Redressing Orbital Dangers

Approaches to Advance India's Interests in Outer Space

Pranav R Satyanath

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Executive Summary

In December 2022, the United Nations overwhelmingly adopted a resolution that called for states to commit not to carry out destructive direct-ascent anti-satellite missile tests. India, however, abstained from voting on the resolution and indicated its preference for legally-binding instruments. Moreover, India has yet to put forward its proposals for members of international fora to pursue. This document recommends four approaches which India can pursue to secure its interests. These recommendations are:

1. Pursue legally-binding instruments which ban the destructive testing of anti-satellite capabilities in outer space.
2. Advocate for mutual proximity notifications wherein states notify one another during close approaches or when one satellite operator notices unusual satellite behaviour by another operator.
3. Promote sharing space situational awareness data to increase the knowledge of the space environment and build transparency and confidence between states.
4. Advance existing norms, rules and responsible behaviours in outer space by adopting and strengthening non-legally-binding measures.

No single recommended approach can redress all the threats in space. India must therefore advocate for multiple approaches in tandem to achieve peace and prosperity in outer space.

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List of Abbreviations

ABM: Anti-Ballistic Missile

ASAT: Anti-satellite

BMD: Ballistic Missile Defence

DA-ASAT: Direct-ascent Anti-satellite

DSA: Defence Space Agency

GEO: Geosynchronous Equatorial Orbit

HEO: Highly Elliptical Orbit

ICBM: Intercontinental Ballistic Missile

ICoC: International Code of Conduct

ISRO: Indian Space Research Organisation

LEO: Low-Earth Orbit

OEWG: Open-Ended Working Group on Reducing Space Threats

OST: Outer Space Treaty

PAROS: Prevention of an Arms Race in Outer Space

PPWT: Treaty on the Prevention of the Placement of Weapons in Outer Space

RPO: Rendezvous and Proximity Operations

SSA: Space Situational Awareness

STM: Space Traffic Management

TCBM: Trust and Confidence-Building Measure

I. Introduction

How must India advance its interests in outer space? What are the options at its disposal to take forward the ongoing dialogue on space security? As the calls for outer space risk reduction measures intensify, India's proactive participation in advocating its interests in outer space becomes imperative. In this context, this document argues that India must advocate for approaches that do not hinder its ability to develop capabilities and technologies to secure its national interests. Second, India's risk reduction approach must not replicate or circumvent the existing legal architecture of space governance. Finally, the approaches advocated by India must attempt to mitigate risks to the legal space activities of all states.

Currently, the major threats to security in space arise from two interconnected phenomena. First, there is a growing perception that outer space is a military domain conducive to warfighting.[1] Amidst the renewal of great power competition and geopolitical uncertainties,[2] states have developed and deployed a panoply of counterspace capabilities and strategies for both offensive and defensive purposes.[3] The second phenomenon deals with the exponential increase in the number of satellites in the Earth's orbit made possible by satellite miniaturisation and easy access to launch services.[4] The dual-use and dual-purpose nature of space assets mean that commercial satellite operations could be misperceived as being malicious and threatening, therefore, setting the precedence for kinetic and non-kinetic attacks against such assets.[5]

Kinetic attacks against satellites risk the creation of large clouds of space debris which could cause secondary damage to other satellites and trigger a cascading effect that damages several other satellites.[6] On the other hand, non-kinetic cyber and jamming attacks against dual-use satellites could disrupt essential civilian service and cause secondary harm to human life.[7] The use of anti-satellite capabilities against dual-use command-and-control assets could also create risks for nuclear escalation.[8] These issues were not as pronounced as the present day when the Prevention of an Arms Race in Outer Space (PAROS) agenda entered the United Nations (UN) and the Conference on Disarmament (CD) lexicon in the 1980s.[9] After three decades of futile efforts to control anti-satellite capabilities, the UN member-states shifted their attention to reducing space threats through the regulations of behaviours and operations in outer space.[10]

In this renewed effort, states at the Open-Ended Working Group (OEWG) on Reducing Space Threats began discussing various aspects of space security from the ground up.[11] The US-led moratorium on destructive direct-ascent anti-satellite (DA-ASAT) testing was among the proposals that garnered wide support. In December 2022, the UN General Assembly adopted Resolution A/C.1/77/L.62, which calls on states to commit not to conduct DA-ASAT tests.[12] The resolution, which was sponsored by the United States and ten countries, garnered 155 votes in favour and nine votes against the resolution and nine abstinences. India was among the nine states that abstained from voting.

India is also among the four countries that have conducted destructive DA-ASAT tests in the past. However, since conducting the test, India has neither made specific commitments nor advocated concrete measures to address its concerns regarding space security. Understanding why India abstained from voting not only helps us unpack its national interests in outer space but also provides a foundation for recommending new measures that the Indian government must advocate for in international fora.

The rest of the document proceeds as follows. The second section evaluates various proposals that call for an ASAT test ban, including the proposal put forward by the US and its partners. Further, it unpacks the advantages and shortcomings of an ASAT test ban and analyses its consistency with the existing legal architecture. The third section examines India's position on space threat reduction by studying the statements and proposals put forward since the 1980s. The fourth section lays down the approaches that India must advocate to secure its interests in space. It also elaborates on the objectives and parameters based on which the recommendations are made. The document concludes by summarising the main arguments made in the previous section. The Appendix provides further discussion of each recommended approach.

II. Analysis of the moratorium on destructive DA-ASAT testing

On April 18, 2022, US Vice President Kamala Harris announced that her country would not be conducting debris-creating direct-ascent anti-satellite (DA-ASAT) tests. The moratorium, in the words of the Vice President, was simple. "Simply put: These tests are dangerous, and we will not conduct them."[13]

The announcement came just weeks before the commencement of the first meeting of the Open-Ended Working Group on Space Threats (OEWG), where US representatives called on other member-states to follow suit.[14] The moratorium was announced just months after Russia conducted its DA-ASAT test, when it launched the PL-19 Nudol interceptor to an altitude of 1200 km and destroyed an old Soviet-era satellite.[15] The test reportedly created 1500 pieces of debris and threatened the operations of other satellites in orbit,[16] including the International Space Station (ISS).[17] The declaration of the moratorium, therefore, aims to address both the safety and security concerns in outer space.

The DA-ASAT test ban: Provisions and its variations

The moratorium was carefully worded, placing a specific restriction on testing while allowing for the greatest possible freedom of action. Both the US-led moratorium and the UN resolution call on states to refrain from testing DA-ASATs in a manner that the test creates space debris. They do not address the testing of space-based ASATs, which also have the potential to create space debris.[18] Further, the wording of the moratorium speaks only of destructive tests. It does not consider a moratorium on non-destructive tests which involve the firing of missiles against simulated targets in empty space. Finally, the moratorium also does not address the non-destructive jamming and dazzling payloads that can be released from ground-based missiles. Such novel capabilities could damage a satellite and create secondary debris.[19]

Calls for an ASAT test moratoria and bans are not new[20] and date back to the later years of the Cold War.[21] In 1983, for example, the Soviet Union unilaterally declared a moratorium on all forms of ASAT testing and called on the US to do the same.[22] Several variations of the ASAT test ban have proliferated in the past 20 years. For example, one variation of the proposal calls for adopting test guidelines that could allow for two categories of ASAT testing. The first category includes the type of tests that creates no debris. Such tests simulate targets in orbit and launch missiles into the emptiness of space. The second category recommends that if a test must create debris, it must do so at a low altitude and in a manner such that the test does not produce long-lived debris.[23]

Despite the differences, the new proposals that have emerged in the past 20 years carry three consistent themes. First, **development and deployment of anti-satellite capabilities are not banned**. Countries can continue to test and improve their capabilities while launching their interceptors toward simulated targets.[24] Second, **the proposals do not necessarily address how individual commitments could be upgraded into a universal legally-binding agreement**.[25] Proponents argue that establishing norms and rules of responsible behaviour must take precedence before embarking on the more ambitious task of negotiating legally-binding measures. Finally, **proposed test bans do not elaborate on the type of verification required for detecting violations**,[26] thus putting into question whether a verification mechanism is really necessary for an ASAT test ban agreement.

The concerns expressed by proponents of the norms-based test ban are not without merit. The dual-purpose nature of DA-ASATs brings a unique set of challenges for arms control. Direct-ascent space interceptors and ballistic missile defence (BMD) interceptors essentially share the same technology — hit-to-kill.[27] Placing any limits on the capabilities of DA-ASATs would impose indirect limits on BMDs, creating a political obstacle to control capabilities.[28] As noted by a seminal report on missile defences, BMD interceptors can be converted to ASATs without significant modification.[29] Moreover, a state possessing long-range ballistic missiles could convert existing missile capabilities into rudimentary ASATs, making limitations of capabilities all the more difficult.[30]

To complicate matters further, countries could employ novel concepts such as placing space-based or direct-ascent kill vehicles on space launch vehicles (SLVs) or intercontinental ballistic missiles (ICBMs) and, therefore, circumvent any ban on capabilities. Such concepts were once employed by the Soviet Union when scientists and engineers conceptualised the Naryad-V ASAT system, which consists of two components: the UR-100N silo-based ICBM, which serves as the booster, and the Briz upper stage, which carries the weapon-system.[31] Such capabilities not only compound the problem of distinguishing SLVs from ballistic missile technologies[32] but also blur the lines between space-based and direct-ascent ASATs.[33]

Coherence with international legal architecture

Given the complexities of controlling ASAT capabilities, a large number of UN member-states believe that an approach based on norms, rules and responsible behaviours could yield more immediate results.[34] Although the norms-based test ban approach has shortcomings, it remains within the existing architecture of space governance. Instead, it serves as a supplement to the existing international laws applicable in outer space. The Outer Space Treaty (OST), signed in 1967, is considered the cornerstone of outer space security.[35] The treaty prohibits the placement of weapons of mass destruction (WMDs) in space but does not explicitly ban the use or placement of conventional weapons in the Earth's orbit.[36]

The OST is also silent on two issues that significantly impact the weaponisation of space. One, it makes no mention about the problem of the placement of conventional weapons in outer space,[37] including novel capabilities such as fractional orbital bombardment systems.[38] Two, Article IX of the OST mandates that State Parties conduct space activities "with due regard to the corresponding interests of all other States Parties to the Treaty," and "conduct exploration of them [outer space] so as to avoid their harmful contamination and also adverse changes in the environment of the Earth".[39] Furthermore, Article IX also allows for consultation if one party believes that the space activities of another party could result in harmful interference. Since the creation of space debris through DA-ASAT testing not only contaminates the outer space environment but could also interfere with or disrupt the space activities of other states, the proposed DA-ASAT test ban is within the purview of the OST.

