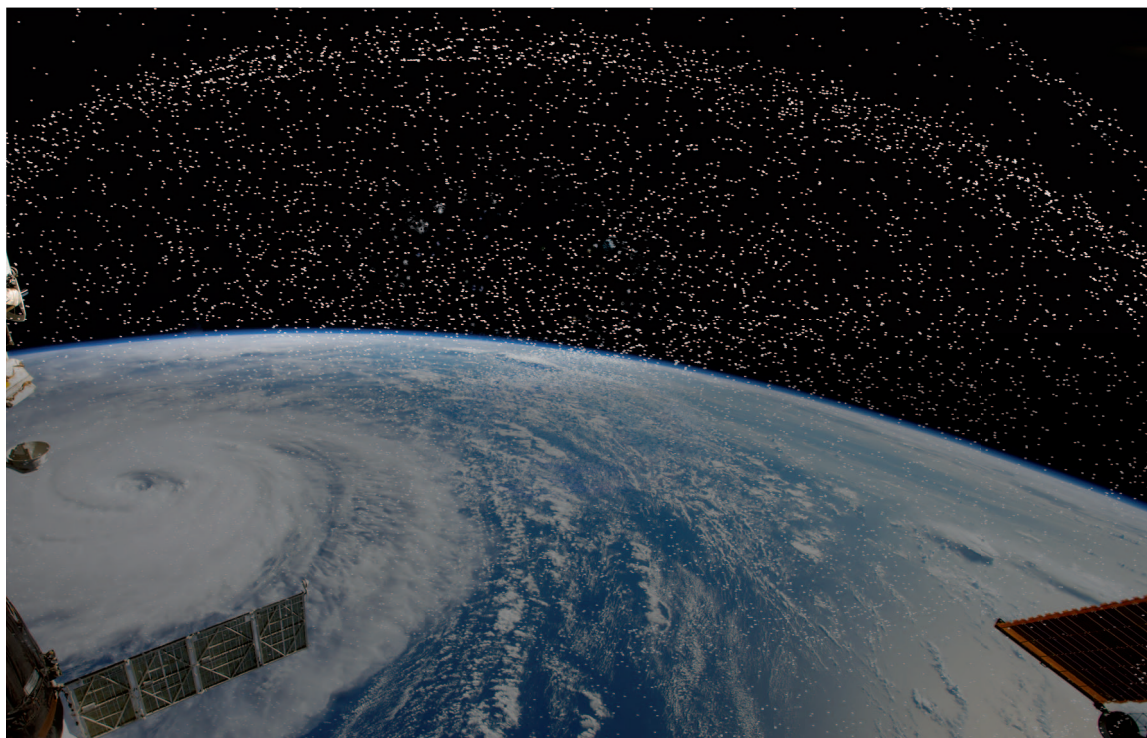


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Responsible Space Behavior for the New Space Era

Preserving the Province of Humanity



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Humans have explored and exploited near-earth space for more than six decades. More recently, the past two decades have seen the start of a *New Space Era*—the current period of space activity that is global, diverse, and rapidly expanding as a result of substantially lower barriers to entry—characterized by more spacefaring nations and companies, more risk of collisions, and growing risk of conflict.¹ Yet the basic treaties and mechanisms that were crafted 50 years ago for governing space activities have only marginally changed.

The calls for more progress on space governance and “responsible” space behavior are growing louder and coming from a larger group.² To help address the problem of the perceived gap between current space governance and needs for the future, this Perspective provides an initial assessment of the need for improvements in responsible space behavior, briefly describes some of the major hurdles to progress, and offers preliminary suggestions on how to make improvements that focus on the areas that most need attention and are most likely to be beneficial to all. This Perspective is intended to inform global policymakers who lack deep space expertise yet have the authority to influence future space policy for their nation or space sectors. This Perspective also aims to begin to chart a course

toward new standards for responsible space behavior that will ensure that space remains available for all as the world continues to travel into the New Space Era.

To prepare this paper, we examined relevant literature, including United Nations (UN) voting records, proposals, government statements, treaties, agreements, and various histories and analyses of the evolution of space treaties, agreements, and norms; organized and conducted a series of RAND Corporation–hosted international responsible behavior workshops; participated in multiple external workshops and events as speakers, moderators, and observers; and conducted multiple informal interviews and discussions with government officials, industry executives, space policy experts, academics, and members of the space observer hobbyist community.³ After gathering extensive input on views of the situation, barriers to progress, and options for solutions, we studied a list of candidate solutions to determine the areas that are most likely to be achievable in the near term (i.e., in the next five to ten years). Our research is only a first step, but it is an important, impartial perspective on the situation, and it is designed to advance the discussion and progress while also identifying the most-pressing areas for further work.

To begin, we offer a brief overview of the development of international treaties and attempts to further codify responsible behavior. This section summarizes the five international treaties that have been negotiated in the UN Committee on the Peaceful Uses of Outer Space (COPUOS). It also describes a few of the more-significant treaty proposals and non-legally binding efforts that have been proposed or adopted over the years. Next, drawing on our research and analysis, we synthesize and summarize some of the key barriers to progress in the effort to develop norms or binding rules for responsible behavior.

Finally, and of most interest to policymakers, we provide a short list of recommended first steps on a trajectory toward responsible space behavior norms that are appropriate for the New Space Era. We focus on a few key themes that should help guide leaders and policymakers toward tangible norms for responsible space behavior.⁴ In some cases, we offer specific examples of areas for initial steps,

Historically, years—sometimes decades—of negotiations and proceedings are required to establish multilateral agreements, let alone treaties.

when these steps are more obvious and seem likely to produce quick wins. Our preliminary analysis suggests that leaders should focus on paths to space norms that

- increase communication and engagement
- increase transparency for all
- begin with quickly achievable demonstrations of progress and accountability (quick wins)
- concentrate on safety before including security considerations
- progress toward security agreements.

The pace of enacting laws or transparency and confidence-building measures (TCBMs) concerning responsible space behavior is almost always slower than the development timelines for modern technologies. Timelines for agreeing on space norms have been stalled for decades by the wide policy chasm between the United States and China and Russia on preferred approaches for space governance and norms. Although it is taking longer to come to consensus on norms, space innovation and activity are accelerating. For example, it took eight years for the European Union (EU) Code of Conduct to reach its current version, and this code remains unadopted and is widely considered to be a dead effort. Historically, years—sometimes decades—of negotiations and proceedings are required to establish multilateral agreements, let alone treaties. By contrast, the past decade has seen an explosion of space operators, launch services, and many more proposals for the near term.

Defining rules and norms for the responsible use of space has been a complicated and contentious issue that has been heavily influenced by national security interests over safety.

A Brief History of Responsible Space Behavior

Defining rules and norms for the responsible use of space has been a complicated and contentious issue that has been heavily influenced by national security interests over safety.⁵ The early approach to space rules and norms was an extension of the Cold War conflict between the United States and the Union of Soviet Socialist Republics (USSR), and a basic understanding of that era is important even today. The first U.S. efforts to draft an international law ensuring “freedom of space” for all began during the Cold War in 1955, when “unimpeded overflight” of the USSR was deemed critical to national security. With unauthorized penetration of another state’s airspace considered to be a violation of international law, the United States looked for a way to continue crucial surveillance of the USSR’s military advancements with intercontinental ballistic missiles under an “open skies policy.”⁶ The U.S. government began to advocate a policy that kept outer space open to all to ultimately allow overflight of other states in space. In response to the USSR’s intention to launch a satellite into orbit, in 1957, the United States and its Western allies sub-

mitted proposals for treaties for the peaceful and scientific use of space.⁷ The USSR rejected these efforts and, months later, successfully launched Sputnik 1 into orbit.⁸

In the 1960s, the United States and USSR jointly tried to reach a resolution on the testing and use of nuclear weapons in space. In 1963, through the Limited Test Ban Treaty, the United States, United Kingdom, and USSR agreed on a ban against the testing or use of weapons of mass destruction in space.⁹ Hoping to build on these guidelines, the United States pushed for additional resolutions on the matter, as long as they did not limit U.S. capabilities for reconnaissance and defense in space.¹⁰ In 1966, after years of heightened concern over nuclear powers’ prospective abilities and intentions, the United States and USSR submitted separate draft treaties regarding the use of space. After six months of negotiations, the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (generally referred to as the *Outer Space Treaty* [OST]) “was opened for signature by the three depository Governments (the Russian Federation, the United Kingdom and the United States of America) in January 1967.”¹¹

In October 1967, the OST was adopted under the UN General Assembly, and it is considered the basis of modern international space law. The OST provides the basic framework on international space law, including the following principles:

- the exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind;
- outer space shall be free for exploration and use by all States;
- outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means;
- States shall not place nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies or station them in outer space in any other manner;
- the Moon and other celestial bodies shall be used exclusively for peaceful purposes;
- astronauts shall be regarded as the envoys of mankind;
- States shall be responsible for national space activities whether carried out by governmental or non-governmental entities;
- States shall be liable for damage caused by their space objects; and
- States shall avoid harmful contamination of space and celestial bodies.¹²

The OST remains the foundation of responsible space behavior and is considered the starting point for all future discussions and agreements regarding international cooperation in outer space. As of 2020, 110 countries are parties to the treaty.

