SECURING OUTER SPACE: A MAJOR GLOBAL CHALLENGE

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Abstract

The article intends to introduce the space security policy portfolio and the main issues and trends involved in the quest for effective space security architecture, and the international coordination of its implementation. It outlines the principal threats to secure space operations, including space debris, orbital crowding, radiofrequency interference, near-Earth objects (NEO), and the emergence of a new geostrategic backdrop. It likewise covers the importance of comprehensive Space Situational Awareness (SSA) capability, including its pivotal role in preserving the sustainable use of outer space. Finally, it addresses space governance issues such as the international Code of Conduct for Outer Space Activities introduced by the European Union (EU), the initiative of the UN Committee on the Peaceful Uses of Outer Space (COPUOS) on long-term space sustainability, and various transparency and confidence-building measures (TCBMs).

Keywords

Space security, space sustainability, space systems, Space Situational Awareness, counterspace, transparency and confidence-building measures.

INTRODUCTION

Space-based assets are essential for supplying a wide spectrum of critical civilian, commercial, and military-related services. In addition to the ever-present issue of orbital debris, the increasing number of space-faring nations and space aspirants, new and emerging space technologies (e.g. microsatellites) and their proliferation to a large number of state and non-state actors, present challenges to security policy decision-makers globally.

Although there is no uniform definition of space security, the Space Security Index, for example, uses a broad characterization based on the 1967 Outer Space Treaty: “the secure and sustainable access to, and use of, space and freedom from space-based threats”. Space security is generally comprised of two distinct concepts. First, preserving the environment of outer space, in particular Earth orbits, as a safe and secure area for conducting space activities, as well as protecting civilian, military, and commercial space assets from natural and man-made threats (including ground-based infrastructure). Second is using space to advance terrestrial security (e.g. the use of communications, navigation and positioning, and earth observation for disaster and crisis management, border control, etc.). The two concepts can be summarized as "security for space" and "space for security", respectively. In the past few years, the concept of space sustainability, or preserving the space environment for future generations, is also gradually appearing on the agendas of foreign and security policy decision-makers.

The actions and developments related to space security are regularly assessed by the annual Space Security Index which examines nine indicators that are organised under three themes. They include the condition of the space environment, space situational awareness and space laws, policies, and doctrines. Other indicators describe the type of actors in space and how space is used with respect to civil space programs and global utilities, commercial space and space support for terrestrial military operations. Finally, the status of space-related technology as it pertains to protecting or interfering with space systems, or harming Earth from space-based systems, space systems negation and space-based strike capabilities.

Without the ability to safeguard space-based systems and assets, there can be no sustainable use of space to contribute to security on Earth. Accordingly, this article will focus on the first concept described above and the main challenges connected with preserving a safe, secure, and stable space environment. Specifically, it will review the current status of space security, describe obstacles to establishing comprehensive Space Situational Awareness (SSA); and outline the need for diplomatic efforts to advance space security, both of a top-down and bottom-up variety.

STATUS OF SPACE SECURITY

The world today relies heavily on communications satellites, environmental monitoring, weather forecasting, and navigation, to name but a few of the services provided by space applications. Space assets (including ground-based) are, therefore, properly regarded as critical infrastructure and their disruption or damage would result in far-reaching economic, political, and geostrategic consequences. Orbiting satellites are operated by some sixty governmental entities, and commercial and academic satellite operators. Accordingly, beyond the two traditional space powers, the U.S. and Russia, other new actors, notably China, changed the geostrategic setting in space and will shape global space policies for the 21st century.

A growing amount of orbital space debris remains one of the key challenges for a safe space environment. Space debris in the altitudes up to 200 km are burned in the atmosphere within days, those in altitudes up to 800 km can orbit the Earth for years and decades, and those above 800 and in the geostationary orbit can remain there forever. China’s destruction of its old weather satellite by an ASAT weapon in 2007, and 2009 collision of Cosmos and Iridium satellites, moved space debris on to the radar screen of a broader world's audience which, until that time, had not been especially sensitive to this issue. The U.S. Department of Defense (DOD) currently tracks approximately 22,000 man-made objects in orbit. About 1,100 of these are active satellites. The Joint Space Operations Center (JSpOC) of the US Air Force screens over 1,000 active payloads against the USG's space catalog daily. Moreover, the US Space Surveillance Network (SSN) performs 1.4 million sensor taskings per week with an average of 190 conjunction warnings and assistance to an average of three satellite maneuvers weekly.

