems arising from the exploration of outer space. COPUOS and its two standing committees—the Scientific and Technical Subcommittee and the Legal Subcommittee—develop recommendations based on questions and issues put before them by UNGA and Member States.

In 2010 the Scientific and Technical Subcommittee established the Working Group on the Long-Term Sustainability of Outer Space Activities. In 2011 a working paper containing the proposal of the Chair for the terms of reference, method of work, and work plan for the Working Group was presented to the Subcommittee. The Working Group is to examine and propose measures to ensure the safe and sustainable use of outer space for peaceful purposes, for the benefit of all countries. It will prepare a report on the long-term sustainability of outer space activities that includes a consolidated set of current practices and operating procedures, technical standards, and policies associated with the safe conduct of space activities.

Also in 2011 the UN Secretary-General established, on the basis of equitable geographical distribution, a Group of Governmental Experts on Transparency and Confidence-building Measures (TCBMs) in Outer Space Activities to conduct a study commencing in 2012 and to report to UNGA in 2013.

While at the end of 2012 the adoption of a Program of Work remained an elusive pursuit for the Conference on Disarmament, overwhelming support for the resolution on the Prevention of an Arms Race in Outer Space (PAROS) at the UNGA indicates broad international consensus in support of consolidating and reinforcing the normative regime for space governance to enhance its effectiveness.

2012 Developments

- Various states deliver statements on PAROS at the CD, although the conference remains unable to agree on Program of Work
- COPUOS remains active; Working Group on Long-Term Sustainability of Space Activities holds first formal meetings
- First meeting of UN Group of Governmental Experts on TCBMs in Outer Space Activities convened
- ITU condemns satellite jamming

INDICATOR 4.3: Other initiatives — Historically, primary governance challenges facing outer space activities have been discussed at multilateral bodies related to, or under the auspices of, the United Nations, such as COPUOS, the General Assembly First Committee, or the CD. However, diplomatic efforts outside these forums have been undertaken.

A notable example is the process to develop an International Code of Conduct for Outer Space Activities. The European Union, which has led the process, made an early decision to carry out deliberations and consultations in an ad hoc manner, not bound by the decision-making rules of procedure of traditional UN bodies. Adoption of the Code would take place at an ad hoc diplomatic conference.

A growing number of diplomatic initiatives relate to bilateral or regional collaborations in space activities. Examples of this include the work of the Asia-Pacific Regional Space Agency Forum and discussions within the African Union to develop an African space agency. The UN Institute for Disarmament Research (UNIDIR)—an autonomous institute within the UN system—has also played a key role to facilitate dialogue among key space stakeholders. Every year UNIDIR partners with civil society actors and some governments to bring together space security experts and government representatives at a conference on emerging security threats to outer space.

2012 Developments

- EU kicks off multilateral consultation process on proposed International Code of Conduct for Outer Space Activities
- Various regional forums tackle space security, cooperation
- UNIDIR hosts 11th annual Space Security Conference

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