National Defence | Défense nationale

Canadian Forces College

Collège des Forces Canadiennes

TRANSPARENCY AND CONFIDENCE-BUILDING MEASURES: ESSENTIAL ELEMENTS TO MITIGATE THE VERIFICATION CHALLENGES OF SPACE COUNTER-PROLIFERATION

Lieutenant-Colonel J. Jobin

JCSP 39 DL

Master of Defence Studies

Disclaimer

Opinions expressed remain those of the author and do not represent Department of National Defence or Canadian Forces policy. This paper may not be used without written permission.

PCEMI 39 AD

Maîtrise en études de la défense

Avertissement

Les opinons exprimées n'engagent que leurs auteurs et ne reflètent aucunement des politiques du Ministère de la Défense nationale ou des Forces canadiennes. Ce papier ne peut être reproduit sans autorisation écrite.

Canada

CANADIAN FORCES COLLEGE – COLLÈGE DES FORCES CANADIENNES
JCSP 39 DL – PCEMI 39 AD

MASTER OF DEFENCE STUDIES – MAÎTRISE EN ÉTUDES DE LA DÉFENSE

TRANSPARENCY AND CONFIDENCE-BUILDING MEASURES: ESSENTIAL ELEMENTS TO MITIGATE THE VERIFICATION CHALLENGES OF SPACE COUNTER-PROLIFERATION

By Lieutenant-Colonel J. Jobin

1 August 2014

Word Count: 14 004

Compte de mots : 14 004

Abstract

After almost sixty years in space, man has rendered Earth's orbit a very congested and cluttered environment. Debris from launch vehicles, satellites and other space objects pose a significant hazard to space operations, and will do so for decades if not centuries to come. The slow rate of decay of some of these objects makes it imperative to create as little debris as possible in future space launches, through a careful approach to the planning and conducting of space operations.

Treaties and other formal legislation attempt to address space security issues, but do so with mixed results. Not only are they short of universal adherence, but it is difficult to generate the buy-in required to achieve their goals due to the very different considerations of each state's pursuits. By comparison, some treaties such as the Chemical Weapons Convention have achieved a large degree of success, which could be argued stems from a robust verification regime which allows to ensure compliance. Such verification can be problematic in space, so additional measures are needed to complement the existing legal framework to protect the space environment.

Transparency and Confidence-Building Measures (TCBM) offer ways to bridge the gap of formal treaties by offering more flexibility based on voluntary measures. This paper does not claim that TCBM in themselves are the answer, but by complementing formal measures they can have a positive effect on the pursuit of space security objectives. Since TCBM do not normally

have the same degree of precision or weight as formal treaties, they may be perceived as not going far enough to address space security issues. Ironically, what are perceived as the TCBM's weaknesses are also their strong suit. The flexibility to define how to best achieve security objectives does hold a definite appeal, and makes TCBM more palatable in some situations. In spite of their less robust nature, TCBM are needed in space to mitigate the challenges of verification of current and future space treaties, as they will foster cooperation, encourage dialogues, and often lead to more formal measures by generating buy-in.

INTRODUCTION

Since its humble beginnings with the launch of Sputnik 1 by Russia on October 4th, 1957, space exploration and the development of related technology has grown exponentially, and will in all likelihood continue to do so for the foreseeable future. The Sputnik launch became a catalyst for the US space program, who poured tremendous resources and efforts in catching up with the Russians, eventually achieving President Kennedy's goal of landing a man on the moon. While the U.S. and Russia have dominated the space race for decades, space is no longer the purview of a select few states. Almost a third of Earth's countries now have physical assets in space, with many of these states having joined this club in the last decade.[1]

Space assets are now key enablers not only for communications and military applications, but also for many aspects of daily life that most take for granted. To say that space technology has invaded every facet of our life would almost be an understatement. Communications, navigation, imagery, and many other capabilities are now dependent in large part, and in some cases almost exclusively on space platforms. These capabilities play a key role in supporting broadcasting, commercial transport, fisheries, search and rescue, financial transactions, meteorology and most facets of commercial, military, industrial, personal and commercial operations.[2] Soldiers rely on GPS information, satellite communications, imagery and satellite-assisted targeting, to the point where space technology has completely altered the modern battlefield. Surveillance and

[1] Union of Concerned Scientist "UCS Satellite Database" Accessed on 21 April 2014. http://www.ucsusa.org/nuclear_weapons_and_global_security/solutions/space-weapons/ucs-satellite-database.html
[2] Hitchens, Theresa. "Transparency and Confidence Building in Outer Space: Inching towards Action." Federation of American Scientists, Winter 2011. 1.

sovereignty operations also benefit from space technology, making space assets vital elements of national security programs. The governmental, commercial and industrial sectors are not immune to this revolution either, as they all rely heavily on space capabilities to plan and conduct operations ranging across a wide spectrum. The benefits of using space technology are not limited to better efficiency in production, transportation and communications. Better health care, increased education opportunities, and even state of the art search and rescue programs are all examples of how space technology benefits humanity.[3] Given our dependence on space technology and the wide ranging benefits that it provides, ensuring the long term viability and security of the space environment is in the best interest of states, organizations and individuals.

Space assets are very expensive to develop, acquire and launch due to their highly technical and specialized nature, and the long time needed for them to come to fruition. Even with decades behind them, space programs are constantly evolving as new technologies make it possible to push boundaries even further. This requires extensive research and development programs to ensure that we can send equipment and personnel in space in a safer and more efficient manner. This research and development comes at a high price, but one that is needed for the continued evolution of our space-faring abilities. In addition, the cost of specialized material and the requirement for highly specialized and therefore highly paid personnel throughout all phases of research, acquisition and production adds to the significant costs of space programs. The launching itself of space assets also carries a very significant cost, which goes up exponentially

[3] International Space Exploration Coordination Group. "Benefits Stemming from Space Exploration." Accessed on 18 Aug 2014 http://www.nasa.gov/sites/default/files/files/Benefits-Stemming-from-Space-Exploration-2013-TAGGED.pdf

according to weight and size of the asset to be launched.

Once launched, the asset will also necessitate operating costs, for purposes such as monitoring, conducting maintenance activities, the maintenance and operation of ground infrastructure and other costs such as licensing and legal fees. Furthermore, the timeline of complex space programs is measured in years, and in some cases decades. Any setbacks not only increases the overall costs of the program, but also delays the fielding of capabilities which could in turn have a significant effect on a multitude of services which depend on a continuous space presence of a specific asset. If a satellite is being launched to replace one that is reaching the end of its service life, any delays could cause a capability gap, potentially affecting users and other systems.

The high cost of researching, developing, producing, launching and operating space assets, combined with the long time required for the successful implementation of space programs, make them key components of states and corporations' strategic inventory, and confer to these assets an intrinsic value that goes well beyond the associated financial costs. For this reason space stakeholders, whether they own, operate or use services that rely on space assets, have much to lose when these assets are threatened in any way, whether by natural occurrences or through human actions. Protecting those assets is therefore a very significant concern.

As the number of objects in orbit continues to grow, so does the complexity of the space environment where debris, man-made or natural, radio interference, radiation, other space objects and human action can pose significant threats to their safety and their ability to operate.

While there is significant cooperation between space going nations, this environment is not void of conflict, although it may be of a different nature than on Earth. Given the economic and strategic advantages of operating space assets, space faring nations will attempt to gain any advantages in outer space just like they do on Earth. While some of these tensions reside in the political arena, other actions are more concrete in nature and can create a significant impact on the space environment.

Anti-satellite (ASAT) tests, deliberate destruction of satellites, as well as collision between satellites are events that occurred in the last decade and which have resulted in a significant increase of orbital debris, posing a threat to the space environment. As a result of these events, the number of space objects catalogued by the US Space Surveillance Network (SSN) from 2005 to 2010 increased from 9,233 to 15,090 respectively, which represents an increase of more than 50% in these five years alone.[4] These events generated significant debate and rallied nations in a common concern to protect the space environment, as this trend would have disastrous consequences if it were allowed to continue unchecked[5].

While space exploration and operations is relatively new for mankind, it is nonetheless already subject to a number of treaties and measures that attempt to provide a framework to guide and regulate the conduct of space users. Is the legal framework enough to ensure the continued use of

---

4 Setsuko Aoki, "The Importance of Making International Rules: to Protect Space Environment." 5 December 2013. http://www.aprsaf.org/annual_meetings/aprsaf20/pdf/program/day3/D3_1020_2_Prof_Aoki.pdf

5 James Clay Moltz *Asia's Space Race: National Motivations, Regional Rivalries, and International Risks*. (New York: Columbia University Press, 2012) 96

space for the benefit of mankind? Can a sustainable and peaceful use of the space commons only be achieved through formal treaties, or can Transparency and Confidence Building Measures (TCBM) complement the legal framework in place, and help preserve the space security environment? This paper will demonstrate that TCBM constitute an essential part of the space security continuum, and complement the existing and proposed space treaties by mitigating the challenges associated with verification in the space domain. Specifically, it will demonstrate that ASAT, debris mitigation and situational awareness are all areas that could benefit from the increased use of TCBM.

This topic will be examined first through an overview of concerns with space counter-proliferation[6] and threats to the peaceful use of space commons, with a focus on activities that could produce space debris or harm objects in orbit. This will be followed by a review of existing space treaties, as well as less formal proposals such as TCBM and code of conducts along with the international community's response to these treaties and proposals. A parallel will be also be drawn with other counter-proliferation areas in the hopes of identifying their own challenges as they relate to verification, and to assess whether or not TCBM have proven successful as a solution to these challenges. The two treaties that will be reviewed for this comparison are the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (known as the Chemical Weapons Convention, or CWC), which will illustrate the benefits of a strong verification program, as well as the Biological and Toxins

[6] Counter-Proliferation as used in this paper is defined as the deliberate pursuit of efforts to prevent the production, transfer and use of destructive space capabilities.