In addition to the perils of space debris, a growing number of space-faring nations and satellite applications are increasing the demand for limited radiofrequency spectrum and orbital slots. Both might be considered common resources, not owned by any nation or organization. The rise in demand also presents a challenge to space governance and a more coordinated and collaborative approach to the allocation of those scarce space resources. Radio frequencies and orbital slots are indispensable tools for space operations and securing them is a prerequisite for space operators in designing any new space mission. The technical ease with which both intentional and unintentional frequency interference can occur will remain a significant space security concern for the foreseeable future.

Since most satellite communication falls below 60 GHz, space actors are competing for a relatively small portion of the radio spectrum. Competition is particularly intense for the segment of the spectrum below 3 GHz. In addition, the number of satellites operating in the 7-8 GHz band [1], commonly used by GEO satellites, has grown rapidly over the past two decades. As a consequence, increasing frequency interference and disputes occur, such as the disagreement over frequency allocation among navigation systems [2]. In this respect, efforts are needed to harmonise radio frequency utilization. Since many satellite operators are seeking advantageous frequencies and ever closer orbital slots, there is an increased risk of accidental signal interference. The crowding of satellite operators in Asia in particular is creating new risks.

The international governance of finite radio spectrum is managed by the International Telecommunication Union (ITU) Constitution demanding that satellites operate in a manner that will not cause harmful interference to other users of spectrum. Although military applications [3] are exempt from the ITU Constitution, they must also observe measures to prevent harmful interference. The commercial sector wishes to acquire a larger portion of the overall spectrum, including predominantly military frequency bands [4].

In order to avoid or mitigate signal interference in this congested environment, new technologies are being developed to manage greater frequency usage demand, thus allowing more satellites to operate in closer proximity without interference. Methods such as frequency hopping, digital signal processing, software-managed spectrum, lower power output or frequency-agile transceivers have been developed with the aim to significantly improve bandwidth use by avoiding possible conflicts in its allocation. Accordingly, current receivers have a higher tolerance for interference. Advanced research is also being conducted concerning the possible use of lasers for communications, particularly by the military. The main advantage of lasers in this respect is that they can transmit information at very high bit rates and yet have very narrow beams, which could allow for more precise tracking of satellites. As a consequence, it can enable the closer placement of lasers without unnecessary interference occurring. This primarily takes place when two spacecraft concurrently require the same frequencies and their fields of view overlap, or if they are transmitting energy in close proximity to one another.

In order to allow for better sharing of data and increased safety and efficiency (including an effort to avoid and resolve radio frequency interference issues), a group of commercial GEO satellite operators announced in 2009 the establishment of the Space Data Association (SDA) [5], a not-for-profit organization founded by Inmarsat, Intelsat and SES. In April 2010, Analytical Graphics, Inc. (AGI) obtained a contract to design and operate the Space Data Center, SDA's automated space situational awareness system designed to reduce the risks of on-orbit collisions and radio frequency interference. Initial Space Data Center operations began in July 2010, and it reached full capacity in April 2011.

The increased competition for orbital slot assignments [6], particularly in geostationary orbits [7], where most communications satellites operate [8], has caused occasional disputes among satellite operators over both intentional and unintentional interference. Due to the long distance and use of high bandwidth signals for television or broadband applications, GEO satellites need to generate high-power transmissions to deliver a sufficiently strong signal to Earth to avoid radio frequency interference. GEO satellites typically have to maintain orbital separation between two and nine degrees depending on their ground antennas field of view, the service provided and the band they are using to transmit and receive signals [9]. Accordingly, only a limited number of satellites might occupy the equator orbital path. The ITU Constitution is dealing with the limited availability of orbital slots and observes that radio frequencies and associate orbits, including those in GEO, "must be used rationally, efficiently and economically…so that countries or groups of countries may have equitable access" to both [10].

It works somewhat differently in practice and equitable access has, at times, been compromised by commercial interests. The orbital slots in GEO are allocated on a first-come, first-served basis. In order to secure respective slots, operators proceed to register satellites before, or without, clear intent to really use them. This has given rise to the term "paper satellites". The rush was accelerated in anticipation of an expected rise in network filling fees imposed by the ITU and motivated inter alia by ITU revenue shortfalls. [11] [12]. Besides this new scheme for registration fees [13] [14], additional measures for reducing unnecessary registrations include a requirement that respective satellites should be launched within seven years after a request, as well as a requirement to provide advanced publication information at the time the satellite enters service. Payment of the filing fees is, of course, also a requirement. Although filling orbits in the MEO segment was not originally a concern for the US GPS and Russia's GLONASS systems, this may be changing. For example, Russia has to carefully consider the addition of more satellites. The EU and China are also moving forward with their own satellite navigation plans. The problem should not occur if operational orbits are sufficiently separated by different inclinations and altitudes. It could, however, pose an issue if MEO satellites would not be properly disposed after their operational life and thus potentially causing threat to the other ones.

