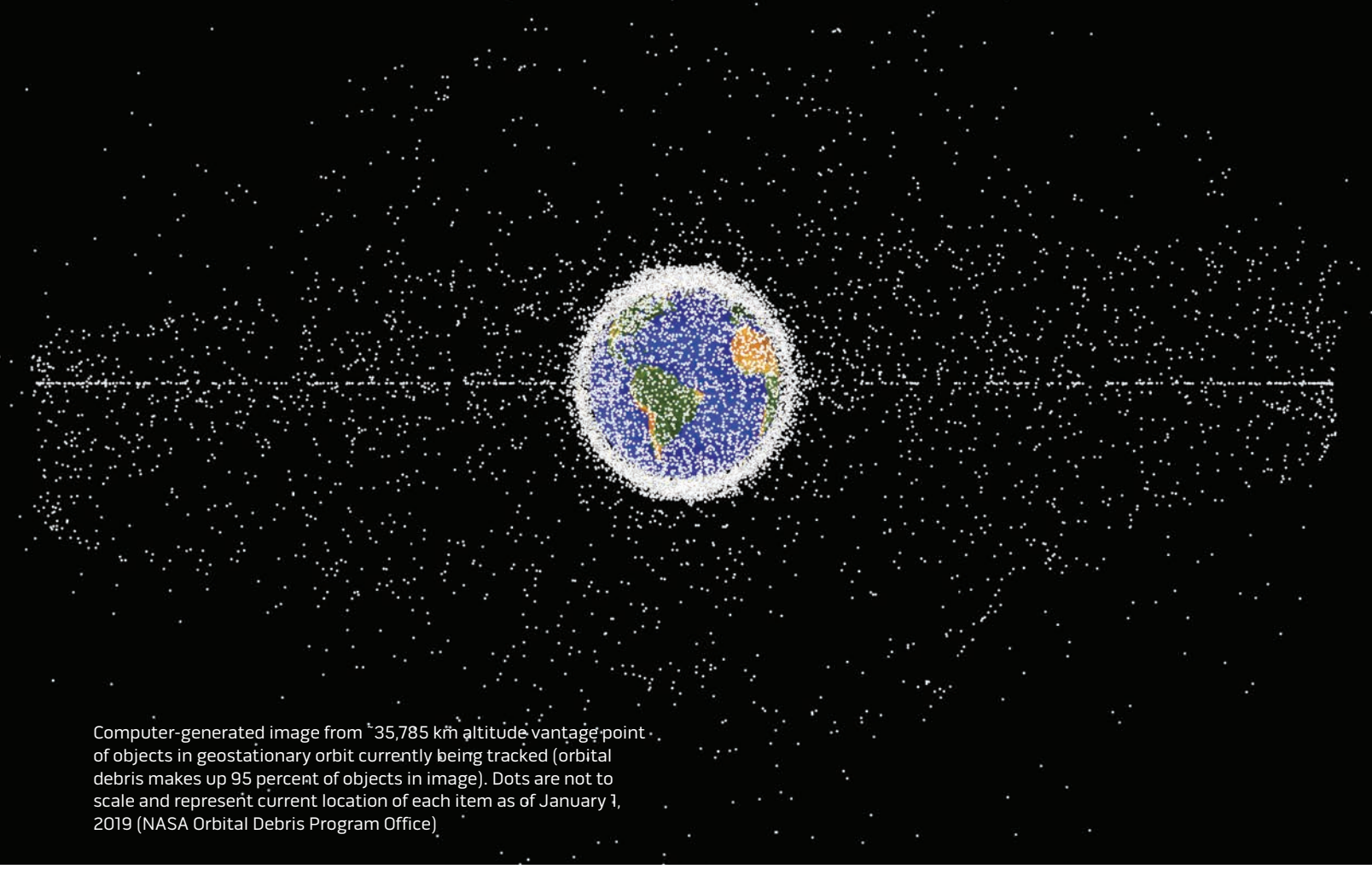

Computer-generated image from 35,785 km altitude vantage point of objects in geostationary orbit currently being tracked (orbital debris makes up 95 percent of objects in image). Dots are not to scale and represent current location of each item as of January 1, 2019 (NASA Orbital Debris Program Office)