On balance, the DA-ASAT test moratorium places no binding restrictions on the design, development, deployment and non-destructive testing of ASATs, thus providing states with a high degree of freedom to conduct military space operations. That raises the question: why did India abstain from voting on the test ban resolution?

III. Examining India's position on outer space risk reduction

On October 2, 2022, the United Nations General Assembly (UNGA) voted on Resolution A/, which calls for a ban on destructive DA-ASAT tests. India was among the nine states that abstained from voting. A nuanced reading of India's position indicated that its decision to abstain resulted from specific preferences for arms control agreements in outer space.

The UN adopted the agenda Prevention of an Arms Race in Outer Space (PAROS) in 1984,[40] at a time when the strategic competition between the US and the Soviet Union was at its peak. India actively participated in the deliberation of PAROS, when much of its energy was dedicated to the general opposition to the militarisation and weaponisation of outer space. Together with Argentina, Greece, Mexico, Sweden and Tanzania (Six Nation Initiative), India believed that the impending arms race in outer space had its roots in the nuclear arms build-up between the two superpowers, and the path to PAROS could be found only through deep reductions of nuclear arms.[41]

At a deeper level, India's diplomats recognised the tight coupling of ASAT and BMD technologies and proposed a package of legally-binding and non-legally-binding measures to cut short the arms race in space.[42] They proposed a package of legally-binding and non-legally-binding measures to cut short the arms race in space. First, India called for a complete ban on ASAT weapons and called for a halt on their research and development. Further, it also believed that stringent verification measures were not a necessary requirement for an ASAT ban treaty and said, "[A] 100 per cent verification could be construed as a pretext for not banning ASAT weapons."[43]

Second, India proposed to extend the Soviet Union's ASAT moratorium to cover the development of ASAT capabilities even further and called for a legally-binding ban on all forms of ASAT testing.[44] Third, through the Six Nation Initiative, India called for an interim ban on all ASAT testing, which could eventually lead to the disarmament of ASAT capabilities.[45]

By the mid to late-1990s, however, India's space security policy began to shift, albeit slowly. Two significant events shaped India's contemporary policy on space risk reduction. Soon after the nuclear tests in 1998, India saw the need to place limited missile defences around the national capital. Suddenly, India's policy was now at loggerheads with security requirements as it sought a capability it once deplored. The Defence Research and Development Organisation (DRDO) began the development of an indigenous BMD system in the early 2000s,[46] which eventually gave rise to the Prithvi Air Defence (PAD) system in November 2006, kickstarting Phase I of the BMD programme. In 2020, the Indian Air Force (IAF) and DRDO said that the BMD shield was ready for deployment around the national capital.[47]

The second significant event that shaped India's space security policy was China's ASAT test in 2007. Before 2007, policymakers in New Delhi and the country's defence and scientific communities showed a lukewarm attitude towards space weapons. China's test came as a wake-up call for a dedicated space security policy, galvanising support for India's own ASAT capability, which would function as a minimum deterrent in space.[48]

China's ASAT test also triggered two parallel mechanisms for risk reduction in outer space. The first mechanism was a legally-binding draft agreement called the Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects (PPWT), which was submitted jointly by China and Russia in 2008.[49] The draft treaty had two major features: one, it called for an explicit prohibition on the placement of weapons around the Earth's orbit or on any of the celestial bodies; two, it called on states to refrain from the use of force and the threat of the use of force in outer space.[50]

The draft PPWT came with problems, the most striking of which was the exclusion of terrestrial-based ASAT capabilities. The PPWT made no mention of DA-ASATs and their deployment and testing. Further, the definition of a 'space weapon' was very contentious, as it could not sufficiently distinguish between a dedicated space-based ASAT weapon and civilian capabilities that could cause damage to other objects in space.[51] India, however, deemed the PPWT worthy of discussion as the draft could be developed into a binding instrument acceptable to all parties.[52] In 2010, India clarified its position even further and said that even though voluntary transparency and confidence-building measures (TCBMs) could be useful in the interim, the main objective of arms control in space was to negotiate a legally-binding agreement.[53]

This position would sharpen even further after the European Union (EU) introduced a parallel risk reduction mechanism called the International Code of Conduct on Outer Space Activities (ICoC).[54] Instead of pursuing legally-binding instruments, which were prone to deadlock, the EU hoped to have non-legally-binding measures for promoting the safety, security and sustainability of space activities.[55] While India welcomed the efforts to suggest alternate proposals, it found the EU's process to be less inclusive than desired.[56] Indian representatives continued to assert the ad-hoc measures that do not lead to a binding treaty.[57]

India continued several rounds of consultations with the European states and negotiations with Russia and China. Unable to secure its preferences, India voted against the ICoC at the UN General Assembly.[58] The BRICS (Brazil, Russia, India, South Africa) issued a statement which outlined the reasons for voting against the resolution.[59] The joint statement criticised the EU for attempting to circumvent the PAROS agenda, which was in the works at the CD. Further, it also said that the work on TCBMs must not delay the negotiation of legally-binding instruments.

Based on the analysis of various statements, India's policy for space threat reduction can be summarised as follows:

1. **The need for legally-binding instruments in space;**
2. **Openness to negotiating non-discriminatory, universally-applicable Transparency and Confidence-Building Measures (TCBMs) which could complement legally-binding instruments; and**
3. **Resistance towards purely non-legally-binding measures, which are deemed ad-hoc and non-universal.**

The ASAT test of 2019 did not change India's position on risk reduction. These preferences are therefore reflected in India's abstinence from the test ban resolution. In the Explanation of Vote, India's representatives stated that the proposed resolution does not address the binding aspects of the test moratorium.[60] Further, in a statement at the second meeting of the OEWG, India said that the first step towards risk reduction is to develop a common interpretation of the existing legal framework in outer space. Furthermore, India said:[61]

"It is our preference to have a legally binding instrument because it elicits stronger guarantee of compliance and a greater commitment by States to adhere to the obligations. However, we are also open to the development of non-binding outcomes such as common rules and norms and transparency & confidence building measures since they are complementary in nature and can serve as a foundation for binding agreements."

Therefore, India's voting on the proposed test is consistent with its preferences for outer space risk reduction measures. The nuanced reading of India's space reduction policy tells us that the Indian government rejected the proposed test ban to prevent a pure norms-based approach from taking precedence in international fora. Indeed, if India's dissatisfaction stems from the fact that the proposed test ban is not a binding agreement, then would a binding DA-ASAT test ban treaty satisfy India's preferences? While a legally-binding agreement would satisfy India's preferred approach, India's policymakers are also likely to seek additional measures that reduce the risk of misperception and miscalculation. Given that the current approach does not address some of the most pressing security threats in space, India could widen the scope of discussion to include the threats that emerge from space-based ASATs.

IV. Recommended approaches for India

What are the measures that India should advocate at the CD and other international fora? The last section has examined India's policy towards arms control and risk reduction in outer space. Having clarified India's policy, this section proceeds to provide four sets of recommended approaches for India's policymakers to pursue.

To be clear, these recommendations are not proposals. Rather, they are broad exploratory ideas that states can pursue and develop over time. The recommended approaches have been put forward previously in several variations. However, this document provides a nuanced assessment of each approach and elaborates on the parameters chosen for the assessment.

Finally, it is important to note that no single approach provides the solution to address all threats in space. India could advocate for multiple approaches in tandem to have the greatest chance of garnering wide acceptance for risk reduction measures.

Objectives of pursuing arms control and risk reduction measures in outer space

Before putting forward the recommendations for arms control approaches, we must first lay down the objectives for pursuing them. The objectives of arms control are understood to consist of three components: 1. Reduce the risk of war; 2. Reduce the costs of preparing for war; and 3. Reduce the level of destruction should war occur.[62] Historically, however, arms control has also been an exercise for gaining competitive advantages[63] and managing uncertainty.[64] While these principles hold true for arms control in outer space,[65] the risk reduction measures must inevitably address some aspects of space safety and space sustainability.[66] Furthermore, since much of the existing space governance architecture is built on foundational treaties negotiated during the Cold War, any arms control or risk reduction instrument must navigate through the tangled web of international law.[67]

What should be the objectives for India in its pursuit of arms control and risk negotiations? As mentioned in the previous section, India stayed clear of the weaponisation of space during much of its time as a space-faring nation.[68] Its space security environment, however, was impacted by China's ASAT test in 2007. From the early to mid-2010s, India also expanded the number of satellites in orbit and began testing the LVM-III heavy-lift rocket to strengthen its space capabilities. The ASAT test of 2019 gave rise to two dedicated military space organisations — the Defence Space Agency (DSA) and the Defence Space Research Organisation (DSRO).[69] In 2020, the Union government opened India's space industry to the private sector through the establishment of Indian National Space Promotion and Authorization Center (IN-SPACe), ushering in a new era for India's nascent yet growing private space sector.[70]

The Indian Space Research Organisation (ISRO) has also built nascent space situational awareness (SSA) capabilities under the name NEtwork for space object TRacking and Analysis (NETRA)[71] which allows it to assess conjunctions and monitor space debris in a limited manner. In mid-2022, ISRO published its first SSA assessment report, which shed more light on the organisation's debris tracking capabilities.[72] Further, India has also forged a memorandum of understanding with the US to share SSA data, thus expanding its overall monitoring ability.[73]

India's **primary national interest is to preserve its use of outer space and safeguard its right to carry out space activities as permitted by the existing legal architecture**. With the exponential increase in space activities in recent years, the Earth's orbits are more congested and contested, ensuring the unhindered use of space becomes even more imperative. While the development of defensive capabilities offers some security against potential space threats, passive steps such as better monitoring of space activities, voluntary transparency initiatives, and clarity on the interpretation of international law help mitigate security concerns. Therefore, India's objectives for space risk reduction must be as follows:

1. **To ensure that any risk reduction approach is not prejudicial to India's ability to develop capabilities and technologies to secure its national interests;**
2. **To ensure that risk reduction approaches do not replicate or circumvent the existing legal architecture of space governance; and**
3. **To seek legally-binding and non-legally-binding risk reduction measures that mitigate risks to the legal space activities of all states.**

These objectives form the basis for the recommendations provided below. Further, these objectives also complement India's official position on space risk reduction.

