

Promising confidence- and security-building measures for space security

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In the last 50 years, outer space has become a domain of critical national infrastructure and of vital strategic and tactical importance. Outer space provides communication, navigation, remote sensing and a myriad of other services to both civil and military clients. Due to the emergence of space as an essential part of modern life, there has been growing discourse concerning the subject of space as a “contested environment”, in which states compete for control of space, rather than allowing space to be used “for the benefit and interest of all countries.”¹ This discourse has led to such initiatives as the Prevention of an Arms Race in Outer Space (PAROS) at the Conference on Disarmament (CD). Given this increasing interest in space both from countries such as China, which are beginning to exploit and benefit from outer space, and veteran spacefaring nations such as the United States and the Russian Federation, which are becoming increasingly dependant on outer space, it is surprising that there is not yet an arrangement or treaty designed to protect the space environment and ensure its continued use for future generations, given the very real potential for armed conflict in this newly contested domain.

This paper seeks to address the issue of space security by laying out the foundations of a space security treaty aimed at preventing physical conflict in outer space in order to preserve its continued use today and well into the future. The paper will address the reasons why a treaty is necessary, the threats currently facing humanity’s collective use of outer space, and postulate suggested confidence- and security-building measures (CSBMs) for space security. Although the idea of a space security treaty is new, the concepts being presented here are not. Many are taken from other disciplines or issues and applied to outer space. We hope that by building onto these older concepts and ideas, it will become easier for countries to both adopt and comply with a space security treaty for the benefit and interest of all countries.

The scourge of space debris

Outer space offers a unique challenge to the concept of conventional conflict among states. Namely, by destroying the satellite of another state, and creating debris, aggressors are also destroying their ability to further use space. Space debris can travel at excessively high speeds (upwards of 7.8km/s in low Earth orbit), turning pieces of damaged or destroyed satellites, as small as 10cm in diameter, into destructive forces capable of delivering the same amount of energy to an object as a 35,000kg truck travelling at 190km/hour.²

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Furthermore, once space debris is created, it will remain in orbit—sometimes indefinitely.³ Outer space cannot cleanse itself of debris as quickly as mankind is able to make it. This leads to a cascade effect, where old debris hits new satellites, creating more debris.⁴ Without efforts to curb this problem, entire areas of space could become unusable for hundreds, or thousands, of years. Since there is no way to effectively remove large amounts of debris from orbit, it is essential that states preserve the orbit's utility through efforts to control the amount of debris that is created. This is especially true with respect to the potential for armed conflict in outer space. For this reason, it is crucial to have in place a set of agreements, coupled with a verification and governance system, to ensure the security of outer space.

Security challenges for outer space

The security challenges facing outer space can be broken down into two distinct types of threat: irreversible and reversible. Irreversible refers to the permanent damage of a satellite, or the destruction of that satellite. Reversible refers to temporarily disrupting signals to or from a satellite, or the denial of such signals to or from that satellite.

IRREVERSIBLE

Lt Col. Bruce M. DeBlois of the US Air Force contends that space weaponization is not an “‘all-or-nothing’ affair.”⁵ DeBlois argues that space threats lie on a continuum, ranging from relatively low to relatively high. On this continuum, DeBlois argues that space-based weapons (whether able to engage other space objects or targets on or above Earth) pose the greatest threat to space security.⁶ This is because space-based weapons have the greatest potential to create space debris. It is estimated that the destruction of a 5–10 ton satellite could double the amount of debris in low Earth orbit.⁷ As such, any full-scale conflict in space would render parts of outer space unusable. Earth-to-space weapons pose a similar, if lesser, threat, though they are still able to cause the same catastrophic effects as space-based weapons. Most important is the need not to purposefully create space debris or even derelicts in outer space that can subsequently collide with space debris to produce yet more debris.

Certain dual-use satellites that could damage or destroy objects also present a space security threat. Dual-use satellites refer to satellites that serve a legitimate civil purpose in space, but can gain the effects of a weapon when used for a military objective, for example, by intentionally colliding with another satellite. This threat can arise where such satellites possess the necessary pursuit sensors and the fine-control rocket engines to enable close proximity operations with a non-cooperative satellite or, alternatively, can illuminate an object with sufficient electromagnetic energy to cause damage, due to the susceptibility of sensitive electronics or optics. The vast majority of satellites do not possess such capabilities and therefore make poor suicide bombers and rather ineffective ray guns.