The PPWT and Ongoing Challenges to Arms Control in Space

By Brian Britt

It was early evening in Washington, DC, on January 11, 2007, when an SC-19 ballistic missile took off from Sichuan Province in the People's Republic of China. The missile climbed 534 miles before releasing a 600-kilogram payload that slammed into the defunct Chinese Fengyun-1C weather satellite. The test generated an estimated 35,000 pieces of orbital debris spanning 2,200 vertical miles, the largest debris-creating event to date that would threaten private, civil, and international assets in space, including the International Space Station.[1]

It was the first such test since 1985 when the United States shot down an American satellite using a direct-ascent air-launched missile.[2] The Chinese test represented a turning point for the space domain, a revitalization in the struggle for outer space supremacy, and the rise of a new threat to stability: antisatellite (ASAT) weaponry. To American policymakers, the violent disassembly of Fengyun-1C made two things clear. First, American satellites are vulnerable to attack from the country's largest foreign competitor. Second, in a domain largely devoid of rules and regulations, anything goes.

Perhaps the largest effect of the 2007 test was the urgency it gave to the cause

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of space arms control. Here was the clearest demonstration that unregulated outer space required better rules. Arms control in outer space, it was stated, could prevent the next disaster.[3]

In the 15 years since China's ASAT test, little progress has been made toward space arms control. One year after the 2007 test, China and Russia jointly proposed the Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects (PPWT) at the 2008 Conference on Disarmament. The original draft treaty and its 2014 successor are rife with loopholes, failing to effectively define a weapon, what constitutes its use, and how accidents could be separated from intentional acts of aggression.[4] PPWT drafts have loitered in purgatory in the face of staunch opposition led by the United States and key allies such as the United Kingdom (UK). In April 2022, the United States was the first nation to unilaterally announce that it would no longer conduct tests of direct-ascent ASAT missiles, formalizing a de facto taboo.[5] But the narrow ASAT definition that enabled the ban's success also limits its effect, which fails to address the growing threat of cyber, directed energy, electronic, or co-orbital attacks. The PPWT remains the frontrunner for comprehensive space arms control treaties, given a notable lack of proposed alternatives.

The PPWT's fate represents the ongoing long-term challenges to codifying comprehensive space arms control for ASATs.[6] Despite the legitimate threat of ASAT weapons, *arms control agreements*—defined here as treaties and regulations that would prevent the proliferation of ASATs and block their development—remain out of reach. During the Cold War, ASAT arms control efforts encountered resistance as the entanglement of ASATs with strategic nuclear weapons and, later, ballistic missile defense prevented governments from credibly controlling one without the other. More recent attempts at ASAT arms control undertaken by U.S. partners and allies have also failed.

In 2014, for instance, the European Union's International Code of Conduct for Outer Space Activities failed to reach a consensus and was pronounced dead after 6 years of repeated revisions and negotiations, despite a voluntary, nonbinding nature that explicitly permits the use of kinetic ASATs for safety and debris-reduction considerations.[7] Recent UK-led efforts to define responsible behaviors in outer space via open-ended United Nations (UN) working groups represent the most recent iteration of attempts to guide behavior in outer space.[8] But this effort is unlikely to produce anything that would meaningfully represent ASAT arms control. As detailed below, definition, attribution, and verification problems make efforts to codify effective, comprehensive, and multilateral ASAT arms control fruitless.

Energy is better spent pursuing narrower, more effective bans on tests of debris-creating kinetic ASATs, increasing transparency and trust through confidence-building measures, and specifying sustainable norms of behavior. Today's small, narrow victories could one day represent the groundwork for something more comprehensive when shifting interests and advanced space surveillance technology heighten the possibility of a sweeping arms control regime that currently remains out of reach.

ASAT arms control attempts suffer from the same four core problems: elusive definitions, verification problems, attribution problems, and adversarial interests.