Some in the space community also believe that greater global attention needs to be paid to the threat of collision with near-Earth objects (NEOs) [15]. The United States spends about $4 million annually searching for NEOs, according to NASA. The U.S. Congress established two mandates for the search for NEOs by NASA. The first, in 1998, now referred to as the Spaceguard Survey, called for the agency to discover 90 percent of NEOs with a diameter of 1 kilometer or greater within ten years. An object of this limited size is considered by most experts to be the minimum that could produce global devastation if it struck Earth. NASA is close to achieving this goal and should reach it within few years. Of the estimated 1,100 objects in this class, NASA tracks approximately 80 percent [16]. However, as the recent discovery of an approximately 2 to 3 kilometer diameter NEO demonstrates, there are still large objects to be detected.

The second mandate, established in 2005, known as the George E. Brown Jr. Near-Earth Object Survey Act, called for NASA to detect 90 percent of NEOs 140 meters in diameter or greater by 2020. The impact of such objects would have the potential to wipe out regions of the Earth’s surface. This ambitious objective is unlikely to be achieved. Discovery of these objects, along with those over 1 km in diameter, would reflect around 90 percent of the risk the Earth faces from NEO collisions.

There is now a growing consensus that the greatest threat is not from asteroids that could destroy Earth, but those that have the potential to destroy large areas such as cities. These are objects approximately 45 m in diameter, one of which caused the Tunguska explosion in Siberia in 1908 that devastated more than 2,000 square kilometers of forest. Researchers estimate that there are over 700,000 NEOs of this size, of which approximately three percent are estimated to pose some risk of impact [17]. Although objects of that size cause considerably less damage, their impact could still have catastrophic consequences.

Technical research is underway concerning mitigating the risk of a NEO collision with the Earth. Mitigation methods often depend on how much warning time there is prior to a potential impact event. Measures include the evacuation of inhabitants, and kinetic deflection whereby one or more spacecraft with massive payload(s) are programmed to impact directly on the target at high speed in the same direction, or the opposite direction. Explosions of nuclear weapons have also been discussed as a method of changing a NEO trajectory. This drastic method would create additional threats, however, to the environment and stability of outer space and would have complex technical and policy ramifications.

As of September 2011, there were more than 8,211 known NEOs, 1,246 of which were Potentially Hazardous Asteroids (PHAs) [18] [19]. Discussions of the governance dimensions of NEO detection and mitigation are therefore of significant value.

For closer illustration of the number of NEOs predicted to approach the Earth between mid-September 2011 and the end of the year, see the NASA close-approach tables below (highlighting those objects that should pass the Earth at the distance closer than 25 LD (lunar distances) [20]:

RECENT CLOSE APPROACHES TO EARTH
1 AU = ~150 million kilometers
1 LD = Lunar Distance = ~384,000 kilometers

Object Name	Close Approach Date	Miss Distance (AU)	Miss Distance (LD)	Estimated Diameter*	H (mag)	Relative Velocity (km/s)
(2011 QS49)	2011-Sep-15	0.0372	14.5	38 m - 86 m	24.2	6.08
(2011 LJ19)	2011-Sep-15	0.0426	16.6	150 m - 330 m	21.3	10.05
(2011 PT)	2011-Sep-17	0.0550	21.4	41 m - 91 m	24.1	3.06
(2007 TD)	2011-Sep-22	0.0160	6.2	36 m - 79 m	24.4	12.11
(2011 QE38)	2011-Oct-05	0.0608	23.7	93 m - 210 m	22.3	8.04
(2010 GM65)	2011-Oct-12	0.0376	14.6	87 m - 190 m	22.4	20.85
(2009 TM8)	2011-Oct-17	0.0023	0.9	5.1 m - 11 m	28.6	8.18
(2009 UC)	2011-Oct-18	0.0571	22.2	13 m - 29 m	26.6	12.96
(2011 LC19)	2011-Oct-29	0.0580	22.6	540 m - 1.2 km	18.5	14.54
(2010 VU98)	2011-Oct-31	0.0462	18.0	30 m - 68 m	24.7	10.22
(2005 YU55)	2011-Nov-08	0.0022	0.8	110 m - 240 m	21.9	13.72
(2003 XV)	2011-Dec-04	0.0262	10.2	12 m - 27 m	26.7	12.66
(2004 BG41)	2011-Dec-14	0.0335	13.0	35 m - 77 m	24.4	8.36
(2011 OV18)	2011-Dec-20	0.0496	19.3	290 m - 640 m	19.8	12.09
(2000 YA)	2011-Dec-26	0.0074	2.9	49 m - 110 m	23.7	13.62
(2003 AK18)	2011-Dec-28	0.0570	22.2	310 m - 700 m	19.6	11.67

* Diameter estimates based on the object's absolute magnitude.

