SPACE SECURITY INDEX 2012

www.spacesecurity.org

Full report at www.spacesecurity.org

SPACE SECURITY INDEX 2012

WWW.SPACESECURITY.ORG

Library and Archives Canada Cataloguing in Publications Data

Space Security Index 2012: Executive Summary

ISBN: 978-1-895722-90-1

Edited by Cesar Jaramillo

Design and layout by Creative Services,
University of Waterloo, Waterloo, Ontario, Canada

Cover image: This unusual image was photographed through the Cupola on the International Space Station by one of the Expedition 30 crew members. Taken December 29, 2011. Image Credit: NASA

Printed in Canada

Printer: Pandora Print Shop, Kitchener, Ontario

First published May 2012

Please direct inquires to:
Cesar Jaramillo
Project Ploughshares
57 Erb Street West
Waterloo, Ontario N2L 6C2
Canada
Telephone: 519-888-6541, ext. 7708
Fax: 519-888-0018
Email: cjaramillo@ploughshares.ca

INTRODUCTION

Space Security Index 2012 is the ninth annual report on developments related to security in outer space, covering the period January to December 2011. It is part of the broader Space Security Index project, which aims to improve transparency on space activities and provide a common, comprehensive 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 express 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 the 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 assets in space and their ground stations, as well as security on Earth from threats originating in space.

The developments covered by the report are organized according to eight chapters:

1) The space environment
2) Space situational awareness
3) Laws, policies, and doctrines
4) Civil space programs
5) Commercial space
6) Space support for terrestrial military operations
7) Space systems resiliency
8) Space systems negation.

The Space Security Index report attempts to take stock of all areas that may have an impact on the sustainability of outer space. In this context, issues such 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 concerns about the militarization and potential weaponization of space are critical.

From search-and-rescue operations to weather forecasting; from banking to arms control treaty verification, the world has become increasingly reliant on the benefits

of 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.

The total amount of human-created space debris in orbit continues to grow and is concentrated in the high value orbits where space assets are primarily located. In recent years awareness of the space debris problem has grown considerably, in part because various spacecraft have been hit by pieces of debris, intentional debris-generating events have occurred, and satellites have collided with one another. As a result, efforts to mitigate the production of new debris through compliance with national and international guidelines have become highly important. The future development and deployment of technology to remove debris promises to increase the sustainability of outer space.

Likewise, the development of space situational awareness capabilities to track space debris provides significant space security advantages if used to avoid collisions. 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 traditionally kept significant data on space activities shrouded in secrecy. But recent developments covered in this report suggest that there is a greater willingness to share space situational awareness data via international partnerships.

The distribution of scarce space resources, including the allocation of orbital slots and radio frequencies to spacefaring nations, has a direct impact on the ability of actors to access and use space. Growing numbers of space actors, particularly in the communications sector, have 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.

The existence of international policy instruments to regulate space activities has a direct impact on space security since 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 the placement of nuclear weapons and weapons of mass destruction in space, and the obligation to ensure that space is used for peaceful purposes. International space law can improve space security by restricting activities that infringe upon the ability of actors to access and use space safely and sustainably, or 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 address the current challenges facing the outer space domain, the development of an overarching normative regime has been painstakingly

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—either legally binding treaties, such as the Sino-Russian proposed ban on space weapons (known as the PPWT), or 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, which is to start deliberations in 2012, is widely seen as a positive step that may lead to the adoption of agreed transparency and confidence-building measures for space activities.

International cooperation remains a key aspect of both civil space programs and global utilities, affecting space security positively by enhancing transparency of the nature and purpose of certain civil programs. Collaborative endeavors in civil space programs can assist in the transfer of expertise and technology for the access to, and use of, space by emerging space actors. International cooperation can also help nations undertake vast collaborative projects in space, such as the International Space Station, or space exploration, the complex technical challenges and prohibitive costs of which are difficult for any one actor to assume.

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 can access and use space or space-based applications, thereby creating a wider pool of stakeholders with a vested interest in the maintenance of space security.

The military space sector is an important driver behind the advancement of capabilities to access and use space. It has played a key role in bringing down the cost of space access, and 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 several states by enhancing battlefield awareness, including precise navigation and targeting support, early warning of missile launch, and real-time communications. Furthermore, remote sensing satellites have served as a national technical means of verification of 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. This can have a positive effect on space security by increasing the collective vested interest in space security, as a

result of heightened mutual vulnerabilities. Conversely, the use of space 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 advantages of those systems. In this sense, the security dynamics of protection and negation are closely related and, under some conditions, protection systems can motivate adversaries to develop weapons to overcome them.

Although each major issue is covered in a different chapter, the *Space Security Index* report recognizes that the boundaries that separate civil, military, and commercial space assets are dissolving, creating interdependence and mutual vulnerabilities.

