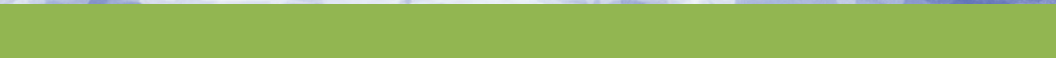
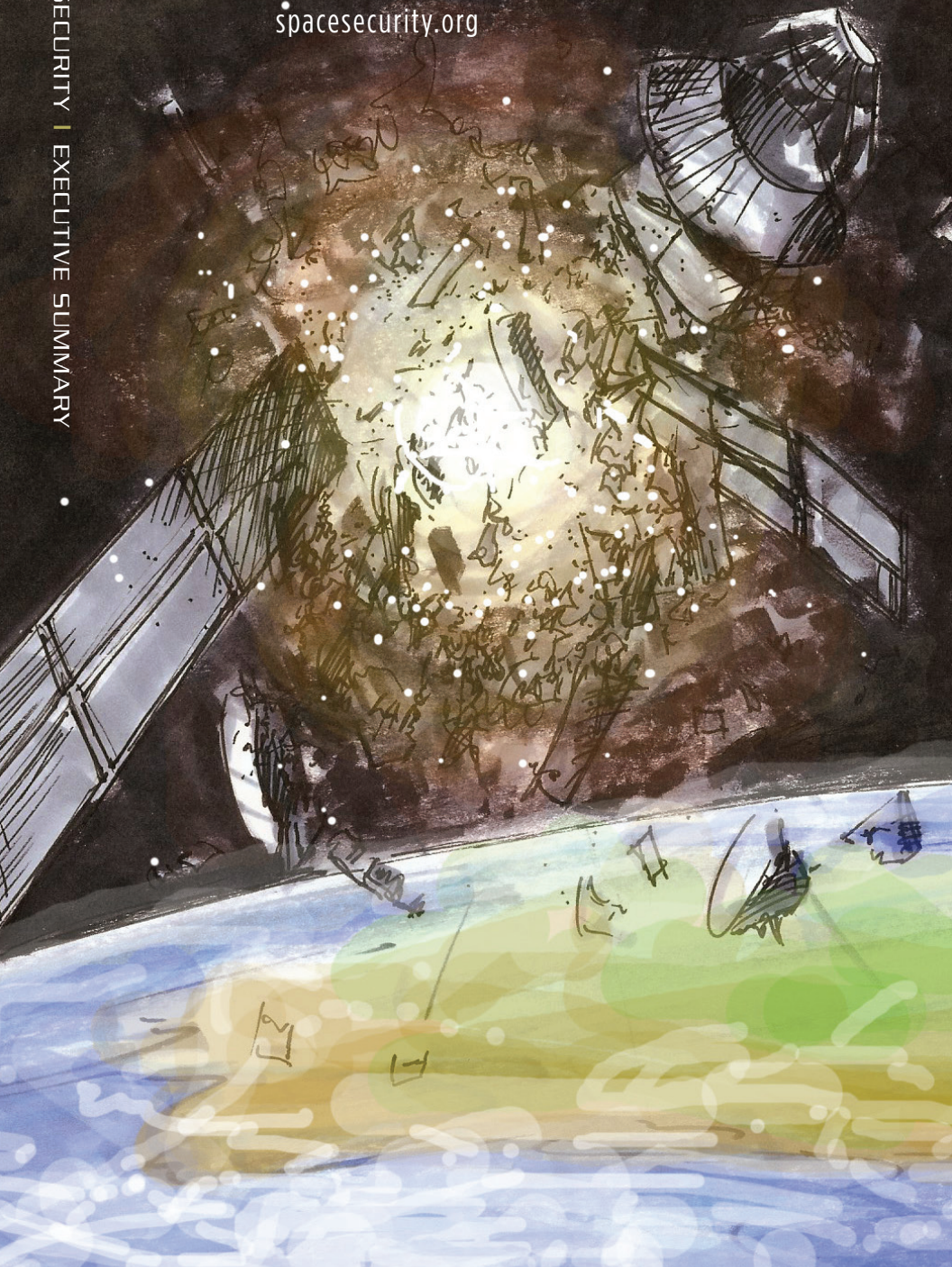


# 2010

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SPACE SECURITY | EXECUTIVE SUMMARY



**SPACE  
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# INTRODUCTION

*Space Security 2010* is the seventh annual report on trends and developments related to security and outer space, covering the period January to December 2009. It is part of the broader Space Security Index (SSI) project, which aims to improve transparency with respect to space activities and provide a common, comprehensive knowledge base to support the development of national and international policies that contribute to space security.

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

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

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

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

- The condition of the operating environment
  - 1) The space environment
  - 2) Space situational awareness
  - 3) Space laws, policies, and doctrines
- The type of actors in space and how space is used
  - 4) Civil space programs and global utilities
  - 5) Commercial space
  - 6) Space support for terrestrial military operations
- The status of space-related technology as it pertains to protecting or interfering with space systems, or harming Earth from space
  - 7) Space systems protection
  - 8) Space systems negation
  - 9) Space-based strike capabilities.

Each of the nine indicators is examined in a separate chapter that provides a description of the indicator and its overall impact on space security. A discussion of the prevailing trends associated with that indicator is followed by an overview of key developments throughout the year, and an assessment of their short-term effects on established trends and the broader security of outer space.

The annual, systematic assessment undertaken by the Space Security Index makes it increasingly possible to note longer-term trends as well as evolving challenges. For instance, the normative regime to maintain the security of outer space remains fragile inasmuch as multilateral efforts to adopt new international treaties are being replaced by either non-binding, technical approaches to govern outer space or by unilateral national legislation on space operations. A cursory analysis of the proposals under consideration for a space security regime, which are highlighted in this volume, suggests that, despite efforts to construct a robust regulatory framework for space activities, the international community has been unable to reach consensus on an overarching and legally binding space security treaty that reflects the current challenges facing an ever more complex domain. Moreover, the predominance of multi-use space assets means that more states are using space systems for both civil and military purposes. As seen in the growing number of public-private partnerships for space operations, the boundaries between civil, military, and commercial space assets are blurring, creating interdependence and mutual vulnerabilities.

An important distinction must be made between militarization and weaponization of space: while the former is a reality, thus far there is no documented evidence of the latter. Although the use of space assets for military applications such as reconnaissance, intelligence, and troop support has been ubiquitous for several years, space apparently has remained weapons-free. To maintain this state, the prevention of an arms race in outer space remains a priority for policymakers at various international forums, since it is assumed that once a state places weapons in space, others will follow suit.