Parameters for assessing recommended approaches

On what basis do we assess the approaches recommended here? The document assesses each approach against four parameters, which are as follows:

Scope and Benefits: What are the space activities covered by the recommended approaches? And to what extent does the approach limit specific capabilities and actions? The scope of an approach or proposal varies in the spectrum of very broad and very narrow coverage of activities. Benefits from an approach are often subjective as different sets of groups perceive the objectives of risk reduction measures differently.[74] For example, some view the US-led test moratorium as beneficial as it grants states the freedom to field capabilities that enhance deterrence in space.[75] Others consider the moratorium detrimental since states in the international system do not share the same views on norms of responsible behaviour.[76] Scope and benefits of an approach must therefore strike a balance between enhancing security and protecting national interests that are consistent with international law.

Limitations and Risks: Do the recommended approaches eliminate major security threats in space? Are these limitations political or technical, and what are the risks that arise from these limitations? Since an agreement cannot address all issues, any approach or proposal is bound to have certain limitations. However, limitations can also arise due to other reasons, such as poorly defined terms that can lead to the risk of misinterpretation.[77] Further, an approach or proposal could also face severe limitations because of the flawed design of agreements.[78] For example, the politically contentious entry-into-force clauses can often leave a treaty in limbo for decades.[79]

Verifiability: What mechanisms could be used to verify the prohibited and restricted activities in a proposed agreement? More importantly, does an approach require verification at all? Verification in arms control involves a set of actions and/or technical tools used to collect, collate and analyse information and determine the state of compliance with an agreement or treaty.[80] Verification is not just a technical process but also a political one, as the domestic preferences of individual states determine the requirements of 'adequate' or 'effective' verification.[81] Verification poses two major hurdles in the context of risk reduction in space. Since space and missile technologies are often sensitive, intrusive on-site inspections — especially in a multilateral setting — might not be acceptable to all states.[82] Further, the asymmetry in verification capabilities among states means that potential member-states must rely on unilateral verification methods to determine the state of compliance. This limits the scope of verification to a handful of member-states, placing another hurdle on verifiable multilateral treaties. Hence, a mix of cooperative transparency measures and unilateral non-intrusive monitoring could create a balanced model for verification.[83]

Degree of Accountability: Is the approach or proposal acceptable to all states in international fora? Measures based on norms and principles might be widely acceptable as they do not impose binding restrictions on states. However, a non-legally-binding approach might also be highly problematic for those states who wish to impose binding measures as they fear that pure norms-based approaches are ad-hoc and might fuel an arms race even further.[84] The EU's ICoC and the insistence on the right to self-defence were among the most contentious issues during deliberation and one reason for limiting its acceptability.[85] Concerning legally-binding instruments, the degree of accountability is contingent upon the scope of the approach and the degree of freedom it offers. The narrow scope of the PPWT, which focused exclusively on space-based weapons, meant that the treaty design severely limited its acceptability. While achieving universal acceptability is tasking, any approach or proposal must consider the positions put forward by all states and later aim to negotiate the specific provisions.

The table below provides a summary of the recommended approaches. The Appendix of the document provides a detailed evaluation of each approach.

Approach	Scope and Benefits	Limitations and Risks	Verifiability	Degree of Acceptability
Legally-binding ban on destructive ASAT tests	Places a legal ban on destructive testing. Ban could include only DA-ASAT tests or both direct-ascent and space-based tests. Freedom to conduct non-destructive testing and development of capabilities.	A complete legally-binding ban on debris-creating DA-ASAT testing could interfere with the testing of BMD capabilities. A pure legally-binding test ban could lull states into a sense of safety and security, and therefore, hinder the negotiations of further measures.	Debris-creation verifiable through SSA capabilities. Multilateral verification is unlikely due to asymmetry of capabilities among countries. Data-sharing SSA arrangements could mitigate the gap between asymmetry and available data.	Medium to high degree of acceptability for ban on destructive DA-ASAT testing. Low to medium degree of acceptability for ban on destructive space-based ASAT tests.
Mutual proximity notifications	The agreement to mutually notify proximity approaches of satellites helps address some concerns regarding rendezvous and proximity operations.	Effectiveness of notification agreement will depend on what states deem as a close proximity approach and timeliness of notification.. Disputes regarding proximity can also arise due to varying interpretations of data.	Detection of proximity approaches depends on two sets on capability: 1. On-board capabilities of a satellite. 2. SSA capabilities of individual states.	Low to medium degree of acceptability.
SSA data-sharing arrangement	Agreement could mandate sharing of data within a prescribed timeframe. No legal restrictions placed on testing and development of capabilities.	While an SSA data-sharing agreement could increase the overall transparency between states, meaningful risk reduction is possible only when widely-accepted standards for the processing and interpretation of data are developed. SSA data-sharing is also best utilised when used to verify other risk-reduction agreements in outer space.	Debris-creation verifiable through SSA capabilities. Multilateral verification is unlikely due to asymmetry of capabilities among states. Data-sharing arrangement could mitigate the gap between asymmetry and available data.	Medium to high degree of acceptability.
Non-legally-binding destructive ASAT tests moratorium	High degree of freedom to conduct non-destructive DA-ASAT tests. High degree of freedom to conduct non-kinetic space operations.	A norms-based test ban gives states a high degree of freedom to improve ASAT capabilities, hence, having little effect on perceived risk reduction. A norms-based and behavioural approach could lock states into a system of non-legally-binding architecture.	States can violate international norms with little consequence. No multilateral verification instrument.	Medium to high degree of acceptability.

V. Conclusion

A renewed interest in preserving the safety, security and space activities has given rise to the US-led proposal to redress the threat posed by destructive DA-ASAT testing. In line with the efforts to reduce space threats through norms, rules and responsible behaviours, the test moratorium is non-legally-binding. It contains no provision that restricts the development and deployment of counterspace capabilities.

A close examination of the US-led proposal demonstrates that it does not undermine India's national interests. India's choice to abstain from the UN resolution of DA-ASAT testing, therefore, is rooted in Indian policymakers' preference for legally-binding instruments and an aversion to a pure norms-based approach. However, sprinting towards a legally binding agreement is not a viable option.

Hence, India must advocate for converting the norm-based test moratorium into a legally-binding instrument. Further, India must advocate for measures to address the threat posed by space-based capabilities. Since there are no provisions to verify the deliberate generation of space debris or monitor close approaches, India must also advocate for measures that foster sharing of SSA data. Indeed, none of these approaches is perfect, and each has limitations.

Nonetheless, pursuing these measures brings with it at least two benefits. First, it legally codifies the test moratorium as it already has wide acceptance in the UN. Second, given that there exists a divide between the US-Europe-led bloc and the China-Russia bloc on the approach to space security, an approach that advocates for mutual proximity notifications might function as a bridge between the norms-based approach and the PPWT approach.

Although all countries use outer space, it is not isolated from the volatility of global power politics. As a rising space power with growing stakes in the civilian and military domains, any space security measure taken at the multilateral level will have significance for India's space sector. If the Government of India hopes to shape space governance in its interest, it must take a proactive stance on approaches across international fora.

Appendix

The fourth section of this document provided a summary of the recommended approaches for India to pursue in various international fora. This Appendix elaborates on each of the approaches and the requirements for their implementation. The recommended approaches are:

1. **Legally binding ban on destructive ASAT testing**
2. **Mutual proximity notifications**
3. **SSA data-sharing arrangement**
4. **Non-legally-binding ASAT test moratorium**

Approach 1: Legally-binding ban on destructive ASAT testing

The proposed approach for India to pursue is relatively straightforward. It aims to push the proposed moratorium on destructive ASAT testing into a legally-binding instrument. In essence, it requires all member-states to commit not to conduct destructive ASAT tests by signing a treaty — with or without specific verification measures.

Scope and Benefits

The proposed legally-binding test ban approach places a complete ban on testing debris-generating anti-satellite weaponry. Unlike other approaches that recommend an altitude ceiling for debris-generating ASAT tests, this proposal calls for a complete ban on all debris-generating tests in space. The approach could take shape in two forms. First, a ban only on destructive DA-ASAT tests. And second, a ban on both DA-ASATs and space-based ASATs.

The proposal does not restrict the non-destructive testing of such capabilities. These include launching interceptors into empty points in outer space or placing space-based capabilities in orbit. Further, the proposal also allows for the development, testing and deployment of BMD capabilities, which include endo-atmospheric and exo-atmospheric interceptors.[86] Since the objective is to ensure that member-states are legally bound by their non-destructive ASAT testing commitments, the recommended approach formalises the measures to foreclose the pressing concern of space debris. At the same time, the scope of the approach is narrow enough to allow states to develop capabilities in their national security interest.

Limitations and Risks

The legally-binding destructive test ban approach comes with two potential limitations or risks. The first is the test ban's possible interference with BMD interceptor testing and development. Midcourse interceptors attempt to engage incoming ballistic missiles during the longest phase of the missile's flight to the target. The notional intercept altitude for midcourse interceptors is well over 500 km above the Earth's surface and could also reach targets above 4000 km.[87] Given the high-altitude testing conditions for BMD systems, a legally-binding destructive ASAT test ban could impose indirect restrictions on BMD intercept testing. These constraints could become pronounced if countries wish to test their missile defence capabilities under realistic conditions.[88] The BMD testing problem could persist unless states agree to define an ASAT test.

