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Space Arms Control: A Hybrid Approach

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Abstract

Space arms control proposals such as the Prevention of the Placement of Weapons in Outer Space (PPWT) have failed to become treaties in spite of countless efforts over the past 50 years. These proposals will not work in the emerging space proximity-operations era. This article proposes a hybrid approach to space arms control based on restricting the locations in space of some potential space weapons while banning other types of space weapons outright. The core of any hybrid space arms control (HSAC) treaty should prohibit satellites, whether for antisatellite (ASAT) or peaceful purposes, from positioning too close to more than an innocuous threshold number of another country's satellites and authorize preemptive self-defense as a last resort countermeasure. This article also proposes a comprehensive list of space arms control measures, which can be added to the core proposal to more effectively manage both traditional and emerging space weapons.

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In June 2018, the United Nations Office for Outer Space Affairs will celebrate the 50th anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space. The conference is an opportunity "for the international community to gather and consider the future course of global cooperation for the benefit of humankind."[1] Indeed, there is much to celebrate since the space age began because the world has reaped abundant benefits from satellites. We have established five treaties and a number of transparency and confidence-building measures for space activities.[2] But, in spite of countless efforts,

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these treaties and measures focus on civil and commercial activities and cannot control space weapons other than weapons of mass destruction in orbit. One of the greatest emerging threats in space comes from unmanned proximity operations. These operations require maneuvering a spacecraft close enough to another object in space to make physical contact with the other object or affect the object in some way.[3] To date, the intent of unmanned proximity operations has been for peaceful purposes such as active debris removal (ADR) or on-orbit servicing (OOS). However, a spacecraft that can perform ADR or OOS can also be readily commanded to grapple and destroy an adversary's satellite. Currently the United States, China, Russia, the European Union, and other countries are pursuing R&D programs for satellites to perform ADR and OOS. Each nation is planning to provide such services in early 2020 and beyond. To perform these peaceful services, a country needs to master the skill of unmanned proximity operations.

In a 2017 *Strategic Studies Quarterly* article, I argued that antisatellite weapons (ASAT), called space stalkers, could be placed on orbit in peacetime and maneuvered to tailgate US satellites during a crisis and attack from such close proximity that the United States would not have time to prevent damage.[4] I further argued that deterring and defending against space stalkers would require prohibiting satellites, whether for antisatellite or peaceful purposes, from being too close to more than an innocuous threshold number of another country's satellites. Today, more arms control measures should be implemented to further improve effectiveness and affordability in dealing not only with space stalkers, but other emerging space weapons as well. Without successful arms control, our continued "peaceful uses of outer space" will be in jeopardy. During 2018, the international community should take advantage of the seriousness and enthusiasm of the momentous 50th anniversary to establish an initiative for a new approach to space arms control. A hybrid space arms control (HSAC) treaty is needed because current proposals have not worked and will not work in the future. Moreover, implementing effective space arms control is urgent because by early 2020, ADR and OOS demonstrations will be completed, regular services will begin, and these spacecraft can be used as space stalkers.

This article first describes the emerging proximity operations era and the problems with traditional space arms control. Then, it presents the core of a hybrid space arms control treaty. Next it proposes additional

HSAC measures to complement the core proposal. Finally, the article arrays space weapons into six categories that could help manage space weapons, creating the ultimate hybrid space arms control. Taken together, the hybrid approach proposed here will help expand the peaceful benefits from space without the threat of space weapons in the emerging proximity-operations era.

The Emerging Proximity-Operations Era and Traditional Space Arms Control

Since 2007, the United Nations Committee on the Peaceful Uses of Outer Space has adopted a set of space debris mitigation guidelines.[5] These guidelines are important and necessary but not sufficient to deal with the growing space debris problem. Following the well-accepted Kessler Syndrome theory,[6] NASA scientist J.-C. Liou found that, if active debris removal starts in 2020 with an annual removal rate of 5 massive intact objects (such as decommissioned satellites and derelict rocket bodies), debris population in the low Earth orbits (LEO) would stabilize over the next 200 years.[7] Space scientist Nicholas Johnson concluded that "in the long term, the removal of large orbital debris will be essential to the sustainability of space operations."[8] Studies at the European Space Agency arrived at a rate "on the order of 5-10 objects" per year.[9] A report based on the Third International Interdisciplinary Space Debris Congress arrived at a rate of 9.1 objects per year.[10] Thus, all these major studies are consistent that roughly a high single-digit number of massive intact objects per year needs to be removed.

However, these studies did not consider the recent dramatic growth of 14,000 to 16,000 small satellites to be launched into LEOs over the next 10 years—in contrast to merely 1,071 LEO satellites of any size worldwide as of 31 August 2017.[11] Extrapolating from the estimate by scientist H. G. Lewis and his team that about one additional intact object needs to be removed per year for the additional 1,080 small LEO satellites they analyzed, I estimate that about 14 additional removals are required for the additional 14,000 to 16,000 small satellites.[12] Adding this to the earlier single-digit removal produces the need to remove about two dozen massive intact objects every year to keep space debris from increasing and to ensure the debris environment remains suitable for peaceful uses. However, uncertainties in prediction and provision of

a safety margin could increase debris removal demand, which in any case should be monitored and updated regularly.