Finally, the threat of accidental collision is ever present in space and steps should be taken to attempt to reduce the probability and consequence of accidental collisions in space.

To summarize, humanity's use of outer space is plagued by four major irreversible threats. They consist of:

- the threat of space-based weapons that are specially designed or modified to damage or destroy;
- the threat of weapons that reach into outer space from Earth to damage or destroy;
- the residual threat of certain dual-use satellites that could also damage or destroy; and
- the residual threat of accidental collisions in outer space or on the surface of Earth.

Any space security regime worth pursuing should address these four threats in a comprehensive manner—not only preventing states from creating excess amounts of debris, but also determining compliance with the regime’s provisions. Here an obligatory governance structure using verification methods based on a collection of space situational awareness (SSA) systems is highly recommended.

REVERSIBLE

In addition to the irreversible or destructive threats for space systems are threats of a reversible or disruptive nature. Reversible threats can include jamming or spoofing uplink or downlink communications channels of satellites.⁸ For example, states use outer space for military purposes such as intelligence, surveillance, reconnaissance, navigation and timing, and communications, among other activities.⁹ Powerful states rely upon the use of these satellites to ensure strategic stability, as was the case during the Cold War,¹⁰ or to gain tactical military advantage for Earth-based military missions.¹¹ These military uses of space can pose security threats for other states, which may require negation under conditions for which the self-defence provision of Article 51 of the UN Charter could be expected to apply.¹²

It is argued that strategic stability is crucial to the maintenance of international peace and security (and indeed life) on Earth. The world need not be reminded of the frightful days of the Cuban missile crisis. Early warning detection, strategic communication and reconnaissance systems are vital to the maintenance of strategic stability. Purposeful interference with these satellite systems risks triggering an escalatory response. In the case of nuclear war, it is difficult for a state to credibly threaten a large-scale nuclear attack, due to the concept of mutually assured destruction.¹³ However, states may engage in limited wars, in which they seek to substantially raise the risk of escalation to nuclear war.¹⁴ Given the inherent difficulties of defending satellites in outer space, a state is more likely to engage in retaliatory or escalatory behaviour should its space assets be interfered with or attacked with weapons.¹⁵ Any escalatory behaviour would be a significant threat to both space and Earth security. For this reason, purposeful interference with satellites that ensure strategic stability is an important security threat that should be addressed, especially by states in possession of nuclear weapons. Here, the security of space is best maintained through “stability more than superiority”,¹⁶ if states are to avoid missteps during crises that could lead to an actual nuclear war.

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Outer space is also becoming essential to conducting tactical military operations on land, sea and in the air. Satellites such as communications and navigation satellites provide invaluable information to troops on the ground in real time. In times of peace, satellites provide reconnaissance information that can help avert crises. By keeping a continuous watchful eye on rival states, it becomes more difficult to misinterpret their actions. Interference with these satellites during peacetime has the potential to be interpreted as an “act of aggression” under the UN Charter. Should a state be attacked in this fashion, Article 51 of the UN Charter would permit it to engage in self-defence. This poses a space security threat since interference with tactical military satellites during peacetime has the potential to trigger a crisis or a conventional war. Should a state already be engaged in hostilities on the surface of Earth or elsewhere, Article 51 of the UN Charter would enable the defending state to purposefully interfere with the satellites, sensors and signals that are taking part in that aggression. The need to assure humanity’s continued use of outer space, including a state’s own use, should prevent any state from physically destroying satellites. A space security treaty should codify this common understanding. A space security treaty should not, however, prevent states from temporarily or reversibly interfering with satellites, sensors or signals for reasons of self-defence, as is allowable under the UN Charter and the Outer Space Treaty (OST).

Finally, inadvertent interference with satellites from radio frequency or electro-optic frequencies remains a growing problem in space and measures should be taken to ensure that this residual threat is also minimized. Here a collection of SSA systems are important for crisis stability, as they will help discern inadvertent accidents and prevent them from being misconstrued as deliberate attacks.

To summarize, outer space is subject to two kinds of reversible threat. They are:

- the threat of purposeful interference with respect to reliance upon the use of satellites to ensure strategic stability, and the use of satellites to gain a tactical military advantage on Earth; and
- the residual threat of inadvertent interference from radio frequency and electro-optic frequencies.