From banking to satellite television, from search and rescue operations to weather forecasting, the world has become increasingly reliant on the benefits derived from space-based technologies. The key challenge is to maintain an environment for the sustainable development of such peaceful applications while keeping outer space from becoming a potential battlefield.

The need for greater collaboration and data sharing among different space actors to prevent harmful interference with space assets is becoming increasingly apparent. Although greater international cooperation to enhance the predictability of space operations is strongly advocated, 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. Not surprisingly, a new tendency is emerging where satellite operators reduce their reliance on government-sourced information on space assets by establishing independent surveillance and data-sharing mechanisms, such as the nascent Space Data Association formed by a group of major satellite operators.

The decreasing costs and wider availability of launch technologies suggest that a possible increase in spacefaring nations is likely in the coming years. But intensifying space use creates governance challenges in managing space traffic, limiting the destructive potential of increased orbital debris, and distributing scarce resources such as orbital slots and radio frequencies. Already, new actors seeking entrance to a congested space environment are questioning the inherent fairness of the first-come-first-served system, which has been the de facto norm for orbital slot allocations.

Developments captured in the SSI also illustrate the challenges and complexities intrinsic to outer space activity. During 2009 the Islamic Republic of Iran successfully launched its first domestically made satellite, becoming the ninth nation to design, build, and launch its own spacecraft. The launch generated intense scrutiny from some Western countries that expressed concerns about the peaceful nature of Iran's space program, given the similarity in launch systems for satellites and ballistic missiles. Another significant event in 2009 was the first ever collision between two orbiting satellites. A retired Russian communications satellite (Cosmos 2251) and a US-owned satellite that provided global mobile phone services (Iridium 33) collided in Low Earth Orbit 790 kilometers over Siberia, creating thousands of pieces of debris, most too small to be tracked with precision. While the incident is widely considered an accident, it underscores the need for greater coordination between operators of space assets so that similar debris-causing events can be prevented in the future. Space debris poses an indiscriminate and increasing risk to all space assets and cannot be removed from outer space with current technology.

*Space Security 2010* does not provide absolute positive or negative assessments of 2009 outer space activities. Instead, it indicates the range of implications that developments could have on the security of space across the various indicators and highlights the difficult challenges faced by policymakers. It is the hope of the Space Security Index project partners that this publication will continue to serve as both a reference source and a policymaking tool, with the ultimate goal of enhancing the sustainability of outer space for all users.

Information contained in *Space Security 2010* is from open sources. Great effort is made to ensure a complete and factually accurate description of events based on a critical appraisal of the available information and consultation with international experts. Strategic and commercial secrecy with respect to space activities inevitably poses a challenge to the comprehensive nature of this report. But space assets and activities by their very nature are generally in plain view to those with the technical ability to observe them. Increasingly that includes so-called amateurs who make their observations of space assets such as satellites widely available.



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

- 1) The annual Space Security Online Consultation provides insights into the perceptions, concerns, and priorities of space stakeholders around the world, as well as critical feedback on the draft research report.
- 2) The Space Security Working Group consultation is held each spring for two days to review the draft text for factual errors, misinterpretations, gaps, and statements 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 provides its comments on the penultimate draft of the text before publication.

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

# ACKNOWLEDGEMENTS

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The content of *Space Security 2010* does not necessarily reflect the views of the SpaceSecurity.org partners: McGill University's Institute of Air and Space Law, Project Ploughshares, Secure World Foundation, The Simons Foundation, and Foreign Affairs and International Trade Canada.

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.

Mr. Phillip Baines

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# EXECUTIVE SUMMARY

## The Space Environment

**TREND 1.1: Amount of orbital debris continues to increase** — Space debris poses a significant, constant, and indiscriminate threat to all spacecraft, regardless of the nation or entity to which it belongs. Traveling at speeds of up to 7.8 kilometers per second, each piece of space debris is, in effect, a projectile that may destroy or severely disable a satellite upon impact. The number of objects in Earth orbit has increased steadily; today, the US Department of Defense (DOD) is using the Space Surveillance Network to track more than 21,000 objects approximately 10 centimeters in diameter or larger. It is estimated that there are over 300,000 objects with a diameter larger than one centimeter, and several million that are smaller. The annual growth rate of new debris tracked began to decrease in the 1990s, largely due to national debris mitigation efforts, but has accelerated in recent years.

### 2009 Developments:

- For the first time ever, two satellites collide in orbit
- Trackable space debris population increases significantly by 15.6%
- The US military continues to track and predict atmospheric reentry of space debris

### Space Security Impact

While 2009 did not see another intentional debris-generating event, it did witness a first-of-its-kind event that generated a significant amount of debris, but might have been avoided. Although the large spike in debris decreases space security, the event might have a positive impact as it appears to have been the catalyst for a change in the attitude of spacecraft operators. All space actors may finally be motivated to put measures into place to tackle the problem of space debris and prevent future collisions, ultimately creating greater space security.

### **TREND 1.2: Increasing awareness of space debris threats and continued efforts to develop and implement international measures to tackle the problem**

— Significant on-orbit collisions, such as the collision of the French military satellite Cerise with a portion of an Ariane rocket in 1996, as well as improved tracking abilities have encouraged the recognition of space debris as a significant threat. Moreover, several debris-generating events, such as the 2007 Anti-Satellite Weapon (ASAT) test conducted by China, the 2008 US destruction of the failed USA-193 satellite, and the 2009 collision between a Russian and a US satellite, have served to underscore the need for effective measures to curb the creation of space debris. Several spacefaring states, including China, Japan, Russia, and the US, as well as the European Union (EU) have developed debris mitigation

standards, and the United Nations has adopted voluntary guidelines, but these guidelines are not universally or regularly followed.

**2009 Developments:**

- Orbital debris continues to have an impact on operational spacecraft
- Worldwide compliance with the UN debris mitigation guidelines are still inconsistent
- Worldwide awareness of the orbital debris problem and progress on solutions continue

**Space Security Impact**

It is becoming increasingly evident to all space operators that the creation of space debris and other irresponsible behavior in space can have negative implications for all space users, given the indiscriminate nature of the adverse effects. While policymakers are working to implement the existing debris mitigation guidelines, scientists 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, creating voluntary guidelines has proven to be insufficient, as demonstrated by the continued failure of spacecraft operators to comply with end-of-life requirements in the Geostationary Orbit (GEO) belt. To enhance the positive impact that the implementation of agreed guidelines may have on debris mitigation, the establishment of enforcement mechanisms at either the international or national level is necessary.