In June 2016, Xinhua, the official press agency of China, reported that onboard the inaugural launch of a new generation carrier rocket Long March-7 was an "Aolong-1" spacecraft, which was a demonstrator of space debris cleaning.[13] It re-entered the atmosphere on 27 August 2016 after completing a short-duration demonstration mission.[14] Spaceflight 101.com reported "according to Chinese space officials, Aolong-1 is only the first in a series of satellites tasked with the collection of space debris as the country develops the technology needed to retrieve small debris up to [the size of an] entire spacecraft to be safely brought to a destructive re-entry."[15] The European Union also has a program to demonstrate the removal of space debris and aims to remove the defunct 8-ton remote-sensing satellite Envisat from LEO around 2023.[16] In essence these developments and others by major spacefaring nations mean that the space will be weaponized by early 2020, even if we do not count demonstrators as weapons.

In addition to debris removal, countries are pursuing on-orbit servicing. For example, the Defense Advanced Research Projects Agency (DARPA) Robotic Servicing of Geosynchronous Satellites R&D program aims to provide services including high-resolution inspection; correction of some types of mechanical anomalies, such as solar array and antenna deployment malfunctions; relocation and other orbital maneuvers; installation of attachable payloads to enable upgrades or new capabilities; and refueling to extend the service life of satellites.[17]

The United States and China will likely complete their developmental and demonstration OOS programs and provide services such as refueling also in the early 2020s. Once any country has such a spacecraft in orbit, there is no reason to deny other countries following suit for commercial and/or national security purposes. Since OOS spacecraft will have rendezvous and robotic capabilities even more advanced than those for ADR, they become even more threatening as space stalkers. In effect, weaponization of space will happen by default in the early 2020s and beyond and will be unavoidable and irreversible.

Traditional Space Arms Control Ineffective

In the emerging space proximity-operations era, space weapons will be technically synonymous with ADR and OOS. The difference is in

the intent of whether such spacecraft are used for peaceful or ASAT purposes. Our space defense and deterrence cannot count on adversaries to always have peaceful intent. Also, in the emerging era, traditional space arms control will not be able to prevent weapons in space. Article IV of the Outer Space Treaty states that "State 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."[18] While it is critical to ban weapons of mass destruction in space, subsequent treaties and transparency and confidence-building measures have done little to control or ban the placement of conventional weapons in space. Treaty proposals under consideration by the United Nations are mainly those proposed by Russia and China.

Russia and China have been taking the lead to ban weapons in space. Their latest version of the draft Prevention of the Placement of Weapons in Outer Space treaty (PPWT, hereafter the Prevention Treaty) was issued 12 June 2014.[19] On 3 September 2014, the US analysis submitted to the Conference on Disarmament stated, "The draft PPWT (CD/1985) proposed by Russia and China, like the 2008 version, remains fundamentally flawed." It concluded that "the United States has determined that the 2014 draft PPWT does not satisfy the President's criteria in the 2010 US National Space Policy for considering space arms control concepts and proposals, namely, that they must be equitable, effectively verifiable, and enhance the national security of the United States and its allies."[20] This conclusion is based on three major reasons.

First, the United States stated: "There is no integral verification regime to help monitor or verify the limitation on the placement of weapons in space. . . . Moreover, the United States has maintained that it is not possible with existing technologies or cooperative measures to effectively verify an agreement banning space-based weapons."[21] Russia and China responded that "PPWT is similar to the provision of the Outer Space Treaty of 1967. . . . The Outer Space Treaty does not provide for any mechanism for verifying the fulfilment of this obligation and during the half a century that it has been in force no questions about verification have been raised."[22] Basically, the United States insists on verification, but Russia and China argue that, if no country including the United States complains about the lack of verification for the Outer Space Treaty, the United States should not demand a verification regime for the Prevention Treaty. Russia and China actually do not object to

verification—if it is possible. As they stated: "However, we continue to believe that the development of a verification mechanism would be desirable for the subsequent full implementation of PPWT."[23]

Second, the United States stated: "Typically, arms control treaties that prohibit the deployment of a class of weapon also prohibit the possession, testing, production, and stockpiling of such weapons to prevent a country from rapidly breaking out of such treaties. The PPWT contains no such prohibitions and thus a Party could develop a readily deployable space-based weapons break-out capability."[24] Russia and China responded that:

> The Russian Federation and the People's Republic of China maintain that the prohibition against the possession, testing, production and stockpiling of space-based weapons does not contradict the purposes of PPWT. Furthermore, one of the principles that guided defining the scope of the treaty consisted in setting limitations that could be monitored. (Such monitoring capability is dealt with, for example, in document CD/1785 submitted by Canada in 2006.) Effective monitoring of 'research, development, production, and terrestrial storage of space-based weapons' — on which there is no prohibition, as is pointed out in the United States document — is not feasible in practical terms for objective reasons.[25]

Basically, Russia and China do not object to "prohibit the possession, testing, production and stockpiling of such weapons," as the United States insists. Rather they are being practical "in setting limitations that could be monitored." Thus, Russia and China should have no objection that the prohibition of tailgating another country's satellites can be observed and thereby, monitored.