The information contained in *Space Security Index 2012* is solely 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 policymaking, 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) Technical and policy experts 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 in PDF format. Comments and suggestions to improve the project are welcome.

ACKNOWLEDGEMENTS

The research process for *Space Security Index 2012* was directed by Cesar Jaramillo at Project Ploughshares. Dr. Ram Jakhu and Dr. Peter Hays provided on-site supervision at, respectively, the Institute of Air and Space Law at McGill University and the Space Policy Institute at The George Washington University. The research team included:

Timiebi Aganaba, Institute of Air and Space Law, McGill University

Kate Becker, Space Policy Institute, George Washington University

Joyeeta Chatterjee, Institute of Air and Space Law, McGill University

Tiffany Chow, Secure World Foundation

Travis Cottom, Space Policy Institute, George Washington University

Laura Delgado, Institute for Global Environmental Strategies

Joel Hicks, Space Policy Institute, George Washington University

Diane Howard, Institute of Air and Space Law, McGill University

Samantha Marquart, Space Policy Institute, George Washington University

David McArthur, Space Policy Institute, George Washington University

Tabitha Smith, Space Policy Institute, George Washington University

The Governance Group for the Space Security Index would like to thank the research team and the many advisors and experts who have supported this project. Cesar Jaramillo has been responsible for overseeing the research process and logistics for the 2011-2012 project cycle. He provides the day-to-day guidance and coordination of the project and ensures that the myriad details of the publication come together. Cesar also supports the Governance Group and we want to thank him for the contribution he has made in managing the publication of this volume.

Thanks to Wendy Stocker at Project Ploughshares for copyediting, to Creative Services at the University of Waterloo for design work, and to Pandora Print Shop of Kitchener, Ontario for printing and binding. For comments on the draft research we are in debt to the international experts who provided feedback on each of the report's chapters during the online consultation process, and to the participants in the Space Security Working Group. For hosting the Space Security Working Group meeting held on 13-14 April 2012 in Montreal, we are grateful to the Institute of Air and Space Law at McGill University.

This project would not be possible without the generous financial and in-kind support from:

- Secure World Foundation
- The Simons Foundation
- Project Ploughshares
- International Security Research and Outreach Programme at Foreign Affairs and International Trade Canada
- Erin J.C. Arsenault Trust Fund at McGill University.

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.

Julie Crôteau

Peter Hays

Ram Jakhu

Paul Meyer

John Siebert

Ray Williamson

EXECUTIVE SUMMARY

The Space Environment

INDICATOR 1.1: Amount of 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 17,000 objects approximately 10 centimeters (cm) in diameter or larger. 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 has 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.

2011 Developments:

- Catalogued space debris population increases by 7.8 percent since 2010, with lowest number of fragmentation events since 2002
- 2011 sees the largest deployment of new spacecraft in a decade

Space Security Impact

Although 2011 saw an increase in the number of launches and new satellites put in orbit, it also saw the lowest number of fragmentation and debris-creating events in almost a decade. This trend is positive for the security of outer space. However, the overall number of pieces of tracked and catalogued debris and of active objects in orbit continues to increase, further congesting already crowded orbits and increasing the risk of accidental collisions. Several spacecraft, including the permanently inhabited International Space Station (ISS), have had to use evasive maneuvers on various occasions to avoid being hit by space debris. Some debris in low Earth orbit (LEO) will reenter the Earth's atmosphere and disintegrate relatively quickly because of atmospheric drag, but debris in orbits of more than 600 km in altitude will remain a threat for decades and even centuries.

INDICATOR 1.2: Awareness of space debris threat and efforts to develop and implement international measures to tackle the problem — Significant debris-generating events as well as improved tracking abilities have encouraged the recognition of space debris as a significant threat. The 2007 Anti-Satellite Weapon (ASAT) test conducted by China, the 2008 U.S. destruction of its failed USA-193 satellite, and the 2009 accidental collision between a Russian and a U.S. satellite have served to underscore the need for effective measures to curb the creation of space debris. Spacefaring states, including China, Japan, Russia, and the U.S., as well as the European Union (EU) have developed debris mitigation standards. The United Nations (UN) has adopted voluntary guidelines. Most states require that residual propellants, batteries, flywheels, pressure vessels, and other instruments be depleted or passivated at the end of their operational lifetimes. All major national debris mitigation guidelines address the disposal of Geostationary Earth Orbit (GEO) satellites, typically in graveyard orbits 235 km above the GEO orbit; most seek the removal of dead spacecraft from LEO within 25 years. However, these guidelines are not universally or regularly followed.