Although the OST is a foundational document, there are various criticisms of it by lawyers, analysts, and policy-makers.¹³ The document itself is only 17 short articles in length and was written in broad language that allows a wide range of interpretation of the articles. In Article IV, “nuclear weapons” and “weapons of mass destruction” are not clarified further, and thus can be interpreted in a way that allows the use of other technologies, such as space-based lasers and antisatellite (ASAT) systems. During the latter 1960s and 1970s, four additional agreements were adopted (see Table 1).

The declining lack of signatories and parties to the treaties can be interpreted in a variety of ways, ranging from a growing lack of consensus on space law issues to potential overreach by negotiators who did not have the backing of their governments. China, Russia, and other states have argued that existing treaties are insufficient for safeguarding outer space as “the common heritage of mankind.”¹⁴ Supplementing the foundational treaties are an array of international principles that are nonbinding; however, these are generally considered inadequate because of their patchwork nature and lack of implementation.¹⁵

To address this longstanding concern, the UN General Assembly’s Special Session on Disarmament mandated that negotiations should take place in what is now the Conference on Disarmament, “in order to prevent an arms race in outer space.”¹⁶ Since the 1980s, the Conference on Disarmament has considered various proposals under the agenda item Prevention of an Arms Race in Outer Space (PAROS), including draft treaties aimed at preventing the placement of weapons in outer space and prohibiting the use of ASAT weapons. One example is the Chinese-Russian treaty proposal to ban weapons in space, formally known

TABLE 1
Major United Nations Space Treaties

Treaty (short name)	Date	Total Parties	Total Signatories
OST	1967	110	23
Rescue Agreement	1968	96	23
Liability Convention	1972	95	19
Registration Convention	1975	67	3
Moon Agreement	1979	18	4

SOURCES: UN, Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, New York, 672 U.N.T.S. 119, April 22, 1968; UN, Convention on International Liability for Damage Caused by Space Objects, New York, 961 U.N.T.S. 187, March 29, 1972; UN, Convention on Registration of Objects Launched into Outer Space, 1023 U.N.T.S. 15, New York, January 14, 1975; UN, Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, New York, 1363 U.N.T.S. 3, December 18, 1979; UNOOSA, "Status of International Agreements Relating to Activities in Outer Space as at 1 January 2020," January 1, 2020; and Jessica West, "Not a Frontier: The Outer Space Governance Framework," briefing at UNIDIR Space Security Workshop at United Nations Headquarters, New York: United Nations Institute for Disarmament Research, January 30, 2019.

as the Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects and commonly referred to as *PPWT*.¹⁷ First introduced by Russia and China in 2008 and introduced again in revised form in 2014, the treaty proposal has been rejected by the United States as fundamentally flawed for reasons that include the lack of a verification mechanism and the lack of restrictions on the development and stockpiling of ASAT weapons on the ground.¹⁸ The PPWT proposal also does not address the threat of space debris as a result of weapon testing. Even though Russia and China still advocate the treaty, it is stalled because of the lack of consensus between major space parties, and resistance to the PPWT appears to be growing.¹⁹

The EU introduced a separate proposal for a *non-binding* Code of Conduct for Outer Space Activities in 2008. The Code was revised as the International Code of Conduct (ICOC) in 2010, and again in the following years,

during multiple multilateral consultations involving more than 100 countries.²⁰ If adopted, the Code would be a voluntary agreement by the subscribing states. The Code proposal lays out guidelines and TCBMs and largely builds on the foundation of the OST, restating the use of outer space for peaceful purposes. If states joined the ICOC, they would agree to not damage or destroy space objects, to minimize the risk of collisions and debris creation, and to abide by and implement the Space Debris Mitigation Guidelines as laid out by the UN COPUOS.²¹ The states would also agree to notify one another of launches, maneuvers, reentries, malfunctions, and collision risks by having established points of contact. The Code also includes an information-sharing policy that would require the creation and maintenance of a designated database for sharing policy, strategy, research programs, and space situational awareness (SSA) information. In addition, the Code proposes access to site visits and demonstrations. The proposal

Despite many years of deadlock on binding treaty proposals and non-legally binding international instruments aimed at building norms of responsible behavior, there have been some promising efforts in the past few decades.

was last revised in 2015 and is generally considered to be a failure because of perceptions of a lack of inclusion in its development and a perception that it could “limit freedom of action in space for military and intelligence activities.”²² Even if the Code were to be adopted, the framework for broader information-sharing has not been created or demonstrated.

Despite many years of deadlock on binding treaty proposals and non-legally binding international instruments aimed at building norms of responsible behavior, there have been some promising efforts in the past few decades. In 2013, the UN published the report *Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities*.²³ The guidelines were based on recommendations from a group of experts from various states, as well as proposals by member states and previous proposals from the 1990s. The 2013 voluntary guidelines outlined ways to build TCBMs that are centered around the transparency of outer space activities. Four categories of information-sharing were highlighted: space policies and national security activi-

ties; outer space activities, such as orbital parameters and spacecraft launches; risk-reduction notices with respect to flight safety and emergencies; and contact and familiarization visits to other states’ facilities. The 2013 Group of Governmental Experts (GGE) report is seen as a rare success in a long-stalled effort toward international cooperation on space norms; however, its implementation is voluntary, and there is no overarching mechanism to measure compliance.²⁴

In 2010, the UN COPUOS began looking at the long-term sustainability of outer space activities. Working groups were established, and, in 2016, COPUOS agreed on a voluntary set of guidelines related to long-term stability. The guidelines were written based on feedback from four groups of experts nominated by each state and intergovernmental organization with permanent status at COPUOS. In 2018, a preamble and nine additional guidelines were added, and, in 2019, the final Guidelines for the Long-Term Sustainability [LTS] of Outer Space Activities were adopted by COPUOS.²⁵ The stated goal of LTS is to “provide guidance on the policy and regulatory framework for space

activities; safety of space operations; international cooperation, capacity-building and awareness; and scientific and technical research and development.”²⁶ Although COPUOS has encouraged states and nongovernmental entities to adopt the LTS guidelines, they are voluntary and nonbinding and are therefore unenforceable unless incorporated into national law and regulation. The LTS guidelines are grouped into four categories: policy and regulatory framework for space activities, safety of space operations, international cooperation, capacity building, and awareness, and scientific and technical research and development.²⁷ Although voluntary, the guidelines are seen as a successful step toward a dialogue on the responsible use of outer space. Unlike previous attempts, which tended to focus on self-defense and armament, these discussions focused more on space for the betterment of humanity. In 2019, the subcommittee agreed to continue discussions on the matter and to further develop the guidelines already produced. Those efforts would focus on safety and transparency in space activities. The UN has recognized that the guidelines should be a “living document” and continually updated

because of the constant evolution of space activities and behaviors. Most of the planned work for COPUOS and its subcommittees for 2020 was postponed to 2021 or limited by the coronavirus disease 2019 pandemic.²⁸ Table 2 provides a summary of some of the select efforts on space norms and behaviors. It is not intended to be a complete summary; rather, it provides a representative sample of the kinds of efforts discussed or developed in the past few decades.

The OST, the four treaties related to the OST, and the various additional nonbinding efforts (such as the 2013 GGE report on TCBMs and the LTS Guidelines) remain important foundational components of responsible space behavior. However, the rapid and significant changes in the space domain and the lack of implementation and verification methods have made them inadequate for long-term sustainability for space for humanity. The following section provides some brief insights into why there is a need for improvements in the overall portfolio of global space governance and responsible space behavior norms and the most-common barriers to change.

The rapid and significant changes in the space domain and the lack of implementation and verification methods have made the treaties inadequate for long-term sustainability for space for humanity.