Third, the United States claimed: "The Treaty does not address the most pressing, existing threat to outer space systems: terrestrially-based anti-satellite weapon systems. There is no prohibition on the research, development, testing, production, storage, or deployment of terrestrially-based anti-satellite weapons; thus, such capabilities could be used to substitute for, and perform the functions of, space-based weapons."[26] Russia and China responded that,

> While anti-satellite weapons as a class of weapons are not prohibited under the draft PPWT, the proliferation of such weapons is restricted through a comprehensive ban on the placement in outer space of weapons of any kind, including anti-satellite weapons. A ban on ground-based anti-satellite (ASAT) weapon systems has been introduced into PPWT through the ban on the use of force, regardless of its source, against space objects.[27]

Russia and China argue that ground-based ASATs are covered in the draft Prevention Treaty "through the ban on the use of force." They clarify their argument by stating that "Furthermore, we would like to emphasize that in acceding to PPWT . . . the placement of weapons of any kind in outer space and the use or threat of force are prohibited."[28] Russia and China have made three additional important observations in their response to the US analysis of the Prevention Treaty:

1. There is a need for "reaching a common understanding of the right to self-defense under the Charter as regards outer space in the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS)."
2. "Furthermore, it is worth noting that the Charter was drafted before the space age had begun and, consequently, in our view, the unqualified and direct application of the provisions of the Charter to such a sensitive area of international relations as outer space development requires further elaboration and clarification through negotiation between States."
3. There is "the need for clarification of the issue of the use of force in outer space on the grounds provided for under the Charter."[29]

"No First Placement" Initiative Led by Russia

On 7 December 2015, the United Nations General Assembly adopted Resolution 70/27 entitled "No first placement of weapons in outer space." It "Encourages all States, especially spacefaring nations, to consider the possibility of upholding as appropriate a political commitment not to be the first to place weapons in outer space."[30] Ambassador Robert Wood, US Permanent Representative to the Conference on Disarmament, explained that the resolution "does not adequately define space weapons, leaving the nonbinding resolution difficult to enforce, or for compliance with the agreed-upon measures to be verified."[31] Indeed, space weapons undefined or ambiguously defined has been an ongoing problem in both the no first placement initiative and the proposed Prevention Treaty. Since the same spacecraft designed for debris removal or servicing can readily serve as a space weapon at a moment's notice, no first placement of weapons in space would amount to no ADR and OOS, which is incompatible with reality. However, a hybrid space arms

control approach that allows ADR and OOS spacecraft but prohibits close proximity to another country's satellites offers a win-win solution. The common ground among the United States, Russia, and China can be used to form the basis for a hybrid approach.

The Core of Hybrid Space Arms Control

While the Outer Space Treaty of 1967 bans weapons of mass destruction in space, there has been little success in controlling conventional space weapons in spite of substantial efforts led by Russia and China over the last 50 years. The United States has yet to offer a viable alternative proposal and has been relegated to a naysayer with diminishing support from other countries, including its allies and friends. For example, on 30 October 2014, the United Nations Disarmament Committee approved the text of a draft resolution to the General Assembly to urge an early start to substantive work on the 2014 updated draft Prevention Treaty. The recorded vote was 126 in favor to 4 against (Israel, Ukraine, United States, Georgia). The European Union, Australia, Japan, South Korea, and others totaled 46 abstentions. The committee also approved the draft resolution on No First Placement Initiative with identical recorded votes. Further, the committee approved the draft resolution on the Prevention of An Arms Race in Outer Space by a recorded vote of 180 in favor to none against, with 2 abstentions (United States and Israel).[32] By proposing and actively pursuing practical space arms control, the United States can regain leadership and worldwide support to ensure beneficial space activities without the dangerous side effects of space weapons.

The current US national space strategy cannot deal with the space stalker threat.[33] However, a new space arms control proposal can deter and defend against space stalkers, while the United States and other countries continue to use their existing and developing strategies and assets to deal with traditional threats such as ground-launched ASATs as well as other new threats such as cyberattack.

This new space arms control differs from traditional approaches such as those proposed by Russia and China, in four important ways:

1. Some space weapons cannot be banned.
2. Non-bannable space weapons can still be controlled.
3. Treaty verification is required.

4. Self-defense should be allowed after treaty violation before or after actual attack.

Non-Bannable Space Weapons in the Emerging Era

The proposed Prevention Treaty defines weapon in outer space as "any outer space object or component thereof which has been produced or converted to destroy, damage or disrupt normal functioning of objects in outer space, on the Earth's surface or in its atmosphere."[34] According to the Prevention Treaty, space stalkers would be prevented from being placed in space. Unfortunately, once ADR or OOS spacecraft are deployed in space, the same spacecraft can be simply retasked, maneuver near any other country's satellites for space stalking, and attack upon command. Therefore, abiding by the Prevention Treaty would imply banning the placement of ADR and OOS satellites.