The European Space Agency announced that one of the three pillars of its new Space Situational Awareness Program will be the detection and tracking of NEOs [21]. The SSA-NEO segment will also provide information on the likelihood of impact and accompanying risk assessments. Other cooperative multilateral efforts to address this challenge would almost surely enhance space security.

With regard to the use of space for military activities, the U.S. and Russia still have the world's foremost capabilities. The U.S. is the largest investor in space technologies globally and Russia has actively sought to replace its ageing space capabilities with an emphasis on deploying its own global navigation system GLONASS. China is the fastest growing new space power and is developing a wide range of space capabilities. It operates a regional navigation system, Beidou, and is developing a global version (Beidou-2). It possesses reconnaissance systems that offer increasingly precise visible, infrared, multi-spectral, and synthetic aperture radar imaging (e.g. the Ziyuan-2 and Yaogan series). It likewise uses a number of domestic and foreign communications capabilities [22]. Finally, China has an array of available launch capabilities, notably the different types of space launch vehicles associated with its Long March Series, together with three launch facilities [23]. China has likewise developed a mobile launch capability, the solid fuel rocket *Pioneer*-1(KT-1) [24]. The KT-1 can carry satellites that weigh less than 100 kg, while the KT-2 can carry up to three 100 kg payloads or one 400 kg payload. China began work on a new generation of launch vehicles in 2001 that are said to become operational between 2011 and 2015 [25].

Since its first satellite was launched in 1970, China has made important strides in its efforts to become a major space power, especially over the past decade. On the civilian side, it has pursued human spaceflight and exploration. In October 2003, China became the third nation to send a man into space. China's first lunar orbiter, Chang'e-1, launched in October 2007, successfully completed its mission and demonstrated that the country had developed the technology to conduct complicated space maneuvers. With its January 2007 first successful test of a kinetic energy anti-satellite (ASAT) weapon referenced above, China became only the third nation to have demonstrated this military capability. Although establishing the China National Space Agency (CNSA) in 1993 to lead its civilian space program, China does not make a clear distinction between its civilian and military space activities, all of which have been overseen by the People's Liberation Army (PLA) [26].

Besides its prominently advertised civilian space program, the country has been actively pursuing a counterspace capability which can temporarily deny, or completely destroy, an adversary's space capability [27]. Such capability can involve action (ground- or space-based) against ground-based components, the down and up communications links, space launchers, or satellites themselves in the form of cybernetic or electronic interference, conventional weapons, directed energy (laser), or nuclear capabilities [28]. China has deployed various kinetic and non-kinetic weapons and terrestrial jammers. It is also exploring counterspace capabilities such as space jammers, high-energy lasers, high-powered microwave weapons, particle beam weapons, and electromagnetic pulse (EMP) weapons [29].

Unlike the U.S. and Russia (and earlier the Soviet Union), countries with decades-long experience with space negation capabilities and the implications of their use, China emerges as a space power in a new geostrategic environment and its intentions and aspirations are currently not clear. Accordingly, improved and strengthened diplomatic channels between major space powers will be necessary to reduce the potential for misperceptions or miscalculations.

SPACE SITUATIONAL AWARENESS (SSA)

In the U.S., the new National Space Policy (NSP) of June 2010, and the 2011 National Security Space Strategy (NSSS), concluded that space, in comparison with the previous decades of the Space Age, is increasingly "congested, contested, and competitive" [30]. Space is more congested due to the growth of global space activities. The U.S. also views space systems, and their supporting infrastructure, as increasingly contested due to the existence of "a range of man-made threats that may deny, degrade, deceive, disrupt, or destroy assets".