2011 Developments:

- Uncontrolled satellite reentries receive mainstream media attention
- Orbital debris continues to have a growing impact on operational spacecraft
- Various states signal compliance with international space debris mitigation guidelines
- International awareness of orbital debris problem increases and progress on solutions continues

Space Security Impact

The growing worldwide appreciation of the threat posed by space debris to the sustainability of outer space is a positive development, as are the efforts to find solutions to the problem. While policymakers are working to strengthen existing debris mitigation guidelines, scientists and engineers have begun research on the next phase—orbital debris removal, that will be a necessary complement to debris mitigation to ensure continued space security. However, voluntary guidelines are not sufficient to address the problem, as demonstrated by the recurring failure of some spacecraft operators to comply with end-of-life requirements in the GEO belt.

INDICATOR 1.3: Demand for radio frequency (RF) spectrum and communications bandwidth — The growing number of spacefaring nations and satellite applications is driving the demand for access to radio frequencies and orbital slots. More satellites are operating in the frequency bands that are commonly used by GEO satellites, increasing the likelihood of greater frequency interference. Satellite builders and operators are coping by developing new technologies and procedures to manage greater frequency usage, allowing more satellites to operate in closer proximity without interference. As well, frequency hopping, lower power

output, digital signal processing, frequency-agile transceivers, and software-managed spectrum have the potential to significantly improve bandwidth use and alleviate conflicts over bandwidth allocation. 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.

2011 Development:

- LightSquared telecommunications plan interferes with Global Positioning System (GPS) signals in the U.S.

Space Security Impact

The finite nature of space resources such as orbital slots and radio frequencies continues to pose complex governance challenges for the ongoing use of space by established and emerging spacefaring actors. The demands of emerging spacefaring states for their own orbital slots and radio frequencies not only add stress to an already congested environment, but also call into question the inherent fairness of an allocation system that has operated on a first-come, first-served basis. Moreover, the occurrence of both intentional and unintentional frequency interference will remain a significant space security concern for the foreseeable future and will require more effective regulatory regimes, as illustrated by the LightSquared development described in this chapter.

INDICATOR 1.4: Threat from NEO collisions and progress toward possible solutions — Near-Earth Objects are asteroids and comets in orbits that bring them into close proximity to the Earth. Over the past decade a growing amount of research has started to identify objects that pose threats to Earth and to develop 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. Some experts have advocated the use of 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.

2011 Developments:

- International awareness of NEO problem and discussions on solutions continue to increase
- Progress in UN COPUOS toward possible creative mitigation solutions

Space Security Impact

Progress made in terms of collaborative NEO detection, warning, and decision-making encourages and strengthens international cooperation on space situational awareness (SSA) data sharing and enhanced space security. While the consequences of a potential NEO collision may themselves be detrimental to the overall security of outer space, cooperative multilateral efforts to address this challenge will likely yield positive results for space security by strengthening ties among diverse space actors.

Space Situational Awareness

INDICATOR 2.1: Space situational awareness capabilities in the U.S. — The U.S. continues to lead the world in space situational awareness capabilities with the Space Surveillance Network (SSN). Sharing SSA data from the SSN could benefit all space actors by allowing them to supplement the data collected by national assets at little if any additional cost. Still, 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 U.S. 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, thus allowing individual space actors to supplement the data collected by national assets.

2011 Development:

- U.S. SSA capabilities continue to improve

Space Security Impact

Although the United States remains the single largest collector and provider of SSA data worldwide, significant gaps remain in its ability to detect and track smaller objects, which are still capable of inflicting damage on expensive and strategically important spacecraft. If the U.S. SSA Sharing Program continues, recent developments, which are aimed at filling those gaps, will significantly enhance safety for all space actors. Increased political capital and budgetary allocations spent on improving SSA capabilities in the U.S. constitute a major positive step for space security, and could become even more beneficial insofar as the U.S. continues to pursue international collaboration on SSA.

INDICATOR 2.2: Global space situational awareness capabilities — 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. Given the sensitive nature of much of the

information obtained through surveillance networks and the resulting secrecy that often surrounds it, states are striving to develop their own SSA systems to supplement and reduce their reliance on the information released by other space actors such as the U.S. For example, Russia maintains a Space Surveillance System using its early-warning radars and monitors objects (mostly in LEO), although it does not widely disseminate data. Similarly, the EU, Canada, France, Germany, China, India, and Japan are all developing space surveillance capabilities for various purposes, although none of these states has aspirations to develop a global system on its own. Amateur observations by individuals have also proven to be useful in gathering and disseminating data on satellites.

2011 Developments:

- Europe continues to develop its own SSA capabilities
- China emphasizes debris monitoring in White Paper
- Space Data Association reaches full operational capability
- Sapphire Satellite System enhances Canada's Space Surveillance System
- Amateur observers continue to demonstrate their capabilities

Space Security Impact

The increase in global SSA capabilities has a positive impact on the security of outer space as it allows for multiple sources of data, improving quality, coverage, and validity. Greater global capabilities also permit the use of SSA data to monitor activities in space, increasing transparency and confidence among space actors, and, eventually, serving as a potential verification mechanism for future agreements.