Weapons Convention (BTWC) which will highlight the challenges associated with a treaty which contains significant obstacles to verification, not so different from those of the space domain. A discussion on the merits of, and arguments against, TCBM will conclude this analysis.

A Crowded Environment

The launch of the first Sputnik satellite triggered a space race that endures to this day, although at a lesser pace than in the sixties and seventies. This race will continue for generations to come, as humankind's presence in space continues to grow. Given the capabilities provided by space assets and the integration of these capabilities in everyday life, we can anticipate that space use and dependency will continue to increase over the next decades as more states join the space race.

While space exploration was reserved to a select few states at the beginning of the space age, there are currently 53 different states which have registered space objects in orbit, whether they are state-owned, or commissioned by organizations or commercial ventures.[7] In the beginning, only states with their own launching capability were able to launch assets in space. This has changed in the last three decades, as the space-faring club now includes not only those states which possess an indigenous launching capability, but those states which use a third party to launch their space assets as well. There are currently 11 states which possess an indigenous launch capability: China, France, India, Iran, Israel, Japan, North Korea, Russia, South Korea, Ukraine and the United States, as well as an international organization, the European Space Agency[8]. Some of these nations provide launching services to other nations which lack this capability, illustrating the growing sense of cooperation and the potential for further

---

[7] Union of Concerned Scientist "UCS Satellite Database" Accessed on 21 April 2014 .http://www.ucsusa.org/nuclear_weapons_and_global_security/solutions/space-weapons/ucs-satellite-database.html
[8] Secure World Foundation website. "The Global Nature of Space Activities." Accessed on 18 Aug 2014 .http://www.swfound.org/space-sustainability-101/the-global-nature-of-space-activities/

development of space capabilities amongst developing nations. This surge in the number of space users has contributed to significantly increase the amount of objects orbiting the earth, and is driving the need for a continued international dialogue to prevent conflict in space and to foster cooperation to preserve this environment.

There are currently over 1,100 active satellites in orbit around the Earth[9]. To this number we must add over 20,000 pieces of trackable debris, which measure 10 cm or larger.[10] These include inactive satellites, rocket bodies and other discarded parts, and various pieces that have broken off space objects after collisions with other debris over the last decades. Those pieces that are large enough to be detected through the use of Earth-based and space-based sensors are catalogued and tracked just like functioning and defunct satellites, to allow for situational awareness and to predict, and in some cases prevent, collisions. In addition to the trackable pieces, there are many more that are too small to track. The estimates vary greatly depending on sources, but some point to over 500,000 pieces of debris sized between 1 and 10 cm.[11] While it is even harder to estimate the number of objects smaller than 1 cm, it is easy to postulate that they number in the millions.[12]

The U.S., Russia, the European Space Agency, and other entities each have their own catalogue of space objects, but while they all attempt to build the same picture, there are differences

[9] Hitchens, "Transparency and Confidence Building…
[10] NASA. "Space Debris and Human Space craft." Accessed on 16 Aug 2014. http://www.nasa.gov/mission_pages/station/news/orbital_debris.html
[11] Ibid.
[12] Ibid.

between each catalogue due to the difficulties in tracking small objects in planes so remote at such high velocities.[13]

Even though Earth's orbit consists of a very large three-dimensional area, it can still be considered crowded, as there is more to this equation than simply the number of objects per given volume. The problem stems from the fact that these objects are in constant motion, and therefore enter in conflict with each other periodically as they complete circuits around the Earth, each on a different course. These conflicts are known as conjunctions, which can be defined as two objects coming into relative proximity during their orbit. Given the high number of objects, the probability of these conjunctions is significant, whether collisions occur or not.

No matter their size, each of these pieces of debris have their own set of orbital parameters, and constitute a physical threat to the safety of active space systems such as satellites, space vehicles and manned stations, as well as any astronauts on active missions. Even though the non-trackable pieces are relatively small, their great velocity makes them very dangerous to other space assets in orbit. Even a paint chip can create significant damage to another object when traveling at high speed. For example, a number of NASA space shuttles windshield had to be changed over the years due to the impact of paint chips which had previously detached from other space objects, and that were now traveling at speeds up to 28,000 km/h.[14] Given this velocity, it is easy to

[13] Weeden, Brian, Secure World Foundation. “The Non-Technical Challenges of Active Debris Removal”. IAF Workshop on Active Debris Removal Vienna, Austria, February 11, 2013.
[14] NASA “Space Debris and Human Space craft” Accessed on 7 April 2014 .http://www.nasa.gov/mission_pages/station/news/orbital_debris.html#.U0NQ3v2RzwI

imagine the kind of damage that heavier or larger pieces can do.

Even a collision between a piece of debris and a defunct satellite or another piece of debris is a concern. Each collision further adds to the space debris problem by generating additional pieces of debris that will in turn constitute as many threats to deployed space assets. Any new piece of debris which is large enough will be catalogued and tracked, and become a part of the clutter that circles the earth. Given the potential danger posed by debris large and small, any collision has the potential to be harmful to the environment. In addition, any event that creates additional debris will also complicate the orbital picture even more, and render the prediction and avoidance of collisions a more complex exercise.

In 1978, a NASA scientist named Donald Kessler warned that a collision could in theory trigger a chain reaction that would not only destroy a number of space assets, but also render Low Earth Orbit unusable as the number of debris pieces grows with each subsequent cascading collision. This is known as the Kessler Syndrome. If such an event were to happen, it would set back space programs and all related technologies for decades or longer, as both manned and unmanned space flights would be impracticable.[15]

With that many pieces of debris in orbit, it becomes important to track them in order to have situational awareness. This allows for conjunction assessments using models to determine the

[15] Space.COM. "Space Junk Explained: How Orbital Debris Threatens Future of Spaceflight." Accessed on 18 August 2014 http://www.space.com/23039-space-junk-explained-orbital-debris-infographic.html

probability of collision, which in turn will allow operators of active satellites to take some evasive action if needed and possible. The US Joint Space Operations Centre (JSpOC) provides 72 hour warnings to all operators of active satellites to help reduce the chances of collisions, for any approaches inside of one km for objects in Low Earth Orbit, and inside of five km for objects in Geostationary Earth Orbit (GEO).[16]

The pieces that are too small to track create their own set of problems, as they will create damage without space operators being able to predict the collisions or initiate actions to avoid them. It is important to note that not all damage will be sufficient to destroy or render a space object inoperative, but in some cases even a small piece of debris can have this effect, if the collision affects a vulnerable component of the space asset. It is also important to note that evasive action is not always possible, nor is it always indicated. Even with orbital data and up to date positional information, it is difficult to arrive to a very precise assessment of the closest proximity of two space objects who are coming in conflict. The conjunction assessment triggers further analysis based on risk management to determine if the threat warrants expanding precious propellant to reposition an object out of harm's way, or if the situation allows to save the propellant for future conjunctions.

Although satellites are built to withstand the inhospitable space environment, it would be impractical to shield them against such collisions due to the additional weight that this would

[16] Secure World Foundation .” 2009 Irridium Cosmos Collision Fact Sheet.” Accessed on 18 Aug 2014 http://www.swfound.org/media/6575/swf_iridium_cosmos_collision_fact_sheet_updated_2012.pdf

add. The cost of placing an object in orbit increases astronomically with the weight of the object being launched, and in most cases a more robust construction would not be sufficient to provide the required protection. In addition, many parts of a satellite cannot be protected such as solar panels, antennas, as well as optical components. These parts may constitute a critical component of a satellite, and yet their very nature requires them to be exposed in order to function normally. This creates a certain vulnerability to debris, especially when dealing with debris that is too small to track. Even through some debris collisions will not have an immediate severe effect on a space asset, the accumulated effect over time of multiple debris strikes will take a toll on a system's effectiveness, and my eventually cause a catastrophic failure.

While space debris has been a concern for a number of decades, it has garnered a lot more attention in the last ten years as states realize the growing severity of the problem. There was however one event in particular that acted as a catalyst in the search for solutions to the space debris problem. In 2007, China conducted a test of their ground-based kinetic ASAT. Their intended target was their own defunct Feng Yun 1C weather satellite.[17] The test was highly successful and destroyed the satellite, but by doing so it added 3,378 pieces of trackable debris to the existing debris field.[18] It appeared that China had underestimated the extent of the damage that this test would cause to the orbital planes, and the international community was quick to condemn the test due to the instant proliferation of space debris caused by this activity. This

[17] Moltz, James Clay. *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*. (Stanford: Stanford University Press, 2008), 297.
[18] Setsuko Aoki, “The Importance of Making International Rules: to Protect Space Environment. 5 December 2013. http://www.aprsaf.org/annual_meetings/aprsaf20/pdf/program/day3/D3_1020_2_Prof_Aoki.pdf

event rallied the international community who realized the disruptive and destructive potential of such activities. In the months and years since the test, much debate has been generated on the topics of space security and on the problem of space debris. While debris had always been a concern before then, this incident really highlighted the fragility of the space environment, and the question of space debris was now making the headlines.[19] In spite of the negative impact of this test in terms of production of space debris, it did bring a high level of attention to the space debris issue, and illustrated how impractical kinetic ASAT weapons could be due to the collateral damage that could damage one's own assets.