TABLE 2
Summary of Select Efforts on Space Norms and Norms of Behavior

	PPWT	International Code of Conduct	GGE Report on TCBMs	LTS Guidelines
Proposer	Russia and China (via Conference on Disarmament)	EU	UN General Assembly (via UN Secretary-General)	COPUOS
Proposed legal standing	Legally binding treaty	Voluntary agreement	Voluntary guidelines	Voluntary guidelines
Verification mechanisms	None	None	None	None
Status	Lack of consensus between major space powers	Lack of consensus	Limited implementation	Limited implementation

NOTE: For various national responses, see UN, *Transparency and Confidence-Building Measures in Outer Space Activities: Report of the Secretary-General*, New York, A/72/65, February 16, 2017. For more information on various U.S. comments and statements of compliance, see Conference on Disarmament, “Note Verbale Dated 29 August 2016 from the Delegation of the United States of America Addressed to the Secretary-General of the Conference on Disarmament Transmitting the Submission of the United States to the Conference on Disarmament: ‘Implementing the Recommendations of the Report (A/68/189*) of the Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities to Enhance Stability in Outer Space,’” New York: United Nations, CD/2078, September 16, 2016; and COPUOS, *Recommendations of the Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities: Views of States Members of the Committee on the Peaceful Uses of Outer Space: Note by the Secretariat*, New York: United Nations, A/AC.105/1080, November 7, 2014.

Finally, and as noted earlier, there remains considerable debate among nations, international organizations, and other stakeholders regarding the terminology applied to the issue of space governance (e.g., *laws, regulations, rules, norms, behaviors*). Therefore, for the purposes of this paper, we have attempted to develop a set of standard definitions of key terms in our analysis. We developed these definitions based on our literature review and our discussion with subject-matter experts. We delineate these definitions in Table 3.

Contemporary Responsible Space Behavior

In the early days of space exploration, few actors had the resources and motivation to place satellites on orbit. Therefore, there was less concern over space traffic, and the focus was primarily on tracking satellites with basic position information to send and receive information or commands. As space has become more congested, the importance of *safety* from collisions has increased in importance. Safety in space hinges on the ability to carry out a satellite’s mission without unintentional interference. The growing

TABLE 3

Terminology Commonly Applied to Space Governance in the International Law Context

Common Term or Phrase	Formal or Working Definition	Definition
Hard law	Working	An instrument that has a binding legal effect (e.g., treaty, protocol). A hard law typically is self-executing or requires domestic legislation; creates mechanisms for interpretation, monitoring, enforcement, and dispute resolution; and increases the damage or cost to state credibility for reneging or violating it. ^a
Customary (international) law	Formal	A body of rules of law derived from the consistent conduct of states acting out of the belief that the law requires such conduct. It is evidenced by treaties, decisions of national courts and international tribunals, national legislation, diplomatic correspondence, opinions of national legal advisers, and the practice of international organizations. ^b
Soft law	Working	Instruments that are nonbinding that facilitate state cooperation without the threat of enforcement. They typically “are easier and less costly to negotiate”; impose lesser “sovereignty costs”; are flexible and adaptable (to cope with uncertainty); and are “available to nonstate actors.” ^c
Regulation	Working	An action by a state or group of states, primarily through treaty-based intergovernmental organizations, to control the conduct of actors through mandatory legal rules with monitoring and coercive enforcement. ^d
Rule	Formal	“An established standard, guide, or regulation. Prescribed guide for conduct or action, regulation or principle. . . . principle or regulation set up by authority, prescribing or directing action or forbearance; as, the rules of a legislative body, of a company, court, public office, of the law, of ethics. Precept attaching a definite detailed legal consequence to a definite detailed state of facts.” ^e
Norm	Formal	“A standard of appropriate behavior for actors with a given identity.” Norms may be broken down into two types: <i>regulative norms</i> , “which order and constrain behavior,” and <i>constitutive norms</i> , “which create new actors, interests, or categories of action.” ^f
Norm of behavior	Formal	A norm that “exists . . . to the extent that individuals usually act in a certain way and are often punished when seen not to be acting in this way”; ^g behavioral regularity in response “to an established rule or guideline, the violation of which generates some kind of external sanction.” ^h
Responsible behavior	Working	An act or actions that are consistent with international codes of conduct, standards, guidelines, and rules for the safe, sustainable, secure, and stable use of a domain in collaboration with other actors. ⁱ
Standard	Working	An international rule, guideline, or characteristic “for activities or their results, aimed at the achievement of the optimum degree of order in a given context.” Standards may take the form of test methods, codes of practice, guidelines standards, and management system standards. ^j

Table 3—Continued

Common Term or Phrase	Formal or Working Definition	Definition
NOTES: For the purposes of this paper, we classify terms as having a <i>formal</i> or <i>working</i> definition. If a term is defined by a legally authoritative document or is otherwise described consistently throughout the academic and subject-matter expertise literature, we classify its definition as formal. If the term is otherwise applied in academic or subject-matter expertise literature, has varying definitions, or is otherwise used in soft law references without clearly being described, we classify its definition as working. ^a Gregory C. Shaffer and Mark A. Pollack, “Hard vs. Soft Law: Alternatives, Compliments and Antagonists in International Governance,” <i>Minnesota Law Review</i>, Vol. 94, 2010. ^b International Law Commission, “Part II: Ways and Means for Making the Evidence of Customary International Law More Readily Available,” <i>Yearbook of the International Law Commission</i>, Vol. II, 1950; and Shabtai Rosenne, <i>Practice and Methods of International Law</i>, New York: Oceana Publications, Inc., 1984, p. 55. ^c Pollack and Shaffer, 2010, p. 719. ^d Adapted from Julia Black, “Decentring Regulation: Understanding the Role of Regulation and Self-Regulation in a ‘Post-Regulatory’ World,” <i>Current Legal Problems</i>, Vol. 54, No. 1, 2001. ^e Henry Campbell Black, Joseph R. Nolan, and Jacqueline M. Nolan-Haley, <i>Black’s Law Dictionary: Definitions of the Terms and Phrases of American and English Jurisprudence, Ancient and Modern</i>, 6th ed., St. Paul, Minn.: West Publishing Co., 1990, p. 1331. ^f Martha Finnemore and Kathryn Sikkink, “International Norm Dynamics and Political Change,” <i>International Organization</i>, Vol. 52, No. 4, 1998, p. 891 (citing Peter J. Katzenstein, ed., <i>The Culture of National Security: Norms and Identity in World Politics</i>, New York: Columbia University Press, 1996, p. 5). ^g Robert Axelrod, “An Evolutionary Approach to Norms,” <i>American Political Science Review</i>, Vol. 80, No. 4, December 1986, p. 1097. See also Vaughn P. Shannon, “International Norms and Foreign Policy,” <i>Oxford Research Encyclopedia of Politics</i>, Oxford: Oxford University Press, June 2017, p. 2. ^h Gretchen Helmke and Steven Levitsky, “Informal Institutions and Comparative Politics,” <i>Perspectives on Politics</i>, Vol. 2, No. 4, December 2004, p. 747. See also Shannon, 2017, p. 2. ⁱ Adapted from Gregory L. Schulte and Audrey M. Schaffer, “Enhancing Security by Promoting Responsible Behavior in Space,” <i>Strategic Studies Quarterly</i>, Vol. 6, No. 1, Spring 2012. ^j Adapted from the International Organization for Standardization definition (see International Organization for Standardization, “1. Standards in Our World,” webpage, undated).		

number of space actors, space objects, and space debris in the New Space Era creates challenges for operating safely in space.²⁹ To provide a sense of magnitude, some estimate that 96 percent of space objects are untracked and the number of satellites on orbit could increase by four to ten times in the next decade.³⁰ Maintaining a safe environment in space requires a chain of interconnected activities that includes detection, tracking, communication and coordination between users, and, if necessary, commands to maneuver satellites to prevent potential collisions. There is also the need for more debris management to mitigate the ever-increasing buildup of inactive objects in space. Nearly

every step in this chain has shortcomings, so there is a compelling need to improve overall safety activities.

Safety and sustainability go hand in hand. Efforts to increase safety in space will also affect the future sustainability of space operations. COPUOS defines the *long-term sustainability of space* as

the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations.³¹

Put simply, sustainability ensures that space continues to be accessible by all nations in the future. The challenge is that space is a shared resource and subject to a tragedy-of-the-commons scenario,³² in which it could become unusable because of the buildup of space debris that prevents use by others.³³ *Tragedy of the commons* refers to a shared-resource system in which individual users, acting independently according to their own self-interest, behave contrary to the common good of all users by depleting or spoiling the shared resource.

Although other domains deal with similar sustainability considerations, the physics of space results in long-term debris problems that are significantly more concerning. Orbital debris above 800 km can stay in space for decades, while debris above 1,000 km can stay in space for more than a century.³⁴

Some Key Problem Areas to Address

In this section, we identify and discuss the five key problem areas that responsible space behavior should address to prevent a tragedy-of-the-commons scenario for space. We also identify and discuss two major barriers to action that currently impede progress toward resolving these problem areas.