The second limitation arises from the fact that the legally-binding destructive ASAT test ban approach limits specific behaviours of states but does not control for capabilities. This is indeed by design, as member-states could thwart any attempt to control capabilities at the multilateral level of discussions. Therefore, seeking a legally-binding treaty could come with two secondary effects. First, states could be lulled into a false sense of safety and security as they come to believe that the ban or limits on destructive ASAT tests will foreclose the most pressing threat to space sustainability.[89] Since the effort to jump from soft law to a legally-binding instrument is itself a strenuous effort, states may also be reluctant to negotiate further measures to address the threats in outer space. Second, the signing of a legally binding detective ASAT test ban agreement also comes with a risk of triggering a stimulating effect, where states redirect resources to develop and deploy new counterspace capabilities so as to avoid being locked into agreements that could curtail their capabilities in the future.[90]

Verifiability

The verification and monitoring of a destructive ASAT test ban involve an assortment of processes and techniques. The requirements for verifying DA-ASAT tests and space-based ASAT tests, for example, utilise two different sets of approaches — where the technologies required for verification are accessible to states markedly disproportionate.

Monitoring and verifying a DA-ASAT destructive test ban involves two separate elements:

Launch detection: States must be able to verify the launch of a missile or space launch vehicle from any point on the Earth's surface. Traditionally, missile and space launches are detected globally using satellites that detect the infrared signatures of launches. These early-warning satellites are deployed in geostationary orbits (GEO) or highly elliptical orbits (HEO) as part of a state's nuclear command-and-control infrastructure.[91] Due to their nature of operations, therefore, the data gathered by the early-warning satellites are kept secret. Moreover, since missile early-warning satellites require enormous investment in their research and development, access to space-based launch detection technology is inaccessible to most states. Hence, launch detection-based verification could either be unilateral or stipulated by a multilateral-level agreement to exchange space launch data.[92] Alternatively, states could tap into novel methods such as acoustic, infrasound and ionospheric detection to monitor and verify space launches on a multilateral scale.[93] In recent years, infrasound detection has proven particularly useful in detecting a wide variety of launches using existing infrasound sensors in the Comprehensive Test Ban Treaty Organisation's (CTBTO) International Monitoring System (IMS).[94] While such novel approaches are technologically attractive and feasible, their adoption will prove politically challenging in the near future.

Debris detection: States must be able to detect the debris created by the collision of the interceptor's kill vehicle and a satellite in orbit. Currently, states use SSA capabilities to monitor satellite activities, track space debris and assess the potential for collision between objects in space. SSA capabilities include a wide range of radars, electro-optical telescopes and space-based satellites used for both civilian and military purposes.[95] In order to verify a state's destructive ASAT test ban commitments, SSA assets must accurately detect the creation of debris after a kill-vehicle has hit the target satellite. The data gathered from the SSA assets must also distinguish a destructive ASAT test from the collision of two objects to avoid false positives or false negatives to avoid misattribution. Much like the technologies required for detecting space launches, SSA capabilities are also disparately distributed between states, complicating the possibility of multilateral verification.[96] However, the rise of hobbyist satellite tracking and the private SSA industry opens the potential for open verification of an ASAT test ban.

The verification process for a destructive space-based ASAT test ban regime also consists of two elements. As discussed above, the ability to detect the deliberate creation of space debris is an essential element of any destructive test-ban regime in space. In addition, a space-based destructive test ban agreement also requires member-states to accurately attribute the cause of debris creation to a space-based weapon. Classifying a satellite as a space-based weapon is not possible through SSA capabilities and requires more intrusive methods, such as a visual attribution from an inspector satellite.[97] While states use inspector satellites regularly for reconnaissance purposes,[98] their wide-scale adoption in a multilateral setting will prove politically contentious, as member-states could disagree on how best to describe a space-based ASAT and differentiate it from on-orbit servicing (OOS) satellites.[99]

Degree of Acceptability

Since legally-binding agreements, to some extent, tie the hands of member-states, their degree of acceptability might not be as wide-ranging as a non-legally-binding commitment. The degree of acceptability for a destructive DA-ASAT test ban could be medium to high, depending on the definition of a DA-ASAT and the model of verification. A unilateral verification model could bring with it a high degree of acceptance.

For a degree of acceptability for a space-based ASAT is, at best, medium. As discussed above, defining what constitutes a space-based weapon is the greatest hurdle to such an agreement. Since countries have yet to demonstrate consensus on whether OOS capabilities pose a genuine threat to space security, building consensus on the threat posed by destructive space-based capabilities also seems unlikely.

Approach 2: Mutual proximity notifications

The proposed approach calls for member-states to mutually notify one another if one state's registered satellite is in the same altitude, orbital plane, phase or at close distance to the registered satellite of another state.[100]

In order to understand the working of such an arrangement, consider two satellite operators, Operator-A and Operator-B, operating Satellite-A and Satellite-B, respectively. If Operator-A notices that Satellite-B is approaching unusually close to Satellite-A, then Operator-A can notify Operator-B of the proximity of their satellite

(Satellite-B). Alternatively, if Operator-B wishes to undertake a series of manoeuvres which might be considered eccentric or in proximity to Satellite-A, then Operator-B can choose to notify Operator-A of such manoeuvres.

The proposed approach could take the form of a non-legally-binding TCBM and eventually be adopted as a legally-binding instrument.

Scope and Benefits

The scope of the proposed approach is strictly limited to notifying member-states of close approaches. The approach does not place any restrictions on the space operations of member-state. Unlike other proposals that call for keep-out zones, safety zones and warning zones, this approach aims to place the onus of notification on member-states without triggering fears of military confrontation.[101]

Having a mutual proximity notification arrangement has two important benefits. First, voluntary notifications strengthen the duty of due regard of member-states, which constitute an essential pillar of existing outer space legal instruments.[102] Second, the approach allows states to have open lines of communication to clarify the intention behind satellite manoeuvres to avoid any misperception regarding space activities and potentially avoid accidents and inadvertent escalations.

Finally, mutual proximity notifications could also help address the potential threat and risks posed by cooperative and noncooperative rendezvous and proximity operations (RPO) satellites. Since the mutual notifications arrangement does not restrict any form of close approaches of satellites, member-states are only required to acknowledge the presence of the satellite in proximity. Such notifications help identify and acknowledge potential threats while leaving the onus of response on states or satellite operators.

Limitations and Risks

The proposed approach comes with two potential shortcomings. First, for any proximity notification arrangement to be successful, states must agree on the conditions that constitute proximity between satellites and the timeliness of the notification. Agreeing on proximate distances is both a political question and a technical one. Satellites perform RPOs in two ways. One, a satellite must change its relative position with respect to its target by performing a series of manoeuvres that involve increasing or lowering the satellite orbit.[103] This form of RPO is relatively slow and, therefore, simple to identify due to the eccentric behaviour of a satellite.[104] Two, a satellite can also change its orbital plane or altitude within the same orbital plane. With enough change in velocity (Δv), a satellite could carry out such manoeuvres quickly.[105] In such cases, the distance between satellites matters less, and the detection of a satellite's Δv and the timeliness of the notification become more significant.[106] Hence, disagreement on a measure of proximity between satellites and the timeliness of notification could leave the mutual notifications arrangement completely ineffective in addressing space threats.

The second limitation arises from the possibility of misinterpretation of SSA data. As mentioned previously, states monitor activities in space through the use of SSA capabilities. Due to the equal distribution of these capabilities, some states may have more data to work with than others. Further, assuming that all parties are operating in good faith, states may also have varying standards of collating and processing data, opening the door for technical misinterpretation and derailing timely notifications.[107] Asymmetries in standards and technologies, therefore, could limit the extent to which a mutual proximity notifications arrangement can be effective.

Verifiability

Since the proposed mutual proximity notifications arrangement does not ban or restrict any form of space activity, the approach does not require any form of verification. However, states must possess some form of SSA capability in order to confidently monitor and identify RPO activities and changes in a satellite's behaviour.

Ideally, a mutual proximity notifications arrangement could function through unilateral verification methods, whereby the SSA assets — which include ground-based, space-based and on-board satellite capabilities — could be labelled as national technical means of verification. As mentioned above, the success of mutual proximity notifications is contingent upon the degree to which states can accurately identify changes in a satellite's behaviour. Therefore, verifying satellites' behaviours is limited to only a few states. However, if states agree to a multilateral SSA data-sharing regime, mutual proximity notifications could become widely acceptable.

Degree of Acceptability

Since the technology required to monitor activities in space is within the possession of only a small number of states, the degree of acceptability of mutual proximity notifications is low within UN member-states. Moreover, even if the arrangement is confined to space-faring nations, the degree of acceptability will likely be low as states might be reluctant to disclose highly secretive national security RPO operations, especially among states which are seen as non-friendly.

Approach 3: SSA data-sharing arrangement

A space situational awareness data-sharing arrangement aims to promote transparency and confidence-building in outer space.[108] The approach calls for states to share SSA data to increase the overall knowledge and picture of the space environment. The proposed approach is consistent with the Guidelines on Long-Term Sustainability (LTS Guidelines), which calls for the promotion, dissemination and sharing of orbital and space debris monitoring information.[109]

Scope and Benefits

The recommended approach advocates for states to explore the sharing of SSA data through a variety of data-exchange models. Given the disparity in capabilities between states, no single data-sharing model fits all use cases.[110] Hence, states must negotiate and update different types of arrangements depending on the political and technological feasibility.

An SSA data-sharing arrangement is open-ended and does not place any form of restrictions on the behaviours or capabilities of states. Instead, states can use the shared data for a variety of purposes, including space traffic management and monitoring of satellite RPOs. The broad scope of the approach means that SSA data-sharing can promote both space safety and space security,[111] thus bridging the divide that currently exists between UN member-states who call for the separation of space sustainability issues from those related to space threats.