INDICATOR 2.3: International cooperation on space situational awareness — While the U.S. moderates access to information from its SSN, it has expanded its SSA Sharing Program. Since the 2009 Cosmos-Iridium satellite collision, the U.S. military has increased the personnel and resources devoted to its SSA program in order to monitor more active satellites for potential collisions. The eventual goal is to provide timely warning of potential collisions for all active payloads on orbit. As part of this development, the U.S. is seeking more outside partners with which to share data on potential collisions. In addition, commercial entities (such as the Space Data Association, formed by a group of major satellite operators) have established independent surveillance and data-sharing mechanisms that will allow them to share data on the positions of members' satellites to help prevent collisions and reduce electromagnetic interference.

2011 Developments:

- International cooperative effort to track and reestablish contact with Russian Phobos-Grunt spacecraft
- The U.S. signs cooperative bilateral agreements with Canada and France on space debris
- The U.S. government continues to expand its SSA Sharing Program

Space Security Impact

Because no single government or entity can provide comprehensive SSA, international cooperation and collaboration are vital. More bilateral agreements and international cooperation on SSA and data sharing create a very positive impact on space security and sustainability. A good example of the collective benefits of sharing SSA data is the widely publicized tracking of the Russian Phobos-Grunt spacecraft in 2010.

Laws, policies, and doctrines

INDICATOR 3.1: International normative and regulatory framework for outer space activities — The international legal framework for outer space early on established 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. While the existing normative framework is widely considered outdated and insufficient to address the current challenges to space security, the focus on multilateral space treaties has been complemented by the pursuit of governance tools that include principles, resolutions, confidence-building measures, and technical regulatory guidelines.

2011 Developments:

- The Permanent Court of Arbitration adopts Optional Rules for Arbitration of Disputes Relating to Outer Space Activities
- International Code of Conduct for Outer Space Activities proposed by the EU continues to receive mixed support
- Satellite industry opposes the International Institute for the Unification of Private Law (UNIDROIT) Space Assets Protocol to the Cape Town Convention
- Orbital slot and frequency allocations continue to be disputed by companies and states
- Reports of significant harmful radiofrequency interference (RFI) or infringements of RF regulations continue

Space Security Impact

Differences of opinion continue to characterize the international discourse on the development of normative frameworks for outer space activities. Although several alternatives are on the table for consideration, international space actors have been unable to reach consensus on the exact nature of a space security regime. While this lack of consensus has significantly slowed down the process of developing international norms, it has generated important debate and revealed a variety of

perspectives and priorities that may contribute to more inclusive rules. It is also becoming apparent that emerging rules will need to acknowledge private sector actors as legitimate stakeholders in the space domain. The extent to which their concerns are considered in policymaking processes and governance structures will be an important determinant of space security going forward.

INDICATOR 3.2: National space policies — While all spacefaring states emphasize the importance of cooperation and the peaceful uses of space, the military doctrines of a growing number of states emphasize the use of space systems to support national security. The increasing development of multiuse space systems, for example, has led some states to view space assets as critical national security infrastructure. In addition, 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 U.K., Germany, Australia, and the U.S., have made the innovation and development of their industrial space sectors a key priority of their national space strategies.

2011 Developments:

- U.S. National Security Space Strategy released
- China issues five-year White Paper on space
- The EU releases communication on an EU space policy
- Austria promulgates new domestic space law

Space Security Impact

The ongoing focus of national space policies on the long-term sustainability of the space domain and a renewed focus on the benefits of international cooperation generally bode well for space security. However, an overreliance on space for national security could lead to a climate of mutual suspicion and mistrust that could ultimately be detrimental to the space domain. Clear rules, greater transparency, and international cooperation are positive indicators of space security, but tensions could also build as more policymakers become aware of the vulnerabilities and fragility of many space capabilities. Greater transparency and openness in national policies would be welcome developments toward the goal of increased cooperation.

INDICATOR 3.3: Multilateral forums for outer space governance — International institutions including the UN General Assembly, the UN First Committee, the UN Committee on the Peaceful Uses of Outer Space (COPUOS), the ITU, and the Conference on Disarmament (CD) constitute the key multilateral forums in which issues related to space security are addressed. The adoption of a Programme of Work at the CD in 2009, after more than a decade of deliberations

with no tangible results, could have allowed the CD to move forward on the Prevention of an Arms Race in Outer Space (PAROS) and to further discussions on a legal instrument to regulate space activities. But stalemate quickly resumed its grip. While at the end of 2011 the adoption of a Programme of Work remained an elusive pursuit for the CD, support for the PAROS Resolution at the UN General Assembly—with 176 in favor, none opposed, and only two abstentions (Israel and U.S.)—is indicative of the broad international consensus supporting the need to consolidate and reinforce the normative regime for space governance and enhance its effectiveness. COPUOS remains active, with a principal focus on non-binding, technical approaches to security in space.