**TREND 1.3: Growing demand for radio frequency spectrum and communications bandwidth**

— The growing number of spacefaring nations and satellite applications is driving the demand for limited radio frequencies and orbital slots. More satellites are operating in the frequency bands that are commonly used by GEO satellites and are causing increasing frequency interference. As a result, satellite operators must spend more time addressing frequency interference issues, including conflicts such as the disagreement over frequency allocation between the US Global Positioning System (GPS) and the EU Galileo navigational system. The increased competition for orbital slot assignments, particularly in GEO, where most communications satellites operate, has caused occasional disputes between satellite operators over both intentional and unintentional interference. The International Telecommunication Union (ITU) has been pursuing reforms to address slot allocation backlogs and other related challenges.

**2009 Developments:**

- Reports of radio frequency interference continue
- Satellite operators form entity to help prevent and resolve radio frequency interference

**Space Security Impact**

The scarcity of both orbital slots and radio frequencies continues to be a problem for continued use of space, with no real solution on the horizon. In fact, the demands of emerging spacefaring states are not only further stressing an already congested environment, but are calling into question the inherent fairness of an allocation system that has operated on a first-come, first-served basis. The technical ease with which both intentional and unintentional frequency interference can occur will be a significant space security concern for the foreseeable future.

**TREND 1.4: Increased recognition of the threat from NEO collisions and progress toward possible solutions**

— Near-Earth Objects (NEOs) are asteroids and comets whose orbits bring them in close proximity to the Earth or intersect the Earth's orbit. Over the past decade a growing amount of research has started to identify such objects that pose threats to Earth and potential mitigation and deflection strategies. Deflection is a difficult challenge due to the extreme mass, velocity, and distance of any impacting NEO, and 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 weapons, which could create additional threats to the environment and stability of outer space and would have complex legal and policy implications.

**2009 Developments:**

- International awareness of the NEO problem and discussions on solutions continue to increase

**Space Security Impact**

The difficulties inherent in an international response to a NEO impact threat are similar to many other space governance, cooperation, and data-sharing challenges common to other aspects of space security. While the threat posed by a potential NEO collision may itself be detrimental to the overall security of outer space, the cooperative nature of the multilateral efforts to address this challenge will likely yield positive results for space security. For instance, the progress being made in collaborative NEO detection, warning, and decision-making could benefit cooperation on Space Situational Awareness (SSA) data-sharing and enhanced space security.

## Space Situational Awareness

### **TREND 2.1: US space situational awareness capabilities slowly improving**

— The US continues to lead the world in space situational awareness capabilities with the Space Surveillance Network. Despite having the most advanced SSA capabilities, however, events such as the February 2009 collision between a US and a Russian satellite (Iridium 33 and Cosmos 2251, respectively) underscores the necessity to further improve both the accuracy of the information collected and the way in which it is managed. Funding increases for SSA programs for FY2010, as well as the partnerships between the US Air Force and contractors such as Lockheed Martin, Raytheon, and Northrop Grumman, reflect a growing desire to improve existing SSA capabilities.

#### **2009 Development:**

- Continued US focus on improving space situational awareness capabilities begins to overcome bureaucratic inertia and produce results

#### **Space Security Impact**

In previous years there had been little real progress in enhancing US SSA capabilities, despite the gradual transition of SSA from a relatively low-priority budget line into a vital tool for the tracking and protection of space assets. Prompted by the abovementioned satellite collision, the US in 2009 saw the first real steps in moving beyond rhetoric to spending political and monetary capital on this issue, a telling recognition of the growing importance of SSA in overall US space operations. This is a major positive step for space security, and could become even more beneficial insofar as the US and other space actors embrace a more cooperative and collaborative approach to SSA.

### **TREND 2.2: Global space surveillance capabilities slowly improving**

— As the importance of space situational awareness is acknowledged, more states are pursuing national space surveillance systems and are 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 reduce their reliance on the information released by other space actors such as the US. For example, Russia maintains a Space Surveillance System using its early-warning radars and monitors objects (mostly in Low Earth Orbit [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. Amateur observations by individuals have also proven to be useful ways to gather and disseminate data on satellites.

**2009 Developments:**

- International SSA capabilities slowly increase
- Increased calls for SSA data to support commercial and civil space activities

**Space Security Impact**

The traditional users and providers of SSA data – militaries and intelligence agencies – are still reluctant to provide the services and information that commercial and civil space users need to operate safely, not only because of the sensitive nature of the information on space assets, but also due to cultural and bureaucratic factors. This longstanding practice of secrecy may adversely affect space security as precise information about the position and trajectory of space assets is fundamental for preventing accidental collisions and otherwise harmful interference. The tide seems to be shifting, however, as these traditional users begin to realize the value gained from increased transparency. Both commercial and civil users are applying increased pressure for data-sharing and are making strides in finding solutions of their own.

**TREND 2.3: Use of SSA capabilities for protection and potential negation of satellites continues to increase**

— The ability to distinguish space negation attacks from technical failures or environmental disruptions is critical in maintaining international stability in space. Early warning allows for defensive responses, but the type of protection available may be limited. Several spacefaring nations have a basic capability to detect a ground-based electronic attack, such as jamming, by sensing an interference signal or by noticing a loss of communications. However, it is very difficult to obtain advance warning of directed energy attacks that move at the speed of light. The limits imposed on the availability of publicly accessible positional data further compound the complexity of the situation, as the same information can be used for benign purposes such as preventing accidental collisions, but also for potentially aggressive activities.

**2009 Developments:**

- Inability to identify cause of satellite failures sparks concerns of potential dual-use technology behind the malfunctions
- States continue to remove positional data on military and intelligence satellites from public databases

**Space Security Impact**

While increased availability of SSA information provides safety benefits, it also can be used for negation purposes and hostile activities. This concern has led an increasing number of states to try to restrict information on the location of their sensitive military and intelligence satellites. Given that anyone with a telescope and basic technical knowledge can observe these satellites, it is unclear just how effective the artificial restriction of such information will be. Still, limiting the information



available for operators may have a negative impact on space security as it could increase the chances of collisions.