The approach could also help establish a regime that provides a full picture of the space environment. Currently, the US has the largest SSA network in the world, utilising both civilian and military assets.[112] Through several bilateral agreements with allies and partners, the US has also expanded its coverage of the space environment to the Southern Hemisphere.[113] However, despite the expansive coverage, the US network still has gaps. Therefore, the cooperative multilateral SSA data-sharing not only helps fill the knowledge gap of the Earth's orbits, but it could help less technologically-capable states to have the same level of access to data as the advanced states. The data gathered from commercial SSA capabilities could also complement state-owned capabilities to provide new and innovative solutions for SSA data processing and visualisation.[114]

Limitations and Risks

Space Situational Awareness data-sharing could be of limited use if states do not develop common standards for assessing, interpreting and processing data gathered by various SSA capabilities.[115] The SSA data interpretation problem is not uncommon, as it persists even among allied states.[116] The impediments to developing a common operational picture could arise from two factors. First, since SSA is predominantly a national security tool, the data gathered could be considered too sensitive for wide dissemination.[117] Second, cooperative SSA might require states to set up an independent international body to collect, process, secure and disseminate data.[118] However, setting up such a formal organisation might be viewed as a step too far for some states. A bottom-up approach to resolving the technical issues behind SSA data-sharing could mitigate the risk of data misinterpretation.[119]

The proposed SSA data-sharing approach will also be ineffective if states do not use the data as risk reduction tools. While SSA is indeed a tool for transparency, sharing SSA data does not automatically reduce risks and threats in space. Hence, states must view SSA data-sharing as complementary to other risk reduction measures, such as an ASAT test ban or mutual proximity notifications agreement.

Verifiability

The verification of SSA data does not work in the same way as used to assess other approaches. Since SSA is itself a tool for verification, the authentication and cross-verification of shared data take prominence. Since the accuracy and authenticity of data is a key pillar of an SSA data-sharing agreement, verifying the accuracy of shared data is all the more important for parties to maintain trust within the agreement.[120] The comparison of data points from various sensors functions as one method of verifying the accuracy and authenticity of shared data

Degree of Acceptability

An SSA data-sharing agreement could garner a medium to a high degree of acceptance if states find an arrangement that is non-discriminatory and equally beneficial to all actors in space.

SSA-data sharing as a stand-alone agreement might attract a high degree of acceptability if all space-faring and SSA-capable states choose to be party to the data-sharing agreement and distribute and disseminate the agreed data to all member-states. However, acceptability could fall in two ways: one, it fails to bring together all space-faring nations; two, SSA data-sharing is bundled as part of a controversial risk reduction measure.

Approach 4: Non-legally-binding destructive ASAT test moratorium

The norm-based ASAT test moratorium aims to take forward the ongoing efforts to promote norms, principles and rules of responsible behaviour. The US-led destructive ASAT test moratorium, for example, could be widely adopted to strengthen the norm of non-destructive testing in outer space.

Scope and Benefits

As discussed in the second section, the scope of a non-legally-binding destructive ASAT test moratorium is extremely narrow. States declare their unilateral commitments not to conduct destructive debris-creating ASAT tests. Under this approach, states maintain a high degree of freedom to conduct non-destructive ASAT and BMD tests.

Non-legally-binding commitments also allow states to conduct intrusive and non-cooperative RPOs in some form or another without facing international backlash. It also benefits states by giving them limited plausible deniability.

Limitations and Risks

Even if a majority of states accept non-legally-binding measures, such as a moratorium on ASAT testing, states who wish to test ASATs will break in norms in any case. Therefore, the effectiveness of the non-legally-binding approach is limited.

Also, non-legally-binding instruments could become impediments to negotiating legally-binding instruments. Since non-legally-binding measures offer states a high degree of freedom to operate in space, those states with high stakes in maintaining counterspace capabilities could refuse to participate in negotiations that hinder their freedom to develop or deploy counterspace capabilities.

Verifiability

Non-legally-binding instruments do not require verification measures. However, states can unilaterally monitor and verify activities in outer space. The data gathered from unilateral capabilities can also be made available to the public to induce responsible behaviour.

Degree of Acceptability

A non-legally-binding measure such as the destructive DA-ASAT test moratorium could garner a high degree of acceptance. The UN resolution on destructive DA-ASAT testing, for example, gained 155 votes of member states in favour.

More importantly, non-legally-binding measures do not require states to make explicit public commitments. A state could adhere to normative commitments without ever making public statements. Indeed, although China did not lend its support for the US-led moratorium, it has not conducted a destructive ASAT test since 2007 and may not conduct a similar destructive test in the near future.

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References

1. Recent examples of space doctrines and strategies of states and alliances include Space Capstone Publication: Spacepower. Doctrine for Space Forces, U.S. Space Force, June 2020, https://www.spaceforce.mil/Portals/1/Space%20Capstone%20Publication_10%20Aug%202020.pdf; UK Ministry of Defence, "Defence Space Strategy: Operationalising the Space Domain," February 2020, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1051456/20220120-UK_Defence_Space_Strategy_Feb_22.pdf; The French Ministry of Armed Forces, "Space Defence Strategy: Report of the "Space" working group, 2019, https://www.gouvernement.fr/sites/default/files/locale/piece-jointe/2020/08/france_-_space_defence_strategy_2019.pdf; and "NATO's overarching Space Policy," 17 January, 2021, https://www.nato.int/cps/en/natohq/official_texts_190862.htm.

2. Dmitry V. Stefanovich and Daniel Porras, "Space as a Competition Domain: Threats and Opportunities," *Journal of International Analytics*, Vol. 13, No. 2 (2022), pp. 95-194. DOI: 10.46272/2587-8476-2022-13-2-95-106.

3. Brian Weeden and Victoria Samson, "Global Counterspace Capabilities," (Washington, DC: Secure World Foundation, April 2022).

4. Stephen Young, "The Meteoric Rise in Satellite Numbers," *Union of Concerned Scientists*, March 17, 2022, https://blog.ucsusa.org/syoung/the-meteoric-rise-in-satellite-numbers/. Accessed: December 18, 2022.

5. For a discussion on lawful targeting of satellites, see Tara Brown, "Can Starlink satellites be lawfully targeted?" *Articles of War*, August 5, 2022, https://lieber.westpoint.edu/can-starlink-satellites-be-lawfully-targeted/ and; Matthew Fitzgerald and Cort Thompson, "What Does Starlink's Participation in Ukrainian Defense Reveal About U.S. Space Policy?" *Lawfare*, April 26, 2022. Accessed: January 4, 2023.

6. Beyza Unal, "Collision risks in outer space due to mega-constellations," *ORF Space Tracker*, October 18, 2021, https://www.orfonline.org/expert-speak/collision-risks-in-outer-space-due-to-mega-constellations/ and; Mike Wall, "Kessler Syndrome and the space debris problem," *Space.com*, July 15, 2022, https://www.space.com/kessler-syndrome-space-debris#:~:text=The%20Kessler%20Syndrome%20is%20a,satellites%2C%20astronauts%20and%20mission%20planners.. Accessed: January 4, 2023.

7. International Committee of the Red Cross, "The Potential Human Cost of the Use of Weapons in Outer Space and the Protection Afforded by International Humanitarian Law," April 9, 2021, https://www.icrc.org/en/document/potential-human-cost-outer-space-weaponization-ihl-protection. Accessed: January 4, 2023.

8. James M. Acton, "Escalation through Entanglement: How the Vulnerability of Command-and-Control Systems Raises the Risks of an Inadvertent Nuclear War," *International Security*, Vol. 43, No. 1 (Summer 2018), pp. 85-87.

9. For a brief history of arms control efforts at the UN and the CD, see Jessica West and Lauren Vyse, "Arms control in outer space: Status, timeline, and analysis," Project Plowshares, March 14, 2022, pp. 6-14.

10. United Nations General Assembly Resolution 75/36, "Prevention of an arms race in outer space," 16 December 2020, https://documents-dds-ny.un.org/doc/UNDOC/GEN/N20/354/39/PDF/N2035439.pdf?OpenElement. Accessed: December 24, 2022.

11. For an overview of various facets of agreement and contention within the OEWG, see Pranav R Satyanath, "Discussing Orbital Dangers: How States Negotiated in the UN's OEWG on Space Threats," Takshashila Discussion Document 2022-05, July 6, 2022.

12. United Nations General Assembly Resolution A/C.1/77/L.62, "Destructive direct-ascent anti-satellite missile testing," October 13, 2022, https://documents-dds-ny.un.org/doc/UNDOC/LTD/N22/630/36/pdf/N2263036.pdf?OpenElement. Accessed: January 20, 2022.

13. The White House, "Remarks by Vice President Harris on the Ongoing Work to Establish Norms in Space," April 18, 2022, https://www.whitehouse.gov/briefing-room/speeches-remarks/2022/04/18/remarks-by-vice-president-harris-on-the-ongoing-work-to-establish-norms-in-space/. Accessed: December 12, 2022.

14. U.S. Statement to the Open Ended Working Group on Reducing Space Threats through Norms, Rules and Principles of Responsible Behavior, May 9, 2022, https://documents.unoda.org/wp-content/uploads/2022/05/US-Space-OEWG-National-Statement-As-Delivered.pdf.

15. Shannon Bugos, "Russian ASAT Test Creates Massive Debris," *Arms Control Today*, December 2021, https://www.armscontrol.org/act/2021-12/news/russian-asat-test-creates-massive-debris. Accessed: December 18, 2022.

16. Chelsea Gohd, "Russian anti-satellite missile test was the first of its kind," *Space.com*, August 10, 2022, https://www.space.com/russia-anti-satellite-missile-test-first-of-its-kind. Accessed: December 18, 2022.