Elusive Definitions

Agreements that ban or control weapons must define what exactly they aim to regulate in order to explicitly articulate what falls under their purview and what does not. Without an ASAT definition that is simultaneously inclusive and precise, international regimes preventing the development, deployment, and use of ASATs are ineffective. Two obstacles make constructing a useful definition nearly impossible: weaponry diversity and the dual-use problem.

The variety of potential ASAT weaponry presents a problem. ASAT weapons are any technology that can temporarily or permanently disable or destroy a satellite's functionality. This means that, taking the liberal perspective, all the following qualify: directed-energy weapons, air- and land-launched kinetic missiles, cyber uplink and downlink interruptions, radio frequency jamming, attacks on ground stations, and maneuverable co-orbital attack satellites.

The diversity of ASAT weapons makes articulating a comprehensive definition difficult. Attempts inevitably leave loopholes because technologies belong to separate domains defined by unique operational requirements, norms, and expectations that require specific regulation.

Controlling these technologies is particularly difficult given that many have legitimate, peaceful, or commonplace uses in orbit. Many ASATs, in other words, are dual-use technologies in their abilities to further both peaceful and violent ends. Satellites are fragile. It takes little force to render them temporarily or permanently ineffective. When a target is defined by fragility, everything is a weapon. The concept of co-orbital repair satellites, for instance, is becoming increasingly popular as a means of revitalizing failing satellites rather than replacing them.[9] But the same capabilities used to repair can be redirected to destroy. In the same vein, any satellite equipped with a radio frequency antenna necessary to receive signals can also emit them with sufficient strength to jam the communications of nearby satellites.[10]

This ability highlights a core problem with the PPWT, which defines a *weapon* as "any outer space object or its component produced or converted to eliminate, damage, or disrupt normal functioning of objects in outer space."[11] This definition is not only constricted but also imprecise. The PPWT takes definitional precedent from the Soviet Union's initial 1981 Proposed Prevention of an Arms Race in Space Treaty, seeking to singularly regulate co-orbital weapons while ignoring those that are operated from land, sea, or air domains.[12] Even with its narrow scope, the treaty is unable to overcome the persistent problem of dual use, as many commonplace objects put into orbit can be used as counterspace weapons. The treaty also does little to differentiate what falls under its purview and what does not, rendering it meaningless.

The definition debate is ongoing.[13] Todd Harrison's counterspace weapon classification system, which categorizes weapons based on both the domain of origin and the domain of effect, is a step in the right direction. But until a more precise, discerning, and enforceable definition is produced, ASAT arms control regimes, no matter their intended scope, will remain elusive.

Verification Problems

Any arms control agreement is pointless if its sponsors cannot know when its regulations are violated. The ability to monitor and differentiate between compliance and noncompliance must be a part of any ASAT arms control. This requires that the international community can identify, characterize, and monitor objects in orbit. But reliable space weapon verification capabilities remain out of reach. For the co-orbital weapons that the PPWT seeks to regulate, it remains remarkably difficult to track objects, understand what they are, and know what they are capable of once deployed in orbit. Beyond this, verifying compliance for nonphysical weapons—such as cyber and jamming capabilities—becomes increasingly difficult.

Even if the international community solidifies the means to reliably track all orbital objects, "verifying the function of a particular space object already in orbit is significantly more difficult."[14] Research such as the "PAXSAT A" study demonstrates that gathering data on the functionality of satellites in orbit is theoretically possible using a four-satellite surveillance constellation.[15] But this method of investigation first relies on the ability of the constellation to position itself near the object in question and second, assumes that form follows function. There are two problems. First, no one—not the United States, other spacefaring nations, or any international organization—has the infrastructure or resources to conduct on-orbit investigations now or in the foreseeable future. Second, the logic that form follows function is fallible. Placing an object in orbit is expensive, leading some to argue that the extra weight and cost needed to obscure the true function of a co-orbital ASAT weapon with façade architecture is too expensive to be realistic. But basing arms control agreements on assumed frugality seems problematic at best.