There are three reasons the United States should not attempt to ban debris removal and servicing spacecraft to deal with space stalking threat. First, ADR spacecraft are necessary in the emerging era to prevent the space debris population from increasing and hindering the peaceful uses of space. Also, as space technologies continue to become more capable and less expensive, it is highly advantageous to have some satellite services performed in space. Second, as noted earlier, China will likely deploy both ADR and OOS spacecraft in the early 2020s and Russia is likely to follow suit in the 2020s. Even if the United States wanted to delay ADR and OOS deployment for the benefit of preventing space stalker threat, it could not dissuade China and Russia from such a deployment. Third, and most importantly, there is a way to both deter and defend against space stalkers and still be able to benefit from the presence of ADR and OOS spacecraft.

Controlling Non-Bannable Space Weapons

Space weapons being non-bannable does not mean they are noncontrollable. Space stalkers can be controlled by prohibiting them from being simultaneously placed too close to and threatening another country's satellites. For example, if the United States wants to deter and defend against simultaneous space-stalking attacks against geosynchronous Earth orbit (GEO) satellites, it could declare that any country positioning its space objects of any kind (i.e. whether space stalker or ordinary

satellite, as one cannot reliably distinguish them once they are in space) within 0.2 degree in longitude (148 km in minimum separation) or inclination of more than a threshold number of another country's satellites as an aggressor. The minimum degree separation requirement should be determined and approved by the DOD before State Department negotiations with the international community. The defender would also have the right to exercise self-defense as the last resort even before an actual attack. Additionally, countries should coordinate and limit the number of ADR and OOS spacecraft in space, as a larger number would increase the possible space stalker threat. It is feasible to arrive at both useful and practical limits. For example, both the United States and China need not reposition any of their operational satellites to observe the above suggested rule of 0.2 degree minimum satellite separation between any pair of US-China GEO satellites.[35]

In sum, China, Russia, and the United States likely agree that ADR and OOS will be needed for essential space missions in the 2020s and beyond. China and Russia will recognize that "a ban on the placement of weapons of any kind in outer space" is no longer possible since ADR and OOS spacecraft can be retasked as weapons.[36] Placing satellites—whether weapons or nonweapons——in space but restricting their locations may well be the only viable alternative to control them. This core or foundational proposal can keep the peaceful and important services of ADR and OOS spacecraft while not allowing them to morph into a space stalker threat. As any country can be threatened by space stalkers, all countries will benefit from controlling them.

Treaty Verification Required

President Reagan's favorite adage, "Trust, but verify," applies to space treaties as well. The United States insists on verification, while Russia and China do not include it in the proposed Prevention Treaty because verification is not possible in their formulation. However, Russia and China "believe that the development of a verification mechanism would be desirable."[37] Since compliance and violation of a 'no simultaneous tailgating' provision can be detected and monitored, the United States, China, and Russia as well as other countries can find verification of this foundational proposal desirable and agreeable. The hybrid approach can resolve the verification issue by allowing certain weapons to be space based but prohibiting their being too closely placed (e.g. within 0.2

degree in longitude or inclination) to another country's satellites. By banning space weapons being too close instead of outright, the United States should find that it is "possible with existing technologies and/or cooperative measures," such as space surveillance systems and requiring ADR/OOS spacecraft to broadcast their positions 24/7, "to effectively verify an agreement banning space-based weapons" being too close to US satellites.[38] Thus, the US condition for verification is satisfied.

At the same time, the United States should understand that "the possession, testing, production, and stockpiling" of some weapons, such as space stalkers, does not lead to "rapidly breaking out of" the hybrid treaty since it is not broken (rather alerted) by the rapidly increased number of space stalkers present in space, but by space stalkers being too close to US satellites. Finally, compared to the current state of no space arms control, a hybrid approach that restricts placement locations would be far better.

Right of Self-Defense

The international community is ambiguous whether a country is allowed to tailgate any number of another country's satellites. Also, the current US national security space strategy is ambiguous about preemptive self-defense, including when it faces a threat from space stalkers.[39] Under these two dangerous ambiguities, China could reason that space stalkers would be the best type of ASATs to present the United States with two bad choices. First, the United States could preemptively destroy the space stalkers to save the targeted satellites so as to maintain space support to military operations during crisis and war. However, without discussing and resolving these two ambiguities with the international community in peacetime, the United States could be condemned as the aggressor who fired the first shot, which led to a war in space possibly spreading to Earth—something both sides tried to avoid. Second, the United States could fight ineffectively without the support of some critical satellites. Facing these two bad choices, the United States might end up not intervening at all. This would be the perfect outcome for China, as it prevented US intervention without firing a single shot.

To attain space security in the emerging era, the world needs to remove these two ambiguities now. First, countries should agree and declare, in peacetime, that the country that positions real or plausible space stalkers to simultaneously threaten another country's satellites is

considered the aggressor. Second, the country whose satellites are under such a threat has the right of preemptive self-defense as a last resort to disable the threat.