17. Idrees Ali and Steve Gorman, "Russian anti-satellite missile test endangers space station crew - NASA," *Reuters*, November 16, 2021, https://www.reuters.com/world/us-military-reports-debris-generating-event-outer-space-2021-11-15/. Accessed: December 25, 2022 and; Andrew Jones, "Chinese satellite in near miss with Russian ASAT test debris," *Space News*, January 20, 2022, https://spacenews.com/chinese-satellite-in-near-miss-with-russian-asat-test-debris/. Accessed: December 24, 2022.

18. David Wright, Laura Grego, and Lisbeth Gronlund, *The Physics of Space Security: A Reference Manual* (Cambridge, MA: American Academy of Arts and Sciences, 2005), pp. 137-138.

19. Although there are no records of such capabilities being deployed or tested, their use have nonetheless been contemplated within the defence community. See, Tom Karako and Masao Dahlgren, "Complex Air Defense: Countering the Hypersonic Missile Threat," Center for Strategic and International Studies, February, 2022, pp. 39-40.

20. The phrase 'test ban' connotes a binding-nature of the proposal. Although not all proposals call for a legally-binding test ban, this document will use 'ban' in the place of 'moratorium' for convenience.

21. See, for example, David A. Koplow, "ASAT-isfaction: Customary International Law and the Regulation of Anti-Satellite Weapons," *Michigan Journal of International Law*, Vol. 30 (2009), pp. 1215-1222; Ross Liemer and Christopher F. Chyba, "A Verifiable Limited Test Ban for Anti-satellite Weapons," *The Washington Quarterly*, Vol. 33, No. 3 (2010), pp. 149-163. DOI: 10.1080/0163660X.2010.492346; Theresa Hitchens and Joan Johnson-Freese, "Toward a New National Security Space Strategy: Time for a Strategic Rebalancing," Atlantic Council Strategy Paper Np. 5, June 2016, pp. 30-31; David A. Koplow, "The Fault Is Not in Our Stars: Avoiding an Arms Race in Outer Space," *Harvard International Law Review,* Vol. 59, No. 2 (Summer 2018), pp. 163-172; Nivedita Raju, "A Proposal for a Ban on Destructive Anti-Satellite Testing: A Role for the European Union?" SIPRI Non-Proliferation and Disarmament Papers Vol. 74, April 2021; Thomas Cheney, "Time for an ASAT Test Ban Treaty," in *Arms Control Idol: Ideas for the Future of Strategic Cooperation and Community*, Centre for Science and Security Studies, 2021, pp. 11-13; Nitin Pai, "Time for a global ban on satellite destruction tests," *Mint*, November 22, 2021, https://www.livemint.com/opinion/columns/we-should-support-a-global-ban-on-destructive-anti-satellite-tests-11637512047924.html. Accessed: December 18, 2022; and Naomi Egel and R. Lincoln Hines, "Governing the Final Frontier: Risk Reduction in Outer Space," *The Washington Quarterly*, Vol. 45, No. 4 (2022), pp. 27-44. DOI: 10.1080/0163660X.2022.2149168.

22. John F. Burns, "Andropov Issues Promise On Antisatellite Weapons," *New York Times*, August 19, 1983.

23. Daniel Porras, "Towards ASAT Test Guidelines," United Nations Institute of Disarmament Research (UNIDIR), Space Dossier File 2, 2018.

24. For examples of simulated DA-ASAT tests, see Secure World Foundation, "History of ASAT Tests in Space," https://docs.google.com/spreadsheets/d/1e5GtZEzdo6xk41i2_ei3c8jRZDjvP4Xwz3BVsUHwi48/edit#gid=1623728214. Accessed: January 4, 2023.

25. United Nations Institute for Disarmament Research, "Outer Space and Global Security, 2003, pp. 8-9 and; Lemur and Chyba, "A Verifiable Limited Test Ban for Anti-satellite Weapons," pp. 154-157.

26. See for example, Raju, "A Proposal for a Ban on Destructive Anti-Satellite Testing," p. 12; Brian Weeden and Victoria Samson, "It's Time for a Global Ban on Destructive Antisatellite Testing," *Scientific American*, January 14, 2022, https://www.scientificamerican.com/article/its-time-for-a-global-ban-on-destructive-antisatellite-testing/. Accessed: January 2, 2023; and Egel and Hines, "Governing the Final Frontier," p. 37.

27. Jeffrey Lewis, ""Hit-to-kill and the threat to space assets," in United Nations Institute of Disarmament Research (UNIDIR), "Celebrating the Space Age: 50 Years of Space Technology, 40 Years of the Outer Space Treaty," Conference Report, 2-3 April 2007, pp. 147-154.

28. During the Cold War, DA-ASAT capabilities were limited by the Anti-Ballistic Missile (ABM) Treaty, which imposed severe restrictions on the deployment of anti-ballistic missiles and their accompanying radars. See Ashton B. Carter, "The Relationship of ASAT and BMD Systems," *Dædalus*, Vol. 114, No. 2 (Spring, 1985), pp. 171-189.

29. National Academy of Sciences, *Making Sense of Ballistic Missile Defense,* (Washington, DC: The National Academies Press, 2012), p.4. Also see David Wright and Laura Grego, "Anti-Satellite Capabilities of Planned US Missile Defence Systems," *Disarmament Diplomacy*, No. 68 (2002-2003), http://www.acronym.org.uk/old/archive/dd/dd68/68op02.htm. Accessed: December 14, 2022.

30. Jaganath Sankaran, "Requirements and Feasibility for the Transition from a Ballistic Missile Capability to an Anti-Satellite (ASAT) Capability," Center for International and Security Studies at Maryland, Working paper, December 2007, https://cissm.umd.edu/sites/default/files/2019-07/sankaran_asat.pdf.

31. Bart Hendrickx, "Naryav-V and the Soviet Anti-Satellite Fleet," *Space Chronicles*, Vol 69 (2016), pp. 1-22.

32. Almudena Azcárate Ortega and Dmitry Stefanovich, "Space launch vehicles and ballistic missiles," in Pavel Podvig (ed.) *Exploring Options for Missile Verification*, (Geneva: United Nations Institute of Disarmament Research, 2022), pp. 43-52.

33. For an overview of counterspace capabilities, see Todd Harrison, Kaitlyn Johnson and Makena Young, "Space Threat Assessment 2022," (Washington, DC: Center for Strategic and International Studies, April 2022), pp. 6-7.

34. UN General Assembly resolution 75/36, "Prevention of an arms race in outer space," December 16, 2020, https://digitallibrary.un.org/record/3895440?ln=en. Accessed: December 26, 2022.

35. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 610 UNTS 205 (entered into force, October 10, 1967) [henceforth OST]

36. Ibid, article IV.

37. For a discussion on the coverage of conventional weapons in the OST, see, Michel Bourbonnière and Ricky J. Lee, "Legality of the Deployment of Conventional Weapons in Earth Orbit: Balancing Space Law and the Law of Armed Conflict," *The European Journal of International Law*, Vol. 18 No. 5 (2007), pp. 873-901. DOI: 10.1093/ejil/chm051.

38. Michael Listner, "FOBS, MOBS, and the reality of the Article IV nuclear weapons prohibition," *The Space Review*, October 17, 2022, https://www.thespacereview.com/article/4466/1. Accessed: December 12, 2022.

39. OST, article IX.

40. Pavel Podvig, "Did Star Wars Help End the Cold War? Soviet Response to the SDI Program," *Science & Global Security*, Vol. 25, No. 1 (2017), pp-3-27. DOI: 10.1080/08929882.2017.1273665.

41. "Letter dated 30 January 1985 from the representatives of Argentina, Greece, India, Mexico, Sweden and the United Republic of Tanzania to the United Nations addressed to the Secretary-General," UN General Assembly A/40/114, February 1, 1985.

42. For an overview of India's opposition to BMDs and the Strategic Defense Initiative (SDI), see Ashely J. Tellis, "The Evolution of U.S.-Indian Ties: Missile Defense in an Emerging Strategic Relationship," *International Security*, Vol. 30, No. 4 (Spring 2006), pp. 117-120.

43. United Nations Institute of Disarmament Research, *Disarmament: Problems related to Outer Space*, (New York, NY: United Nations, 1987), p, 99.

44. Statement submitted by India to the Conference on Disarmament," *Conference on Disarmament*, February 14, 1989.

45. "Letter dated 88/02/15 addressed to the President of the Conference on Disarmament by the Permanent Representatives of Argentina, India, Mexico and Sweden transmitting a document entitled the "Stockholm Declaration" adopted in Stockholm on 21 January 1988 by the 5 Heads of State or Government of Argentina, Greece, India, Mexico and Sweden and the 1st President of Tanzania," *Conference on Disarmament*, February 19, 1988.

46. United News of India (UNI), "India to design ABM on the lines of Star Wars: Kalam," *Rediff.com*, January 4, 2000, https://www.rediff.com/news/2000/jan/04abm.htm; and Ajai Shukla, "An untold story: How India got its missile defence," *Business Standard*, June 14, 2013, https://www.business-standard.com/article/economy-policy/an-untold-story-how-india-got-its-missile-defence-108013001071_1.html. Accessed: December 16, 2022.

47. Snehesh Alex Philip, "India's ballistic missile shield ready, IAF & DRDO to seek govt nod to protect Delhi," *The Print*, January 8, 2020, https://theprint.in/defence/indias-ballistic-missile-shield-ready-iaf-drdo-to-seek-govt-nod-to-protect-delhi/345853/. Accessed: December 14, 2022.

48. Rajeswari Pillai Rajagopalan, "India's Changing Policy on Space Militarization: The Impact of China's ASAT Test," *India Review*, Vol. 10, Issue 4 (2011), pp. 354-378. DOI: 10.1080/14736489.2011.624018.

49. Ministry of Foreign Affairs of the People's Republic of China, "China and Russia jointly submitted the draft Treaty on PPWT to the Conference on Disarmament," February 18, 2008, https://www.fmprc.gov.cn/mfa_eng/wjb_663304/zzjg_663340/jks_665232/jkxw_665234/200802/t20080212_599177.html#:~:text=On%2012%20February%202008%2C%20China,PPWT)%20in%20its%20Plenary%20Session. Accessed: December 14, 2022.