## **Laws, Policies, and Doctrines**

### **TREND 3.1: Gradual development of legal framework for outer space activities**

— The international legal framework for outer space establishes the principle that space should be used for “peaceful purposes.” Since the signing of the Outer Space Treaty (OST) in 1967, this framework has grown to include the Astronaut Rescue Agreement (1968), the Liability Convention (1972), the Registration Convention (1979), and the Moon Agreement (1979), as well as a range of other international and bilateral agreements and relevant rules of customary international law. However, the existing regulatory framework is widely considered to be outdated and insufficient to address the current challenges to space security, which have been exacerbated by the growth in the number of actors and space applications. Furthermore, what began as a focus on multilateral space treaties has transitioned to a focus on what some describe as ‘soft law’ – referring to a range of non-binding governance tools, including principles, resolutions, confidence-building measures, and policy and technical guidelines – as well as unilateral regulations at the national level.

#### **2009 Developments:**

- US Space Policy undergoes review process
- New US administration hints at support for banning certain types of space weapons
- China and Russia reiterate the need for multilateral measures to prevent the weaponization of space

#### **Space Security Impact**

Although there does not seem to be enough appetite or consensus right now for a major multilateral convention on a space security regime, a tendency to develop regulations can be observed at the national level. In launching a full review of US national space policy in 2009, the Obama administration has signaled a degree of willingness to enhance security in outer space through cooperation and consensus. Yet the exact outcome of the US review, slated for release in 2010, which spans multiple agencies and departments, is far from clear. It remains to be seen what position the US leadership will take on treaties and Transparency and Confidence-Building Measures (TCBMs), which are perceived by some sectors in the US Congress to constrain US freedom of action in outer space. Meanwhile, by addressing questions about their joint proposal for a legally binding agreement that would ban weapons in space, Russia and China continued to assert in 2009 that adoption of the Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects (PPWT) would be

the best way to enhance space security. However, the PPWT is still regarded by some as incomplete due to its lack of a verification principle, as well as its inability to shield against ground-based interceptors. Regardless of the proposals' merits, the fact that alternatives for a space security regime are being discussed by stakeholders constitutes a positive development.

### **TREND 3.2: COPUOS and the Conference on Disarmament continue to be the key multilateral forums for outer space governance** —

A range of international institutions, such as the UN General Assembly, the UN Committee on the Peaceful Uses of Outer Space (COPUOS), the ITU, and the Conference on Disarmament (CD), have been mandated to address issues related to space security. Despite the adoption of a Program of Work at the CD in 2009 after more than a decade of deliberations with no tangible results, it remains unclear whether efforts to move forward on the Prevention of an Arms Race in Outer Space (PAROS) and to reach consensus on a legal instrument to regulate space activities will bear fruit in the short term. COPUOS remains active, with a principal focus on non-binding, technical approaches to security in space.

#### **2009 Developments:**

- The Conference on Disarmament agrees on a program of work
- The EU submits a draft Code of Conduct to the CD, launches consultation process
- Canada calls for security guarantees at the CD
- COPUOS examines long-term sustainability of outer space

#### **Space Security Impact**

The adoption of a program of work for the first time in over a decade and the subsequent failure to implement that program before the closure of the session highlight the hope and frustration felt at the CD in 2009. While any progress is worth noting, the reality is that accomplishments made during one session do not carry forward to the next. Despite objections from a few states over the necessity of consensus in the CD, it will likely remain a requirement for action and continue to impede efforts to engage in substantive work on PAROS. Nevertheless, 2009 saw work proceed on a number of proposals to improve the sustainability of the space environment. Although the EU Code of Conduct was not opened to subscription, a consultation process was launched and the body of the text was introduced to the CD. As well, Canada used the CD as a platform to introduce its proposal for new outer space security guarantees. And COPUOS established a timetable to formulate a report and a set of Best Practices Guidelines that address various sustainability issues in space. These proposals constitute positive developments as they may provide the basis for a future space security treaty.

**TREND 3.3: National space policies emphasize cooperation and the peaceful uses of outer space** —

Spacefaring states consistently emphasize the importance of cooperation and the peaceful uses of space, but with caveats based on national security considerations. Several cooperation agreements on space activities have allowed emerging spacefaring nations to reap benefits from space applications that are conducive to social and economic development. During 2009, for instance, countries as diverse as Brazil, China, Pakistan, Ukraine, the UAE, and Switzerland were engaged in various bilateral cooperation agreements. As well, India set a target date of around 2015 to launch its manned space program and is working aggressively to meet it.

**2009 Developments:**

- The US considers changes to International Traffic in Arms Regulations (ITAR)
- National space agencies strive to implement COPUOS debris mitigation standards

**Space Security Impact**

A significant shift in US national space policy would occur in the event that the US established a new export control system, granting the president authority to remove satellites and related components from the United States Munitions List, as stipulated in the bill referred to the Senate Foreign Relations Committee in June 2009. Fewer and less stringent regulations would constitute a positive development by opening the way for greater cooperation between NASA and such foreign civil space agencies as the European Space Agency, which has in recent years specifically cited export controls as an impediment to its cooperation with the US. Meanwhile, efforts to implement COPUOS debris mitigation standards by national space agencies constitute a positive development as they underscore the growing recognition that debris poses a major threat to peaceful space operations. Observable improvements in this area indicate that most spacefaring states are inclined to cooperate to ensure the peaceful uses of outer space.

**TREND 3.4: Growing focus within national space policies on the security uses of outer space** —

Fueled by a technological revolution, the military doctrines of a growing number of states emphasize the use of space systems to support national security. This tendency can be seen, for example, in the increasing development of multi-use space systems. The growing reliance on multi-use capabilities has led several states to view space assets as critical national security infrastructure. Past US military space doctrine has focused on the need to ensure US freedom of action in space through the use, when necessary, of “counter-space operations” that prevent adversaries from interfering with US ability to operate freely in space. The US is certainly not the only spacefaring nation with policies that reflect the importance of space assets as a fundamental element of national security; other countries are starting to capitalize on the military benefits of space applications.

**2009 Developments:**

- Australia releases new white paper on defense
- Japan announces details of Basic Space Plan
- China clarifies position on arms race in outer space
- Russia establishes national security strategy until 2020

**Space Security Impact**

The 2009 Australian Defence White Paper illustrates the growing realization among a number of smaller spacefaring states that outer space is a key military domain. Its emphasis on the importance of satellites for surveillance, coordination, and ground strike capabilities, as well as the threat of counter-space technologies, underscores the connection for many states between national security and outer space policy. The impact of the Japanese Basic Space Plan should not be overly negative, given that the portion of the space budget allocated to the Ministry of Defense continues to be used exclusively for defensive purposes. The clarification of China's view of an arms race in outer space as a "historical inevitability" needs to be understood in the context of the domestic political system. While the significance of a comment by one commander should not be overblown, it helps to understand that the civilian and military branches of government have different priorities and compete for authority over the direction of space affairs.