The problem areas are

- SSA and space traffic management (STM)
- debris mitigation
- ASAT testing
- rendezvous and proximity operations (RPOs)
- conflation of safety and security.

The barriers to action are

- motivations and interests
- lack of a rule-of-law framework.

To arrive at these two lists, we applied the following methodology. First, we identified recurrent problems and barriers in the existing academic and subject-matter-expert literature and workshops related to space operations and governance. Limiting our focus to recurring themes ensured that we did not focus on outliers. Second, we narrowed the list to include only steps that could lead to the development of norms. Much of the existing literature and many of the discussions on space norms occur at a theoretical or values level without any clear path to tangible results. This narrowing was based on qualitative conclusions that we drew from the literature and from the interviews and workshops we conducted. In sum, each of these lines of effort suggested that the problem areas and barriers identified were those for which there is already some level of agreement (within the space community and among space stakeholders) on the need for action. Third, we focused on (1) barriers and areas in which our lines of effort suggested that there is the greatest potential for near-term, achievable goals toward development of more-formal norms or rules and (2) areas that were in most need of attention, based on relative risks of continued inaction. Fourth, we selected the problem areas for improvement and barriers to action that are the most-widely applicable to the space stakeholder community.

We acknowledge that experts and analysts debate the various problems that warrant attention and need to be addressed to prevent a tragedy of the commons. However, drawing on internal and external responsible space behav-

ior workshops, review of key literature, and interviews with experts and policymakers, we focused on these problem areas and barriers as a potential first step toward developing internationally accepted norms. We present additional support for this assertion in more detail later. This Perspective is not meant to provide an exhaustive list or an exhaustive discussion of each problem area or barrier. Rather, it is designed to help focus on the most-important areas and barriers needing attention.

Space Situational Awareness and Space Traffic Management

More-reliable, more multisource-integrated, and more widely available SSA and STM systems are needed to ensure the safety and sustainability of space operations between active satellites and orbital debris. This is true both in the United States and more broadly.³⁵ Compared with the estimates of debris offered earlier, there were more than 1,700 active satellites on orbit in 2017 and 3,000 more planned to launch before 2026.³⁶ Satellites range in size from India's KalamSat-V2, which can fit in a person's hand, to precision military satellites, which are the size of a

school bus.³⁷ Unfortunately, the terms SSA and STM do not have internationally accepted definitions. One study found 14 different definitions for SSA and five for STM.³⁸

There is an increasing dialogue in the international space community of the growing importance of both SSA and STM because of a growing number of on-orbit collisions or near misses. One recent near miss provides an instructive case study because it shows the multiple players and gaps in the existing systems for coordination. On September 2, 2019, two active satellites were on a course to potentially collide in low earth orbit (LEO).³⁹ One of the European Space Agency's (ESA) earth observation satellites (Aeolus) and one of SpaceX's proliferated Starlink satellites were flagged as being in danger of colliding. The U.S. government, which currently provides broad SSA services, alerted the satellite operators to the potential collision, but, because there are no international guidelines on how to handle collision avoidance, it was left up to the space operators to determine a response.⁴⁰ Because of a glitch in SpaceX's software, SpaceX never got the email sent by ESA to discuss mitigations. ESA had to make the decision on what to do next, ultimately deciding to maneuver away and avoiding a debris-generating collision.⁴¹ Unplanned

More-reliable, more multisource-integrated, and more widely available SSA and STM systems are needed to ensure the safety and sustainability of space operations between active satellites and orbital debris.

maneuvers dip into precious onboard fuel reserves, which, in most cases, determine mission life of a satellite. Defining the party responsible for maneuvering in different circumstances is an important detail to work out prior to potential collision events. Although a disaster was avoided on this occasion, the lack of international process and guidelines when it comes to STM means that this scenario could happen again with different results.⁴²

For many years (from 1958, via NASA's Orbital Information Group, through early 2021, via U.S. Space Command's SSA Sharing program), the U.S. government was the principal provider of SSA information.⁴³ Over the past decade, as the number of space operators and the amount of congestion in space increased, more entities have developed and are using their own SSA systems and information, greatly increasing available data but also introducing the possibility for conflicting information. Russia has had its own SSA system for decades.⁴⁴ The Space Data Association began coordinating SSA-sharing between operators in 2009, and, as of 2020, the EU has at least seven nations participating in its own Space Surveillance and Tracking Support Framework.⁴⁵ There is currently no international organization that provides global SSA and STM oversight, but there is increasing interest in the development of one.⁴⁶ Filling the vacuum of a comprehensive system, nations and operators are creating their own standards. Stovepiped SSA and STM have the potential to increase the information burden already felt from the number of collision alerts sent out. The U.S. government sent out 655 emergency alerts to satellite operators in 2017 (579 were in LEO) and witnessed 310,000 close calls.⁴⁷ The number of alerts (and conflicts between systems about data

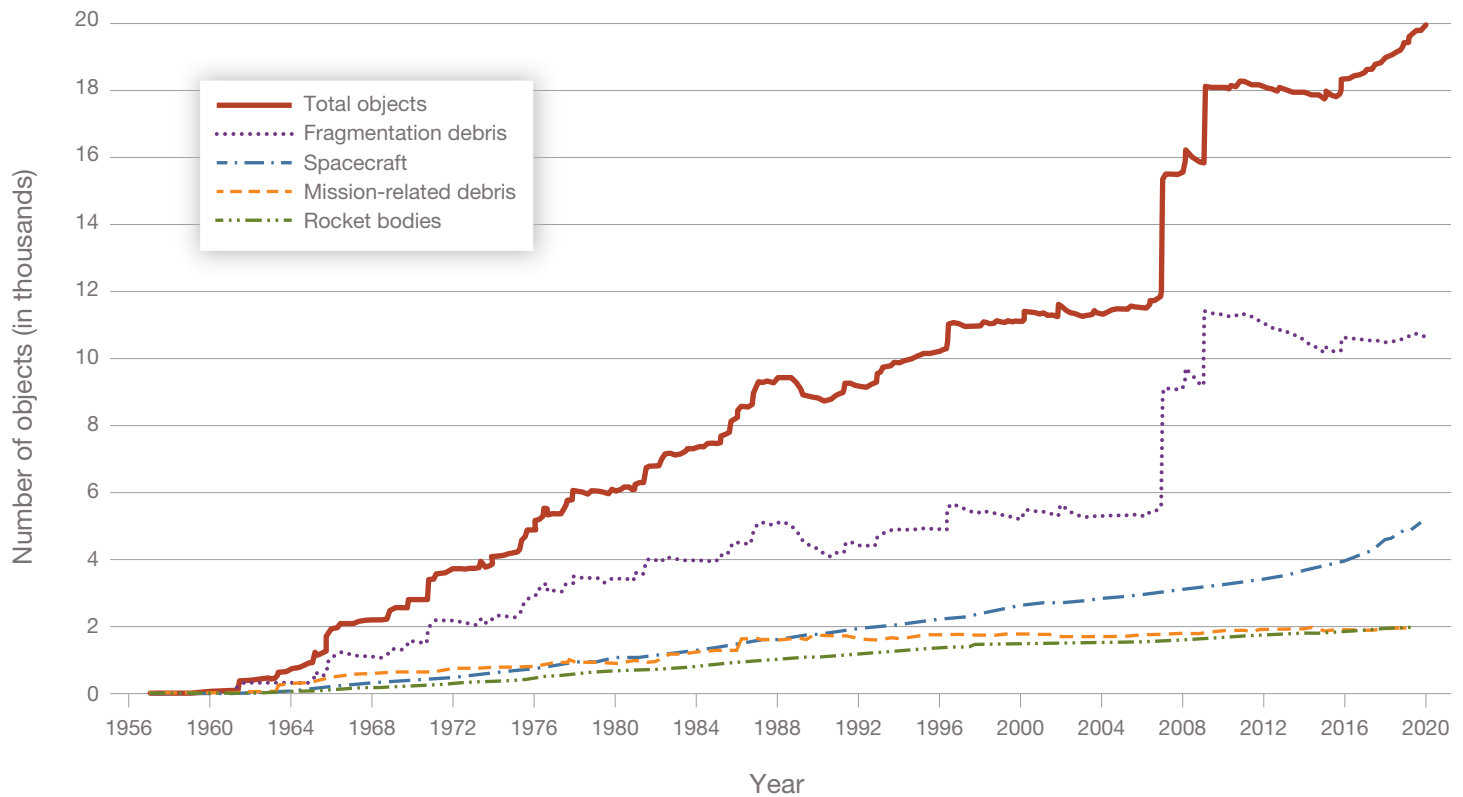
Defining the party responsible for maneuvering in different circumstances is an important detail to work out prior to potential collision events.

accuracy) will increase as the catalog of space objects grows and the number of entities providing SSA increases.