50. PPWT, article II.

51. PPWT, article Ib. For a critique of the PPWT, see Fabio Tronchetti and Liu Hao, "The 2014 updated Draft PPWT: Hitting the spot or missing the mark?" *Space Policy*, Vol. 33, Part 1 (August 2015), pp. 38-49. DOI: 10.1016/j.spacepol.2015.05.004.

52. "Statement by Hamid Ali Rao, Ambassador and Permanent Representative to the Conference on Disarmament," Geneva, February 28, 2008, p. 4.

53. "Statement by Hamid Ali Rao, Ambassador and Permanent Representative to the Conference on Disarmament," Geneva, August 17, 2010, p. 3.

54. The EU's ICoC began as a bottom-up approach to by non-governmental organisation effort to revitalise outer space risk reduction. Henry L. Stimson Center, "Model Code of Conduct," September 16, 2010, https://www.stimson.org/2010/model-code-of-conduct/. Accessed: December 25, 2022.

55. Michael Krepon, "Space Code of Conduct: Inadequate Mechanism—A Response," in Ajey Lele (ed), *Decoding the International Code of Conduct for Outer Space Activities* (New Delhi: Institute of Defence Studies and Analysis, 2012), pp. 9-12.

56. Rajeswari Pillai Rajagopalan, "The Space Code of Conduct Debate: A View from Delhi," *Strategic Studies Quarterly*, Vol. 6, No. 1 (Spring 2012), pp. 143-145.

57. See "Statement by Ambassador Sujata Mehta Permanent Representative of India to the Conference on Disarmament," June 5, 2012, and; "Statement by Mr. Vipul, Counsellor (Disarmament), PMI to CD, on PAROS in the CD Plenary," Geneva, February 8, 2013.

58. Michael Krepon, "Space Code of Conduct Mugged in New York," Arms Control Wonk, August 4, 2014, https://www.armscontrolwonk.com/archive/404712/space-code-of-conduct-mugged-in-new-york/. Accessed: December 27, 2022.

59. BRICS Joint Statement Regarding the Principles of Elaboration of International Instruments on Outer Space Activities, https://russiaeu.ru/en/news/brics-joint-statement-regarding-principles-elaboration-international-instruments-outer-spac%D0%B5-ac. Accessed: December 26, 2022.

60. United Nations, "Approving 21 Drafts, First Committee Asks General Assembly to Halt Destructive Direct-Ascent Anti-Satellite Missile Tests in Outer Space," November 1, 2022, https://press.un.org/en/2022/gadis3703.doc.htm. Accessed: January 4, 2023.

61. "Statement by Ambassador Anupam Ray at the Open Ended Working Group on Reducing Space Threats," Geneva, September 13, 2022.

62. Thomas C. Schelling and Morton H. Halperin, *Strategy and Arms Control* (New York, NY: The Twentieth Century Fund, 1961), pp. 9-24.

63. See John D. Maurer, *Competitive Arms Control: Nixon, Kissinger, and SALT, 1969-1972* (New Haven, CT: Yale University Press, 2022); and James Cameron, "Soviet-American Strategic Arms Limitation and the Limits of Co-operative Competition," *Diplomacy & Statecraft*, Vol. 33, Issue 1 (2022), pp. 111-132. DOI: 10.1080/09592296.2022.2041812.

64. Amy Nelson, "Arms Control as Uncertainty Management," CISSM Working Paper, April 2018, https://cissm.umd.edu/sites/default/files/2019-07/ArmsControlAsUncertainty_042318.pdf.

65. For a discussion on arms control challenges in outer space, see Jessica West and Gilles Doucet, "A Security Regime for Outer Space: Lessons from Arms Control," Project Plowshares Special Report, October 2022, pp. 14-21.

66. Jinyuan Su, "The environmental dimension of space arms control," *Space Policy*, Vol 29, Issue 1 (February 2013), pp. 58-66. DOI: 10.1016/j.spacepol.2012.11.005.

67. Ram S. Jakhu and Steven Freeland (eds.), *The McGill Manual on International Law Applicable to Military Uses of Outer Space: Volume I - Rules*, (Montreal: Centre for Research in Air and Space Law, 2022); Cassandra Steer and Dale Stephens. "International Humanitarian Law and Its Application in Outer Space," in Cassandra Steer and Matthew Hersch (eds.), *War and Peace in Outer Space: Law, Policy, and Ethics* (New York, NY: Oxford University Press, 2021), pp. 23-53; and David A. Koplow, "Reverse Distinction: A U.S. Violation of the Law of Armed Conflict in Space," *Harvard National Security Journal*, Vol. 13, No. 25 (2022), pp. 25-120.

68. U.R. Rao, *India's Rise as a Space Power* (New Delhi: Cambridge University Press, 2013).

69. Rajeswari Pillai Rajagopalan, "India's emerging space assets and nuclear-weapons capabilities," *The Nonproliferation Review*, Vol. 26, Issue 506 (2019), pp. 474-479. DOI: 10.1080/10736700.2019.1717144.

70. Indian Space Association and Ernst & Young, "Developing the space ecosystem in India: focusing on inclusive growth," October 2022, https://www.communicationstoday.co.in/developing-the-space-ecosystem-in-india-focusing-on-inclusive-growth-ey-report/. Accessed: December 24, 2022.

71. Indian Space Research Organisation (ISRO), "ISRO SSA Control Centre Inaugurated by Dr. K. Sivan, Chairman, ISRO/ Secretary, DOS," December 2020, https://www.isro.gov.in/ISRO%20SSAControl%20Centre.html. Accessed: December 21, 2022.

72. Indian Space Research Organisation (ISRO), "Space Situational Assessment 2021," June, 2022, https://www.isro.gov.in/ISRO%20SSAControl%20Centre.html. Accessed: December 21, 2022.

73. United States Department of State, "Fourth Annual U.S.-India 2+2 Ministerial Dialogue," April 11, 2022, https://www.state.gov/fourth-annual-u-s-india-22-ministerial-dialogue/. Accessed: December 16, 2022.

74. John D. Maurer, "The Purposes of Arms Control," *Texas National Security Review*, Vol. 2, Issue 1 (November 2018), pp. 8-27. DOI: 10.26153/tsw/870.

75. Kevin Chilton, "The anti-satellite test ban must not undermine deterrence," *Defense News*, April 29, 2022, https://www.defensenews.com/opinion/commentary/2022/04/29/the-anti-satellite-test-ban-must-not-undermine-deterrence/. Accessed: December 26, 2022.

76. Steve Lambakis, "The U.S. ASAT Test Ban: Implications for Security," National Institute of Public Policy Information Series No. 529, July 18, 2022, https://nipp.org/wp-content/uploads/2022/07/IS-529.pdf. Accessed: December 26, 2022.

77. For an overview of definitions for arms control agreements in space, see Bhupendra Jasani (ed.), *Peaceful and Non-Peaceful Uses of Space: Problems of Definition for the Prevention of an Arms Race* (Geneva: United Nations Institute of Disarmament Research, 1991).

78. Sarah E. Kreps, "The Institutional Design of Arms Control Agreements," *Foreign Policy Analysis*, Vol. 14, Issue 1 (January 2018), pp. 127-147. DOI: 10.1093/fpa/orw045.

79. Jyotika Saksena, "Regime Design Matters: The CTBT and India's Nuclear Dilemma," *Comparative Strategy,* Vol. 25, Issue 3 (2006), pp. 209-229. DOI: 10.1080/01495930600956237.

80. Allan S. Krass, *Verification: How Much Is Enough?* (Stockholm: Stockholm International Peace Research Institute, 1995), pp. 8-9 and; Office for Disarmament Affairs, *Verification in all its aspects, including the role of the United Nations in the field of verification* (New York, NY: United Nations, 2008), p. 11. \

81. Nancy W. Gallagher, "The Politics of Verification: Why 'How Much?' is Not Enough," *Contemporary Security Policy*, Vol. 18, Issue 2 (1997), pp. 138-170. DOI: 10.1080/13523269708404165.

82. Jane Vaynman, "Better Monitoring and Better Spying: The Implications of Emerging Technology for Arms Control," *Texas National Security Review*, Vol. 4, Issue 4 (Fall 2021), pp. 33-56. DOI: 10.26153/tsw/17498.

83. Kenneth W. Abbott, "Trust But Verify: The Production of Information in Arms Control Treaties and Other International Agreements," *Cornell International Law Journal*, Vol. 26, No. 1 (Winter 1993), pp. 1-58.

84. For an overview of the shortcomings of the norms-based approach, see, Jessica West and Almudena Azcárate Ortega, "Norms for Outer Space: A Small Step or a Giant Leap for Policymaking?" United Nations Institute of Disarmament Research (UNIDIR), Space Dossier 7, 2022. DOI: 10.37559/WMD/22/Space/01.

85. For a discussion on the ICoC's acceptability challenge, see Jack M. Beard, "Soft Law's Failure on the Horizon: The International Code of Conduct for Outer Space Activities," *University of Pennsylvania Journal of International Law*, Vol. 38, No. 2 (2017), pp. 381-410.

86. For an overview of ballistic missile defence systems, see Arms Control Association, "Missile Defense Systems at a Glance," Fact Sheet, Last Reviewed August 2019, https://www.armscontrol.org/factsheets/missiledefenseataglance. Accessed: January 8, 2023.

87. See, for example, Laura Grego and David Wright, "Incremental Progress but No Realistic Capability Analysis of the Ground-based Midcourse Missile Defense Test FTG-15 (May 30, 2017)," Union of Concerned Scientists, January 2018.

88. Report by the American Physics Society on Public Affairs, "Ballistic Missile Defense: Threats and Challenges," (Washington, DC: American Physics Society, January 2018), pp. 23-25.