Confidence- and security-building measures for space security

Having established the threats that need to be addressed for space security, this paper will now focus on proposing possible CSBMs aimed at laying the foundation for a comprehensive space security treaty.

IRREVERSIBLE

The first and most significant irreversible threat to space security is the threat of space-based weapons that are specially designed or modified to damage or destroy targets in outer space, on a trajectory above the surface of Earth, or on the surface of Earth. We can address the threat of space-based weapons by building upon the existing Outer Space Treaty, specifically Article IV.¹⁷

CSBM (1) States shall not place in orbit around Earth any weapons or objects carrying weapons, install weapons on the Moon or any other celestial body, or station weapons in outer space in any other manner.¹⁸

This proposal raises a couple of questions: one concerning the definition of the word “weapon”, and another concerning what such a prohibition would encompass. For the purposes of a space security treaty, a “weapon” is defined using a combination of the ordinary meaning of the word “weapon” and select parts of the Anti-Ballistic Missile (ABM) Treaty and the Missile Technology Control Regime as “a device based on any physical principle, specially designed or modified, to injure or a kill a person, irreparably damage or destroy an object, or render any place unusable.”¹⁹

To assist with discerning a space-based weapon from an ordinary satellite, the concept of “form follows function” may be employed. Coined by Louis H. Sullivan in 1896, form follows function is the idea that the design or look of an object directly relates to the purpose it serves.²⁰ Sullivan writes: “All things in nature have a shape, that is to say, a form, an outward semblance that tells us what they are, that distinguishes them from ourselves and each other.”²¹ In essence, objects of the same class tend to look alike. Further, “where function does not change, form does not change.”²² As such, there is no need to change the design of an object if the function of that object does not change.

Nam P. Suh further developed this idea: he establishes a direct mathematical relationship between the functional requirement of an object and the design parameters of that object.²³ Suh argues that the best designs are ones that fit one functional requirement with one design parameter. Anything beyond this represents improper design.

Using these design theories we can discern space-based weapons from satellites, as they imply that a satellite that is designed to be a weapon will also look like a weapon, and a satellite that is designed to be benign will look benign.²⁴ One recognizable example of these design principles drawn

from our ordinary experience is revealed in the comparison of a butter knife with a bayonet. A butter knife is short and it is dull-edged. Clearly this utensil has been designed for the purpose of benign kitchen tasks and the use of human safety factors are in ample evidence. A bayonet, on the other hand, is sharp, pointed, very long, double-edged and possesses the structural rigidity necessary to repeatedly harm human beings.

A similar type of analysis can be performed by experts, aerospace engineers and other intelligence analysts to distinguish the functions of objects in outer space. Indeed, even in the absence of a space security treaty, states must keep a vigilant watch on activities in outer space in order to maintain an ordered targeting list for the negation of space objects that could project harm in outer space or onto Earth.

These ideas were employed in the Strategic Arms Limitations Talks (SALT) II Treaty between the Soviet Union and the United States. In this treaty, these design principles were referred to as functionally-related observable differences (FRODs).²⁵ FRODs suggest that certain aeroplanes could be distinguished from others as being able to perform functions that fell into the domain of the SALT II Treaty. As such, FRODs became a standard method of verification. If it looked like it might be able to violate the SALT II Treaty, then it fell to the two countries to discuss and consult with each other to find a resolution to the compliance issue.

Observations by national technical means can ascertain, based on FRODs, whether a space object is “specially designed or modified” to serve as a weapon. Should situations arise in which the observable difference is too close to call by national technical means alone, the use of the treaty’s executive council structure as a means to consider these compliance issues would be far more beneficial for international peace and security than the alternative reliance on a deterrence strategy based on threats, retaliation, reprisals and other uses of force among nuclear-armed powers.

In addition to form, satellites are deployed in highly specialized orbits. The relation of a satellite to others or to the surface of Earth tells a great deal about the function the satellite is to perform. For example, satellites are deployed in the geostationary orbit in order to gain a view of one-third of the surface of Earth. This location makes it ideal for strategic communication and early warning missions. Likewise, satellites deployed in low Earth orbit gain proximity to Earth’s surface that can be exploited by remote sensing satellites to gain sharp resolution images of Earth. The behaviour of satellites within these orbits can also indicate their purpose. For example, most satellites have no need to approach other satellites. Future in-orbit repair or refuelling missions, requiring rendezvous or docking functions, would exhibit behaviours (and forms) that are different from most satellites. Like form, behaviour in space and in time can be used to distinguish a belligerent satellite from a benign satellite.