Debris Mitigation

With the expansion of the use of outer space, the number of objects in space has been steadily growing (Figure 1).⁴⁸ Not all objects in space are active; more than 90 percent of objects in near-earth space are nonfunctional and considered space debris (e.g., dead satellites, launch vehicle stages, fragments from collisions in space).⁴⁹ Space debris poses challenges that threaten the safe and long-term use of space. SSA becomes more complex the more objects there are in space to track. According to NASA's Orbital Debris Program Office, "More than 21,000 orbital debris larger than 10 cm are known to exist. The estimated population of particles between 1 and 10 cm in diameter is approxi-

FIGURE 1
Monthly Number of Objects in Earth Orbit, by Object Type



SOURCE: Adapted from NASA, *Orbital Debris Quarterly News*, Vol. 24, No. 1, February 2020.

mately 500,000. The number of particles smaller than 1 cm exceeds 100 million.”⁵⁰ Some estimates place the total number at around 160 million.⁵¹ STM also becomes more difficult with the increase in the potential number of collisions. The collision of objects in space, in turn, creates more debris and is already a current reality.⁵²

The first recorded collision between an active satellite and debris occurred in 1996, when a French government spacecraft collided with a piece of debris from an ESA rocket body.⁵³ In 2009, a collision occurred between the inactive Russian satellite Cosmos 2251 and the active U.S. commercial communications satellite Iridium 33, creat-

ing 1,875 pieces of debris greater than 10 cm. Iridium had not received any warning of the potential collision.⁵⁴ Since then, the number of near misses has increased. In 1978, Donald Kessler looked at the possible implications of the potential effects of space debris, including a scenario in which debris created from one collision sets off a long-term chain of events, and the new debris causes more collisions that outpace the time required for natural orbital disposal. Eventually, space becomes so full of debris that safe space operations are no longer viable.⁵⁵ Today, this scenario is known as the *Kessler Syndrome*.

The potential for a Kessler Syndrome event and real-life collision between space objects has led to a greater push for satellite end-of-life (EOL) planning in the design phase to include maneuvers for orbital disposal. Spacecraft either maneuver back to earth, where they are destroyed during reentry, or are sent to graveyard orbits for long-term storage. Although EOL planning can help better manage inactive space debris, building in the extra fuel for these maneuvers adds cost. Planned proliferated constellations in LEO composed of thousands of satellites will further crowd space, increasing the potential for debris-generating collisions.⁵⁶ NASA has been a leader in creating orbital debris-mitigation guidelines both nationally and internationally, issuing the first-ever set of comprehensive guidelines in 1995. These guidelines were later adopted and developed into the U.S. government's Orbital Debris Mitigation Standard Practices.⁵⁷ In 2007, the UN General Assembly endorsed the voluntary Space Debris Mitigation Guidelines of the COPUOS and invited member states to implement those guidelines through relevant national mechanisms.⁵⁸ Although helpful, the voluntary guidelines lack measures for accountability, and recent studies indicate that the lack

of compliance with debris-mitigation guidelines is the biggest contributor to greater collision risk.⁵⁹ One modest but potentially helpful initiative designed to improve accountability of satellite operators is the Space Sustainability Rating (SSR). The SSR is intended to encourage responsible space behavior in space "through increasing the transparency of organizations' debris mitigation efforts. The SSR will provide a score representing a mission's sustainability as it relates to debris mitigation and alignment with international guidelines."⁶⁰

Anti-Satellite Testing

Aside from collisions of space objects, testing of kinetic ASAT weapons has created large debris fields in space and has both safety and security implications. Early in the Cold War, both the United States and the USSR designed and tested ASAT weapons, but many of those efforts ended in the 1980s.⁶¹ In 2007, China conducted an ASAT test on one of its failed satellites near 865 km, creating more than 35,000 pieces of debris, in the largest debris-generating incident to date. The 2007 Chinese ASAT test increased the amount of debris in space by 20 percent and received international condemnation.⁶²

Since then, other nations, including India, Russia, and the United States, have tested aspects of systems capable of kinetic ASAT attacks on orbit or used direct-ascent missiles to destroy inactive satellites. However, these post-2017 events were typically planned with the goal to minimize orbital debris generation. For example, in March 2019, an Indian ASAT test generated approximately 400 fragments that will decay in weeks or perhaps a few months because the target was orbiting at less than 300 km. As of the end

of 2019, less than 20 pieces of the debris created from the Indian ASAT test earlier that year remained on orbit.⁶³ More recently, Russia has reportedly conducted several tests of both direct-ascent ASATs and systems purported to be co-orbital ASATs.⁶⁴ Although more-recent tests by India and Russia were executed in a way to minimize debris, they are adding to the catalog of space debris and normalizing a culture of on-orbit kinetic ASAT testing. The lack of a prohibition on debris-generating ASAT tests, and, some would say, on ASAT testing in general, is a widely acknowledged challenge for both space sustainability and space security.

Rendezvous and Proximity Operations Standards

RPOs are planned orbital maneuvers that place a spacecraft in the vicinity of another spacecraft on the same orbit and approach it for a specific purpose. Such operations have been used since the 1960s and are used to connect supply vessels with space stations. More recently, interest has been steadily increasing for such applications as satellite on-orbit servicing, refueling, and debris mitigation. RPOs can be cooperative or noncooperative. An RPO is cooperative

when information flows mutually between the two spacecraft during a planned operation; it is noncooperative when information is transferred only one way. The International Space Station has carried out multiple cooperative RPOs, including some docking operations. A noncooperative RPO can be consensual when it is a coordinated effort (e.g., to retrieve a failed satellite or to remove space debris), or it can be nonconsensual (e.g., to interfere with another user's asset).⁶⁵ Sample RPOs are shown in Figure 2.

The Defense Advanced Research Projects Agency (DARPA) has been working to develop RPO and on-orbit servicing technologies for the United States and established the U.S.-led Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) to engage industry in establishing responsible RPO behaviors.⁶⁶ In 2020, a commercial defense contractor demonstrated on-orbit servicing of a commercial satellite.⁶⁷ Separately, in December 2020, NASA released a handbook that details best practices for on-orbit conjunction assessment and collision avoidance. The handbook, developed in cooperation with U.S. Space Command,

discusses the maneuverability, tracking, reliability, and disposal of space hardware. Additional topics

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include space vehicle and constellation design, spacecraft trackability, prelaunch preparation and early launch activities, in-orbit collision avoidance, and automated trajectory guidance and maneuvering.⁶⁸

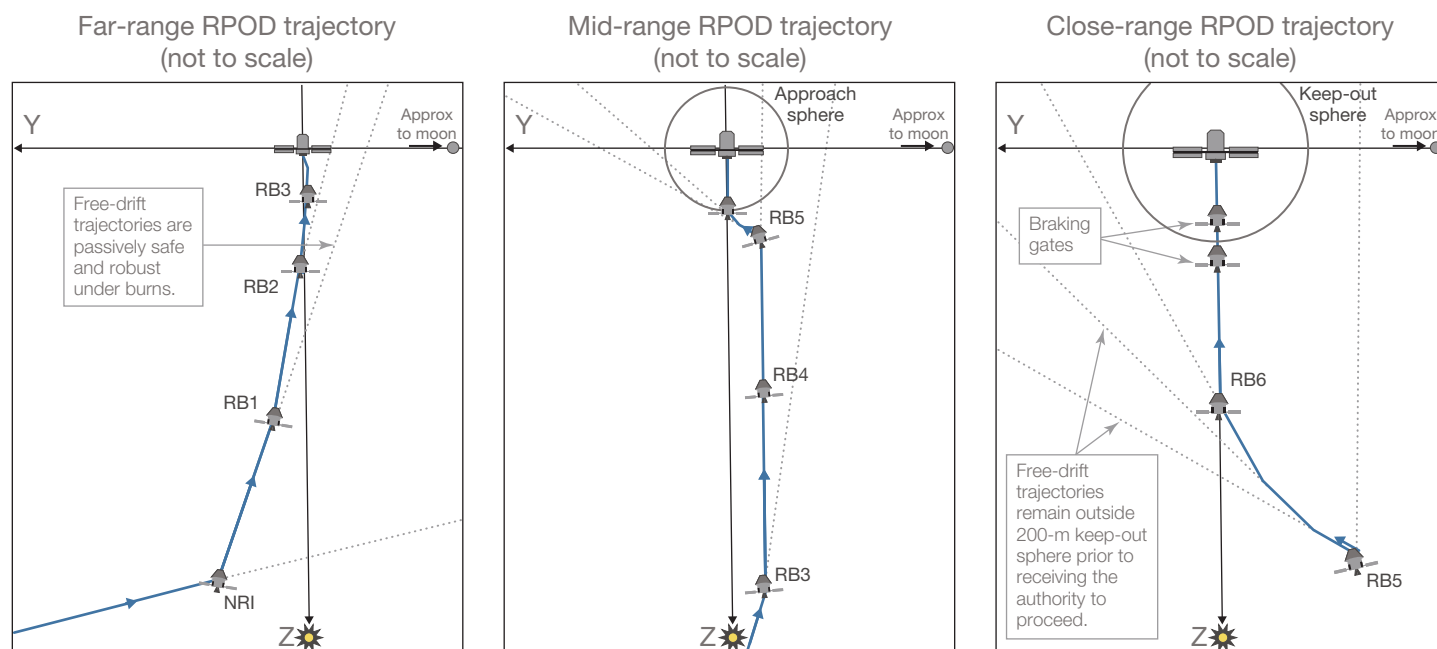
Although positive steps, the approaches outlined in NASA's *Best Practices Handbook* are voluntary and leave specifics about how to decide maneuvers up to satellite operators. CONFERS is also a positive step but leaves much unresolved regarding international norms. There is no