Space Situational Awareness (SSA) supports the safe and secure operation of space assets and related services, as well as risk management (on orbit and during re-entry) and liability assessment. Increasing numbers of space-faring nations and space aspirants, as well as new and emerging space technologies, complicate space surveillance and make comprehensive SSA of space objects a difficult task. There have been a number of efforts to advance space security through SSA, including an effort on the part of the U.S. to cooperate in preventing on-orbit collisions via sharing SSA-derived information with commercial operators and other governments. The U.S. SSA Sharing Program offers services to users and partners. The U.S. Department of Defense has also signed bilateral SSA statements of principles with Canada, France, and Australia, and seeks to expand cooperation with other countries as well [31]. Another initiative is that of the Space Data Association (SDA), referenced above, which seeks to exchange SSA information among satellite owners and operators. Indeed, broader discussions are already underway on the need to create a more comprehensive SSA picture and share data and information internationally. These discussions are aimed at contributing to the improved security of space assets for responsible space-faring nations.

The sharing of Space Situational Awareness (SSA) data is likewise perceived as an important transparency and confidence- building measure (TCBM). It is now evident that SSA is a prerequisite for safeguarding satellites and spacecraft as it enables the tracking of objects, timely warnings of potential collisions, avoidance of radiofrequency interference and real-time information about "situations" in space. SSA-generated information is likewise necessary to detect irresponsible space behavior and monitor the actions of potential adversaries.

For its part, Europe recognizes that SSA is essential for the protection of critical European space infrastructure as well as for reliable and safe space-based operations and services. SSA capability is likewise viewed as an important element of Europe's extensive efforts to promote the peaceful uses of outer space. The European Space Agency (ESA) and European countries more generally, are largely dependent on U.S. Strategic Command (USSTRATCOM) concerning space object location, tracking and other information. Europe possesses some radar and optical capabilities for space surveillance, often operated by different countries. Accordingly, Europe is seeking to construct a Continent-wide SSA system that would support the safe and secure operations of European space assets. Not surprisingly, there exist impediments to information exchanges due to national security considerations. The Ministerial Council of the European Space Agency (ESA) authorized an optional SSA Preparatory Programme (SSA-PP) in 2008 with thirteen ESA Member States (MS) currently participating. The approval for further development of the SSA System is expected at the next ESA Ministerial Council in 2012.

Commercial operators constitute an important contributor to SSA as they share with each other, on a regular basis, information about their flight operations. Commercial firms can help fill in gaps or shortfalls in government capabilities as evidenced by the establishment of the Space Data Association (SDA). The SDA seeks to address the risks of collision and radiofrequency interference which costs them dearly in foregone annual revenues. As of January 2011, the SDA provides conjunction assessment (CA) to 311 satellites of 20 different operators (197 satellites in geostationary orbit and 114 satellites in low-earth orbit). This initiative is emblematic of the thirst for broader bottom-up support for space security.

The bottom-line is that space operations rely heavily on SSA. It is one of the most important elements of ensuring safety and security of all functioning satellites and spacecraft, and enabling the monitoring and understanding of a constantly changing space environment. SSA also represents an important venue to enhance the peaceful use of space.

SUSTAINABLE USE OF SPACE

The expanding number of space actors, objects and debris multiplies threats to safe and secure space operations. Accordingly, the norms established by the 1967 Outer Space Treaty (OST) are more relevant than ever. The ability of states, however, to ensure adherence to the OST and implement various provisions of the Treaty have been inadequate to date. Carefully-crafted transparency and confidence-building measures (TCBMs) that take into account operational characteristics of space can go a long way toward remedying this situation and bolstering space sustainability.

TCBMs are already present in existing, legally-binding space agreements and related UN resolutions. The concept of TCBMs for space was adopted by the UN, for the first time, via Resolution 60/66, entitled “Transparency and Confidence-Building Measures in Outer Space Activities” [32]. Space TCBMs were likewise introduced in a 2006 Russian and Chinese working paper (CD/1778) and led to a number of UN Resolutions [33]. Existing TCBMs for space carry benefits as well as associated baggage. Both Russia and China, which proposed the Conference of Disarmament-related TCBMs, are proponents of a legally-binding treaty on banning space weapons which lacks proper verification end enforcement provisions. There is also a history of terrestrial TCBM disappointments, especially in the arms control and missile proliferation arenas. These mixed results complicate persuading some space actors of the benefits of TCBMs for non-binding agreements [34]. At the same time, various space-related TCBMs are currently being considered.