2011 Developments:

- U.S. confirms engagement with Group of Governmental Experts for Transparency and Confidence-Building Measures in Space
- The CD could not agree on a Programme of Work during 2011
- Terms of reference for COPUOS Working Group on Long Term Sustainability of Outer Space Activities agreed

Space Security Impact

The continuing failure to adopt a Programme of Work at the Conference on Disarmament (the result of issues unrelated to outer space) is highly problematic; it is unclear if the deadlock will end in the near future. The fact that the deadlock at the CD has prevented substantive negotiations on one of its core agenda items, PAROS, has a negative impact on the security of outer space. While ineffective multilateral forums such as the CD stagnate, the Group of Governmental Experts established by the UN General Assembly and the COPUOS Working Group on the Long Term Sustainability of Outer Space Activities are very promising developments that could advance important and necessary confidence-building measures related to peaceful space operations.

Civil Space Programs

INDICATOR 4.1: Priorities and funding levels within civil space programs — 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. Following the cancellation

of the Constellation program, the U.S. has focused on encouraging private sector development of new launchers rather than by 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.

2011 Developments:

- Changing budgetary allotments for civil space programs
- Various countries pursue human space exploration programs
- Scientific exploration missions continue to be developed worldwide
- States continue to pursue Moon exploration programs

Space Security Impact

The fact that government spending on space activities saw a significant global increase during 2011 indicates that spacefaring states attach high priority to their national space programs. This positive development demonstrates that states see a strong link between space exploration and socioeconomic development. More scientific exploratory missions and a renewed interest in manned spaceflight and lunar missions by national space agencies may further enhance international cooperation on space activities and could lead to a higher level of trust among spacefaring nations.

INDICATOR 4.2: International cooperation in civil space programs — International cooperation remains a key feature of both civil and global utilities space programs. It enhances transparency into the nature and purpose of certain civil programs that could potentially have military purposes. The most prominent example of international cooperation continues to be the International Space Station, a multinational effort with a focus on scientific research and an estimated cost of over $100-billion to date. 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. Likewise, cooperation agreements enable established spacefaring countries to tackle high-cost, complex missions as collaborative endeavors with international partners.

2011 Developments:

- Increasing number of cooperation agreements on space activities
- U.S. eases export controls with India
- U.S. bill limits NASA interaction with China
- Various states continue to pursue cooperation with China on space activities

Space Security Impact

The increased cooperation in space activities is a positive development; it builds confidence and fosters transparency among various spacefaring nations. In addition, international cooperation leads to tangible benefits from such collaborative space activity as scientific research. Given the sometimes prohibitively costly nature of space endeavors, international cooperation makes major missions possible by sharing costs and technologies.

INDICATOR 4.3: Space-based global utilities — The use of space-based global utilities, including navigation, weather, and search-and-rescue systems, has grown substantially over the last decade. While key global utilities such as the 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 U.S., the EU, Japan, China, and India have or are developing satellite-based navigation capabilities. Although these systems can increase the accuracy and reliability of satellite-based navigation, their simultaneous operation faces significant coordination challenges.

2011 Developments:

- Improvement in global access to Earth observation data
- Satellite navigation systems around the globe continue to evolve

Space Security Impact

The increasing reliance on space systems for global utilities such as disaster management, earth observation, telecommunications, weather, position, navigation, and timing may constitute a positive development for space security. Spacefaring nations are encouraged to promote safe and responsible space behavior and to focus on the long-term sustainable use of space resources. 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

INDICATOR 5.1: Growth in commercial space industry — Commercial space revenues have steadily increased since the mid-1990s. 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. Individual consumers are a growing source of demand for these services, particularly satellite television and personal GPS devices. 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.

2011 Developments:

- Despite predictions of downturn, satellite industry positioned for continued growth
- Inmarsat develops business by securing financing from U.S. Export-Import Bank for Global Xpress system, while expanding maritime operations
- High-throughput satellites (HTS) drive growth
- Eutelsat leases Chinese satellite to preserve orbital slot
- Commercial launch market continues to expand
- LightSquared telecommunications plan interferes with GPS signals in the U.S.

Space Security Impact

The pool of stakeholders with a direct interest in preserving space as a peaceful domain has increased in recent years as a result of the continued overall growth in the commercial space industry. This constitutes a positive development for space security. Moreover, cooperative efforts and the resulting cost-effectiveness will likely encourage greater space access and socioeconomic development for both established and emerging spacefaring states. As well, the development of new products and services lessens dependence upon one facet of commercial activity, thus helping to insulate against fluctuations in specific markets. However, as commercial space activity increases, issues of congestion, competition, and spectrum management become of greater concern.