The space debris issue in itself was only half the equation. While the event was condemned and the debris problem became an even more heated issue, the practicality of kinetic ASAT weapons was cast in doubt, and serious questions arose as to their acceptability as an acceptable means of warfare. If a single ASAT test was capable of creating this much debris, then it became easy to see the catastrophic impact of multiple kinetic attacks on satellites, and the harm to the space environment that they would cause. In addition, the initial debris field from this event would eventually grow as newly created pieces would break down further through collisions with other pieces as well as with space objects. Unlike Earth where conflicts usually occur over a defined area, any incident in space has the potential to affect areas that are being used by multiple countries, and affect systems that provide services to large segments of population across the globe. This fact, along with the long term impact of this event has resulted in widespread condemnation of this ASAT test.

[19] Moltz, James Clay. *The Politics of* … 298

This event also highlighted another impractical aspect of ASAT weapons. While in theory a state would benefit from destroying an enemy's space capabilities, it would likely do so at great risks to its own space assets, as it would be hard to predict the short and medium term effects of the debris fields created, and whether or not some of this debris would eventually harm your own assets. If destroying your enemy's satellites will render one's own space assets useless, then the risk would likely outweigh the benefits, unless you have a limited reliance on space assets and your opponent relies very heavily on them. Still, such a scenario may prevent the attacking country from deploying its own space assets in the long term, but there may be situations where the benefits would outweigh the disadvantages. There are a number of other ways to disable satellites, such as through the use of lasers, harmful interference, and other physical means that aim to cause more precise damage, rather than the physical destruction of the entire system.

In 2008, the U.S. destroyed one of its own satellites using an existing missile system that was modified for this purpose. While the stated driving force of this event was the need for the destruction of the satellite and not the test of the missile system itself, it still allowed the Americans to test an ASAT capabilities. There were however, significant differences between the Chinese and the American tests. China's satellite was orbiting at over 800 km from earth at the time it was destroyed, which is the reason for the continued presence of the debris over such a long period. By contrast, the U.S. satellite was shot down while at approximately 250 km from Earth, and most of the associated debris was estimated to re-enter Earth's atmosphere in a matter of months.[20] Also, while China did not announce its intent to test, the U.S. did announce that it would shoot down its own satellite before the fact, and was doing so in order to mitigate the danger posed by the harmful chemicals on board the defunct satellite. Regardless, while the U.S. event had a lower impact on the space environment, it was still criticized for destroying their own satellite, as it demonstrated a destructive space capability.[21]

The Chinese and American ASAT tests took place after the end of the voluntary moratorium on destructive ASAT test which lasted 22 years.[22] With the advances in missile defense related technologies, the number of systems that can be used for ASAT has grown, even though it may not be the system's primary purpose. After more than two decades without destructive tests, the end of the moratorium in itself did appear as a significant step backwards, but the fact that this moratorium lasted so long does provide some reassurance that such measures can play a key role in the pursuit of space security.

Not all major debris events are intentional. On 10 February 2009, a collision between the active Iridium 33 satellite (US) and the defunct Cosmos 2251 satellite (Russian) created over 1,400 pieces of trackable debris, and an unknown number of non-trackable pieces. NASA estimates that some of the pieces will remain in orbit until the end of the 21st century.[23] This highlights the

---

[20] Lt Col James Mackey, USAF. "Recent US and Chinese Antisatellite Activities". Air and Space Power Jounal,. 1 Sep 2009.
[21] Stimson Centre "After the ASAT Tests". 24 March 2008. http://www.stimson.org/spotlight/after-the-asat-tests/
[22] Ibid.
[23] UNITED STATES. National Aeronautics and Space Administration. "Consequences of the Collision of Iridium 33 and Cosmos 2251" Presentation to the 52nd Session of the Committee on the Peaceful Uses of Outer Space United Nations, 3-12 June 2009

long-term negative effects of such events, and why it is important to prevent them. The risk of damage to space assets, as well as the risk of increasing this debris field even more through collisions with other debris will remain high for many decades, and in some case for over one hundred years. Just like for the Chinese ASAT test, the consequences of this event far exceeded the destruction of the objects themselves, and these consequences will be long lasting.

This incident generated a lot of debate as to the responsibility for avoidance of space collisions, as it involved an active and a defunct satellite. The United Nations Convention on International Liability for Damage Caused by Space Objects stipulates that states whose space objects damage another space object are liable only if the damage is its fault. However, the Convention does not include a legal definition of fault. Since the Russian satellite was inactive, Russia argued that it had no means to change its course, and therefore collision avoidance was the responsibility of the Iridium operators. Complicating the issue was the fact that the Iridium satellite was operated by the US, but had been launched from Kazakhstan aboard a Russian launcher.[24] As one can imagine, Such litigation can be protracted and quickly become expensive for all parties involved, but while it may eventually set precedent for space incidents, it does not have any immediate effect to the cluttering of the space environment engendered by the event.

The space debris issue is complex and has long term implications. The closer an object orbits the earth, the sooner it will re-enter earth's atmosphere and generally burn on re-entry. However, as

[24] Secure World Foundation . "2009 Irridium Cosmos Collision Fact Sheet". Accessed on 18 Aug 2014 http://www.swfound.org/media/6575/swf_iridium_cosmos_collision_fact_sheet_updated_2012.pdf

seen in the Iridium 33 and Cosmos 2251 satellites collisions, debris that reaches higher orbit will have a lasting presence in space, in the order of decades or more. There is therefore a limited amount of debris that is eliminated each year due to natural re-entry, but debris in higher orbits will remain there for much longer, and remain a threat to other objects for as long as they are in orbit, while also occasionally adding more pieces of debris due to larger pieces splitting up upon colliding with other pieces. The laws of physics will eventually take their course, but in order to expedite the de-cluttering of the space debris more active solutions will have to be examined.

There is however no easy solution when it comes to debris removal. While there are various programs that currently pursue physical debris removal options, the physics involved render these options very technically challenging and also very cost prohibitive. In addition, there are political and legal factors to consider. A physical mean to remove a piece of debris could very well be also used to harm other satellites. Any technology that can physically interfere with a piece of debris could interfere with an active space object as well, and therefore could lead to doubt as to the intent behind the deployment of such an object.[25] In the international arena where every move is scrutinized and questioned, this could have an opposite effect to confidence-building, as it could be seen as an effective way to disguise an ASAT program.

Given the amount of debris and the various orbits affected, even the prioritizing of debris earmarked for renewal could be contentious, as this choice could benefit certain countries more

---

[25] The Space Review "A brief look at the legal and political implications of Japan's space debris removal plans." Accessed on 19 Aug 2014 .http://www.thespacereview.com/article/2441/1

than others by favouring the protection of certain assets over others.[26] Getting members of the international community to agree on which pieces should be removed first could be a difficult proposition. It should be noted that removing debris is not the same as destroying it, as destroying any object in space would simply create smaller pieces which would be just as destructive, but in some cases now be impossible to track due to their reduced size. Removal could include the physical capture of objects, as well as changing their orbital parameters to either accelerate their re-entry, or to move them out of certain orbits.

Since physical means of removing debris are not yet part of the solution, preventing the creation of additional debris is the most important way to protect the future usability of this domain. As more pieces of debris leave their respective orbits and re-enter the earth, preventing the formation of additional debris would result in a gradual reduction of the amount of debris in space. Of course, more debris will continue to form regardless of human actions, as pieces will continue to collide with each other and break into smaller pieces. However, by taking measures to avoid creating more debris through human actions, we can only increase our chances of causing a gradual reduction of the amount of debris in space.

Space debris is a concern for all, including states that do not have a space presence yet, or that have very modest space programs. This was well illustrated by the Ecuadorian Pegaso satellite incident. This was Ecuador's very first satellite placed in orbit on 26 April 2013. Less than one

[26] Weeden, Brian, Secure World Foundation. “The Non-Technical Challenges of Active Debris Removal”. IAF Workshop on Active Debris Removal Vienna, Austria, February 11, 2013

month after launch, the satellite collided with debris from a Russian launcher which had been in space since 1985.[27] This collision damaged the satellite's antenna, and prevented any communications to and from the object.[28] Nine months after the collision, Ecuador was eventually able to re-establish communications with Pegaso by using a repeater antenna from another satellite which they launched six months after the Pegaso collision.[29] It is easy to imagine the devastating effect of such an event on a country which had successfully deployed their first satellite less than 30 days before the collision. While any damage to space assets can be considered a setback, damaging a state's only space asset is definitely significant for that country.

Not all states have the same stakes when it comes to protecting their assets. As states with a heavy space presence, the US and Russia would be affected severely should a catastrophic event take place in space, as it could cause the destruction of a number of satellites or render certain orbits unusable. However, even though the larger space users would be affected strongly, so would states, corporations, organizations and individuals that rely on the services that these space assets provide. This is true for many domains, but even more so for technologies and processes in which space assets have come to play a critical role.

[27] Setsuko Aoki, "The Importance of Making International Rules: to Protect Space Environment". 5 December 2013. p.6. http://www.aprsaf.org/annual_meetings/aprsaf20/pdf/program/day3/D3_1020_2_Prof_Aoki.pdf
[28] Wired. "Ecuador's first satellite collides with Soviet rocket debris, possibly survives" 24 May 2013 http://www.wired.co.uk/news/archive/2013-05/24/ecuador-satellite-crash.
[29] Fox News Latino."Ecuador receives South America images, recovers lost satellite signal." Accessed on 18 August 2014 http://latino.foxnews.com/latino/lifestyle/2014/01/25/ecuador-receives-south-america-images-recovers-lost-satellite-signal/

Some navigation systems for example would be useless without certain satellites, and the same can be said of communications to and from remote locations. It would also affect developing countries who were on the verge of establishing their own presence in space, but who would now have to wait much longer before being able to launch due to the increased debris presence. The risks involved in space exploration and exploitation were recognized early, and a framework of legislation and treaties has been developed in the last half century to address these concerns.