Even assuming perfect capabilities for monitoring launches and orbital object-tracking, significant monitoring gaps remain. Many ASATs are ground-based, meaning these weapons can be developed and deployed outside of the scope of orbital object monitoring systems. For platforms (to include dual-use systems) capable of damaging or disabling satellites via nonkinetic effects, verification is simply impossible. No mechanism exists, for example, to verify compliance with moratoriums against developing or deploying cyber weapons or jamming capabilities. Verification mechanisms with present technologies remain costly, complicated, and ineffective. Moreover, without effective verification capabilities, arms control agreements are useless.

Attribution Problems

Attribution capabilities, or the lack thereof, present another problem for ASAT arms control. Some forms of ASAT attacks are attributable; others are not. Nonphysical attacks are particularly difficult to tie to national actors. In the event a directed-energy weapon is used against a space asset, for example, satellite operators would have a difficult time identifying the actor responsible. In the harsh space environment, systems frequently fail without explanation. Unless the targeted satellite is equipped with sensors that could identify a "spike in thermal energy or sudden saturation of optical sensors," there is no way to differentiate between a random satellite failure and a malicious laser attack.[16] Even if such capabilities exist, there is no guarantee one could attribute the laser's use to a specific location on the globe and/or a national actor.

Jamming attacks are similarly difficult to attribute. Satellites use a narrow range of the electromagnetic spectrum to communicate. Increasingly crowded orbits mean it is increasingly common for multiple space assets to use similar or identical frequencies and, as a result, unintentionally jam the communications of a neighboring satellite. Differentiating between intentional and unintentional jamming is difficult, if not impossible. In this environment, verification and compliance mechanisms are complicated to construct.

Recent cyber attacks have laid bare the difficult, lengthy, and uncertain process of attributing, much less identifying and understanding, cyber incursions. Russia's massive SolarWinds hack in 2020 demonstrated a lack of an ability to definitively identify the scope and duration of a cyber penetration.[17] Similar problems will plague efforts to assert arms control regimes on cyber ASAT weapons.

Adversarial Interests

International participation is a key ingredient of effective ASAT arms control regimes. But many of America's key space-capable competitors perceive possession of ASAT weapons as a strategic necessity. As RAND reports, "The difference of individual self-interest versus collective thinking has long been a barrier to development in responsible space negotiations."[18] The United States relies on its space assets for a "diverse array of political, military and economic activities" fundamental to its national security.[19] America's adversaries view the U.S. military's reliance on space systems for its conduct of operations as a potential weakness. This "dependence on space creates a vulnerability that is an attractive target for our foreign adversaries," something they could reliably exploit.[20]

China and Russia in particular view space as a vital and contested strategic domain, and ASATs give them the ability to project force in this domain against the United States. From their perspective, ASATs are an equalizer that allows them to overcome a relative conventional weakness. The perceived strategic value of ASAT weapons makes unlikely any arms control agreements that seek to legitimately and comprehensively eliminate or reduce the ability of countries to develop and possess ASATs. Comprehensive ASAT arms control regimes will remain infeasible until the incentives for arms

United Nations Conference on Disarmament meeting, Palais des Nations, in Geneva, January 24, 2012 (Courtesy U.S. Mission Geneva/Eric Bridiers)

racing fall and/or the consequences of using ASATs rise, unifying currently disparate interests and forcing competing states to the negotiating table.