Referring to DeBlois’s oft-cited article, the above CSBM addresses the highest level of threat,²⁶ as it would prohibit orbital bombardment systems, orbital anti-satellite (ASAT) weapon systems, and space-based missile defence interceptors or directed energy weapons. This prohibition on weapons in outer space also enables further prohibitions to be considered for weapons on Earth that may reach into outer space, for without this first prohibition, states could not be expected to agree to the prohibition of terrestrially-based anti-satellite weapons for the fear of creating a sanctuary for space-based weapons.

Moving along DeBlois’s continuum then, to the threat of weapons that reach into outer space from Earth to damage or destroy.

CSBM (2) States shall not test or use a weapon on any satellite so as to damage or destroy it.

Once again, clarification is needed on a certain aspect of this CSBM. As was the case in the first CSBM, the definition of weapon remains the same. The word test, however, should be restricted

to a validation activity conducted in the open. That is, “test” means to field or flight test in a manner observable by the national or multinational technical means of observation available to a state. This helps to ensure that the prohibition, as worded, can be verified by national technical means of observation.

In terms of prohibitions, this CSBM would prohibit inflicting damage or destruction on a satellite, *regardless of the weapon’s location*, but would still allow ballistic missile defence (BMD) systems located on the surface of Earth to pass through outer space and engage ballistic missiles also passing through outer space. This CSBM would prohibit dedicated land-, sea- or air-based ASATs and modified BMD interceptors that are tested or used in an anti-satellite weapon role. CSBM 2 also prohibits the test or use of directed energy weapons on satellites that can harm satellites at a distance. This ensures that satellites placed into outer space may serve their natural lives and, at the end of their useful lives, execute their pre-arranged disposal plans to protect against the further production of space debris. This CSBM therefore would prohibit all activities that could deliberately create a derelict in orbit that may subsequently collide with space debris, as well as the direct production of space debris from a deliberate collision with an interceptor. It would not impede the development or test or use of ballistic missile defence systems against sub-orbital ballistic missiles.

Certain dual-use satellites, as articulated above, pose a more interesting and unique threat to space security than the two previous threats. This is due to the nature of certain satellites and their intended uses.

CSBM (3) States shall not test or use a satellite, itself, to gain the effects of a weapon through any direct action.

Such an undertaking would prevent satellites from inflicting damage or destruction themselves, but would still permit the use of outer space for the aid of military forces on Earth. The main challenge for this CSBM is maintaining sufficient awareness to provide accountability for activities in outer space. If, for example, a state uses a satellite that is capable of executing a pursuit to purposefully collide with another satellite in an attempt to damage or destroy that satellite, how will the world know who caused the resulting collision? For the most part, awareness of an attack in space currently only comes when people on Earth notice its effects.²⁷ That is to say, in space, it is very hard to see an attack coming if you are not looking. By the time one satellite has collided with the other, it may be difficult to properly attribute the attack, assuming it was an attack at all and not just an accident. It is for these reasons that robust SSA systems are fundamental to determining compliance with this and other CSBMs. SSA is crucial to attributing attacks and distinguishing attacks from accidents.²⁸ Moreover, SSA is essential to deterring such attacks. If a state is aware that it will get caught by engaging in such action, it will be less likely to do so.

Accidental collisions in outer space or on the surface of Earth pose the least significant threat for the security of space. However, they pose a great threat to the continued use of space. Space debris is created from accidental collisions just as it is from intentional ones and efforts must be made to reduce these occurrences. Likewise, to obtain crisis stability, it is important to be able to distinguish between an accident and a deliberate attack. The following series of CSBMs address this residual threat.

CSBM (4) A State should undertake to provide at least 72 hours prior notice of all space launch attempts from the territory, vessels, aircraft or satellites under its jurisdiction and control.

CSBM (5) When a State has reason to believe that a satellite maintained on its registry may re-enter the atmosphere of Earth sooner than within the next thirty (30) days, such a

State should provide notice without delay to all States that it has reason to believe may be affected.