Space Cooperation, Treaties and Legislation

Early on, states recognized the need to build a framework to ensure cooperation for access to, and use of space. While the US and Russia were the only two states with a launching capability in the 50s and 60s, it was not to remain this way for long. Since many states would not be in a position to join the space race for decades to come, they had to take measures to ensure their future access to space, and participation in early space treaties was a way to have a say in a field in which they would eventually become players. Complicating this issue in the early space years was the development of Inter-Continental Ballistic missiles (ICBM), which would transit through space to deliver warheads across the globe. As nations realized the potential advantage that space could proffer, the perceived importance of proper legislation and international cooperation grew even more.

In 1958, the UN General Assembly instituted an AD HOC committee on the Peaceful Uses of Outer Space, and established is as a permanent body one year later. The Committee on the Peaceful Uses of Outer Space (COPUOS) has for mandate to foster cooperation in the peaceful uses of outer space through the development of programs under the UN umbrella, to encourage research and the sharing of information on space, and to assess legal issues related to the exploration of outer space.[30] From the original 24 members in 1959, the committee has since

[30] United Nations Office for Outer Space Affairs. “United Nations Committee on the Peaceful Uses of Outer Space”. Accessed on 28 March 2014 http://www.oosa.unvienna.org/oosa/COPUOS/copuos.html

.

grown to 76 members. COPUOS also includes the Scientific and Technical Sub-committee, which focuses on the long term sustainability of outer space activities, as well as the Legal Sub-committee which deals with issues such as outer space treaties, legal definitions, debris mitigation responsibilities, and many more legal issues of this complex environment.[31]

In 1961, recognizing the growing pace of space launches and the need for shared situational awareness in space, COPUOS tabled a resolution asking the General Assembly to maintain a public launch registry to track the launch of objects into earth's orbit or beyond. This registry has been maintained since 1962 by the Secretariat of the UN's Office for Outer Space Affairs[32] as per resolution 1721. This resolution "...calls upon States launching objects into orbit or beyond to furnish information promptly to the Committee on the Peaceful Uses of Outer Space, through the Secretary-General, for the registration of launchings".[33] This resolution constitutes a very good example of a TCBM due to the voluntary nature of the request for information. Through this registry, launching states can provide details such as launching site location, launching date & time, orbital parameters, as well as information regarding the purpose of the satellite.[34] While the information shared can be argued to be minimalistic in nature, it is nonetheless a way for space users to take part in voluntary measures that foster cooperation and good will in the use of space.

---

31 Ibid.
32 United Nations Office for Out of Space Affairs. "Registration of Objects Launched into Outer Space" Accessed on 6 July 2014 http://www.oosa.unvienna.org/oosa/SORegister/index.html
33 United Nations Office for Outer Space Affairs. "RESOLUTION ADOPTED BY THE GENERAL ASSEMBLY: 1721 (XVI). International co-operation in the peaceful uses of outer space" Accessed on 6 July 2014 .http://www.oosa.unvienna.org/oosa/SpaceLaw/gares/html/gares_16_1721.html.
34 United Nations Office for Outer Space Affairs. "Convention on Registration of Objects Launched into Outer Space: Reports" Accessed on 13 july 2014. http://www.oosa.unvienna.org/oosa/en/Reports/Regdocs/ser671.html.

In 1967, the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (known as the Outer Space Treaty) became the first comprehensive treaty to address space activities and exploration. Its sixteen articles address cooperation, freedom of use, responsibility, mutual assistance, the placement of weapons in space and many other facets of space activities and exploration. Article I sets the tone as to the declaration of space as a domain that should benefit mankind as a whole, free for exploration and use according to the principles of international law:

> The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.
>
> Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.
>
> There shall be freedom of scientific investigation in outer space, including the moon and other celestial bodies, and States shall facilitate and encourage international co-operation in such investigation.[35]

Article II is particularly significant due to its declaration of space commons as a domain that is free of sovereignty claims. It states: "Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."[36]

---

[35] UNITED NATIONS. "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies" (Known as the Outer Space Treaty) 1967. Article 1.

[36] Ibid., Article 2.

The importance of this article lies in the inability of any state to appropriate any parts of outer space, including orbits. This lack of permanent ownership allows all states to share in the use of space, but activities need to be coordinated to avoid conflicts. This is especially true of the Geosynchronous Earth Orbit (GEO). This particular orbit is of great interest as the satellites that occupy it are orbiting the earth at the same rate of rotation over the equator, thereby maintaining a fixed position over earth's surface. This is particularly useful for communications, as a satellite in a geosynchronous orbit will never move in relation to a given ground station, thereby allowing for large volume of communications and constant line of sight. However, the properties of this orbit and the need to deconflict frequencies allocation result in a limited number of GEO slots. GEO slots are allocated to countries by the International Telecommunication Union (ITU), with caveats on frequency allocation to avoid radio interference between satellites.

Article VI assigns the responsibility for non-state-owned space object to the sponsoring States Parties:

> States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty. When activities are carried out in outer space, including the Moon and other celestial bodies, by an international organization, responsibility for compliance with this treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization.[37]

---

[37] Ibid., Article VI

This is a very important clause, especially with the growing number of non-governmental entities that now commission, launch, own and operate satellites. This article ensures that those entities have to abide by the rules of the Outer Space Treaty if they are from a nation that is a State Party to the Treaty.

The Outer Space Treaty was preceded in 1963 by the United Nations' Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space. These principles influenced the text of the Outer Space Treaty four years later.[38] In the decades to follow, wording from this declaration has made its way into various space treaties such as those related to broadcasting from space, remote sensing from space, the use of nuclear power sources in space, and many others.

The United Nation's Convention on International Liability for Damage Caused by a Space Object renders launching states liable for damage caused by their launched objects on the surface of the Earth, to aircraft in flight, and to other space objects.[39] While any litigation regarding damage caused by space objects is bound to be a long and costly endeavour, this convention offers a basis for such action nonetheless.

The United Nations' Agreement on the Rescue of Astronauts, the Return of Astronauts and

[38] United Nations. Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space. 13 December 1963.
[39] United Nations Office for Outer Space Affairs. "United Nations Treaties and Principles on Outer Space, and other related General Assembly resolutions. (New York:UN, 2005) 13.

Return of Objects Launched into Outer Space, provides for the assistance to, and safe recovery of, any astronauts in distress, as well as the return of any space object to the launching party.

In addition to legally binding resolutions and treaties, there are a number of less constraining vehicles that attempt to enhance space security. The EU is leading an effort to foster international cooperation and encourage the peaceful use of space through their Code of Conduct for Outer Space Activities, which they first introduced in 2008. This draft code provides a voluntary framework that lets each users define their best way to avoid producing space debris.[40] The aim of this code is “to enhance the safety, security, and sustainability of outer space activities.” It also states:

> This Code forms a regime of transparency and confidence-building measures, with the aim of creating mutual understanding and trust, helping both to prevent confrontation and foster national, regional and global security and stability, and is complementary to the normative framework regulating outer space activities.[41]

The flexibility of this voluntary code could be its greatest strength. Some states may resist signing a legally binding treaty that would hinder their pursuit of national interests, but be willing to develop and operate within their own guidelines to achieve a common goal in ways that offers fewer restrictions. For example, the United states have been reluctant in the past to enter into treaties that may limit its freedom of operation or otherwise hinder their national

---

[40] Gallagher, Nancy in “Space Strategy in the 21st Century: Theory and policy”. Edited by Eligar Sadeh. Series: Space Powers and Politics. School of Advanced Air and Space Studies, USAF Air, Maxwell, USA. (New York: Routledge, 2013) 57.

[41] European Union “International Code of Conduct for Outer Space Activities”. Accessed on 3 May 2014. http://eeas.europa.eu/non-proliferation-and-disarmament/pdf/space_code_conduct_draft_vers_16_sept_2013_en.pdf

interests. A less restrictive approach such as this code of conduct may be more palatable that a binding treaty which could compromise their ability to continue to leverage space capabilities in a more restrictive way. While the code is not yet in final form, it continues to generate significant interest within the space policy forums.[42]

In 2007, in an effort to limit the production of debris, reduce the likelihood of collisions and prevent intentional destruction of space objects, the UN COPUOS adopted a set of guidelines which were endorsed by the UN General Assembly. These guidelines, titled Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space, allowed space users to best determine how to achieve these goals, but through an accepted framework from which viable solutions could be applied.[43] The guidelines are:

"Guideline 1: Limit debris released during normal operations."[44] This addresses the release of items such as sensor covers, separation mechanisms and deployment articles. The challenge is to find a way to ensure that these items do not join the debris field, but rather are kept with either the launch vehicle, or the launched object. While it does seem like an easy guideline to implement, we must keep in mind the significant costs associated with space programs, and any measures that changes the way that previous missions were done is sure to add costs, as well as pose a technical challenge.

---

[42] Arms Control Today. "Fate of Space Code Remains Unclear." July/August 2014. http://www.armscontrol.org/act/2014_0708/News/Fate-of-Space-Code-Remains-Unclear%20

[43] Gallagher, Nancy in "Space Strategy in … 56

[44] United Nations Office for Outer Space Affairs. "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space" (Vienna, 2010.), 2.

"Guideline 2: Minimize the potential for break-ups during operational phases."[45] This addresses the issue of selection of design to prevent break-ups. Once again, the implementation of measures under this guideline may translate in additional costs, but it can also be incorporated in the design philosophy in the early phases of a program.