Unintended Consequences of Control

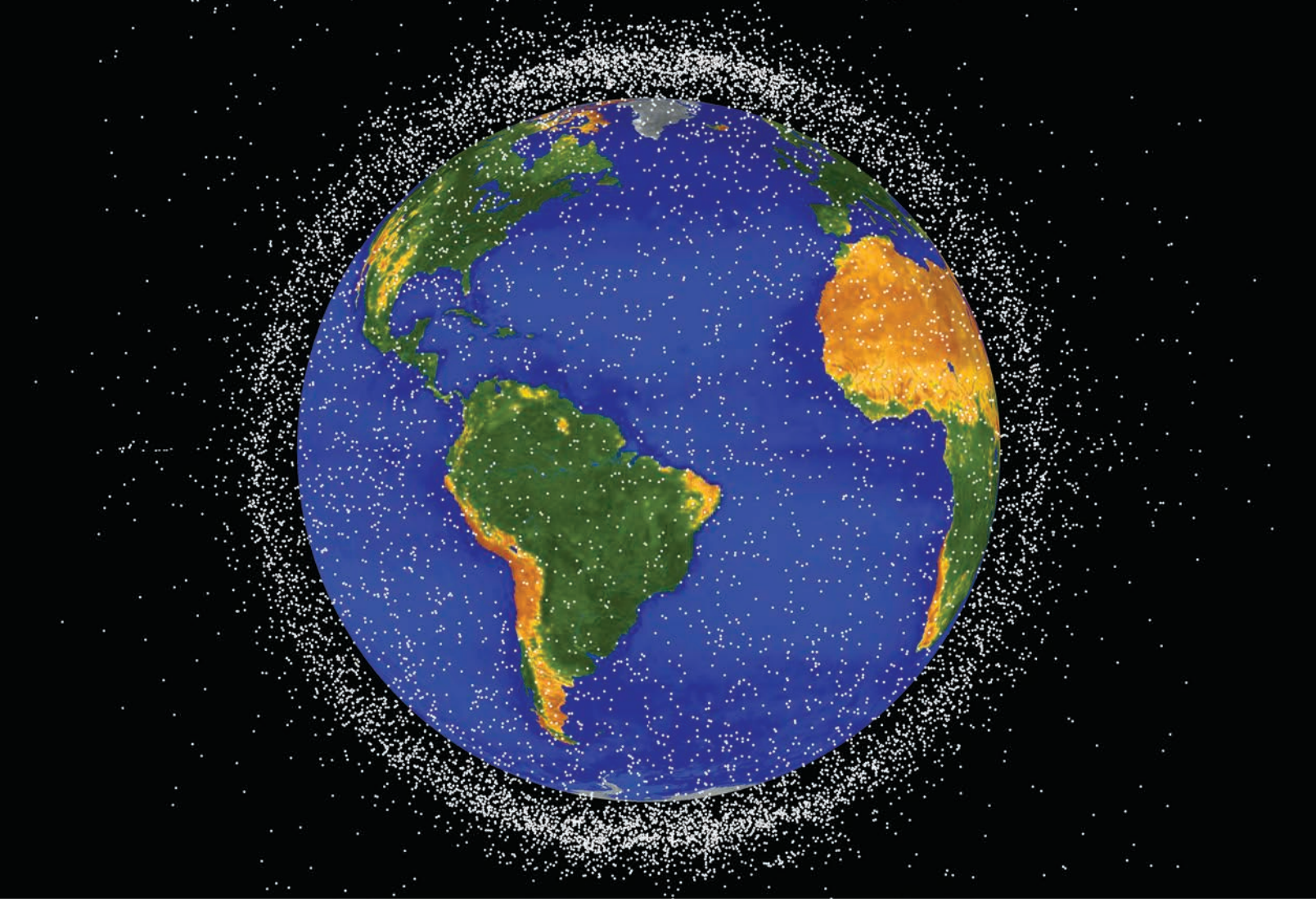
ASAT arms control agreements would likely have unintended second-order effects that could deepen, rather than resolve, the problems posed by counterspace weapons. Arms control agreements, in their initial renditions, will do more to shape the direction of, rather than prevent, an ASAT arms race. If agreements do occur, they will at first be narrow and less than comprehensive. This would incentivize states to develop ASAT weapons that fall outside of the agreements' jurisdiction. If an agreement bans kinetic ASAT weapons, for instance, space-capable nations would push to develop more effective nonkinetic weapons that fall outside the regime's scope.

ASAT arms control would also have more sinister impacts. It could increase the incentives to camouflage and disguise ASAT technology, making it increasingly difficult to differentiate between weapons and peaceful infrastructure, worsening a problem that the agreement set out to resolve. Restrictions on counterspace weapons would incentivize states to commingle innocent infrastructure and ASATs to avoid detection.