89. During the Cold War, critics of arms control argued that arms control could provide a false sense of security and thus result in a relaxed defence posture. For an assessment of lulling effects of arms control, see Sean M. Lynn-Jones, "Lulling and Stimulating Effects of Arms Control," in Albert Carnscale and Richard M. Haas, *Superpower Arms Control: Setting the Record Straight* (Cambridge, MA: Ballinger, 1987), pp. 223-273.

90. Ibid; On the stimulating effects of arms control and the quest for advantages, see Brendan Rittenhoue Green, *The Revolution that Failed: Nuclear Competition, Arms Control, and the Cold War* (Cambridge, UK: Cambridge University Press 2020), pp. 121-189.

91. See, for example, CSIS Missile Defense Project, "Space-based Infrared System (SBIRS)," June 26, 2021, https://missilethreat.csis.org/defsys/sbirs/; and Bart Hendrickx, "EKS: Russia's space-based missile early warning system," *The Space Review*, February 8, 2021, https://www.thespacereview.com/article/4121/1. Accessed: January 8, 2023.

92. Launch-detection data sharing agreement could also be bilateral in nature. See, for example, U.S. Department of State, "Memorandum of Understanding on Notifications of Missile Launches (PLNS MOU)," Signed December 16, 2000, https://2009-2017.state.gov/t/avc/trty/187152.htm. Accessed: January 6, 2023.

93. See, for example, Jürgen Altmann, "Acoustic-Seismic Detection of Ballistic-Missile Launches for Cooperative Early Warning of Nuclear Attack," *Science and Global Security*, Vol. 13, No. 3 (2005), pp. 129-

168; Sameh Aboul-Enein and Bharath Gopalaswamy, "The missile regime: Verification, test bans and free zones," *Disarmament Forum*, Vol. 4 (2005), pp. 43-52; and Masaru Ozeki and Kosuke Heki, "Ionospheric holes made by ballistic missiles from North Korea detected with a Japanese dense GPS array," *Journal of Geophysics Research*, Vol. 115, Issue A9 (2010), pp. 1-11. DOI: 10.1029/2010JA015531.

94. L.G. Evers, J.D. Assink, and P.S.M. Smets, "Infrasound from the 2009 and 2017 DPRK rocket launches," *Geophysics Journal International*, Vol. 213, Issue 3 (June, 2018), pp.1785-1791. DOI: 10.1093/gji/ggy092; and Christoph Pilger, Patrick Hupe, Peter Gaebler, and Lars Ceranna, "1001 Rocket Launches for Space Missions and Their Infrasonic Signature," *Geographic Research Letters*, Vol. 48, Issue 8 (2021), pp. 1-10. DOI: 10.1029/2020GL092262.

95. For an overview of SSA capabilities, see Bhavya Lal, Asha Balakrishnan, Becaja M. Caldwell, Reina S. Buenconsejo, and Sara A. Carioscia, "Global Trends in Space Situational Awareness (SSA) and Space Traffic Management (STM)," (Washington, DC: Institute for Defense Analysis, April, 2018).

96. For a discussion on various models of space verification, see Michael P. Gleason, "No Haven for Misbehavin': A Framework for Verifying Space Norms," Centre for Space Policy and Strategy, May, 2022, pp. 10-16.

97. During the 1980s, Canadian researchers proposed a space-to-space verification satellite called Paxsat 'A' for verifying space-based ASATs based on physical properties of a satellite. See, F.R. Cleminson, "Paxsat and progress in arms control: Canadian research focuses on remote sensing applications," *Space Policy*, Vol. 4, Issue 2 (May 1988), pp. 87-102.

98. Kaila Pfrang and Brian Weeden, "History of Rendezvous and Proximity Operations," May 14, 2022, https://docs.google.com/spreadsheets/d/1pHzvC-zGjF34Jrd6TdmM40dTL_MinBBoS_ld9X3jsW4/edit#gid=1782604784. Accessed: January 12, 2023.

99. John Tziouras, "On-Orbit Servicing: Security and Legal Aspects," in Annette Froehlich (ed.), *On-Orbit Servicing: Next Generation of Space Activities* (Cham: Springer, 2019), pp. 55-68.

100. For definitions of rendezvous, proximity and docking, see Rebecca Reesman and Andrew Rogers, "In Your Space: Rendezvous and Proximity Operations Lessons," Center for Space Policy and Strategy, May, 2018, p. 3.

101. Brian G. Chow, "Space Arms Control: A Hybrid Approach," *Strategic Studies Quarterly*, Vol. 12, No. 2 (Summer 2018), pp. 107-132; James M. Acton, Thomas D. MacDonald and Pranay Vaddi, *Reimagining Nuclear Arms Control: A Comprehensive Approach* (Washington, DC: Carnegie Endowment for International Peace, 2021), pp. 61-68; Matthew Stubbs, "The Legality of Keep- Out, Operational, and Safety Zones in Outer Space," in Cassandra Steer and Matthew Hersch (eds.), *War and Peace in Outer Space: Law, Policy, and Ethics* (New York, NY: Oxford University Press, 2021), pp. 201-228; and Lucas Mallowan, Lucien Rapp, and Maria Topka, "Reinventing treaty compliant ''safety zones'' in the context of space sustainability," *Journal of Space Safety Engineering*, Vol. 8, Issue 2 (June 2021), pp. 155-166. DOI: 10.1016/j.jsse.2021.05.001.

102. For a discussion of due regard in outer space, see Jinyuan Su, "The Legal Challenge of Arms Control in Space," in Cassandra Steer and Matthew Hersch (eds.), *War and Peace in Outer Space: War, Policy and Ethics* (New York: Oxford University Press, 2021), pp. 195-213.

103. Wright, Grego, and Gronlund, *The Physics of Space Security*, pp. 53-54.

104. See, for example, Marco Langbroek, "Kosmos 2558, a Russian inspector satellite targetting the US IMINT satellite USA 326?" *SatTrackCam Leiden blog*, August 2, 2022, https://sattrackcam.blogspot.com/2022/08/kosmos-2558-russian-inspector-satellite.html. Accessed: January 8, 2023.

105. Wright, Grego, and Gronlund, *The Physics of Space Security*, pp. 137-138.

106. The author would like to thank Brian Weeden for highlighting this point.

107. For a discussion on the need for SSA standards, see Daniel L. Oltrogge and Salvatore Alfano, "The technical challenges of better Space Situational Awareness and Space Traffic Management," *Journal of Space Safety Engineering*, Vol. 6, Issue 2 (June 2019), pp. 72-79. DOI: 10.1016/j.jsse.2019.05.004.

108. For definitions of space situational awareness and space traffic management, see Dan Oltrogge and James Cooper, "Space Situational Awareness and Space Traffic Management," in Matteo Madi and Olga Sokolova (eds.), *Space Debris Peril: Pathways to Opportunities* (Florida: CRC Press, 2021), pp. 12-17.

109. Committee on the Peaceful Uses of Outer Space, "Guidelines for the Long-term Sustainability of Outer Space Activities," A/AC.105/2018/CRP.20, 27 June, 2018, https://www.unoosa.org/res/oosadoc/data/documents/2018/aac_1052018crp/aac_1052018crp_20_0_html/AC105_2018_CRP20E.pdf, pp. 10-12.

110. Brian Weeden, Paul Cefoa, and Jaganath Sankaran, "Global Space Situational Awareness Sensors," (undated), https://cissm.umd.edu/sites/default/files/2019-07/amos_jaganath.pdf.

111. Harvey Reed, Ruth Stillwell, Nathaniel Dailey, Nick Tsamis, and Kevin Toner, "Sharing Operational Risk Information in the Space Domain to Facilitate Norms Development and Compliance Monitoring," *Paper presented at the 2022 Advanced Maui Optical and Space Surveillance Conference,* September, 2022, https://amostech.com/TechnicalPapers/2022/Poster/Reed_2.pdf.

112. Lal, Balakrishnan et, al., "Global Trends in Space Situational Awareness," pp. A-1-A-9.

113. Project Space Track of the US Air Force provides public access to SSA data. The data can also be accessed by non-governmental entities upon formal request. See https://www.space-track.org/. Accessed: January 12, 2023.

114. Jason Rainbow, "Getting SSA off the ground," *Space News*, June 17, 2022, https://spacenews.com/getting-ssa-off-the-ground/. Accessed: December 24, 2022.

115. Robert J. Rovetto & T. S. Kelso, "Preliminaries of a Space Situational Awareness Ontology," *Proceedings of AAS/AIAA Spaceflight Mechanics Meeting, in Advances in the Astronautical Sciences,* (February 2016), pp. 4177-4192.

116. See, for example, The NATO Science and Technology Organization, "Technical Considerations for Enabling a NATO-Centric Space Domain Common Operating Picture (COP)," TR-SCI-279, December, 2020.

117. See, for example, Stuart Eves, "Space Situational Awareness Warfare," Freeman Air and Space Institute Paper 6, 2019, https://www.kcl.ac.uk/warstudies/assets/ssa-warfare.pdf.

118. Michael Dominguez (Chair), *Space Traffic Management: Assessment of the Feasibility, Expected Effectiveness, and Funding Implications of a Transfer of Space Traffic Management Functions* (Washington, DC: National Academy of Public Administration, August 2020), pp. 66-68.

119. The scientific cooperation undertaken during the CTBT negotiations is one example of how scientific engagement can help resolve political roadblocks. See Ola Dahlman, Frode Ringdal, Jenifer Mackby and Svein Mykkeltveit, "The inside story of the Group of Scientific Experts and its key role in developing the CTBT verification regime" *The Nonproliferation Review*, Vol. 27, Issue 1-3 (2020), pp. 181-200. DOI: 10.1080/10736700.2020.1764717.

120. National Space Council Users' Advisory Group Technology and Innovation Subcommittee, "Recommendations on Trust and Interoperability in Space Situational Awareness Data," September 2, 2020,
https://www.nasa.gov/sites/default/files/atoms/files/white_paper_on_saa_data_findings_and_recommendations_rev2020-10-22b.pdf. Accessed: January 12, 2023.

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