So, what should be the common understanding of the right to self-defense under the charter as regards outer space? The self-defense doctrine for US policies in space and on Earth, as well as other nations' policies, has long been strongly influenced by Article 51 of the United Nations Charter: "Nothing in the present Charter shall impair the inherent right of individual or collective self-defence if armed attack occurs against a Member of the United Nations."[40] Georgetown University professor of government and foreign service Anthony Arend stated, "Although the basic contours of Article 51 seem straightforward, its effect on the customary right of anticipatory self-defense is unclear."[41] There are two interpretations: restrictive and broad of "armed attack occurs" in Article 51. Legal scholars, who are proponents of a restrictive interpretation, allow self-defense only after attack has started. Other legal scholars take a broad view that the charter does not "impair the inherent right" embedded in the customary international laws, which allow anticipatory or preemptive self-defense if certain conditions are met. Typical conditions were suggested as far back as 1842 by US Secretary of State Daniel Webster in the Caroline case. Subsequently, jurists like Roberto Ago in 1980 came to a similar set of conditions: "necessity," "proportionality," and "immediacy."[42] The 9/11 terrorist attacks in 2001 confirmed the need of preemptive self-defense in specific situations and led to the 2002 US National Security Strategy: "For centuries, international law recognized that nations need not suffer an attack before they can lawfully take action to defend themselves against forces that present an imminent danger of attack."[43] This premise should apply to preemptive self-defense against space stalkers as well because Ago's three conditions are met.[44] Thus, preemption against space stalkers would comply with the broad view of Article 51. However, for those insisting on its restrictive interpretation, the United States should respond that such an interpretation drafted in October 1945 understandably could not anticipate and counter the space stalker threat seven decades later. As quoted earlier, Russia and China observed that "the [United Nations] Charter was drafted before the space age" and that the "application of the provisions of the Charter" to "outer space development requires further elaboration and clarification."[45] Article 51 was designed against armed attack that takes time

to prepare and gives warning by the massing of soldiers and weapon systems for an attack. The defender would have alternative responses, including the referral of the threat to the United Nations for peaceful resolution. Articles VI and VII of the Prevention Treaty also recommend "assistance of the executive organization of the Treaty, submitting relevant evidence for further consideration of the dispute, which includes the claim that a violation of the Treaty is taking place.[46] However, in the case of space stalkers, there is no time for referral and no means other than preemption to neutralize the imminent threat.

In sum, the common understanding of the right to self-defense should include the preemption of space stalkers. Should Russia, China, and/or the United States reject such preemptive actions, they need to offer a viable alternative and explain why the alternative is more practical and effective than the one proposed here.

Benefits of the Hybrid Core

The foundational or core proposal is a significant improvement in three ways. First, it is better than the status quo of no space arms control at all. Currently, the world is ambiguous whether space stalking is threatening or peaceful and whether preemption as last resort is defensive or a pretext for aggression. Consequently, a country could be tempted to use space stalkers to prevent a third country's intervention in a conflict or intimidate its adversary into submission. The use of space stalking could create crisis instability and trigger a war in space and on Earth that could kill untold numbers of combatants and noncombatants. The core proposal clarifies and condemns space stalking as aggression and permits preemption. It unambiguously informs the aggressor that blackmailing with space stalkers is destabilizing and, in any case, futile.

Second, Russia and China stated that the purpose of the Prevention Treaty is "very specific: a ban on the placement of weapons of any kind in outer space and a ban on the use of force or threat of the use of force against outer space objects."[47] Thus, the means is banning "placement of weapons," while the goal is banning "the use of force or threat of the use of force." However, the means of the Prevention Treaty is not possible in the presence of ADR and OOS satellites in the emerging era of proximity operations. Most interestingly, by replacing the means of outright banning with prohibiting the threatening configuration of space stalking, the foundational proposal can now attain the goal of PPWT.

China and Russia, as well as the United States, should find that the foundational proposal offers a viable new means to attain their ultimate goal of banning "the use of force or threat of the use of force against outer space objects."

Third, if the foundational proposal fails to gain support from countries such as China and Russia, the proposal could still have a second chance to turn into a treaty. As long as the United States gains overwhelming support from its allies and friends, it can still declare that it will unilaterally observe the proposal, namely, that it will not pose a space stalking threat to another country's satellites but that it will reserve the right of preemption as the last resort if its satellites are threatened by space stalkers. Once the United States adopts this policy, the space stalking threat would no longer deter US intervention. Naturally, China and Russia could have preferred no change in US space security strategy so as to maintain the potency and leverage of their space stalkers. However, once the foundational proposal rendered space stalkers ineffective, China and Russia could decide it would be better to join the proposed treaty. In sum, the foundational proposal deters and defends against space stalkers that cannot be banned from space in the emerging era of unmanned, close proximity operations.

Additional HSAC Measures

Additional control measures can improve deterrence and defense against not only space stalkers but also many of the traditional and new threats. The United States and other countries need to consider and decide which ones should be added to the foundational or core proposal. Control measures described below start with those that are relatively easy then progress to those far more difficult to implement but which could control space weapons far more effectively and affordably.