INDICATOR 5.2: Commercial sector support for increased access to space products and services — Lower launch costs for commercial satellites have enabled greater accessibility to space, particularly by developing countries that found space access prohibitively expensive in the past. A few years ago, Earth-imaging data were only available to a select number of governments. Today any individual or organization with access to the Internet can use these services at no cost, through various widely available online mapping applications. An embryonic private spaceflight industry continues to emerge, seeking to capitalize on new advanced, reliable, reusable, and relatively affordable technologies for launch to suborbital trajectories and low Earth orbit.

2011 Developments:

- Various companies continue to develop services for the commercial human spaceflight and space tourism markets
- AISSata-1 improves Automatic Identification System (AIS) tracking
- Full control regained over Intelsat's Galaxy 15 satellite
- Plans advance for on-orbit servicing of satellites

Space Security Impact

Increased access to space affects space security both positively and negatively. As more entities, both governmental and private, are able to reach space, the benefits of the resource spread, ideally in an equalizing manner. However, increased access to space also translates into a more congested environment, making more urgent effective regulatory mechanisms for the allocation of scarce resources. The increasing number of private citizens with a vested interest in space security may yield a positive impact on space security. However, 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 to the largely uncharted realm of space tourism. Finally, although effects seem positive, it is too early to assess the full impact of on-orbit satellite servicing, which aims to extend the operational life of active satellites.

INDICATOR 5.3: Interactions between public and private sectors on space activities — The commercial space sector is significantly shaped by the particular security concerns of national governments. Various national space policies place great emphasis on maintaining a robust and competitive industrial base and encourage partnerships with the private sector. The retirement of the NASA space shuttle will certainly provide new opportunities for the commercial sector to support U.S. government activities. Moreover, national export regulations could gradually be influenced by the growing number of international partnerships formed by the commercial sector.

2011 Developments:

- Hosted payloads gain traction
- NASA awards contracts, funding to various commercial space companies
- Australia invests in national broadband network
- European Space Agency continues to scrutinize Arianespace finances

Space Security Impact

The increased synergy between the public and private sectors has a positive impact on space security insofar as the concept of space security broadens to reflect the needs of the commercial sector as well as the national security of spacefaring states.

However, the benefits of such partnerships could be offset by an increased reliance on commercial dual-use assets by the militaries of several countries. As this mutual dependence deepens, multiple-use spacecraft built by commercial operators could become military targets in the future, resulting in an overall decrease in security. On the other hand, the proliferation of dual-use assets in space could make a military attack less useful and, therefore, less likely.

Space Support for Terrestrial Military Operations

INDICATOR 6.1: U.S. military space systems —The U.S. 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 U.S. began to expand the role of military space systems, integrating them into virtually all aspects of military operations, from providing indirect strategic support to military forces to enabling the application of military force in near-real-time tactical operations through precision weapons guidance. The DOD Space-based and Related Systems funding category includes, inter alia, the development of the Evolved Expendable Launch Vehicle, the Advanced Extremely High Frequency satellite constellation, the Space Based Infrared System, and the Wideband Global SATCOM System. The U.S. currently leads in deployment of dedicated space systems to support military operations, accounting for roughly half of all dedicated military satellites, and currently outspends all other states combined on military space applications.

2011 Development:

- The U.S. continues to update existing space capabilities

Space Security Impact

The use of space systems in U.S.-led military operations—a key example of the critical role of space systems in defense—has mixed impacts on the security of outer space. Its significant reliance on space systems encourages the U.S. to reduce conflict in space. However, that same reliance enhances the strategic value of targeting U.S. military space systems in the event of terrestrial conflict. Nevertheless, U.S. efforts at international cooperation, along with repeated statements and practices that advocate for the responsible use of space and deterring aggression in space through resiliency and transparency, have a markedly positive effect on long-term space security. Interdependence and cooperation increase, while uncertainty among other space actors is reduced.

INDICATOR 6.2: Russian military space systems — Russia maintains the second largest fleet of military satellites. Its early warning, imaging intelligence, communications, and navigation systems were developed during the Cold War. Because between 70 and 80 per cent of spacecraft have exceeded their designed lifespan, their current operational status is uncertain. Forced by funding constraints to prioritize upgrades, Russia focused first on its early warning systems. It continues work to complete the Global Navigation Satellite System (GLONASS), which was allocated 3.7-billion rubles for 2010-2011. Since 2004, Russia has focused on "maintaining and protecting" its fleet of satellites and developing satellites with post-Soviet technology. In 2006, the first year of a 10-year federal space program, Russia increased its military space budget by as much as one-third, following a decade of severe budget cutbacks. Despite the recent growth in Russia's spending, capabilities will only gradually increase, because significant investments are required to upgrade virtually all of its military space systems.

2011 Development:

- Amid continuing launch failures, Russia updates some satellite constellations, declares GLONASS fully operational

Space Security Impact

Russia's steady progress to update its military space systems has been hindered by widespread launch failures that impact both civil and military activities. Russian critics have focused on the cost of setbacks and failures, but have also praised the value of successes such as a fully operational GLONASS. These developments have a positive impact on space security as they increase the negative consequences of an eventual conflict in space, particularly when considered in light of Russian international cooperative efforts in launch and Global Navigation Satellite System (GNSS) capabilities.