**Civil Space and Global Utilities****TREND 4.1: Increase in the number of actors gaining access to space**

— The rate at which new states gain access to space increased dramatically in the past decade, and is expected to continue increasing as launch costs decrease and some states indigenously develop space technologies. In 2009, the Islamic Republic of Iran joined the ranks of spacefaring nations with independent orbital launch capacities and became the 10<sup>th</sup> nation to demonstrate this capability. In addition, over 60 nations or consortia currently have assets in space that have been launched either independently or in collaboration with others. In 2003 China joined Russia and the US as the only space powers with demonstrated manned spaceflight capabilities, but eventually they could be joined by other states that have expressed an interest in human spaceflight programs.

**2009 Developments:**

- More countries launch new satellites
- New launch capabilities continue to be developed; Iran's success and North Korea's failure
- National and international space bodies continue to expand and increase

### **Space Security Impact**

The launch activities of Iran and North Korea, despite different degrees of success, caused a great deal of concern about the peaceful nature of their space programs. The launching of new satellites reflects the ever increasing interest of states in conducting space activities, but also highlights the need to adhere to relevant international treaties and other regulations, such as those setting technical standards. Increasing international cooperation (as in the development and launching of UAE and Swiss satellites) contributes to better space security because it requires different states to coordinate their efforts, thus further entrenching the practice of international cooperation on space activities. However, a potentially negative impact of the increasing number of new actors with access to space is that space becomes a more crowded environment, thereby increasing the risk of accidental interference with space assets.

### **TREND 4.2: Changing priorities and funding levels within civil space programs**

— Civil expenditures on space have continued to increase in several countries in recent years, as the social and economic benefits derived from space activities have become more apparent. Past decreases in the space budgets of the US, the EU countries, and Russia have begun to reverse. Increasingly, civil space programs include security applications, with multi-use satellites becoming increasingly ubiquitous. Several states, such as Brazil, Nigeria, and South Africa, are placing a priority on satellites to support social and economic development. Such space applications as satellite navigation and Earth imaging are a growing focus of almost every existing civil space program.

#### **2009 Developments:**

- Spacefaring states continue to fund Moon exploration programs
- Mix of successes and failures in the development of new launch vehicles
- More countries develop human space exploration programs
- Number of scientific missions is on the rise
- Space budgets remain unchanged or increase slightly

### **Space Security Impact**

The fact that expenditures for space activities did not drop in response to the 2008 economic crisis constitutes a positive development that indicates the high priority given by states to their space activities. The increased number of scientific missions may further encourage international cooperation on space operations and thereby enhance the level of trust among different spacefaring nations.

**TREND 4.3: Steady growth in international cooperation in civil space programs**

— The most prominent example of international cooperation continues to be the International Space Station (ISS), a multinational effort with a focus on scientific research, with an estimated cost of over \$100-billion to date. It epitomizes the benefits to be gained from peaceful cooperation on space activities. In 2009 the ISS completed nine years of uninterrupted inhabitancy. International civil space cooperation has played a key role in the proliferation of the technical capabilities needed by states to access space as it allows states to pool resources and expertise that yield shared benefits. 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 such high-cost, complex missions as the exploration of Mars by NASA and the European Space Agency.

**2009 Developments:**

- International cooperation continues to provide access to space for developing countries
- The number of cooperation agreements between developing and developed countries on the rise

**Space Security Impact**

Greater cooperation on space activities has an overall positive impact on space security. It fosters an environment of multilateral cooperation in scientific research. Cooperation among countries with different levels of development also allows more opportunities for space exploration by nations not traditionally involved. Cooperation can also increase the transparency of space activities, further reducing potential conflicts in a strategic environment. However, adopting criteria to engage in space cooperation that leads to the exclusion of some states may have a negative impact on space security by further isolating such actors as Iran and North Korea, which would decrease the likelihood of bringing them into an eventual space security regime.

**TREND 4.4: Growth in global utilities as states seek to expand applications and accessibility**

— The use of space-based global utilities, including navigation, weather, and search-and-rescue systems, has grown substantially over the last decade. These systems have spawned space applications that have become almost indispensable to the civil, commercial, and military sectors. Advanced and developing economies alike are heavily dependent on these space-based systems. Currently Russia, the US, the EU, Japan, China, and India have or are developing satellite-based navigation capabilities. Although the different navigational systems are theoretically interoperable and able to increase the accuracy and reliability of satellite-based navigation, the simultaneous development of competing systems faces significant challenges related to international coordination on issues such as orbital crowding and use of signal frequencies.

### **2009 Developments:**

- Satellite navigation systems around the globe continue to evolve
- Disaster relief and remote sensing capabilities continue to be developed

### **Space Security Impact**

Earth observation satellites provide valuable data that can be used to support decision-making for peaceful national purposes. It is not yet clear if collaborative projects such as the Global Earth Observation System of Systems will be a success. It remains to be seen whether the systems that make it up will work more effectively when integrated. 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. Satellite navigation activities should not have any negative impact on overall space security but, given the considerable international coordination and cooperation that is required, the interoperability of these systems may face some difficulties related to the allocation of frequencies as well as to the issue of disposal of old satellites.

## **Commercial Space**

### **TREND 5.1: Continued overall growth in the global commercial space industry**

— Commercial space revenues have steadily increased since the industry first started to grow significantly in the mid-1990s. 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 recent years, Russia has dominated the space launch industry, having the most commercial launches, while US companies have led in the satellite manufacturing sector. International competition in both of these sectors is increasing.

### **2009 Developments:**

- Consumer television services drive growth in space-based commercial sector
- Economic crisis impacts some aspects of commercial space while others prove immune
- Major satellite operators form coalition

### **Space Security Impact**

The continued overall growth in the commercial space industry and the ever increasing revenues that it produces constitute a positive development for space

security insofar as the pool of stakeholders with a direct interest in preserving space as a peaceful domain is steadily growing. Moreover, cooperative efforts in this industry and the resulting coalitions that lead to cost effectiveness in commercial space operations will likely be conducive to greater space access. If demand for space resources such as orbital slots and radio frequencies exceeds supply, as is already starting to be the case, the result could be friction among providers of commercial services, to the detriment of space security.