Facilitating the Monitoring of ADR and OOS Spacecraft

The following measures can make verification easier for any country that is concerned about an adversary's ADR and OOS spacecraft being repurposed temporarily or permanently as space stalkers. First, each of these spacecraft, as well as its technical and performance description relevant to ascertaining potential ASAT capability, should be submitted to the secretary-general for inclusion in the United Nations Register, as

over 92 percent of all prior satellites have been.[48] However, this control measure should be made more acceptable to some countries by not allowing it to be used to reveal capabilities such as sensor resolution that are proprietary and/or military sensitive but not critical for determining a satellite's potential ASAT capability. Since the maintenance of the Register had been delegated to the United Nations Office for Outer Space Affairs (UNOOSA), these ADR and OOS data can be managed by the same office as well. Second, each ADR or OOS spacecraft should be required to make its location and orbital track known to the public and the spacecraft should be easily detectable 24/7 by broadcasting its position. Third, the service provider or owner will preannounce to the public the itinerary of any repositioning well before the journey starts so any country can prepare for defense accordingly, should the precaution be necessary. These measures to facilitate monitoring are consistent with, but go beyond, Guideline 6, "Enhance the Practice of Registering Space Objects," in "Guidelines agreed by the United Nations Working Group on the Long-term Sustainability of Outer Space Activities (UNWG Guidelines)" to "be used as the basis for producing the next official version of the guidelines for the long-term sustainability of outer space activities."[49]

Perhaps some countries and spacecraft owners prefer to keep some information such as a spacecraft's new destination private. One option is to exempt a pre-agreed number of ADR and OOS spacecraft from preannouncement and even registration. However, there seems little justification for any exemption as an ADR mission is for common good and should be public knowledge. As to OOS spacecraft, even if one wanted to keep the maintenance and repair record of a satellite, especially a military one, confidential, one could still preannounce the OOS spacecraft's new destination but mask the record by adding some unnecessary visits to the satellite being serviced.

Prohibiting Test of Simultaneous Unmanned Proximity Operations

On-orbit testing and demonstration are required for the deployment and upgrades of proximity operations including robotics. However, there is little need over the next decade to test or perform multiple peaceful ADR or OOS missions simultaneously. Yet, such simultaneous activities would greatly facilitate these spacecraft being repurposed for simultaneous space stalking that any space arms control for the emerging era

would need to prevent. Should hybrid space arms control become a treaty and remain in place for several years, this testing prohibition can be relaxed to allow simultaneous ADR or OOS missions.

Prohibiting Ground-Launched Ballistic-Missile ASAT Tests

As discussed, the United States stated, "The Treaty [PPWT] does not address the most pressing, existing threat to outer space systems: terrestrially-based anti-satellite weapon systems."[50] Two possible control measures exist. First, countries may consider banning further ground-launched (i.e. terrestrially based) ballistic-missile ASAT tests. Since testing in space is observable and verifiable, the test ban can result in slower development or upgrade of such ASATs. But, since the United States withdrew from the 1972 Anti-Ballistic Missile Treaty on 13 June 2002, this control measure would also affect the testing of ground-launched ballistic-missile defense systems. One compromise is to take advantage of the fact that the maximum apogee altitude is around 1,300 km for a non-lofted ICBM with a range of about 10,000 km.[51] The apogee actually is lower for ranges greater than 10,000 km.[52] Thus, a control measure can prohibit all ballistic missile intercept tests against both real or virtual targets, whether for ASAT or any other purpose such as missile defense, above 2,000 km (the upper limit of LEOs).[53] This prohibition would reduce the ground-launched, ballistic-missile ASAT threat to medium Earth orbit (MEO) and GEO satellites yet would not prevent tests of ground-launched ballistic-missile defense system against ballistic missiles of any range.

Second, even if countries decide to remain silent about banning all ground-launched, ballistic-missile ASAT tests as in the Prevention Treaty, they can still consider banning simultaneous tests for the same reasons as the above measure for banning test of simultaneous proximity operations. However, countries that want to preserve the option for simultaneous ground-launched ballistic-missile defense intercept tests would have to identify some observables to distinguish ASAT flight-test profiles from those of ballistic-missile defense intercept.

Prelaunch Inspections Required for All Space Launches

This measure calls for a series of inspections before the launch into orbit of any spacecraft from any member country. Clearly, delaying the adoption of a measure, such as prelaunch inspections, would require

grandfathering all space systems already in orbit and, thus, degrade the effectiveness of the measure. These inspections of every spacecraft are in addition to providing to the United Nations Register its registration and technical and performance specifications. All these data together are designed to discern, once any spacecraft is in orbit, its technical capability including convertibility to perform ASAT missions such as close-in attacks (e.g. space stalking) or attacks from far away. Before the United States proposes such a drastic but highly useful measure, it needs to carefully consider the benefits and costs to the United States as well as to other countries, especially China and Russia. Overly intrusive inspections could delay a launch, add costs, and, most critically, reveal trade secrets and military capability. On the other hand, without inspections, treaty members would have far less assurance that their satellites would not be attacked or would be protected.

During the early period of implementing this measure, the inspection team will include, but not be limited to, space experts from China, the United States, Russia, the European Union, and other major spacefaring nations. Their participation is needed to ensure that other countries' space systems would not have a potential ASAT capability that a given expert's country cannot deter or defend against. As the inspection procedure becomes objective and reliable in uncovering potential ASAT capability, trust among countries might eventually permit the inspection duty to be taken over by a third-party team under the auspices of the United Nations.