"Guideline 3: Limit the probability of accidental collisions in orbit."[46] This addresses the adoption of collision avoidance procedures, to prevent the formation of additional debris. Information from earth-based and space-based sensors can be used to take collision avoidance measures, but it is not a simple issue, as any object in orbit will have a finite amount of propellant to complete such manoeuvers. It then becomes a matter of risk management to determine the threshold for manoeuvering based on the estimated closest point of approach. The number of conjunctions grows exponentially with the increase in debris.

"Guideline 4: Avoid intentional destruction and other harmful activities."[47] This guideline recommends that intentional destruction should only be conducted when absolutely necessary, and that they should be done at low altitudes to expedite re-entry of debris.

"Guideline 5: Minimize potential post-mission break-ups resulting from stored energy."[48] This

---

[45] Ibid.
[46] Ibid., 3.
[47] Ibid.
[48] Ibid.

guideline guideline recommends the depletion of all on-board energy sources when they are no longer needed for mission operations. This reduces the risk of catastrophic break ups.

"Guideline 6: Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission."[49] This guideline aims to minimize the chances of collision or interference with crafts passing through the LEO to reach higher orbits.

"7: Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous Earth orbit (GEO) region after the end of their mission."[50] As previously discussed, GEO has a finite number of slots and is becoming very crowded. Any additional objects that operates or transit through GEO should minimize its time in this area to prevent collisions.

Some will argue that the effectiveness of these voluntary guidelines is debatable, as only 11 of 29 satellites in geosynchronous orbit were de-orbited properly upon becoming unserviceable in 2009.[51] However, the guidelines do make sound recommendations to avoid the unnecessary creation of debris. By providing guidelines rather than hard rules, individual states can tailor their respective approaches to best fit their programs, while working towards the same goals. In any case, it can be argued that any step towards cooperation is better that leaving the space

49 Ibid.
50 Ibid., 4.
51 Gallagher, Nancy in "Space Strategy … 57

domain to the individual good will of the users, as states will act in support of their national interest when no other considerations exist.

The United Nations also adopted a number of resolutions and principles regarding various aspects of space, which follows the philosophy outlined in the Outer Space Treaty. The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies designates the Moon and other celestial bodies as the province of mankind, and prohibit any threat, use of force or hostile act on the Moon. In addition, this agreement prohibits the establishment of military bases installations and fortifications on the Moon, as well as the testing of any type of weapons and the conduct of military manoeuvres. However, it does allow the use of military personnel for peaceful uses.[52]

In an effort to prevent the weaponization of space, an AD HOC committee was formed in 1985 within the Conference on Disarmament (CD) to advance a proposed treaty on the Prevention of an Arms Race in Outer Space (PAROS). A deadlock led to the dissolution of this group in 1994, but PAROS is being voted on annually as a resolution of the CD. PAROS receives near universal support yearly, with the exception of Israel who abstains, and the U.S. who opposes PAROS. The U.S. position is due to their assertion that there is no arms race in outer space at this time, and therefore no need for PAROS. [53] A distinction should be made between the

---

[52] United Nations. "Agreement Governing the Activities of States on the Moon and Other Celestial Bodies." 5 December 1979

[53] Federation of American Scientists. "Prevention of an Arms Race in Outer Space." Accessed on 26 July 2014 .http://fas.org/programs/ssp/nukes/ArmsControl_NEW/nonproliferation/NFZ/NP-NFZ-PAROS.html

militarization of space and the weaponization of space. Military systems have been present in space for many decades, and provide communication, imagery, reconnaissance and many more capabilities. This militarized aspect of space is not prohibited by any treaty. By contrast, weaponization refers to the actual placement of weapons in space, which is what PAROS seeks to avoid.

The Value of Verification – a Look at the CWC and BTWC

Verification is an important part of the arms control, counter-proliferation and disarmament spectrum. The value of verification is twofold: the deterrence of non-compliance, and the increased confidence that others are following their treaty obligations. Through verification, activities and declarations of States Parties can be monitored, and confirmed to be in accordance with the stipulations of a specific treaty. This provides a significant deterrent to non-compliance, as activities not allowed under a given treaty would have a high probability of detection if proper verification is conducted. At the same time, verification instills a level of confidence that goes beyond declarations, by providing facts and evidence that supports the fulfilling of responsibilities by the verified States Parties.

While there are a significant number of treaties to draw from, two have been selected to examine the issues of verification. While not related to the space domain, the Chemical Weapons Convention will offer a glimpse of a treaty where a solid verification regime has contributed to the treaty's enviable success, while the Biological and Toxin Weapons Convention will provide a good example of a treaty without a verification system, which hinders the advancement of the treaty's objectives.

The CWC is a highly successful story in the realm arms control, counter-proliferation and disarmament. The treaty, which came into force in 1997, is governed by the Organization for the Prohibition of Chemical Weapons (OPCW) which has the role of implementing body. At time of writing, the number of member states to the OPCW stands at 190, which is very close to universal adherence. Two additional states have signed but not ratified the treaty, and four states have neither signed nor acceded to the convention.[54] How can we explain the success of the CWC when other treaties are struggling to make headways? The answer to that question lies in both the universal aversion to chemical warfare, and in the CWC's rigorous verification regime which bolsters the treaty's credibility and greatly reduces the likelihood of non-compliance.

While chemical warfare has been used in various conflicts during certain periods of the 20th century, its use has been heavily condemned due to its inhumane nature and the suffering that chemical weapons can cause. Some of the nerve agents such as VX can kill fairly quickly, but others such as mustard gas will maim horribly, and leave terrible scars while causing unimaginable pain. This aversion to chemical warfare has contributed to the creation of the CWC, a treaty which aims to prevent the development, production, stockpiling use and transfer of chemical weapons, and to destroy existing stockpiles. The CWC has gathered a very strong membership in large part due to the universal condemnation of chemical warfare. However, this aversion to chemical weapons on its own is not enough to explain the CWC's success. The world holds the same aversion to biological weapons as it does chemical weapons, and yet the BTCW is failing as a treaty, mainly due to a deadlock on the inclusion of a viable verification regime.

The aversion to chemical weapons does contribute to the CWC's success, but that success

[54] OPCW. "About the OPCW". Accessed on 4 May 2014 http://www.opcw.org/about-opcw/

depends in great part on the solid verification capability of the CWC. The CWC contains a very robust verification regime that inspires confidence that states parties are meeting their treaty obligations. This verification regime includes provisions for routine inspections as well as challenge inspections. Routine inspections allow the OPCW to verify that activities of member states are in accordance with the provisions of the treaty.[55] They consist of visits by teams from the OPCW, and focus on compliance with regards to activities and possession rules of chemicals identified in the CWC schedules. It is important to note that routine inspections are not limited to state-owned facilities, but also extends to industry under article VI. This helps ensure that not only the States Parties themselves are in compliance, but also that there is verification in place to prevent illicit manufacturing or transfer of banned chemicals regardless of origin.

In addition to routine inspections, challenge inspections provide for the inspection of any facilities which is suspected of contravening to the Convention. If a state suspects another state of carrying activities prohibited by the CWC, it can ask for a challenge inspection to ascertain these facts. While there has not been any challenge inspections requested since the CWC came into effect, the mere existence of this provision creates a certain deterrent effect which greatly adds to the effectiveness of this treaty.

It is also important to note that the CWC includes provisions for training and technical assistance, which further fosters cooperation between its members. Examples of this technical

[55] Ibid.

assistance could include the provision of decontamination training to a state member, or the sharing of protective equipment. By increasing the ability of countries to defend against chemical weapons through this program of assistance, the CWC helps to render chemical weapons a less attractive option, as it reduces the perceived effectiveness of these weapons. This cooperation also engenders good relations between CWC members, and constitutes another incentive for states member to remain in good standing of their treaty obligations. This further builds confidence that other states are living up to their obligations.

As of June 2014, the OPCW had verified the destruction of over 60,000 metric tonnes of chemical agents, in addition to just short of 5,000,000 chemical munitions and containers. . This constitutes 78% of the declared chemical weapons.[56] Verifying the destruction of chemical weapons is an important activity, as it ensures that chemical weapons or their components are not diverted to nefarious uses while the rest of the world believes that the weapons are destroyed. While there is still a significant amount of chemical weapons left to destroy, this is nevertheless clear progress towards the goal of destroying 100% of declared chemical weapons. It should be noted that the CWC had initially set a deadline of 29 April 2007, which marked the 10 year anniversary of the Entry Into Force of the CWC, to complete the destruction of all chemical weapons. This deadline was extended to 29 April 2012 when it became clear that this universal destruction could not be achieved by 2007. While there were no provisions for an extension beyond 2012, six States Parties had not completed their chemical weapons destruction by this

[56] OPCW "The Chemical Weapons Ban: Facts and Figures." Accessed on 19 Aug 2014 http://www.opcw.org/news-publications/publications/facts-and-figures/

deadline. These six States Parties continued to work towards 100% destruction under OPCW verification, as per the Executive Council decision dated 1 December 2011.[57]

The OPCW conducted 115 Chemical Weapons related inspections in 2012, which covered a total of 45 sites. In addition, it conducted 239 Article VI inspections (industry inspections), each conducted at a different location.[58] These numbers are a good indication of the strength of the OPCW verification regime, and highlight the support given to this aspect of the Convention by the OPCW and States Parties.