internationally accepted standard, or distancing guidelines, to define how close is too close, and Article VI of the OST only requires governments to loosely supervise such non-traditional space activities as RPOs.⁶⁹

Conflation of Security and Safety

The U.S. military's dependence on and advanced capabilities in the space domain over the past several decades have not gone unnoticed. China and Russia have reorganized

FIGURE 2
Sample Rendezvous and Proximity Operations



SOURCE: Adapted from Peter Z. Schulte, Peter T. Spehar, and David C. Woffinden, GN&C Sequencing for Orion Rendezvous, Proximity Operations, and Docking, Washington, D.C.: National Aeronautics and Space Administration, JSC-E-DAA-TN77227, January 30, 2020.

NOTE: NRI = near-rectilinear halo orbit insertion; RB = rendezvous burn; RPOD = rendezvous, proximity operations, and docking.

The possibility of a terrestrial conflict extending into space or a conflict beginning in space is becoming increasingly real.

their militaries to emphasize space warfare and have accelerated efforts to develop both kinetic and nonkinetic capabilities to deny and exploit the perceived U.S. asymmetrical advantage in space.⁷⁰ North Korea and Iran have been developing their own arsenals of kinetic counterspace assets, which is particularly concerning considering their lack of space assets.⁷¹ As mentioned earlier, India also recently conducted an ASAT test. Although there have been efforts to develop space weapons since the Cold War, the United States recently declared space a warfighting domain, established the U.S. Space Force, and revived the U.S. Space Command.⁷² France has followed suit, standing up its own military space command, while other countries, such as Australia, are considering similar steps. The North Atlantic Treaty Organization has also recognized this shift in space, declaring space an operational domain.⁷³ The various organizational changes are a symptom of the growing dependence on space and the increasing number of space actors that can contest space. The possibility of a

terrestrial conflict extending into space or a conflict beginning in space is becoming increasingly real.

Conflict is already a possibility and often a reality in other domains, such as the land, maritime, air, and even cyber domains. Yet space is considered, by treaty, the “province of all mankind,” and conflict in space can have implications that can extend well beyond the interests of the immediate parties to a conflict. Counterspace capabilities designed for combat thus become a threat to the benign environment of space, intertwining space security with safety. The current leaders of the U.S. Space Force recognize the connectivity between security and safety. In the recently published *Chief of Space Operations’ Planning Guidance*, Gen John W. Raymond states, “We will partner with and lead others to further responsible actions in, and use of, space to promote security and enhance prosperity.”⁷⁴ Complicating matters further, space technology being developed by the commercial sector has the propensity to be dual use, allowing for applications by both the commercial and military sectors. Dual-use technology creates further security challenges, making it difficult to read intentions in space. Robotic technology designed for satellite repair, servicing, or debris removal could also be used for tampering with an adversary’s asset. Inspection satellites that require proximity operations to potentially fix or refuel broken satellites could be used for military purposes. In 2017, Russia deployed an inspector satellite that it claimed was used to diagnose one of its own satellites that was experiencing technical difficulties; however, it was noted that the inspector satellite’s behavior was inconsistent with on-orbit inspection capabilities, creating international suspicion.⁷⁵ Even if it were possible to regulate space technology, such an approach would limit potential

commercial opportunities and capabilities that are beneficial to space, such as debris management. This drives the need for a set of globally accepted behaviors rather than globally imposed technology restrictions. Defining responsible behaviors in space is necessary, but not sufficient, to promote security and ensure access.

Barriers to Action

Although this section focuses on the two major themes regarding barriers to creation of responsible behaviors in space, one foundational barrier that must be discussed is a lack of awareness of the problem. In the beginning of the space era, collisions between two objects were considered unlikely. This assumption breaks down as more and more objects populate space. Space operators can no longer rely on the idea that space is vast and there is no need for coordination as the number of actors, objects, operations, and collisions in space increases every year.⁷⁶ More broadly, there is an apparent lack of appreciation for the importance of space to the global community. Many people—both citi-

zens and leaders—outside of major space powers still lack an appreciation for the global dependence on space. All space stakeholders, not just the major and emerging space powers, must first understand the problems facing the New Space Era and the potential tragedy of the commons that applies, or there will be little incentive for change.

Motivation and Interests

The difference of individual self-interest versus collective thinking has long been a barrier to development in responsible space negotiations. Collective thinking, developed through an agreed-upon, legitimate bureaucratic process, is crucial for the successful development of norms, voluntary or nonbinding rules, or the passage of any future legal framework. Notwithstanding the value of a recognized collective process for developing norms, in the past few decades, there has been a divergence of individual interests because of a lack of a common benefit. With the rise of the commercial space sector and academia, more and more players have a say in what they believe responsible

All space stakeholders, not just the major and emerging space powers, must first understand the problems facing the New Space Era and the potential tragedy of the commons that applies, or there will be little incentive for change.

space should look like. Governments, commercial actors, academic institutions, and nations—whether mature space-faring nations or aspirant spacefaring nations—all have different goals and interests in space, making it more difficult than ever to prioritize collective thinking. Leading space powers inherently have a self-interest in their space programs, often relating to self-defense measures. This leads to a complication in defining a common benefit, especially when the common benefit is individually protecting a state's own defense interests. From the earliest days of the OST, differing interpretations of “peaceful uses of outer space” and acceptable use of self-defense have made it increasingly difficult for space actors to come to a consensus regarding their military assets in space.⁷⁷

While each space actor sees weaponization of space as something to avoid, most states are not willing to sign something that will limit their capability for self-defense. Some states see true nonmilitarization of space as not only forgoing testing of space weapons but also limiting research and development of these weapons to begin with. Some states, such as Russia and China, argue that a ban on the implementation of weapons in space is enough. A key critique of the PPWT by the United States is that, although

it disallows deployment of weapons in space, it does not stop development, testing, and storage of weapons.⁷⁸ China has publicly stated that it sees space as a critical warfighting domain, and Russia has openly discussed its development of counterspace capabilities, both aligning with their own self-interests of pursuing a robust military capability in space. The 2020 U.S. Defense Space Strategy lists first and foremost the U.S. Department of Defense's desire to maintain space superiority, including the ability to “deter and defeat adversary hostile use of space.”⁷⁹ The self-interest of one player can ruin space for all. The problem can arise because all states see self-defense as their number-one priority in all domains. Although most states want to limit the production of counterspace weapons by others, those that have the capability to do so do not want to give up their right to develop these systems as a means for self-defense. This divergence of a common benefit of space has only fractured further in the past decade as capabilities of counterspace systems have become much more robust.⁸⁰

Self-defense and preservation of space capabilities (usually directly tied to the preservation of the space asset) are top priorities for state actors, but commercial actors' goals also present a difficulty in responsible space

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negotiations. The private sector tends to prioritize the stability of its revenues, through satellite collision avoidance, on-orbit rendezvous and servicing operations, and debris-mitigation best practices.⁸¹ This can lead to a divide between states and the private sector about regulations and rights in space.