Alternative Measures

This article highlights three overlapping approaches that could overcome or circumvent the pitfalls that plague ASAT arms control agreements. These options are not comprehensive end-solutions but serve as achievable, intermediary efforts toward more complete agreements in the future.

First, as Michael Krepton suggested, is an international moratorium on kinetic ASAT tests that generate debris and make the space environment more operationally dangerous.[21] Kinetic tests have characteristics that make them amenable to multilateral agreements. It is clear when one happens, how it happens, and where it comes from—in other words, tests like these are straightforward to define, monitor, verify, and attribute. They also invite international agreement. Debris-generating ASAT tests make the space environment more difficult for all to operate in and are, therefore, against the interest of all space-faring nations. The suitability of the U.S. ban on direct-ascent kinetic testing is evident, given recent developments. Since its inception, Australia, Canada, Germany, Japan, New Zealand, South Korea, Switzerland, and the United Kingdom have endorsed U.S. efforts with self-imposed bans of the same nature.[22] The effort may continue to propagate—the UN Open-Ended Working Group on Reducing Space Threats continues to hold consultations and negotiations on responsible space behaviors. These sorts of destructive tests should be treated as significant and acceptable events by the international community. Any ban of this kind must be backed by a punitive enforcement mechanism to have any real sway over state behavior. With the right consensus



Computer-generated image of objects in low Earth orbit currently being tracked (orbital debris makes up 95 percent of objects in image). Dots are not to scale and represent current location of each item as of January 1, 2019 (NASA Orbital Debris Program Office)

and enforcement mechanism, such a ban would contribute to a self-reinforcing taboo against this behavior.

A second option is less a method of arms control than it is a transparency and confidence-building measure. If a sufficient definition of *space weapons* remains out of reach, the international community could instead designate certain orbital altitudes as transparency zones where inspection is a prerequisite to the placement of objects in these orbital bands. Space is not a unitary area, so it should not be treated as such. Bands of orbit that are disproportionately vulnerable to the Kessler syndrome—the concept of a debris-generating positive feedback loop in orbit—could be designated as international transparency zones.[23] If a nation sought to place assets in these zones, the assets would be subject to examination through an inspection mechanism like that of the International Atomic Energy Agency.[24] Mutual inspection regimes have historically been used as a means of verification in arms control regimes, but isolating the practice of mutual inspection outside the scope of codified regulation could be useful in unifying interests, eliminating distrust, and increasing bilateral or multilateral situational awareness.[25] This would avoid definition problems by refraining from attempts at restriction, instead acting as a simple, straightforward transparency and confidence-building measure. If this approach is to be taken, it is necessary to ensure that any increased transparency does not harm U.S. competitiveness.

Third, norms have their place as apparatuses through which, as Audrey Schaffer explains, to "highlight abnormal behavior, enabling warning of and protection against space threats."[26] They cannot constrain or punish malicious action, so they should not be confused with or substituted for arms control. But they could serve to flag violations and increase international clarity as to what is right and wrong in the space domain. Norms are important to the United States and the global community because they serve as self-strengthening behavioral guidelines that act as the first building blocks to codified rules. Therefore, the international community should continue efforts to establish norms of behavior that dictate activity in outer space. The United States has a key role to play in this process that requires unifying its internal outlook on norms so that it can better export this viewpoint to the international community. Consolidating the fragmented efforts at defining norms across the U.S. Government—including the White House Space Priorities Framework, the 2020 National Space Policy, and the Department of Defense's Tenets of Responsible Behavior in Space—and

popularizing a nationally unified version will lend the United States an advantage in shaping the dynamics of the space domain and build on meaningful UN progress (for example, Guidelines for the Long-Term Sustainability of Outer Space Activities[27]) with regard to defining what is acceptable and what is not.[28]

ASAT weapons are a legitimate threat to global interests, and the space domain would benefit from more relevant, stronger rules of the road. But the solution is not the PPWT. The PPWT, if it ever became a treaty, would harm the interests of the United States and the international community. Instead, effort would be better spent supporting what works, even if only partially. Comprehensive ASAT arms controls might be politically pleasant, but realistically, they are practical pitfalls. **JFQ**

Notes

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