CSBM (6) A State should not test or use a satellite maintained on its registry to purposefully approach, rendezvous, or otherwise operate in close proximity of another satellite, without providing sufficient prior notice to the State of registry of that other satellite. A State should also not dock or make purposeful physical contact with another satellite, without the prior approval of the State of registry of that other satellite.

CSBM (7) When a State has reason to believe that an active satellite maintained on its registry has a significant risk of collision with another satellite that it also believes is active, the State shall provide notice, without delay, to all other States that it has reason to believe may be affected.

CSBM (8) In the isolated event that a single satellite maintained on the registry of one State collides with another satellite maintained on the registry of another State, or one satellite purposefully approaches or makes physical contact with another satellite without giving the prior notice or gaining the appropriate approval required under CSBM 6, each affected State should consult with one another without delay.

Adhering to these CSBMs will significantly reduce accidental collisions in outer space and on the surface of Earth, as well as misunderstandings that could arise from such accidents. These proposed CSBMs have their roots in Article IX of the OST, which calls on states to mutually assist and cooperate with each other.²⁹ In effect, these CSBMs provide timelines and best practices to follow when operating in the outer space environment. Under these CSBMs, a state commits to provide notice to other states that may be affected by its activities in outer space. These notices enable the affected states to make better use of the consultation mechanisms that are available to them under Article IX of the OST. Increased communication opportunities, coupled with multiple robust SSA systems, will go a long way in reducing both the number of instances, and possibly the severity, of accidental collisions in outer space.

REVERSIBLE

In order to deal with reversible threats to outer space, it is important to ensure the continuity of communication, observation and early warning signals. When discussing satellites that provide strategic stability, it is important for all states, nuclear or not, to ensure that these crucial systems remain free from purposeful interference. Strategic stability comprises two main facets: observation and communication. The loss of one or both of these abilities can threaten the strategic stability among states that possess nuclear weapons.

CSBM (9) All States that possess nuclear weapons should use redundant and independent early warning systems that are based on more than one type of sensor.

CSBM (10) No State should purposefully interfere simultaneously with two or more early warning systems of any State that possesses nuclear weapons.

CSBM (11) No State should purposefully interfere with national or multinational technical means of observation operating in accordance with the generally recognized principles of international law.

These CSBMs address the observation facet of strategic stability and ensure that states in possession of nuclear weapons maintain at least two early warning systems based on separate indicators in order to ensure that any nuclear launch can be verified. If only one indicator were to be used, a malfunction in that system could be misinterpreted as a hostile launch. In order for this fail-safe to function properly, it is important that no state interfere with two or more of these systems at once. If a state is able to deceive both systems simultaneously, it may force the defending state to launch its nuclear weapons. The idea of redundant early warning systems as a necessary fail-safe measure has been in place since the early days of the Cold War.³⁰

CSBM (12) States that possess nuclear weapons should establish redundant and independent communication channels among their respective national command authorities consistent with their national security and foreign policy interests.

CSBM (13) No State should purposefully interfere with the signals of any such communication channels.

CSBM (14) No State should purposefully interfere with the command and control signals between the national command authorities of States that possess nuclear weapons and their military forces in possession of such weapons.

In terms of communication, it is important for states in possession of nuclear weapons to establish communication links among themselves in an effort to avert possible misinformation or misinterpretation of activities, especially during crises or conventional hostilities. During the Cold War, the United States and the Soviet Union established the Hot Line Agreement to facilitate such communication.³¹ Extending this to other states in possession of nuclear weapons is recommended. Furthermore, interference with these lines of communication should be avoided at all times, as should interference between those with the authority to launch nuclear weapons and those military commands in possession of them.

The CSBMs described above were self-evident to the United States and the Soviet Union during the Cold War as both superpowers defined “red lines” of international behaviour, which were designed to signal that certain activities were threatening vital interests.³² In fact, it is argued that the maintenance of peace during the Cold War was due in part to this series of conditions (communications, rational decision making, informed strategic planning, and a mutual sense that nuclear war was not in the interest of either country).³³ It is evident that the measures outlined in CSBMs 9–14 are simply restating already recognized international norms. As such, they would not necessarily need to be included in a space security treaty. The states that possess nuclear weapons may also want to retain the communication of red lines within their normal conduct of international relations in order to control the escalation ladder during situations that they might face in the future. A benefit of this reservation is that a space security treaty can address reversible threats more simply, as outlined below.