The number of spacecraft with exemptions from registration and/or specification can be negotiated. However, the number can be small or even zero especially when countries are willing to trade the sacrifice of some military expedience with the tremendous benefits of space arms control.

Article II of the Convention on Registration of Objects Launched into Outer Space stated that "when a space object is launched into earth orbit or beyond, the launching State shall register the space object by means of an entry in an appropriate registry which it shall maintain."[54] While Article II intends to make transparent what objects are in space, prelaunch inspections further this goal.

Acceptable and Effective Prelaunch Inspections

The foundational proposal by itself is a significant improvement over the status quo of no agreement. However, if prelaunch inspections are

added to the foundational proposal, comprehensive space arms control on a wide variety of space weapons would become possible or far more effective. Discussed below are suggestions on how inspections can be designed to be acceptable to the international community and effective in maintaining a peaceful space environment.

First, business practices—particularly regarding exports—provide lessons learned on how to inspect space systems without exposing essential trade secrets. Military systems, which contain many proprietary and highly sensitive hardware and software, are exported to foreign entities including potential adversaries. The recipients can take their time to repeatedly open up, inspect, test, and reverse-engineer their acquired systems to learn about trade-secrets. Yet, the United States and others are capable of protecting these secrets and comfortable in exporting them. If countries can do so on these exported sensitive systems, they should be able to do the far easier job of protecting the secrets through only prelaunch inspections, which are far more time constrained and far less intrusive.

Second, gathering even general information through prelaunch inspections could adequately specify the designed or retasked ASAT capability of a space system. Take ADR or OOS spacecraft as an example. Knowing the type, number and power of thrusters; the type and dimensions of the solar panel; the dry mass of the spacecraft; and the amount of propellant could be adequate for assessing the maneuverability and speed capability of unmanned rendezvous proximity operations for ASAT. The availability of a robotic arm also shows the spacecraft's potential ASAT capability. Again, as for ADR and OOS spacecraft, the intent of both specifying technical and performance information during registration and the data obtained through prelaunch inspections on every space launch should exclusively focus on determining the potential ASAT capability, should the space system be retasked to do so. This focus should lessen the danger of revealing other sensitive information for non-ASAT purposes.

Third, prelaunch inspections can be designed so the revealed information does not lessen a country's capability or offer much help to adversaries. For example, one may be concerned that such inspections could degrade the benefits of using a potentially militarily sensitive reconnaissance, surveillance, or intelligence satellite such as a LEO imaging satellite or US Geosynchronous Space Situation Awareness Program satellite. A country may want to sneak in for a picture or close look of

a ground or space target in its unalerted and unconcealed state. However, prelaunch inspections would not reduce the satellite's ability to surprise, because inspection data offer little help to the targeted country in knowing whether the satellite is at a suitable location for such a peek. For the targeted country to prevent a surprise look, it would have to rely on direct observation of the location of the reconnaissance satellite, and prelaunch inspection data would be of little help.

Fourth, as discussed before, 14,000 to 16,000 small satellites are expected to be launched into LEOs over the next decade. They will add a significant burden to space tracking, because they are both numerous and small. Just like the control measure to facilitate the monitoring of the ADR and OOS spacecraft discussed above, these small satellites should have their locations as well as their repositioning plans known to the public and be easily detectable 24/7. Also, since they have no peaceful reason to be placed at or travel to GEOs or even high MEOs, they should stay at LEOs and low MEOs only. Without these requirements or restrictions, they could serve as numerous and hard-to-track space stalkers as well, making the defense against stalking more difficult. These measures can be used as "design solutions that increase the trackability of small-size space objects and all other space objects that are difficult to track" as described in Guideline 30 of the UNWG Guidelines.[55]

Fifth, there have been reports of stealth spacecraft such as Misty, which are supposed to be difficult to detect.[56] Should such spacecraft exist and be used for ASAT, they would make satellite defense far more difficult. Countries should consider whether to ban them outright. The risks of having stealth satellites may outweigh the benefits. Again, prelaunch inspections can prevent them from being placed into space and lurking for attacks.

Sixth, in the emerging era of proximity operations, space weapons cannot be banned. As space weapons will always be present in space, it would be foolish to ban the use of space weapons for defensive purposes.

Seventh, by seeing the interior of a spacecraft, one can inspect whether anything is hiding inside that could be a potential ASAT. It should be noted that the most important purpose of prelaunch inspections is to ensure there is no long-range ASAT capability hiding in the spacecraft, because any short-range ASAT including space stalker can be adequately handled by the foundational proposal. The subsection below further

explains that banning space-based long-range ASATs can pave the way for a truly comprehensive and effective space arms control.

Ultimate Space Arms Control

Incorporating the foundational proposal and all of the above control measures that are compatible could be the basis of the ultimate space arms control treaty that the United Nations has been seeking since the Outer Space Treaty entered into force in 1967. The foundational proposal should be the core of any ultimate space arms control treaty. In addition to these two actions, space weapons should be arrayed into six categories to help manage them:

1. Space-based less-than-10km-range ASAT weapons. The final range demarcation is to be determined by DOD and the international community.
2. Space-based less-than-10km-range defensive weapons
3. Space-based 10km-or-more-range ASAT weapons
4. Space-based 10km-or-more-range defensive weapons
5. Ground-launch ASAT weapons
6. Space-based weapons against terrestrial targets

Since spacecraft such as those for ADR or OOS or even garden-variety satellites can be potential weapons, they either would be controlled as if they were weapons or could not be converted into weapons. In other words, the control measures for each weapon category should cover both weapons and potential weapons alike or prelaunched inspections should ensure the inconvertibility into weapons.