## **TREND 5.2: Commercial sector supporting increased access to space**

— Commercial space launches have contributed to cheaper space access. Lower launch costs for commercial satellites have enabled greater accessibility to space, particularly by developing countries. The commercial space industry is also opening up access to Earth imaging data, which until a few years ago was only available to a select number of governments. Today any individual or organization with access to the Internet can use these services through Google Maps, Google Earth, and Yahoo Maps programs. An embryonic private spaceflight industry continues to emerge, seeking to capitalize on new concepts for advanced, reliable, reusable, and relatively affordable technologies for launch to suborbital trajectories and low Earth orbit.

### **2009 Developments:**

- Private human access to space slowly continues
- Investment in commercial space on rise
- Commercial operators expand availability of imagery and satellite services
- New launchers with increased capacity under development

### **Space Security Impact**

Increased access to space has both positive and negative impacts on space security. As more entities, both government and private, are able to reach space, the benefits of the resource spread, ideally in an equitable manner. However, increased access to space also translates into a more congested environment, thus further straining an already complex domain that lacks effective mechanisms for the allocation of scarce resources. Private access to space, although still at an embryonic stage, may yield a positive impact on space security as private citizens, many previously oblivious to the security challenges facing outer space, will expand the number of stakeholders with a vested interest in space security beyond governments and commercial operators. Such access may also challenge both the sustainability of the space environment as well as the applicability of international laws to the largely uncharted realm of space tourism.



**TREND 5.3: Government dependency on the commercial space sector means that subsidies and national security concerns remain important**

— The commercial space sector is significantly shaped by national governments with particular security concerns. In 1999 the US placed satellite export licensing on the State Department's US Munitions List, bringing satellite product export licensing under the ITAR regime and significantly complicating participation by US companies in international satellite launch and manufacturing ventures. Government regulations on export controls may gradually be influenced more and more by the way in which the controls affect the commercial sector's ability to engage in international cooperation. The US Air Force's joint development with companies such as Boeing of strike systems with possible space applications is an example of a rising number of military contracts with the commercial sector. The impending retirement of the space shuttle further opens the door for the commercial sector to provide what were formerly government-controlled services. The 1998 US Space Launch Cost Reduction Act and the 2003 European Guaranteed Access to Space program provide considerable government subsidization of the space launch and manufacturing markets. The US and European commercial space industries also receive important contracts from government programs.

**2009 Developments:**

- Military dependence on the commercial sector continues to expand
- Public-private partnerships on the rise
- Revision of export controls considered in the US

**Space Security Impact**

As the relationship between the public and private sectors becomes more collaborative and cooperative, the polarity between them decreases. This interdependence has a positive impact for space security as conceptions about what constitutes space security will merge and take into consideration the needs of the commercial sector as well as the security of states. As this mutual dependence deepens, multiple-use spacecraft built by commercial operators could become military targets, resulting in an overall decrease in security. On the other hand, the proliferation of dual-use or multi-use assets in space could make a military attack less useful and, therefore, less likely. The range of peaceful space applications could potentially decrease as the commercial industry, lured by profitable government contracts, might divert much of its research and developments efforts to military applications.

## Space Support for Terrestrial Military Operations

**TREND 6.1: The US and Russia continue to lead in deploying military space systems** — Almost half of all global spending on space is for defense-related programs that provide early warning, communications, weather forecasting, reconnaissance, surveillance, and intelligence, as well as navigation and weapons guidance applications. The US is not only the biggest spender on military space programs but is also the most dependent on space systems. While US dominance in space systems is undisputed, the level of expenditures is increasing in other countries around the world. Although the operational status of many of Russia's space systems is uncertain, Russia is known to be replacing its Soviet-era military space assets and in 2009 continued to move forward with its Global Navigation Satellite System (GLONASS). By the end of 2009 there were over 175 dedicated military satellites worldwide, of which the US operated roughly half and Russia approximately one quarter.

### 2009 Developments:

- Despite some setbacks in satellite capabilities, the US continues to upgrade its systems
- Russia moves forward with GLONASS and maintains aggressive satellite launch schedule

### Space Security Impact

Given the increasing reliance by the US and Russia on military space systems, their assets in space may increasingly be seen as strategic targets by an adversary with the necessary means to interfere with them, thus increasing the vulnerability of these countries assets in space. Aware of this vulnerability, the continuing development of US and Russian military space systems and the ability of these countries to maintain them may have a positive impact on space security, as they will have a direct interest in advancing a norm of no hostile interference with space assets. On the other hand, the delicate boundary between militarization and weaponization of space risks becoming ever more blurry as more states embrace the use of space-based military applications.

**TREND 6.2: More states are developing military and multi-use space capabilities** — Traditionally, military satellites not owned by the US or Russia have been almost exclusively intended for telecommunications and imagery. Recently, however, states such as Canada, China, France, Germany, Japan, Israel, Italy, and Spain have been developing multi-use satellites with a wider range of functions. As security is becoming a key driver of these governments' space programs, expenditures on multi-use space applications are going 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. EU member states have

exhibited a remarkable predisposition for collaboration by sharing several space capabilities with their partners. During 2009 such navigation systems as China's Beidou, India's IRNSS, and the EU's Galileo continued to advance.

**2009 Developments:**

- The Indian Space Research Organization (ISRO) begins to develop military capabilities
- Various countries pursue satellite navigation systems
- Canada's multi-use space capabilities continue to be developed
- Europe moves forward with Galileo navigation system and deepens military cooperation on space projects
- China rapidly upgrades space-related technologies
- Japan outlines military space strategy
- Australia releases defense white paper addressing, inter alia, space situational awareness and access to space-based imagery

**Space Security Impact**

As more states develop the technologies and partnerships required to access space, accessibility of the space environment increases, which is positive for space security. Further, the increased collaboration among states, as in Europe, will allow countries that do not have the requisite technology or resources alone to have a chance to experience the benefits of access to space. Nevertheless, the impact of the development of space-based military capabilities by more states can be negative as the environment becomes congested and the number of potential targets increases. At the same time, these developments could also have a positive impact for space security as states will have an incentive to develop temporary, reversible offensive capabilities as more actors have a direct stake in this field. Further, as mentioned in Trend 5.1, the investments being made by multiple countries into satellite-based navigation could have a positive impact on space security as more options are presented to users and more redundancy is introduced. Finally, Japan's release of its military space strategy and the publication of Australia's defense white paper can be seen as positive for space security as the sharing of their plans reduces uncertainty.