The use of satellites for tactical military objectives, as discussed earlier, should be approached differently during peacetime and during hostilities, including the outbreak of hostilities. Actions taken by states against satellites performing these roles can differ both in terms of legality, as well as consequence, depending on this divide, established by the UN Charter. As such, proposed CSBMs must reflect this divide.

CSBM (15) No State should purposefully interfere with any satellite sensor or signal that is operating in accordance with the generally recognized principles of international law, except when it considers that such purposeful interference is both necessary and allowable by the UN Charter.

CSBM (16) No State should use a satellite to originate, from itself, any purposeful interference, except when it considers that such interference is both necessary and allowable by the UN Charter.

These two measures would help reduce the risk of the initiation of a crisis by one state interfering with another state's satellite's sensors or signals, but they can each engage in this behaviour should they need to respond to an "act of aggression" pursuant to Article 51 of the UN Charter. In such instances, it would normally fall to the UN Security Council to seek a resolution to the outbreak of hostilities. CSBM 15 is recognizable as a variant of similar provisions within the ABM Treaty and in the Treaty on Conventional Armed Forces in Europe.³⁴

Further discussion of CSBM 16 is warranted by its clarification of CSBM 15. There is the possibility that purposeful interference originating from a satellite will act as an accelerant for the development of dedicated anti-satellite weapons or the modification of ballistic missile defence interceptors to negate the source of the interference in outer space with means that could produce space debris. After all, radio frequency or electro-optic jammers on the surface of Earth are often engaged with bombs or other explosive devices during hostilities. To prevent physical conflict in outer space, such interference should only originate from the surface of Earth, where terrestrially-based weapons may ultimately deal with the source of the interference. In a similar way to the current protective measures employed for the defence of aircraft, satellites in the future could become equipped with on-board jamming pods or flares to address the residual threat of terrestrially-based ballistic missile defence interceptors being modified to serve as anti-satellite weapons. By using electronic warfare measures against these residual threats, states would be adhering to both the UN Charter and a space security treaty.

The final threat to address is that of inadvertent interference between states. This paper suggests building upon the consultation mechanism of Article IX of the OST with a series of best practices for dealing with inadvertent interference.

CSBM (17) A State should cooperate, without delay, in the resolution of radio frequency or electro-optic frequency interference with another State upon the receipt of a notice of such interference.

CSBM (18) A State should give at least 72 hours prior notice of any high-power laser or microwave illumination of any point in outer space originating from the territory, vessels, aircraft or satellites under its jurisdiction and control, where it has reason to believe that there would be a significant risk of disrupting or denying the observation or communication signals of an active satellite maintained on the registry of another State.

The promise of CSBMs

The international community can go a long way toward ensuring the security of space for this generation and for generations to come by implementing a space security treaty that encompasses the CSBMs postulated above. These CSBMs reflect a grand bargain that is necessary in order to attain the security of a state's continued use of assets in the especially fragile domain that is outer space, without sacrificing its own national security interests with respect to threats originating from that domain. However, simply signing and ratifying a treaty based on these principles would not be enough. To be complete and effective, a treaty would need prohibitions and obligations, a verification process to ensure its adherence and a governance system to ensure its viability.

Verification and governance

Verification and governance are crucial to the success of any space security treaty.

Verification and governance are crucial to the success of any space security treaty. A violation of its provisions could undermine the purposes of the agreement. In the context of outer space, there are two types of verification: adequate and effective. Although the differences between the two are not spelled out, it is generally understood that effective verification entails stricter requirements and more rigorous inspections.³⁵ Adequate, however, is a verification standard consistent with the standard needed to wage war in outer space.³⁶ Essentially, in order to conduct physical conflict in space, one would need to be able to discern between military and civilian targets (as required by the Geneva Conventions).³⁷ Moreover, in the absence of a ban on space weapons, militaries would be required to have robust space situational awareness in order to maintain a targeting list of possible threats. This ability to discriminate between military and civilian targets, or to establish an order of priority for targets based on their ability to harm other objects, can also be used as a verification standard for ensuring that space-based weapons are never deployed.