Lack of a Rule-of-Law Framework

It can reasonably be argued that the single most significant impediment to establishing globally recognized standards for responsible space behavior is the 1967 OST itself, in addition to the four subsequent space treaties that encompass the existing body of space law.⁸² Although these five treaties theoretically have the binding force of law within the countries that ratified them, all fail to establish a comprehensive, hard-law, space governance system that is necessary to provide a predictable system of behavior among space-capable states. The reasons for this are primarily twofold.

First, none of the five treaties incorporates an enforcement mechanism to constrain or punish aberrant behavior in space by state or nonstate actors. This is particularly so for issues related to SSA, STM, and debris management, which were not immediate concerns in 1967 given the few states that maintained space capability at the time (i.e., the United States and the USSR). We define *aberrant behavior* as conduct or actions that fall outside the stipulated conditions or requirements of the treaties, customary international law, or the soft-law nonbinding system of norms or other informal agreements that have developed since ratification.⁸³ The nonbinding system represents customary conduct and documented or undocumented guidelines that

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states have regularly followed since 1967 with respect to SSA or STM, or both. The 2019 COPUOS LTS Guidelines discussed earlier are an example of a recent attempt to develop additional nonbinding, but formally documented, rules of space behavior. Sovereign states can then choose to adopt rules as part of their national laws and regulations.

Each signatory to the five treaties maintains its sovereign right to regulate (through its own domestic legislation and executive action) its own conduct in space and the conduct of actors who launch objects into space within its boundaries. The UN institution dedicated to space issues (i.e., COPUOS) is essentially collaborative and an advisory forum without the authority to enforce treaty requirements or conditions.⁸⁴ Although the UN Security Council maintains jurisdiction to sanction treaty violators, such an action would require agreement by nine voting mem-

bers, including concurring votes from the five permanent members.⁸⁵

SSA and STM, particularly when considered in conjunction with the issue of space debris, provide an example of the impact of the lack of enforcement mechanisms. Because no independent and objective international entity exists with the authority to enforce any SSA or STM standards, there is no “traffic cop” in space to identify, police, and arrest violative actors. Although the United States operates Space-Track.org, which provides SSA information, this system fails to provide a comprehensive SSA or STM solution. Experts note that Space-Track.org has a high alert rate and, because it fails to register numerous U.S. space objects, lacks the full transparency that would be a prerequisite for encompassing SSA and STM.⁸⁶ Moreover, there is no independent tribunal before which SSA issues or STM

The five treaties—particularly the OST—incorporate operative language that is vague and ambiguous and lends itself to arbitrary application by the signatory states.

disagreements among member states may be adjudicated, determined, and enforced.

A recent SSA event illustrates the significant risks associated with the lack of a fixed adjudicative and enforcement mechanism. In 2015, a Russian satellite was positioned between two Intelsat satellites in geostationary orbit with an assigned International Telecommunications Union orbital slot, putting all of the satellites in serious danger of collision.⁸⁷ Intelsat appealed directly to Russian officials, but the Russians did not substantively address the incident.⁸⁸ Because there was no authoritative body to appeal to or enforcement mechanism to apply, Russia’s disregard for norms associated with communications and operating procedures went essentially unaddressed. This might be an invitation to other state and commercial actors to ignore existing norms whenever it is in their perceived interest to do so.

In practical terms, the lack of an enforcement mechanism results in an inability to prevent, deter, or punish—by means of legal or regulatory consequences—behaviors in space that could dramatically increase the risk for a catastrophic Kessler Syndrome event. Not surprisingly, therefore, such incidents as the Chinese and Indian ASAT tests, which significantly increased the difficulties and risks associated with SSA and STM for all nations, have gone unpunished as a legal matter. States are constrained from engaging in such violative behaviors only to the extent that they believe that refraining from such behaviors is in their political, economic, and international self-interests. This defies most accepted definitions of what constitutes the rule of law, which requires that every political actor in a system, including the state, be subject to enforceable rules.⁸⁹

Second, the five treaties—particularly the OST—incorporate operative language that is vague and ambiguous and lends itself to arbitrary application by the signatory states. Because no international authority or tribunal with the power to define terms and phrases universally exists, each signatory may interpret the language of the various treaty requirements and conditions in accordance with its own legal customs, traditions, and teleological approach.⁹⁰ In addition to a lack of definition of *SSA* and *STM*, even basic terms, such as *space objects* and *space debris*,⁹¹ are not defined in a lexicon that is uniformly accepted by all states. Additionally, such phrases as “due regard to the corresponding interests of all other States Parties,”⁹² “harmful interference,”⁹³ and “peaceful purposes”⁹⁴ are not further delineated or described by the treaty and are broadly open to interpretation by its signatories.⁹⁵

Without a clear definition of what constitutes space debris, nations are free to define at will or to accept (or reject) definitions provided by such organizations as COPUOS and its supporting subcommittees and independent national efforts.⁹⁶ Some industry groups have recognized the lack of a standard lexicon and have begun efforts to standardize space terminology.⁹⁷ However, it is unclear whether states and commercial actors are adopting either UN or industry terminology standards, or, if they are, to what degree they are adhering to them. Because of this lack of clarity and uniformity, and because the OST provides that a nation maintains exclusive jurisdiction over any object that it launches into space in perpetuity,⁹⁸ it is not clear that any space debris can be removed by any entity other than the original launching nation. This would include even the removal of debris that is a danger to navi-

gation or to other satellites or spacecraft.⁹⁹ Any collective efforts among states to remove debris would be further complicated if a nation chose to define *space debris* in such a manner that the nation would—by its own laws—either not be responsible for its currently derelict objects that it had launched in the past, or be empowered to seize the space objects (derelict or active) of other nations that it perceived to be a danger to STM.

Potential Solutions

So far, we have briefly described the evolution of space treaties, discussed five key problems, and summarized some barriers to action. Now what? There are countless commentaries, white papers, and assessments that discuss why norms for responsible space behavior are needed.¹⁰⁰ There are fewer products that describe how to establish responsible space behavior practices that can be implemented. There are several ways to move forward to more formally establish responsible space behavior. This section highlights a few of the most important potential solutions to help catalyze tangible progress needed.

We focus on a few key themes that should help guide leaders and policymakers toward tangible norms for responsible space behavior. In some cases, we offer specific examples of areas for initial steps, when these steps are relatively obvious and seem likely to produce quick wins. Our preliminary analysis suggests that leaders should focus on paths to space norms that

- increase communication and engagement
- increase transparency for all

- begin with quickly achievable demonstrations of progress and accountability (quick wins)
- concentrate on safety before including security considerations
- progress toward security agreements.

Increase Communication and Engagement

Although the knowledge level of the space policy community is quite high, indications are that there is less awareness of the importance of space to daily life outside the relatively small expert community. The lack of awareness of the significance of space for daily life, at the citizen and leadership levels in entry-level and nonpacefaring countries, demonstrates the need for increased communications and engagement. The risks of continued inaction are greater than they were for the maritime and air domains because of the possibility of long-term damage to the space environment and the resultant impacts on humanity's collective way of life on earth. Therefore, we recommend a proactive and coordinated global information campaign that will not only build awareness but also facilitate the alignment of nations on the importance of

space for all. This campaign should include multiple space actors rather than just one organization. COPUOS, using UNOOSA, already has some initiatives in this area, such as the Promoting Space Sustainability Project and a program titled "Space Law for New Space Actors: Fostering Responsible National Space Activities."¹⁰¹ More broadly, the UN General Assembly adopted a UK proposal in December 2020 titled "Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours." This proposal is a good first step because it encourages all UN member states to "study existing and potential threats" and to share national space security policies, strategies, or doctrines and expresses "the desire that all Member States reach a common understanding of how best to act to reduce threats to space systems in order to maintain outer space as a peaceful, safe, stable and sustainable environment."¹⁰² As many nations as possible should submit inputs to the Secretary General to ensure maximum inclusion and awareness for the final report that is expected by the UN General Assembly's 76th Session in late 2021.¹⁰³

Given the slow pace and stagnation in various UN venues for an agreement and the limited ability of the UN

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space organizations to shift public opinion, leading space nations should also seize this opportunity to foster more dialogue *outside* UN expert groups and committees and in the broader public domain. One clear standout in this regard is the United Kingdom, which underwrites the UNOOSA Promoting Space Sustainability Project and has undertaken multiple efforts to educate and inform a global audience.¹⁰⁴ The United States has consistently claimed a leadership role in international space cooperation; it should lead or underwrite efforts similar to those funded by the United Kingdom (akin to U.S. leadership with regard to developing TCBMs). A specific, helpful step would be to augment a wider discussion about the economic importance of space for everyone on earth and the tragedy-of-the-commons scenario that could play out without concerted action. In its own modest way, this Perspective is intended to contribute to that effort by summarizing the history, evolution, problems, challenges, and potential solutions for those outside the space expert community. Nations and industry should also continue the important work of establishing a common lexicon for space terms and activities. Standardizing the language of space would facilitate the development of the more-complex aspects of SSA and STM. This comprehensive approach to increase communication and engagement will set the stage for voluntary increases in transparency regarding space activities.