## Space Systems Protection

**TREND 7.1: Efforts to protect satellite communication links increase but ground stations remain vulnerable** — Many space systems lack protection from determined attacks on ground stations and communications links. Because the vast majority of commercial space systems have only one operations center and one ground station, they are particularly vulnerable to negation efforts. While many actors employ passive electronic protection capabilities, such as shielding and directional antennas, more advanced measures, such as burst transmissions, are generally confined to military systems and the capabilities of more technically advanced states. Laser communications still have the best potential to reduce vulnerabilities of satellite communications links, but are proving difficult to implement. Furthermore, the link between cyberspace and outer space is of utmost importance as the vast majority of space assets depend on cyber networks, which constitute a critical vulnerability.

### 2009 Developments:

- Despite uncertainties, development of US Cyber Command moves forward
- Development of the Rapid Attack Identification Detection and Reporting System (RAIDRS) continues

### Space Security Impact

The creation of US Cyber Command (USCYBERCOM) can help the US achieve not only advanced capabilities to combat cyber threats, but also higher levels of security in their space missions. Although the implementation of a single cyber command has the benefit of higher levels of integration among different government and military forces, it is still unclear how such integration is to be achieved. Other issues to be solved include the specification of minimum requirements, roles, and responsibilities of the entities involved in its operation, which in turn could lead to security breaches. Although RAIDRS B-10 has been scaled down to five deployable sites, its development has continued and deployment is scheduled for 2010. As a result, the US military will be able, in the near future, to detect and identify attacks against their ground and space assets, which would have a positive impact on space security.

**TREND 7.2: Protection of satellites against direct attacks is improving but still limited** — The primary source of protection for satellites stems from the difficulties associated with launching an attack into space. Passive satellite protection measures also include system redundancy and interoperability, which have become characteristic of satellite navigation systems. Most key US, European, and Russian military satellites are hardened against the effects of a high-altitude nuclear detonation. Nonetheless, physically protecting a satellite from a direct

kinetic attack remains difficult. While no hostile ASAT attacks have been carried out, recent incidents, such as the ASAT test conducted by China when one of its own satellites was destroyed in 2007 or the US destruction of USA-193 in 2008 using a modified SM-3 missile testify to the availability and effectiveness of missiles to destroy even a hardened satellite should they be used in a hostile manner.

**2009 Developments:**

- US Air Force delays launch of Space Based Surveillance System
- More reliable evasive maneuvers for small satellites under development

**Space Security Impact**

Determining the precise positioning of space objects and fine-grained maneuvering of spacecraft can be used in performing evasive operations to avoid collisions, thus contributing to higher security in space. The same capabilities, however, could be used to precisely determine the position of a foreign spacecraft, perform fly-around maneuvers, and attack it. The distribution of information processing among several picosatellites can help reduce the burden of power consumption in an individual spacecraft during onboard processing. Consequently, picosatellites could rely on enhanced attitude control to perform evasive maneuvers, thereby improving security. As well, the use of cryptographic mechanisms in System F6 could increase the overall security of its communications systems to the extent that it would become virtually immune to attackers, thereby achieving high security levels.

**TREND 7.3: Efforts under way to develop capacity to rapidly rebuild space systems following direct attacks, but no operational capabilities**

— The ability to rapidly rebuild space systems after an attack could reduce vulnerabilities in space. Although the US and Russia are developing elements of responsive space systems, no state currently has this capability. A key US responsive launch initiative is the Falcon program, developed by Space Exploration Technologies (Space X), which consists of launch vehicles capable of rapidly placing payloads into LEO and GEO. As well, by the end of 2009 the X-37B Orbital Test Vehicle continued to be developed under a shroud of secrecy, with a maiden flight for the reusable, unpiloted spacecraft scheduled for April 2010 to test new reusable space launch vehicle technologies.

**2009 Development:**

- Research and development of low-cost launch capabilities progress

**Space Security Impact**

Quick launch with minimum cost can be considered primordial capabilities to allow for fast recovery of space assets following attacks. Although delayed in their schedule, Falcon launch vehicles can help reduce launch cost and time, thereby

contributing to higher levels of security for space systems. The progress made with the X-37B is expected to help the further development of technologies for reusable spacecrafts, which could be used for in-orbit repairs. While the X-37B's mission has been broadly described as testing reusable space technologies, there has been some as yet unfounded apprehension from nations like China that it could be used as part of a weapons system. Though such a claim is unsupported, if true, it would have a negative impact on space security by promoting distrust among other spacefaring nations and potentially triggering a weapons race in space.

## Space Systems Negation

**TREND 8.1: Proliferation of capabilities to attack ground stations and 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 incidents of intentional jamming of communications satellites have been reported in recent years. The US leads in developing doctrines and advanced technologies to temporarily negate space systems by disrupting or denying access to satellite communications, and has deployed a mobile system to disrupt satellite communications without inflicting permanent damage to the satellite.

### 2009 Developments:

- Satellite communication resources remain vulnerable to attack
- Facing growing threat of cyber warfare, Pentagon plans creation of military command for outer space

### Space Security Impact

Attackers have been successful in hijacking the transponders linked to older satellites as well as in jamming communications links, drawing attention to the vulnerability of the ground components of space systems. The operations of some space systems can therefore be compromised using low-cost equipment and with relative ease by individuals, groups, or governments, consequently reducing the security of space assets. Additionally, the number of highly sophisticated attacks against computer systems has increased. As a result, the US Government Accountability Office issued a report detailing the lack of appropriate security and the consequences to national space assets; if enhanced security measures are instituted, as recommended, the renewed vigilance may help increase security levels of space systems through improved awareness of the vulnerabilities of ground stations.

**TREND 8.2: Ongoing proliferation of ground-based capabilities to attack satellites** —

Space surveillance capabilities for debris monitoring and transparency can also support satellite tracking for space negation purposes. The US and Russia maintain the most extensive space surveillance capabilities and the US has explicitly linked its development of enhanced space surveillance systems to efforts to enable offensive counter-space operations. China and India also have satellite tracking, telemetry, and control assets essential to their civil space programs. France, Germany, Japan, and Europe are developing independent space surveillance capabilities that can also support tracking for negation purposes. Beyond surveillance systems to track for negation purposes, some spacefaring nations possess the necessary means to actually inflict intentional damage on an adversary's space assets, although such an occurrence has not yet transpired. While the development of ground-based anti-satellite weapons employing conventional, nuclear, and directed energy capabilities dates back to the Cold War, no hostile attacks using any of these means have been recorded. The US, China, and Russia lead in the development of more advanced ground-based kinetic-kill systems that have the capability to directly attack satellites. They have access to advanced laser programs, which have inherent satellite negation capabilities in LEO.