The first step toward a robust verification and governance system is a collection of robust SSA systems. As discussed above, it is important to know what functions objects perform in outer space, who is in control of them, what orbits they occupy and how they behave in these orbits. This knowledge will not only act as a deterrent to the weaponization of space, but also reduce the risk of accidental collisions or interference.³⁸

The independent SSA systems of China, the Russian Federation and the United States could become the basis for Regional Space Operation Centres (RSpOCs) that would each maintain extensive knowledge of what activities are taking place in outer space on a real-time basis. These RSpOCs could serve as a form of clearing house, in which sufficient space information would be made available to other states in a format that is consistent with the national security and foreign policy interests of these three major space powers. As every state will have a significant relationship with at least one of these powers, every spacefaring state could gain access to the necessary and sufficient information for its safe and sustainable use of outer space. This would be particularly true were both China and the Russian Federation to make similar data available to third parties as the United States currently does under its Commercial and Foreign Entities project.³⁹ Looking forward, these RSpOCs, enhanced by Joint Data Exchange Centres established among them, could serve as the foundation for the multilateral verification of a space security treaty.⁴⁰

The second step toward a robust verification and governance system for space security is an executive council established under a space security treaty designed to report to the UN Security Council on compliance matters relating to the treaty. This executive council could serve as a basis for consultations concerning both compliance and whether or not a given satellite qualifies as a weapon based on its design and behaviour. This sort of governance system would be much more mutually beneficial and adhere to the spirit of Article IX of the OST, in contrast to a system of deterrence and tit-for-tat reprisals which may, in turn, lead to an arms race in outer space.

Conclusion

The production of space debris is a serious threat to humanity's continued use of outer space. Only through control of this debris can the world ensure the use of space for future generations. It is important to achieve the security of space as a means of controlling debris. States must not fight the first war in outer space, since humanity could lose its use of this domain for centuries or millennia to come. In addition, the use of space is only made possible through international cooperation in the coordinated use of the radio frequency spectrum. Interference with this aspect of space should be

made only in conformance with international law and pursuant to the UN Charter. When necessary, any interference should be temporary, localized and reversible.

This paper has proposed that a grand bargain be struck in order to preserve our continued use of outer space for all humankind. Physical violence in outer space must be prohibited and purposeful interference should be restricted to reasons of self-defence as permitted by the UN Charter. A space security treaty has been proposed with prohibitions and obligations to codify this balance of interests. While the principles have been presented in the form of a legally binding treaty, the principles could be first codified in a code of conduct in order to begin state practice and attain space security for the benefit of all humankind.

Notes

1. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty), signed at London, Moscow and Washington, DC, 27 January 1967.
2. Jessica West et al., 2007, *Space Security 2007*, Waterloo, Project Ploughshares, p. 21.
3. David Wright et al., 2005, *The Physics of Space Security: A Reference Manual*, Cambridge, MA, American Academy of Arts and Sciences, p. 22.
4. Ibid.
5. Lt Col. Bruce M. DeBlois, 1998, "Space Sanctuary: A Viable National Strategy", *Airpower Journal*, vol. 12, no. 4, Winter, p. 41.
6. Ibid., p. 42.
7. David Wright, 2007, "Orbital Debris Produced by Kinetic Energy Anti-Satellite Weapons", in *Celebrating the Space Age: 50 Years of Space Technology, 40 Years of the Outer Space Treaty, Conference Report, 2-3 April 2006*, Geneva, UNIDIR, p. 160.
8. Wright et al., op. cit., p. 118.
9. DeBlois, op. cit., p. 42.
10. "DSP (Defence Support Program)", Mission and Spacecraft Library, NASA, at <msl.jpl.nasa.gov/Programs/dsp.html> (archived site).
11. "Global Positioning System (GPS)", Mission and Spacecraft Library, NASA, at <msl.jpl.nasa.gov/Programs/gps.html> (archived site).
12. "Nothing in the present Charter shall impair the inherent right of individual or collective self-defence if an armed attack occurs against a Member of the United Nations, until the Security Council has taken measures necessary to maintain international peace and security. Measures taken by Members in the exercise of this right of self-defence shall be immediately reported to the Security Council and shall not in any way affect the authority and responsibility of the Security Council under the present Charter to take at any time such action as it deems necessary in order to maintain or restore international peace and security." Charter of the United Nations, Article 51.
13. Robert Powell, 2003, "Nuclear Deterrence Theory, Nuclear Proliferation, and National Missile Defense", *International Security*, vol. 27, no. 4, Spring, p. 89.
14. Ibid., p. 90.
15. Ibid., p. 89 and Harrison et al., 2009, *Space Deterrence: The Delicate Balance of Risk*, Eisenhower Center for Space and Defense Studies, p. 12.
16. James Clay Moltz, 2008, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*, Palo Alto, CA, Stanford University Press, p. 56.
17. "States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner. The moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military manoeuvres on celestial bodies shall be forbidden. The use of military personnel for scientific research or for any other peaceful purposes shall not be prohibited. The use of any equipment or facility necessary for peaceful exploration of the moon and other celestial bodies shall also not be prohibited." Outer Space Treaty, Article IV.
18. Note that this prohibition has been written using legally binding language through the use of the words "shall not". A non-legally binding CSBM could express the vision as "should not", as is demonstrated in later CSBMs.