The adoption by the UN General Assembly of the Inter-Agency Debris Mitigation Guidelines in February 2008 is an example of a successful bottom-up approach and is perceived as one of the most significant contributions to preserving the outer space environment since the signing of the OST [35]. Another TCBM-related effort is the draft Code of Conduct for Outer Space Activities introduced in 2008 by the European Union (EU), and a revised version of which was put forth in September 2010. This top-down initiative is an effort on the part of the EU to play a normative role in space security through the “principled” identity it seeks to achieve [36]. The EU Council Conclusions state that the Code includes TCBMs and will be open to all states for voluntary compliance. The U.S. announced in January 2012 its readiness to support negotiations on an “International Code of Conduct“. In addition to the U.S. and Europe, Japan, Australia and several other countries have expressed their support for this initiative. The general nature of the objectives outlined in the Code, however, leaves ample room for various interpretations. Accordingly, guidance on more concrete TCBMs could help substantiate formal initiatives such as the Code of Conduct.

At the UNCOPUOS Scientific and Technical Subcommittee (STSC), the topics of space debris, space weather, near-earth objects, nuclear power sources in space and other topics closely related to space sustainability have been on the agenda for many years. A new item on the agenda of the STSC, originally initiated by France and introduced formally in February 2010, is entitled “long-term sustainability of space activities”. It seeks to adopt a comprehensive approach to preserving space for the generations ahead. A Working Group was established, and met for the first time in June 2010, to advance establishment of practical measures, accompanied by voluntary guidelines, to enhance space sustainability [37]. The overarching goal is to formulate “best practices guidelines” for safer operations in space.

Many familiar with the consensus-based work of the UN argue, quite justifiably, that the evolution of space-related realities is proceeding faster than the UN’s uneven pace. It has been pointed out that the UNCOPUOS is perhaps being sidelined by other initiatives such as that of the EU on the Code of Conduct or the SDA on data sharing. Moreover, UNCOPUOS has yet to address the question of the involvement of private actors, whose role is increasingly relevant for deliberations on space activities. Nevertheless, the UNCOPUOS will remain an essential platform with global reach to encourage TCBMs and other space sustainability-related activities, including the establishment of a mechanism for improved SSA-sharing [38].

CONCLUSION

Space is an important strategic asset for many nations in the 21st century. There is now a widespread recognition of global dependency on space systems accompanied by a desire by most space actors for maximum autonomy in a number of areas. Research, scientific knowledge, and technological innovation in the information age are the foundation of space activities that enable operations in space, understanding of space phenomena, and the observation and monitoring of the Earth. At the same time, new dual-use technologies complicate the effort to establish well-rounded measures that enhance stability and predictability in space. A number of space security-related initiatives are already underway, including in the areas of orbital debris, collision and radiofrequency interference mitigation, SSA, and a code of conduct for outer space activities. Although virtually all space-faring nations desire to mitigate orbital debris, secure free access to space and avoid misunderstandings and "incidents", the means of implementing certain of these objectives remain elusive. Given the complex space environment involving new actors and technologies, there is a need for more creative transparency and confidence-building measures (TCBMs), especially given the fact that no new viable space treaty presently on the horizon.

Different efforts to address space security, both top-down and bottom-up, will likely continue to proceed in parallel. It is the responsibility of governments to educate their respective publics about the issues connected with safe and secure operations in space. For those engaged in these activities on a daily basis, there is a requirement to identify creative ways to strike a balance between multiplying the benefits of enhanced cooperation and affordability/security. Finally, those charged with managing space security need to take into account the inevitable intersection of terrestrial conflicts and the space environment.

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NOTES and REFERENCES

[1] Communications satellites are mostly using the L-band (1-2 GHz) and S-band (2-4 GHz) for mobile phones, ship communications, and messaging, the C-band (4-8 GHz) for roving telephone services and the Ku-band (12-18 GHz) for connections between satellite users. The Ka-band (27-40 GHz) is now being used for broadband communications. It is US policy to reserve the Ultra-High Frequency, X-, and K-bands (240-340 megahertz, 8-12 GHz, and 18-27 GHz, respectively) for the US military.

[2] In 2004 the US and EU agreed to major principles over frequency allocation and interoperability between the US GPS and the EU Galileo navigational

system [39]; after finalizing details in 2007 for a common GPS-Galileo civilian signal allowing for interoperability of the two systems while also maintaining the integrity of the US military signal, [40] an added conflict has arisen from China's announcement that it wants also launch a global satellite navigation system; it has filed with the ITU to transmit on signals that would overlay both Galileo and the US M code. Chinese sources indicate that it is willing to cooperate with the other systems, but there is no sign of efforts to reach an agreement.85

[3] During the US-led invasion of Afghanistan in 2001, the US military used some 700 megabytes per second of bandwidth, up from about 99 megabytes per second used during the 1991 US operations in Iraq.