**2009 Developments:**

- Directed energy weapons continue to be developed and tested
- Development of indigenous launch capabilities in Iran and North Korea raises concerns about peaceful intentions of their space programs
- Development of ASAT capabilities discussed in a number of countries

**Space Security Impact**

In experiments in the US Air Force Research Laboratory, low-power lasers have successfully compromised small aircrafts. Although not tested against satellites, low-power lasers could have the potential of temporarily or permanently damaging non-hardened components of the spacecraft. Although US satellites experienced only decreased performance when purportedly illuminated by Chinese laser beams in 2006, such an incident could have led to reciprocal actions and therefore have contributed negatively to security in space. Another factor potentially affecting space security is the sustained testing of launch vehicles by Iran and North Korea. Since those launch vehicles could also be employed for non-peaceful objectives, the conduct of these countries has been scrutinized. The development of ASAT weapons remains highly contentious. The actual hostile use of a weapon against a space asset could result in a weapons race in space, thus considerably reducing space security.

### **TREND 8.3: Increased access to space-based negation capabilities**

— Space-based negation efforts require sophisticated capabilities, such as precision on-orbit maneuverability and space tracking. Many of these capabilities have dual-use potential. For example, microsattellites 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. The US leads in the development of most of these enabling capabilities, although there is no evidence to suggest that they have been integrated into a dedicated space-based negation system.

#### **2009 Development:**

- US updates military doctrine on space operations and advances its rendezvous capabilities

#### **Space Security Impact**

The inclusion of sections on rendezvous and proximity operations and offensive space control in the US doctrine for planning, executing, and assessing joint space can have serious implications for space security. Those capabilities can be employed not only to increase the security of US space assets by allowing for evasive maneuvers, but also to rendezvous with and compromise foreign spacecrafts. Enhanced rendezvous operations have already been demonstrated by the DARPA MiTEx microsattellites when inspecting the non-operational DSP-23 satellite. Several foreign nations can interpret such developments as potential threats to their space assets. A consequence of such a development could be the acceleration of investments in enhanced negation capabilities worldwide, thereby negatively impacting space security.

## **Space-Based Strike Capabilities**

### **TREND 9.1: Funding cuts in the US reflect a move away from the development of a missile defense space-based interceptor**

— Although the US and USSR developed and tested ground-based and airborne ASAT systems from the 1960s through the 1980s, there has not yet been a deployment of space-to-Earth or space-to-space missile strike systems. Under the Strategic Defense Initiative in the 1980s, the US invested several billion dollars in the development of a space-based interceptor concept called Brilliant Pebbles, and tested targeting and propulsion components required for such a system. The US and USSR were both developing space-based directed energy strike systems in the 1980s, although today these programs have largely been halted. Similarly, in 2009 the US House Budget Committee resolved that no funding should be provided for space-based interceptor research or development for FY2010.



### **2009 Developments:**

- Space-based missile interceptor technologies face funding cuts in the US
- US reiterates policy of not actively developing “space weapons”
- Development of Space Tracking and Surveillance System (STSS) moves forward while related Space Based Surveillance System (SBSS) project remains stalled

### **Space Security Impact**

The absence of functioning space-based strike systems undoubtedly has a positive impact on space security. What’s more, the US government seems to be voluntarily backing away from the pursuit of space-based interceptor technology by cutting the funding for the research and development of these programs. Likewise, the Pentagon’s reiteration of its policy of not actively developing “space weapons” has a positive impact for space security. The fact that the country with the most advanced space capabilities chooses not to actively pursue space-based weapons serves to delegitimize these weapons among other spacefaring states. Although the development of the STSS continued to move forward during 2009, this technology is not necessarily applicable to space-based strike systems; the direction this system takes when operational will indicate its overall impact on space security.

### **TREND 9.2: Advanced technologies that could potentially be used for space-based strike-enabling capabilities continue to be developed**

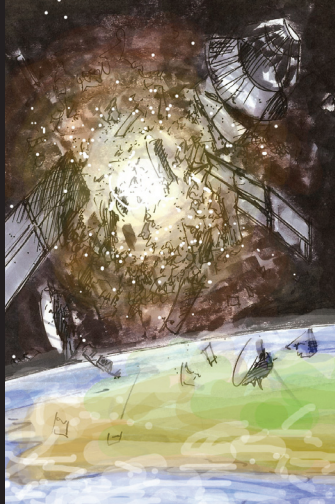
— The majority of advanced, space-based strike-enabling technologies are dual-use and are developed through civil, commercial, or military space programs. While there is no evidence to suggest that states pursuing these enabling technologies intend to use them for space-based strike purposes, such developments do bring these actors technologically closer to this capability. For example, recent successful tests conducted by the US Air Force have demonstrated the efficacy of air-based laser weapons that could potentially lead to the development of space-based weapons of a similar nature. China, India, and Israel are developing precision attitude control and large deployable optics for civil space telescope missions. Five states in addition to the European Union are developing independent, high-precision satellite navigation capabilities. China, India, and the EU are developing Earth-reentry capabilities that provide a basis for the more advanced technologies required for the delivery of mass-to-target weapons from space to Earth.

### **2009 Developments:**

- Boeing conducts successful test of air-based laser weapon for US Air Force
- Space-based strike enabling capabilities continue to be developed

**Space Security Impact**

Space-based weapons designed to strike terrestrial targets will require sophisticated technological developments that, at present, few spacefaring states seem able or willing to attempt. Although there is no evidence to definitively suggest that states are developing the abovementioned technologies for space-based strike purposes, the potential for space-to-Earth strike systems will continue to pose a challenge to the international community. The technology behind the air-based laser weapons developed by Boeing, for example, would have a negative impact for space security should it be conceived as a steppingstone toward a space-based weapon. Similarly, the push for a debut of the Prompt Global Strike program by 2015 could also represent a negative for space security; this program can be seen as another step toward the development of a space-based strike ability, even if the current program has another goal. Nevertheless, restraint in adopting these technologies is being observed. Continued restraint bodes well for space security.



# 2010

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