All category 1 space-based less-than-10km-range ASAT weapons and ASAT-capable spacecraft such as those for ADR and OOS will be controlled by prohibiting them from tailgating another country's satellites beyond a pre-agreed innocuous number.

Once weapons and potential weapons of the first category are present, it is far better to allow weapons of the second category for defense, because using "guns" to defend against "guns" in space is far more effective than using no "gun" to defend against "guns" especially in the proximity-operation era. On the other hand, since weapons and potential weapons of the first two categories cannot be observably distinguished from one

another, we should consider it a treaty violation if these defensive weapons and potential weapons are too close to more than the threshold number of an adversary's satellites. Also, whenever possible, defensive weapons that can produce reversible or soft kill are the first choice, while defensive weapons that result in hard kill but with little enduring space debris are the second choice.[57] For the latter, a defensive weapon with a robotic arm can disable a space stalker with little debris.

Space weapons of the third and fourth categories are banned outright. Prelaunch inspections are needed to ascertain their range or potential range and prevent such weapons and potential weapons from being launched into orbit. The foundational proposal works well when these long-range weapons and potential weapons are absent in space, because short-range space-based weapons can be kept from reaching satellites even when the satellite population is large. In contrast, if long-range space-based weapons were not banned, they could attack satellites far away. Then, the defensive weapons would be forced to be long-range as well. Alternatively, the number of short-range defensive weapons around each critical satellite would have to be greatly increased to counter the threat of multiple space-based long-range ASAT weapons because, even if they are far away from the target satellite, they can still quickly concentrate their attacks on the same target to overwhelm the defense. Longer range and/or increased numbers of weapons are major causes of a space arms race that should be prevented for more efficient space arms control.

Space weapons of the fifth category cannot be banned because the banning cannot be monitored. However, as discussed earlier, the testing of ground-launch ASAT weapons can be banned or restricted to LEOs only.

If countries agree to ban space weapons of the sixth category, prelaunch inspections will prevent them from being launched in orbit. But, if countries wanted to allow, a space-based missile defense system, some specific give-and-take would have to be worked out. For example, the system can be restricted to being located only in LEO. The range of the defensive missile can only be long enough to intercept incoming ballistic missiles but short enough to be unable to attack MEO and GEO satellites. It may even be possible to structurally fix the sensor, the firing mechanism, and the interceptor to only look and shoot downward and thus render the system incapable of attacking any satellite far above the system's altitude. The prelaunch inspections would have to be designed

to ensure that the system cannot be used or reconfigured in space to hit any satellite that the system has been designed and committed not to hit.

Finally, it would make satellite defense easier if the numbers of rendezvous proximity operation–capable spacecraft such as those for ADR or OOS are limited. Many of them can be controlled and managed by a United Nations organization so as to prevent any country from retasking its spacecraft controlled by a neutral independent party for space stalking or other offensive purposes.

Conclusion

The 50th anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space in 2018 is a time to celebrate the establishment of the Outer Space Treaty and many other accomplishments, which guide the civil and commercial activities in providing peaceful benefits of space. It is also time for reflection on how we have failed to arrive at a treaty to control space weapons and the space arms race to ensure peace in space in spite of countless effort over the last 50 years. Space is irreversibly entering into an era of unmanned, rendezvous proximity operations, in which space weapons are inevitable and space will become weaponized. The world needs to face this reality. Fortunately, while space weapons cannot all be banned, they can still be effectively controlled. A foundational space arms control treaty would be better than the status quo of no space arms control or continuing the impossible tradition of banning weapons of any kind in outer space.

A core space arms control proposal that deals with space stalkers can be negotiated and established by itself. It can also be used as the core of a more comprehensive hybrid space arms control proposal as only some space weapons are banned outright while others are prohibited from being too close to an adversary's satellites. A comprehensive set of control measures can be added to the core proposal from the start or gradually over time after the core treaty is first established. These added measures will allow countries to better deter and defend against not only traditional threats and space stalkers but also emerging space threats. Both the foundational proposal and the additional measures aim to provide effective space arms control and are reasonable for adoption by countries. All suggested measures are verifiable, recognize the right of self-defense as the last resort after treaty violation, and most importantly, can lead to peace in space.

In the worst-case scenario where no space arms control comes out of this hybrid approach, the United States would still have acted in good faith for pursuing an international space arms control treaty. Consequently, the world would have more understanding and support toward the United States as it had no choice but to switch to unilateral space arms control measures to ensure space security and stability.

Space arms control permits the continued benefits from peaceful space activities yet prevents the horror of war in space. While the emerging era of proximity operations will be upon us in the early 2020s, space arms control is still within reach, provided countries are open to ideas new and old and are willing to promptly deliberate, negotiate, and compromise for the benefit of humankind. SSQ

Notes

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