19. "...based on any physical principle...", see Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems, signed 26 May 1972; "...specially designed or modified...", see Missile Technology Control Regime Guidelines and Equipment and Technology Annex.
20. Louis H. Sullivan, 1896, "The Tall Office Building Artistically Considered," *Lippincott's Magazine*, March.
21. *Ibid.*
22. *Ibid.*
23. Nam P. Suh, 1995, "Designing-in Quality through Axiomatic Design", *IEEE Transactions on Reliability*, vol. 44, no. 2, June.
24. For an example of this, one needs to look no further than the Multiple Kill Vehicle (MKV) versus the GFZ-1 research satellite.
25. Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Strategic Offensive Arms, signed at Vienna, 19 June 1979. For FRODs, see Article II(3), First Common Understanding.
26. DeBlois, *op. cit.*, p. 42.
27. Harrison et al., *op. cit.*, p. 15.
28. Harrison et al., *op. cit.*, p. 16.
29. "In the exploration and use of outer space, including the moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space, including the moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. States Parties to the Treaty shall pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty which has reason to believe that an activity or experiment planned by another State Party in outer space, including the moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including the moon and other celestial bodies, may request consultation concerning the activity or experiment", Outer Space Treaty, Article IX.
30. Michael D. Wallace et al., 1986, "Accidental Nuclear War: A Risk Assessment", *Journal of Peace Research*, vol. 23, no. 1, March, p. 25.
31. Dianne DeMille, 1988, *Accidental Nuclear War: Reducing the Risks*, Canadian Center for International Peace and Security, p. 7.
32. Giandomenico Picco, 1994, "The UN and the Use of Force", *Foreign Affairs*, vol. 73, no. 5, September/October, p. 18.
33. Ilan Berman, "The Iranian Nuclear Crisis: Latest Developments and Next Steps, Testimony before the US House of Representatives", reproduced in Joint Hearing before the Subcommittee on Terrorism, Nonproliferation and Trade and the Subcommittee on the Middle East and South Asia of the Committee on Foreign Affairs, House of Representatives, 110th Congress, First session, 15 March 2007.
34. Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems, Article XII; Treaty on Conventional Armed Forces in Europe, signed at Paris, 19 November 1990, Article XV.
35. Michael Krepon, 1986, "The Politics of Treaty Verification and Compliance", in Kosta Tsipis, David W. Hafemeister and Penny Janeway (eds), *Arms Control Verification: The Technologies that Make It Possible*, Elmsford, NY, Pergamon-Brassey's International Defense Publishers, p. 21.
36. Phillip J. Baines, 2006, "Adequate Verification: The Keystone of a Space-based Weapon Ban", in *Safeguarding Space Security: Prevention of an Arms Race in Outer Space, Conference Report, 21–22 March 2005*, Geneva, UNIDIR, p. 92.
37. Geneva Convention (IV) Relative to the Protection of Civilian Persons in Time of War, 12 August 1949, Common Article 3.
38. Harrison et al., *op. cit.*, p. 16.
39. National Defense Authorization Act for Fiscal Year 2004, public law 108–136, section 913, 24 November 2003, available at <celestrak.com/NORAD/elements/Section913.pdf>.
40. See Office of the Press Secretary, The White House, Memorandum of Agreement between the United States of America and the Russian Federation on the Establishment of a Joint Center for the Exchange of Data from Early Warning Systems and Notifications of Missile launches, 4 June 2000, at <clinton5.nara.gov/WH/New/Europe-0005/factsheets/memo--joint-warning-center.html>.