INDICATOR 6.3: Chinese military and dual-use space systems — China's governmental space program does not maintain a strong separation between civil and military applications. Officially, its space program is dedicated to science and exploration, but like the programs of many other actors, it is believed to provide support to the military. China's space program is led by the Space Leading Group, whose members include three senior officials of government bodies that oversee the defense industry in China. Most of China's satellites are civilian or commercial, but many have capabilities that could also be used for military purposes. China has advanced remote sensing capabilities that could support imagery intelligence and also operates the Beidou regional navigation system designed to augment the data received from the U.S. GPS system and enable China to maintain navigational capability if the U.S. were to deny GPS services in times of conflict.

2011 Development:

- China continues deploying space-based military capabilities

Space Security Impact

China conducted more launches in 2011 than any other single year, demonstrating a commitment to growing its space capabilities, including its military space constellation. Continued limited transparency of China's space capabilities and intentions is a concern for space security. For example, China continues to classify satellites believed to be of dedicated military or dual use as "scientific," increasing the likelihood of misinterpretation and mistrust and negatively impacting space security. This trend further highlights the value of transparency and information sharing among actors to reduce the possibility of conflict in space.

INDICATOR 6.4: Indian multiuse space systems — India has one of the oldest and largest space programs in the world, with a range of indigenous dual-use capabilities. Space launch has been a driving force behind the Indian Space Research Organisation (ISRO). India has several remote sensing and at least one dedicated military surveillance satellites. The Cartosat series of remote sensing satellites are generally considered dual-use. The Indian National Satellite System is one of the most extensive domestic satellite communications networks in Asia. To enhance its use of U.S. 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.

2011 Development:

- India continues growing its remote sensing constellation

Space Security Impact

Future dedicated military satellites are part of India's plan to continue growing its space capabilities. While it is early to tell, growing reliance on space systems may have a beneficial impact on long-term space security. The deciding factor may be India's willingness to maintain transparency about its space activities and intentions; a lack of openness could increase misinterpretation and mistrust, spurring competition and conflict.

INDICATOR 6.5: Development of military and multiuse space capabilities by other countries — 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. Hence, 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. Europe continues to pursue the development of the Galileo navigation system; EU member states exhibit a strong predisposition for collaboration by sharing space capabilities with partners.

2011 Developments:

- Canada joins Wideband Global SATCOM (WGS) Project
- Chile's first military intelligence satellite is launched
- Europe revises cost estimate upward to fund Galileo; launches delayed In-Orbit Validation (IOV) satellites
- Iran launches second indigenous remote sensing satellite "Rasad," plans for bigger, more complex satellites
- Japan launches reconnaissance satellites, approves national GNSS capability

Space Security Impact

Increased access to space by more actors reduces the advantage of those countries that already rely on space assets and increases the community of actors with a stake in protecting this resource through long-term space security. An ongoing positive impact will depend on continuous cooperative efforts by both established and emerging actors to enhance space situational awareness, avoid interference between systems, and promote transparency and information sharing.

Space Systems Resiliency

INDICATOR 7.1: 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 be less well protected. 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. 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.

2011 Developments:

- Rapid Attack, Identification, Detection, and Reporting System (RAIDRS) Block 10 nears initial operational capability
- Programs under way to mitigate risk of cyber attack
- High-integrity GPS (HIGPS) demonstrates full functionality

Space Security Impact

Efforts to identify and report sources of interference and to continue operations despite degradation to critical systems are leading to increased resiliency. Space actors may refrain from interfering with well protected space systems if such attacks seem both futile and costly. Moreover, the consolidation of cyber security efforts internationally and across agencies and programs will mitigate the damage posed to space security infrastructures by potential cyber-attacks. Policies allowing offensive action against cyber threats, if they become a trend, have the potential to have space security implications beyond the cyber domain.

INDICATOR 7.2: Capacity to rebuild spacecraft and integrate distributed architectures into space operations — The ability to rapidly rebuild space systems after an attack could reduce vulnerabilities in space. Although the U.S. 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, such as the U.S. Defense Advanced Research Projects Agency (DARPA) System F6, is meant to provide system redundancy and increase assurance of continued operation of critical space infrastructures.

2011 Developments:

- The U.S. launches and deploys two Operationally Responsive Space (ORS) satellites
- U.S. Combatant Command utilizing Cubesats for missions
- DARPA System F6 program selects prime contractor
- Commercially Hosted Infrared Payload (CHIRP) mission begins

Space Security Impact

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 these assets less attractive, they may decrease trust and transparency if assets are more difficult to track.