Although fueled by the same intent as the CWC, the BTWC has not known the same degree of success in its goal of preventing the development, production and use of biological weapons. This is due in large part to the lack of verification measures of the BTWC, and the unwillingness of some states to include such measure in the convention. The US in particular has stated on many occasions that they were opposed to the inclusion of any verification measures in the BTWC, as these measures could severely hurt the US bio-pharmaceutical industry due to its dual-use nature. The lack of support for verification caused compliance negotiations to collapse during the 2001 BTWC review conference. The impasse on verification and compliance has been a long standing issue with the BTWC States Parties. All discussions regarding legally binding verification mechanisms and protocols, as well as compliance issues were not included

[57] OPCW Conference of the States Parties. "Report of the OPCW on the Implementation of the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction in 2012". 4 December 2013. 1.
[58] Ibid., 4.

in the intersession meetings from 2003 to 2010.[59]

This unwillingness to include verifications has led to a deadlock which has undermined the effectiveness of the BTWC as a treaty. While the ability to conduct verification activities is an essential part of any successful arms control, disarmament and counter-proliferation treaty, the nature of biological agents greatly complicates the verification issue. More specifically, the dual nature of biological agents is a complicating factor in the inclusion of compliance or verification protocols.

The BTWC's task is complicated by the fact that the same processes and equipment can be used to conduct both lawful bio-medical research as well as fabricating biological agents. While some chemicals have been developed by man solely for their use as weapons, most deadly pathogens are naturally occurring in nature, or a modified strain of a naturally occurring agent. Long before chemical or biological agents were used in warfare, deadly epidemics of flu, plague and smallpox had already taken a huge toll on human lives. Medical research aimed at combating pathogens has been around since modern medicine began, but this research requires an understanding of the disease and the agent that causes it to be effective. This understanding is acquired through examination and testing using the same pathogens that put humanity at risk.

---

[59] Kirk C. Bansak "Enhancing Compliance With an Evolving Treaty: A Task for an Improved BWC Intersessional Process" Arms Control Today, June 2011.

A similar path has to be followed to develop and produce biological weapons. Identifying a desired pathogen, cultivating it, and finding ways to disseminate it are all activities that require working with pathogens, using the same type of equipment and facilities. For example, a pharmaceutical company can use virus samples to develop a better flu vaccine, while another lab pretending to conduct the same research could use the same type of pathogen to weaponize the virus by finding ways to make it more transmissible and more potent. These two organizations could be using the same or very similar equipment, and keeping the same quantity of virus on hand.

The example above highlights the difficulty in verifying activities in a field where the same pathogens and equipment can be used for lawful purposes or to develop biological weapons. It would then become fairly easy for an organization in breach of the BTWC to hide its tracks behind the premise of doing lawful research. By the same token, any facility conducting lawful research could be accused of contravening to the convention by a rival state or company, since intent is not always easy to determine. Similar dual-use concerns exist for space-related issues such as ASAT, which as this paper will illustrate complicates verification of space treaties.

There are other characteristics of biological agents that further create concerns. Biological agents are easy to replicate using standard bio-medical equipment. An entity with ill-intent could divert a small portion of a sample towards illegal use, and regrow the initial sample to original size to avoid suspicions. By the time an inspection takes place, there would be no indication that a portion of the sample had been diverted to other purposes, and yet they would now be in possession of a pathogen that could be used to create a biological weapons. Given this ability and the fact that a very small quantity of a biological agent can be fairly easily grown to larger volume, it becomes very challenging to conduct verification. An inventory may very well confirm that all biological material is accounted for, but it would not reveal any theft of material that has been regrown since.

Another factor which complicates the verification issues is that viable biological weapons do not have to be created in a large scale to be effective. Contrary to chemical weapons, which requires large quantities and effective dissemination to affect a large number of people, biological weapons can achieve their aim with a very small quantity, as a single infected person could then spread the disease on a large scale. Given the ease and availability of air transportation and the multiple opportunities to expose an infected person to masses through large gatherings, it is conceivable that a successful biological attack could start with a small biological agent manufactured in an illicit and conceivably ill equipped laboratory. Such attempts would be hard to notice unless prior intelligence was available, and therefore this would not fall under the scope of any verification regime.

For the above reasons, some states argue that verification is a non-starter for the BTWC, as it would result in measures that could hinder legitimate pursuits while being largely ineffective as a deterrent. In addition, bio-pharmaceutical research is a highly competitive field in which very large sums of money are in play. The successful development and marketing of new medication is costly and requires a number of years, sometimes over a decade to be completed. Any exposure to verification by a third party would raise significant concerns with regards to industrial espionage, as any information that is revealed through an inspection could potentially cause severe damage to a company's advantage in a given market. In large part due to these reasons, President Obama and his predecessor have both refused the inclusion of verification measures in the BTWC.[60] The US also argues that the main threat when it comes to biological weapons is non-state actors and terrorists, which means that a treaty is unlikely to have the desired effect if it targets states and corporations. The desire is rather to seek measures to prevent the illicit transfer of materials and equipment to non-state actors and terrorist organizations.

It should be noted that unlike the CWC, which has the support of a full implementing body, the BTWC only has the support of a secretariat which comprises three staff. It is therefore more challenging to advance issues related to the BTWC, as they are discussed at review conferences and during intersession work, but with little drive or ability to progress issues shown in the last decade. While there are different factors that can be linked to the lack of success of the BTWC, the lack of viable verification measures can definitely account for a significant part of the blame.

As demonstrated above, the BTWC's lack of a viable verification regime has hurt the Treaty's

---

[60] Arms Control Now Blog. “Don't neglect the Biological Weapons Convention”. Accessed on 16 June 2014. http://armscontrolnow.org/2012/01/12/dont-neglect-the-biological-weapons-convention/

effectiveness and support. Worse, it also hinders further developments that would help advance the Treaty's objectives. This is important to keep in mind as the framework for space related counter-proliferation measures continues to grow. The example of the BTWC should serve as a reminder that counter-proliferation efforts are a slow moving and sometimes fragile endeavour, which can be stalled if they contain or lack elements that are not acceptable to the potential signatories. As the existing set of space treaties continue to evolve and grow, the space stakeholders need to remain aware of the impact of a sound verification regime or of the lack of, and of the need to compensate with other measures if verification becomes a difficult proposition.

TCBM – A Lack of Teeth?

An argument can be made that the most appealing trait of TCBM is also their greatest weakness. On the one hand, the less intrusive nature of TCBM does make them a more palatable option than formal treaties for some specific cases. Why agree to a treaty that could possibly jeopardize an existing edge over a competitor, be it state or non-state, when one can participate in the same pursuit to a lesser degree, and maintain that advantage by not revealing as much information to these competitors? It is not their attractiveness as an option that is debatable, but rather their effectiveness. TCBM are not legally binding, and the information divulged under the TCBM umbrella will not have the same weight as a formal inspection since it is left to the good will of participants. In a world void of conflict this might be enough, but the reality is that states have been caught cheating on treaty obligations before, and therefore a declaration as part of TCBM may not always be taken at face value. Their very purpose is to generate trust in the system, but it may be difficult to do so when declarations are not verified.

As an example, the BTWC's verification deadlock has generated much debate regarding TCBM. Since verification appears to be a non-starter, some states are pushing for TCBM to take on a greater role in this treaty. Rather than an intrusive verification system, a series of voluntary declarations and reports could to a certain degree achieve some of the treaty's objectives. However, the existing TCBM included in the BTWC have a questionable success rate, and so the addition of more TCBM may not have much of an impact on future success of the treaty. The Final Declaration of the BTWC Fourth Review Conference highlighted the challenges of relying on TCBM due to the poor track record of state members: "The Conference recognizes that participation in the confidence-building measures since the last Review Conference has not been universal, and that not all responses have been prompt or complete."[61]

The voluntary nature of TCBM combined with the fact that they are submitted from sole sources, does put their credibility into question. A state which is delinquent towards its treaty obligations may have difficulties to hide its transgressions from a formal inspection, but it could easily fool the international community through its submission of voluntary TCBM, if they were taken at face value. Unless another state has evidence that a TCBM was submitted using false declarations, it will stand as the official declaration, and could effectively contribute to a false sense of security. While a country can also try to hide its transgressions when dealing with a formal inspection regime, it is much more difficult to do so due to the intrusive nature of verification.

[61] BTWC Website. "Actions to be taken by States Parties". Accessed on 13 July 2014. http://www.opbw.org

C is for Confidence, Not Certainty

France considers confidence-building measures to be an essential mechanism under the BWC, creating greater transparency and building greater confidence between the States Parties to the Convention.

–France Diplomatie website

This excerpt from the *France Diplomatie* website captures the intent of TCBM very clearly. As previously discussed verification is not making any headway in the BTWC. This places TCBM at the forefront of compliance issues, even if it is not a formal mean of verification. Still, the intent of TCBM is clear: to create transparency and to inspire confidence. If TCBM can fill a portion, albeit a small one, in the void of verification for the BTWC, then wouldn't they play the same role for other non-proliferation domains as well?

While TCBM do not carry the same weight as formal treaty obligations, they can nonetheless have an impact on the desired outcome. TCBM are designed to inspire confidence and to show others that there is nothing to hide. While it would be naïve to think that this in itself would be enough to achieve all counter-proliferation goals, it should be noted that the success of TCBM lies in perception. If a TCBM requires participants to disclose certain aspects of a program annually, states will generally not risk being singled out as being delinquent, as it may lead to perceptions of wrongdoing which could in turn eventually lead to formal accusations. There is of course no guarantee that TCBM declarations are 100% truthful, but any untruthful statement runs the risk of being exposed, and to ultimately embarrass the originator. The TCBM's strength lies in a simple fact: any measures that encourage states to share information will contribute to dispel some of the mistrust that will naturally occur within the international community.