[4] The US Department of Defense is releasing a portion of the military-reserved spectrum from 1.710-1.755 gigahertz to the commercial sector for third-generation wireless communications. India, however, has the world's fastest growing telecoms market, and there is an ongoing struggle between the commercial sector and the Indian Department of Defence over spectrum use.

[5] The SDA's charter is to seek and facilitate improvements in the safety and integrity of satellite operations through wider and improved coordination among satellite operators and to facilitate improved management of the shared resources of the space environment and the RF spectrum.

[6] Today's satellites operate mainly in low earth, medium earth and geostationary orbits (LEO, MEO and GEO). There were, as of 23 June 2011 according to [w] 958 operational spacecraft, approximately 49 percent of which are in LEO, 6,5 percent in MEO, 40,5 percent in GEO, and about 3,5 percent in either Highly Elliptical Orbit (HEO) or planetary trajectories [41]. HEO is increasingly being used for specific applications, such as early warning satellites and polar communications coverage. LEO is often used for remote sensing and earth observation, and MEO for space-based navigation systems. Most communications and some weather satellites are in GEO.

[7] A satellite in geostationary orbit orbits the earth in exactly 24 hours and is placed above the equator. The angle with the equator is 0 degrees. As a result the satellite seems to stand still as seen from the earth. These satellites are used for communications and Satellite TV.

[8] Out of 966 operational satellites in the mid of 2011, 555 are dedicated to communications, 81 to Earth observation/remote sensing, 72 to navigation, 69 to military surveillance while the others execute primarily scientific missions.

[9] SCHERAGA, Joel D. "Establishing Property Rights in Outer Space." 6 Cato Journal (1987).

[10] Constitution and Convention of the International Telecommunication Union, Art. 33, para. 2.

[11] "At one time there were about 1300 filings (applications) for satellite networks before the ITU and about 1200 of them were for paper satellites."

[12] JAKHU, Ram. "Legal Issues of Satellite Telecommunications, the Geostationary Orbit, and Space Debris." 5(2) Astropolitics (2007): 182.

[13] Filing fees for ITU cost recovery grew from about $1,126 in 2000 to $31,277 in 2003, resulting in patterns of non-payment and tensions between satellite operators and the ITU. A fee schedule implemented in January 2006 links charges to the complexity and size of a filing. While most incur a flat fee of $500, they can reach almost $60,000 for complex requests requiring extensive coordination.
[14] MATAS, Attila. “Cost Recovery for Satellite Network Filings.” ITU Regional Radiocommunication Seminar, Abu Dhabi (22-26 April 2007).
[15] NEO are asteroids and comets whose orbits bring them in close proximity to the Earth or intersect the Earth’s orbit. NEOs are subdivided into Near Earth Asteroids (NEAs) and Near Earth Comets (NECs).
[16] SCHWEICKART, Russell. “The Asteroid Impact Threat: Decisions Upcoming.” Presentation. The 37th COSPAR Scientific Assembly, Montreal, Quebec, Canada. July 2008.
[17] Ibid.
[18] A PHA is defined as an asteroid whose orbit comes within 0.05 astronomical units of the Earth’s orbit and has a brightness magnitude greater than 22 (approximately 150 m in diameter).
[19] “NEO Discovery Statistics.” 22 Sept. 2011. NASA Near Earth Object Program. <http://neo.jpl.nasa.gov/stats>.
[20] „NEO EARTH CLOSE APPROACH TABLES.“ 22 Sept. 2011. NASA Near Earth Object Program. <http://neo.jpl.nasa.gov/neo>.
[21] KOSCHNY, Detlef. “ESA’s Space Situational Awareness Near-Earth Object Programme.” Presentation. The Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space, Vienna, Austria. February 2009. <http://www.oosa.unvienna.org/pdf/pres/copuos 2009/tech-13.pdf>.
[22] HAYS, Peter L. “Space and Sino-American Security Relations.” Space and Defense, Winter 2009 Vol. 2, No.3. Colorado: Eisenhower Center for Space and Defense Studies, 2009. 29-30.
[23] POLLPETER, Kevin. “Building for the Future: China’s Progress in Space Technology During the Tenth 5-Year Plan and the U.S. Response.” The Strategic Studies Institute. March 2008: 27-28.
[24] “2008 Report to Congress of the US-China Economic and Security Review Commission.” Nov. 2008. US Government Printing Office. Washington. 158.
[25] POLLPETER, Kevin. “Building for the Future: China’s Progress in Space Technology During the Tenth 5-Year Plan and the U.S. Response.” The Strategic Studies Institute. March 2008: 7-9.
[26] HAYS, Peter L. “Space and Sino-American Security Relations.” Space and Defense, Winter 2009 Vol. 2, No.3. Colorado: Eisenhower Center for Space and Defense Studies, 2009. 18-21.
[27] “Counterspace Operations” 2 Aug. 2004. Air Force Doctrine 2-2.1. 22 Sept. 2011. <http://www.dtic.mil/doctrine/jel/service_pubs/afdd2_2_1.pdf>.
[28] “Space Systems Negation.” Space Security 2010. 154.