Space Systems Negation

INDICATOR 8.1: Capabilities to attack space communications links — 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 instances of intentional jamming of satellite communications continued throughout 2011. For example, European satellite signals, including broadcasts of BBC Persian language, Deutsche Welle, and France's Eutelsat, have been intentionally jammed from Iran, though it has not been determined that the jamming is state-sponsored. The challenges in addressing cases of jamming that are not always easily attributable to one particular actor have been at the forefront of space security debates.

2011 Development:

- Jamming incidents and capabilities continue to proliferate

Space Security Impact

Jamming is clearly widespread, affecting both wealthy and poor nations. The ubiquity of the problem should encourage international cooperation, although effectively enforcing anti-jamming regulations will likely remain challenging for the foreseeable future. Countermeasures will likely be developed to protect against military jamming, thus ensuring continued satellite communications and producing a positive effect on space security.

INDICATOR 8.2: 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. The U.S., 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 U.S. in 2008) underscore the detrimental effect that such systems have for space security. Such use can not only aggravate the space debris problem, but contribute to a climate of mistrust among spacefaring nations.

2011 Developments:

- India continues to signal interest in the development of ASAT capabilities
- U.S. Airborne Laser Test Bed (ALTB) comes to an end, but directed energy weapons continue to be developed

Space Security Impact

The continued development of capabilities that can enable a spacefaring actor to intentionally compromise the physical and operational integrity of space assets has a negative effect on space security as it can directly restrict the secure access to space by others. While possession of such capabilities does not necessarily entail their imminent use, their very development may heighten tensions and have a negative effect on regional and international stability. Clearly, the interest in ASAT capabilities expressed in India and the recent use of ASAT weapons by the U.S. and China do not bode well for the security of outer space. Despite continued research on directed energy weapons, the ALTB program has been terminated and there are no indications that such capabilities will materialize in the near future.

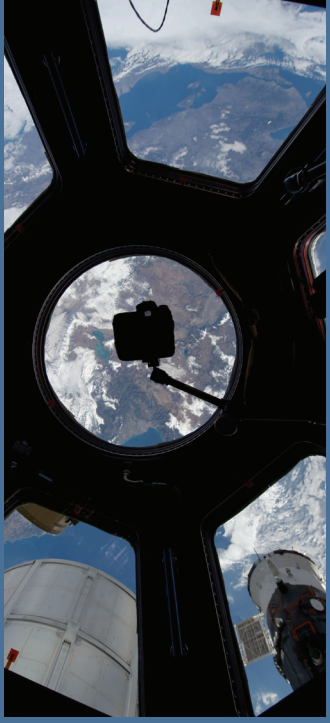
INDICATOR 8.3: Space-based negation enabling capabilities — Space-based negation efforts require sophisticated capabilities, such as precision on-orbit maneuverability and space tracking. Deploying space-based ASATs—using kinetic-kill, directed energy, or conventional explosive techniques—would require enabling technologies somewhat more advanced than those used for orbital launch. 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. While several nations have developed such technologies, there is no evidence to suggest that they have been integrated into a dedicated space-based negation system.

2011 Developments:

- Pursuit of greater abilities for small spacecraft to rendezvous with satellites
- China successfully conducts docking maneuver
- X37B 2 space plane successfully launched

Space Security Impact

While space-based systems negation remains largely theoretical and no space assets have been deployed with a dedicated negation mission, there are many extant capabilities that could potentially be used for this purpose. The further development of technologies that potentially enable space-based ASAT capabilities may force spacefaring nations to incorporate greater protection measures into their spacecraft and invest more in effective space situational awareness. Rendezvous and proximity operations, for example, could be perceived as having potentially hostile applications, unless they are conducted transparently.



2012

Full report at **www.spacesecurity.org**

"The space environment is a valuable asset for human development, and it is of critical importance to sustain its capacity to serve in this role. Each year, the Space Security Index catalogues and assesses the impact on the space environment of its use by some 80 nations for civil, military, and commercial purposes. The Index has developed a solid reputation as a significant data reference on the utilization and management of space assets and on the threats posed by human activity to the space environment."

Karl Doetsch
President, Doetsch International Space Consultants
(Former President, International Space University)

"The Space Security Index continues to represent the most thoughtful, informed, and nonpartisan summary of annual space activities and policy developments relevant to the safe access to and use of space. In its broad view of space security, covering issues ranging from space weapons to orbital debris and space traffic management, the Index has contributed to defining the field."

Jonathan McDowell
Astrophysicist, Harvard-Smithsonian Center for Astrophysics

"I recommend the annual monograph by Space Security Index to my students, experienced aerospace professionals, policymakers, diplomats, and security officials. It is a really independent source of information and reflection on the evolution of space affairs. There you can find the most accurate data and the best policy analysis."

Bertrand de Montluc
Associate Professor, Institut d'Études Politiques de Paris; Senior member, Association Aéronautique et Astronautique de France