While verification provides a high level of certainty that States Parties are compliant, it does not constitute a guarantee that this is the case. Materials and equipment can be moved or disposed of and inspections will be geared towards declared facilities, and therefore not address any facilities or activities that a State Party fails to disclose. While there is little that can be done in these cases, this highlights the fact that even verification does not provide a 100% solution. In this regard, the limitations of TCBM are not unique, in that there is never a guarantee that you will achieve 100% compliance.

The greatest value of TCBM is that they can become a catalyst to for states to eventually move towards a set of firmer legislation. TCBM can offer a progressive way to wade in, rather than demand a full-fledged commitment from the start. As such they can act as a stepping stone, and as more and more states follow suit, the building blocks are slowly put in place to take the next logical steps, and thus advance the security agenda through constant and hopefully steady progress. Just like their name suggests, TCBM will help create a climate that encourages transparency, and which promotes confidence that all parties are working towards the preservation of the space environment.

The Need for TCBM in the Space Domain

Why do we need TCBM in space? The answer lies in the difficulties associated with conducting any activities within the space environment. There are two main challenges to overcome in space when it comes to fostering a cooperative environment. First there is the issue of verification, or more specifically, the challenge of conducting verification in a domain so remote. Verification entails not only being able to look at something, but also having the ability to "dig deeper" and to look beyond what others may want us to see. For example, under the CWC, a routine inspection would entail the visit of specific facilities, the review of records and various documentation, the inspection of equipment and storage space, as well as various sampling to rule out the possibility that chemicals have simply been moved prior to an inspection. The verification is conducted within a specific framework which aims to confirm that a state is in compliance with its obligations. This framework includes very specific details as to what is allowable under various conditions, such as the maximum allowed quantity of individual agents and precursors amongst others in the case of the CWC. Verification results are visible to all States Parties, ensuring the proper transparency and accountability.

Such verification activities become very difficult to do with an object launched in space. While launching sites and other ground stations can be inspected (if agreed to), it becomes very challenging to visually inspect an object with any degree of precision after that object has been placed into orbit. For example, any object or cargo being deployed from a satellite in orbit could be detectable by sensors if the object is large enough, but it would be very difficult to ascertain the purpose of such an object, as it could be used for many reasons, such as in-flight servicing for other satellites or other legitimate purposes, or for disruptive and/or destructive purposes such as physical attack or harmful interference. Such objects deployed from other satellites could be used as an ASAT capability, whether they use explosive or other means to harm another object once in proximity. The action would not have to be immediate either, as the object could be prepositioned for future use, especially if hard to detect due to its small size.

In the example above, since it would be extremely difficult to ascertain the purpose of an object after it separates from the satellite, it would be more practical to determine its purpose before it is launched, but this would likely be unachievable in today's security environment. While states may be willing to provide some basic launch information on a voluntary basis, they would not be willing to reveal too many details on the satellite itself or on its operation through formal inspections, as they may fear revealing vulnerabilities or technological advantages of their space assets. This renders verification a very difficult proposition for space related activities and assets for some countries, as stated by President Reagan in 1987: *"...ASAT arms control verification measures that required any form of access to U.S. space systems might create an unacceptable risk of compromising the protection of information regarding certain U.S. space systems associated with national security."*[62]

[62] United States. "The U.S. Anti-satellite (ASAT) Program: a Key Element in the National Strategy of Deterrence." Presidential Foreword. May 1987. http://fas.org/spp/military/program/asat/reag87.html

The second challenge associated with space is the difficulty of conducting forensic activities. Forensic attribution plays a strong role in deterrence, as it means that actors cannot act anonymously. For example, being able to identify a specific viral or bacterial strain can help authorities determine who was responsible for its release. This in turn would make someone think twice, as they would not be able to act with impunity. While forensic attribution is practical in areas such as chemical, biological, radiological and nuclear weapons, it is not always so with objects in space, in spite of Earth-based and space-based sensor capabilities.

Some aspects of space events can be determined from Earth thanks to various sensors and tracking capabilities. Such was the case for the Iridium satellite collision and the Chinese ASAT test. However, the responsibility for some acts would be harder to attribute depending on their nature and circumstances surrounding the events, as physical evidence will likely be out of reach.[63] In all likelihood there will often be an element of plausible deniability when it comes to the investigation and prosecution of space incidents.

Given the difficulties in conducting verification of space assets and activities, as well as the limited forensic attribution capabilities, a certain level of reassurance is needed to inspire confidence that all space faring actors are playing within the internationally agreed rules and norms. To be effective, this reassurance would have to be provided in a way that does not

---

[63] The Space Review "Space and Nuclear Deterrence". 16 September 2013. http://www.thespacereview.com/article/2367/1.

compromise the national interests of the various states involved. This would mean striking a delicate balance between disclosing enough information to dispel doubts as to the intent behind specific space activities, and the need for the protection of vital information. The desired effect would be to provide a certain level of reassurance that a specific object or program does not constitute a threat to the space environment. While this effect is desirable, the secretive nature of some space programs constitutes a major hurdle to achieving this goal.

Given the likely resistance to discuss technical specifications, the focus would have to be on other sharable information. Such an example would be for a state to voluntary disclose specific events such as the launch of a micro-satellite from one of its full-size satellite. While prior notification that a satellite is deploying a smaller object would not provide reassurance as to the specific role of this object, it would nonetheless constitute a voluntary disclosure of information which could go a long way towards increasing transparency. Another example of space-related TCBM would be to voluntary disclose any manoeuvring and change in orbital parameters of space objects before such manoeuvring takes place. This type of voluntary disclosure would contribute to improve cooperation and communications on ongoing space operations, which in turn would contribute to create a climate favourable to a better security environment.

Dr Rajeswari Pillai Rajagopalan made a strong case for space related TCBM, at the EU Non Proliferation and Disarmament Conference of 2013 :

> TCBMs... are the means to strengthen dialogue and interactions while

> encouraging openness, transparency, and information sharing. These are unlike the legal measures. These are voluntary in nature, and countries willingly opt to join them and continue with this level of openness and transparency measures in this regard. It is important to institute TCBMs at this stage, particularly in the outer-space arena, because it becomes a, first of all, an intermediate step between a functional need of an instrument and a binding instrument. Once a need for a specific arms-control measure is recognised by a state, TCBMs can be the early step, can be the first step, to kind of...for the countries to start talking to each other, build up the confidence, and trust in each other to develop something into a more binding mechanism at a slightly later stage.[64]

This emphasis on the voluntary aspect of TCBM is very important, as it demonstrates the willingness to work towards the common goal of space security in this instance. Dr Rajagopalan's suggestion that TCBM can lead to more binding mechanisms down the road has much merit, as such an evolution would build on the trust demonstrated by states through the submission of TCBM.

TCBM must play a role in the counter-proliferation of ASAT. This could come in the form of declarations regarding rocket launches and specific ASAT capabilities, or guidelines such as restrictions not to launch in the direction of neighbouring states to avoid having launches misinterpreted as a missile attack.[65] It should be noted that some missile defence capability can also constitute a kinetic ASAT capability, as it involves destroying a missile in space or at very high altitude. As such, successful ASAT TCBM need to encompass missile defence considerations. To highlight the importance of voluntary measures, it should be noted that the

[64] Dr Rajeswari Pillai Rajagopalan, "Ballistic Missiles and Outer Space : Transparency & Confidence Building." EU Non Proliferation and Disarmament Conference 2013, Special Session 2. 30 Sep 2013.
[65] Mistry, Dinshaw. *Containing Missile Proliferation: Strategic Technology, Security Regimes, and International Cooperation in Arms Control* (Washington:University of Washington Press, 2005.), 177.

Chinese ASAT test of 2007 was more criticized than the U.S. destruction of their own satellite of 2008. The Chinese test produced a lot more debris, which will remain in orbit for decades to come. More important though, they did not provide advanced notification of this test, unlike the US did a year later. While the U.S. was also criticized for their own test, their notification prior to the actual event did provide some appeasement within the international community. By voluntary disclosing the imminent intercept, they sent the right message to the effect that this was an action that they had to take for the sake of safety. Whether or not everyone agreed with the stated intent is another story, but the fact remain that they showed transparency by communicating their intent, which in turn made the test appear more acceptable to some than the Chinese test from the previous year. In addition, the U.S. did follow the debris mitigation guidelines by destroying their satellite in low orbit, which in turn resulted in fewer debris, and an overall lower impact than the Chinese ASAT test.

The UN COPUOS debris mitigation guidelines offer general recommendations that, if followed, would contribute to reducing the current debris field. While the track record for the use of these guidelines has not been so great in the past, they do constitute a good example of TCBM which could have an impact on the debris issue. A strong emphasis on the adoption of these guidelines is needed to improve procedures from the design phase all the way to the end of the service life of space objects. By voluntarily taking these guidelines into consideration and developing plans that are consistent with them, states can promote the responsible use of space and prevent the creation of additional debris. They would do so within these voluntary guidelines, but still maintain overall control in terms of how to best achieve the aim of each respective guideline.

In addition to activities such as ASAT, there is a strong need to prevent collisions, whether they involve active or decommissioned satellites or space debris. Data from various sources such as the U.S. Space Surveillance Network is already used for that purpose, but there is a need for improved integration of data sources in order to better predict conjunctions. Given the significant number of objects to track and the disparities between the different databases, continued effort is needed to predict and avoid collisions. Refining the precision of conjunction predictions is vital in this regard. By minimizing the unnecessary manoeuvring of satellites and other space objects caused by erroneous conjunction predictions, precious propellant can be saved and used when really needed to prevent collisions.