[29] HAYS, Peter L. “Space and Sino-American Security Relations.” Space and Defense, Winter 2009 Vol. 2, No.3. Colorado: Eisenhower Center for Space and Defense Studies, 2009. 30.

[30] „Department of Defense. National Security Space Strategy.“ Jan. 2011. Department of Defense 28 Mar. 2011. <http://www.defense.gov/home/features/2011/0111_nsss/docs/NationalSecuritySpaceStrategyUnclassifiedSummary_Jan2011.pdf>.

[31] ROSE, Frank A. “U.S. Remarks on Space Security at UNIDIR Conference, April 2011” 4 Apr. 2011 Council on Foreign Relations. 2 Mai. 2011. <http://www.cfr.org/defensehomeland-security/us-remarks-space-security-unidir-conference-april-2011/p24615>.

[32] United Nations General Assembly. Resolution adopted by the General Assembly entitled “Transparency and confidence-building measures in outer space activities.” UN Doc. A/RES/60/66 of 6 Jan. 2006. New York: United Nations.

[33] Conference on Disarmament. “Working Paper: Transparency and Confidence-Building Measures in Outer Space Activities and the Prevention of Placement of Weapons in Outer Space.” Doc. CD/1776 of 22 May 2006. 26 July 2007. <http://www.reachingcriticalwill.org/political/cd/papers06/22MayChinaRussia1.pdf>.

[34] ROBINSON, Jana. “The Role of Transparency and Confidence-Building Measures in Advancing Space Security“. ESPI Report 28. 2 Mai 2011. <http://www.espi.or.at/images/stories/dokumente/studies/ESPI_Report_28_online.pdf>: 30.

[35] WILLIAM, J. Flynn. “Remarks on Space Policy. “ High Frontier February 2011: 40.

[36] ROBINSON, Jana. “Enabling Europe’s Key Foreign Policy Objectives via Space“ ESPI Report 30. 2 Mai 2011. <http://www.espi.or.at/images/stories/dokumente/studies/ESPI_Report_30_FINAL.pdf5>.

[37] PRUNARIU, Dumitru-Dorin. „Space Sustainability: Setting a Technical Baseline for New Regimes.“ UNIDIR Space Security Conference 2011: Building on the Past, Stepping Toward the Future.

[38] SCHROGL, Kai-Uwe. „Is UNCOPUOS Fit for the Future? Reflections at the occasion of the 50th session of its Legal Subcommittee 2011.” German Journal of Air and Space Law (ZLW) (60,1) 2011, 93-102.

[39] “EU and US a Step Further to Agreement over Galileo Satellite Navigation following Brussels Negotiating Round.” 22 Sept. 2011. European Commission 25 February 2004. <http://www.eurunion.org/news/press/2004/20040030.htm>.

[40] “EU, US to Make GPS and Galileo Satellite Networks Compatible.” EU Business 31 July 2007 <http://www.nfia.com/nieuws.html?id=105>; “US says to reach GPS-Galileo agreement this week.” Reuters (16 July 2007). <http://www.reuters.com/article/2007/07/16/us-galileo-us-idUSL1674424620070716>.

[41] “Satellite Quick Facts,” Union of Concerned Scientists (23 June 2011). <http://www.ucsusa.org/assets/documents/nwgs/quick-facts-and-analysis-6-23-11.pdf>.
[42] SILHAN, Vladimir. „Current Status and Trends in Use of Outer Space“. Vojenské rozhledy 1/2012, 132-147.
[43] Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies, Committee to Review Near-Earth-Object Surveys and Hazard Mitigation Strategies, US National Academy of Sciences, 2010, ISBN 978-0-309-14968-6.
[44] SILHAN, Vladimir. “Status and Trends in Space”. CESES FSV UK. Working paper 7/2011. 13 July 2011. <http://ceses.cuni.cz/CESES-157-version1-TRS_WP_07.pdf>.