Along the same lines, continued work towards developing an ability to track objects smaller than 10 cm will potentially increase the scope of conjunction predictions. While this in itself will greatly complicate the issue by exponentially increasing the conjunction calculations, the improved situational awareness that would result from being able to track smaller pieces would be greatly beneficial in the long run.

Continued dialogue and cooperation on space issues is also needed in the long run. The distribution of lessons learned for example can help space users reduce the amount of debris produced during launches by sharing proven ways to tackle specific related issues. This is a domain when learning from other's mistakes is better than learning from one's own.

The 2010 US National Space Policy does indicate a certain openness towards formal arms control proposals, but only if they are "equitable, effectively verifiable, and enhance the national security of the United States and its allies".[66] Given the difficulties in achieving the stated qualities of some of the formal arms control proposals, it appears that TCBM may hold a certain appeal for the US. As a major space player along with Russia, the U.S. has a pivotal role to play, and their use and endorsement of TCBM would generate a lot of momentum amongst the international community.

The EU's Code of Conduct for Activities in Outer Space is a promising step in the search for space cooperation. However, while this code does address issues of concerns like space debris, some states are still not willing to adopt it. The latest proposed iteration, tabled during a meeting in Luxembourg in late May 2014, still includes language that is unacceptable to some states. Specifically, it contains references to self-defence, a fact that some countries find incompatible with the goal of the code, which includes the prevention of an arms race in outer space. Weapons that can be used for self-defence can also be used offensively, hence the opposition to the inclusion of wording to this effect. Others, including the U.S., Canada and the United Kingdom, support the inclusion of the self-defence language as it is deemed consistent with the UN Charter. In spite of the lack of unanimity on this code of conduct, its importance lies in the fact that it brings interested parties to the table and generates dialogue. Eighty countries were represented during the May 2014 meeting to discuss the latest draft, up from sixty from the

---

[66] United States. "2010 National Space Policy". 28 June 2010. http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf

previous meeting six months prior, which is a testament to the increasing interest that this form of TCBM generates.[67] The fact that so many countries are working on making this code of conduct a better product is a strong indication that they are willing to support this as a form of TCBM, to complement the existing formal treaties. The EU has been reaching out to not only the major space powers, but also to countries with emerging space capabilities. Their inclusion in the drafting stages of this code of conduct has brought great credibility to this process and generated significant buy-in.[68] This is significant as constitutes a forward looking endeavour that caters not only to those who are part of the space club, but also to those who aspire to join once they develop the required capabilities.

---

67 Arms Control Today "Fate of Space Code Remains Unclear." July/August 2014. http://www.armscontrol.org/act/2014_0708/News/Fate-of-Space-Code-Remains-Unclear%20

68 Arms Control Today. " New Draft of Space Code Seen as Stronger." January/February 2014. http://www.armscontrol.org/act/2014_01-02/New-Draft-of-Space-Code-Seen-As-Stronger%20

CONCLUSION

Space is quickly becoming a congested environment where debris, mostly man-made, poses a threat to the safety of any objects transiting through or operating within the earth's orbit. While there exists a legal framework and guidelines to attempt to mitigate the debris situation, we are still far from reaching the point where debris will no longer be produced through our launches and space activities. The debris already in orbit will continue to pose a hazard to satellites, space ships and astronauts, and to further break down into smaller pieces while slowly making their way to lower orbits for decades to come. Preventing the formation of new debris is the best way to effect a lasting reduction of the debris orbiting the earth. By discouraging activities such as kinetic ASAT, implementing voluntary guidelines to reduce debris and improving situational awareness, we can increase our chances to see the debris field diminish over time as pieces re-enter earth's atmosphere, while preventing incidents which have the potential to harm the space environment with catastrophic results.

Formal treaties go a long way towards the protection of the space environment, but they may not be enough on their own. Their rigidity and the level of commitment that they require generate a certain level of resistance among states, often ending in deadlock for many years, even decades. As with other areas, competing national interests will continue to influence states' decisions and actions with regards to space exploration and exploitation. In addition, international politics and inter-state conflicts will affect decisions on the signing of formal treaties.

While TCBM will likely never be enough to achieve the stated goals by themselves, they can nevertheless act as a stop gap measure to complement formal treaties. Their less intrusive nature makes them a viable option for countries that are wary of over compromising on their respective space strategy, and still offer ways to work towards counter-proliferation goals. Creating good will is a long term investment, and space, like other areas of arms control, disarmament and counter-proliferation can definitely benefit from the adoption of TCBM. In the long term, TCBM could lead to more stringent legislation and wider acceptance of formal treaties as ways to protect the space environment. Specifically, TCBM that help prevent ASAT tests, mitigate the production of space debris, and improve space situational awareness can have a significant impact on the preservation of the space commons. Given the importance of the space domain and the level of degradation that humanity has brought to it in the last half century, don't we owe it to future generations to do everything in our power to ensure that it remains a viable environment for future generations?

Bibliography

Bansak, Kirk C. "Enhancing Compliance With an Evolving Treaty: A Task for an Improved BWC Intersessional Process." *Arms Control Today,* June 2011.

Bormann, Natalie, and Michael Sheehan. *Securing Outer Space*. New York: Routledge, 2009.

Harvey, Brian, Henk H.F. Smid, and Theo Pirard. *Emerging Space Powers: The New Space Programs of Asia, the Middle East, and South America*. Chichester: Praxis Publishing, 2010.

Dr Rajeswari Pillai Rajagopalan, *Ballistic Missiles and Outer Space : Transparency & Confidence Building*. EU Non Proliferation and Disarmament Conference 2013, Special Session 2, 30 Sep 2013.

Gallagher, Nancy, in "Space Strategy in the 21st Century: Theory and policy". Edited by Eligar Sadeh. Series: Space Powers and Politics. New York: Routledge, 2013.

Greece, Ministry of Foreign Affairs, Centre for Policy Analysis and Planning. "Conference on Nuclear Proliferation", Athens, 2003.

Hitchens, Theresa. "Transparency and Confidence Building in Outer Space: Inching towards Action." Federation of American Scientists, Winter 2011.

Lambakis, Steven. *On the Edge of Earth – The future of American Space Power*. Lexington: The University Press of Kentucky, 2001.

Maini, Anil K. and Varsha Agrawal. *Satellite Technology : Principles and Applications*. West Sussex: John Wiley and Sons Ltd, 2007.

Mistry, Dinshaw. *Containing Missile Proliferation: Strategic Technology, Security Regimes, and International Cooperation in Arms Control*. University of Washington Press, 2005.

Moltz, James Clay. *Asia's Space Race: National Motivations, Regional Rivalries, and International Risks*. New York: Columbia University Press, 2012.

Moltz, James Clay. *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*. Stanford: Stanford University Press. 2008.

OPCW Conference of the States Parties. "Report of the OPCW on the Implementation of the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction in 2012". 4 December 2013.

Setsuko Aoki, "The Importance of Making International Rules: to Protect Space Environment." 5 December 2013.

United Nations "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies" (Known as the Outer Space Treaty) 1967.

United States. National Aeronautics and Space Administration. *Consequences of the Collision of Iridium 33 and Cosmos 2251* Presentation to the 52nd Session of the Committee on the Peaceful Uses of Outer Space United Nations, 3-12 June 2009.

United States. National Space Policy of the United States of America. 28 June 2010.

United Nations Office for Outer Space Affairs. "United Nations Treaties and Principles on Outer Space, and other related General Assembly resolutions". New York: 2005.

Weeden, Brian, Secure World Foundation. "The Non-Technical Challenges of Active Debris Removal". IAF Workshop on Active Debris Removal Vienna, Austria, February 11, 2013

Internet

Arms Control Today. "U.S. Backs Efforts to Draft Space Code." March 2012. http://www.armscontrol.org/act/2012_03/US_Backs_Efforts_to_Draft_Space_Code

Arms Control Today. "New Draft of Space Code Seen as Stronger." January/February 2014. http://www.armscontrol.org/act/2014_01-02/New-Draft-of-Space-Code-Seen-As-Stronger%20

Arms Control Today. "Fate of Space Code Remains Unclear." July/August 2014. http://www.armscontrol.org/act/2014_0708/News/Fate-of-Space-Code-Remains-Unclear%20

Federation of American Scientists. "Prevention of an Arms Race in Outer Space." Accessed on 26 July 2014. http://fas.org/programs/ssp/nukes/ArmsControl_NEW/nonproliferation/NFZ/NP-NFZ-PAROS.html

France Diplomatie. "Non-proliferation of biological weapons". Accessed on 11 March 2014. http://www.diplomatie.gouv.fr/en/french-foreign-policy-1/disarmament-and-non-proliferation/france-and-non-proliferation-of-7768/article/non-proliferation-of-biological

"International Code of Conduct for Outer Space Activities." Accessed on 3 May 2014. http://eeas.europa.eu/non-proliferation-and-disarmament/pdf/space_code_conduct_draft_vers_16_sept_2013_en.pdf

OPCW website. "About the OPCW". Accessed on 4 May 2014

.http://www.opcw.org/about-opcw/

Secure World Foundation Website. “2009 Irridium Cosmos Collision Fact Sheet.” Accessed on 18 Aug 2014
http://www.swfound.org/media/6575/swf_iridium_cosmos_collision_fact_sheet_updated_2012.pdf

Stimson Centre Website. “After the ASAT Tests.” 24 March 2008
http://www.stimson.org/spotlight/after-the-asat-tests/

The Space Review. “Space and Nuclear Deterrence”. 16 September 2013.
http://www.thespacereview.com/article/2367/1.

United Nations Office for out of Space Affairs. Accessed on 28 Mar 14.
http://www.oosa.unvienna.org/oosa/COPUOS/copuos.html