Increase Transparency for All

An important aspect of increased communication and engagement is the imperative to increase SSA transparency for all. Space has traditionally been a domain in which it has been more difficult to detect and attribute behavior,

Nations and industry should continue the important work of establishing a common lexicon for space terms and activities.

and only a few nations have been able to maintain SSA on the most-important space objects. From a broader perspective, the early decades of the space era were similar to the Golden Age of Sail, the period between the mid-18th century and the early 19th century when use of commercial sailing vessels was at its peak but there was limited ability to maintain maritime domain awareness.¹⁰⁵ The invention of the telegraph signaled an intermediate period in maritime domain awareness in which awareness of vessels improved. Space awareness is at a similar intermediate period because of limited coverage, lack of a common operating picture, and debates about data accuracy. Just as the world experienced an evolution from limited maritime domain awareness for a few key maritime powers to an era in which maritime domain awareness is much more widely available, stakeholders need to develop SSA that is widely available.

There likely will always be exceptions to full transparency for national security imperatives in space, just as there

All major space players should cooperate on increased transparency regarding on-orbit operations. Failing to do so undermines the credibility of those that claim to favor transparency and responsible behavior.

are for other domains (and we discuss these security considerations later). However, space powers would be better served by acknowledging the existence and orbits of space platforms, especially when they are more easily detected today than decades ago—not only by other nations but by amateur observers who widely share the information. The United States has taken some preliminary steps to be more transparent in this area by adding previously unacknowledged satellites to its own public database.¹⁰⁶ However, there are still numerous objects that the United States, China, Russia, and others do not add to the UN registry or that these nations do not acknowledge or include in the current SSA system.¹⁰⁷ Leading space powers should

acknowledge that their platforms exist and then provide updates on their activities without fully releasing the capabilities of these platforms. The lags or lack of reporting by spacefaring nations when objects are detected and cataloged by multiple sources undermines the credibility of major space powers and demonstrates a lack of full commitment to existing space treaties.¹⁰⁸ All major space players should cooperate on increased transparency regarding on-orbit operations. Failing to do so undermines the credibility of those that claim to favor transparency and responsible behavior. The powers that demonstrate tangible transparency first are more likely to emerge as leaders in the longer-term effort to develop norms for responsible behavior, while those that continue to attempt to hide in plain sight will lose credibility and influence. The U.S. intention to transition SSA to the U.S. Department of Commerce and introduce an Open Architecture Data Repository is a promising step that would position the United States to build a reputation as a more transparent space nation and the potential leader in the important area of SSA and, eventually, STM. However, the leadership of the United States is not a foregone conclusion. Several years of wrangling over U.S. government SSA and STM leadership have frustrated the commercial sector and created room for the EU and other organizations to develop their own systems.¹⁰⁹ Most space operators already understand that pooling their satellite data allows them to more effectively manage and mitigate much of their potential collision risk, and some are already sharing data informally, but there remain many technical and organizational challenges, not to mention legal ambiguities.¹¹⁰ The space nations that step in to fill the global gap in SSA and STM have the greatest chance of emerging as leaders for space norm development.

Begin with Quickly Achievable Demonstrations of Progress and Accountability (Quick Wins)

As nations and, ultimately, the international system work toward common definitions and a comprehensive system for SSA and STM, there is a need for near-term progress on norms for responsible behavior that include accountability methods. The limited successful cases at the UN level suggest that an all-or-nothing approach that proposes comprehensive programs or norms is likely either to fail or to stall for many years in negotiation and debate. The structure of the UN and the deadlock between the United States and its primary competitors, China and Russia, make it unlikely that anything of substance will move through the UN anytime soon.

Creating the initial movement and speeding up the process of norms likely will require smaller groups of nations or industry partners working together to establish standards for responsible behavior that become more widely accepted over time. There is already some precedent for this in space, such as the best practices established by

industry.¹¹¹ Another example is CONFERS, the industry-led effort established by DARPA that is working to develop RPO guidelines. There are even useful examples of nations establishing standards that are then promulgated more widely, such as the NASA debris-mitigation standards that were first issued in 1995 and were modified into the U.S. government Orbital Debris Mitigation Standard Practices two years later.¹¹² Several other countries followed the U.S. lead and went on to develop their own guidelines, and the UN published debris-mitigation guidelines in 2010.¹¹³

This “quick wins” phase is more likely to be successful because it does not require full buy-in from the Conference on Disarmament, where deadlock is likely to continue for the foreseeable future. It also offers opportunities for select nations or consortiums to be exemplars. This does not mean that leading space powers can “lead by decree.” Such nations as China, Russia, and even the United States will need to adapt approaches that work through multipolarity rather than unilateral actions. This subtle distinction between leading by example and attracting supporters is significant. If done in an inclusive manner that attracts

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Existing and emerging best practices, guidelines, and standards need to include a method for measuring compliance that accrues a benefit to entities that comply and some cost to those that do not.

like-minded constituents, it could set the stage for select nations to agree to standards for responsible behavior between each other that could then be promulgated more widely. Part of this shift will require China, Russia, and the United States to be willing to propose standards that apply to everyone, not just others. This is an extension of the concept of greater transparency and might be harder to achieve for space powers that are used to setting rules that apply to others but not necessarily themselves. Some countries, such as the United States, will need to resolve internal debates about space norms—a problem that they have failed to solve thus far.¹¹⁴ Russia, for its part, would need to recognize its diminishing role in space and the threat of a rising

China and see that agreements with the United States are a way to remain relevant. Russia would also need to be willing to act in good faith, something that has been missing in its pursuit of a treaty banning weapons in space even as it develops and tests them.

Methods for measuring compliance are key elements of any of the quick wins with smaller groups. The best practices, guidelines, and standards that currently exist generally lack any method for measuring compliance by owners, operators, and even nations. As a result, there is limited motivation for any entity (whether a state or a commercial entity) to comply unless its own benefit is assessed as greater than the cost to itself rather than the entire space community. Existing and emerging best practices, guidelines, and standards need to include a method for measuring compliance that accrues a benefit to entities that comply and some cost to those that do not. Initially, this cost-benefit system may be based solely on public reputation, similar to an airline safety rating or a free market rating. Over time, it likely will need to include tangible benefits for entities that comply, in terms of lower insurance costs and greater influence in the global market (such as a safe-driver discount for insurance or a tax incentive for environmental stewardship).¹¹⁵

Concentrate on Safety Before Including Security Considerations

Many discussions about space norms fall into two categories: safety and security.¹¹⁶ As part of any discussion, the first step is to establish universal definitions for these terms, something that is still lacking in the international space community. Although there are obvious areas of

overlap between the terms, it is possible to delineate some considerations that are clearly more about safety than security. Current discussions about responsible space behavior are often derailed by debates about safety versus security, whether in or between the relevant UN committees and their subordinate groups or between governments and industry. Both elements are important and require attention. As we have indicated thus far, we recommend that the initial focus be on safety considerations. For example, debris prevention and mitigation are safety areas in which there is already broad consensus on the need for action to protect the space domain for all. Debris removal, although likely important in the future, often derails discussions because those platforms can also be used as ASATs. Therefore, the initial discussion should focus on the safety aspects of concerns like debris and maneuvering notifications before including the more-complicated discussions about security activities. For example, banning *on-orbit* debris-generating ASAT *testing* should be discussed early in the development of norms, since it can be designated a safety decision because it prevents the creation of debris in a peacetime environment that affects everyone. This narrowly defined ban would not preclude nations from developing and testing ASAT weapons in other ways. This approach is like the Limited Test Ban Treaty that prohibits certain kinds of nuclear tests but does not prohibit nuclear powers from other forms of development and testing as part of a broader strategic stability construct. Although arguably a subset of the concept of *pursue quick wins*, the early distinction between safety and security is important given the growing role of space as a warfighting domain by several space nations, regardless of whether they acknowledge it.

The initial discussion should focus on the safety aspects of concerns like debris and maneuvering notifications before including the more-complicated discussions about security activities.

Progress Toward Security Agreements

We encourage early emphasis on communication, transparency, and addressing threats to safety in space because these are the areas that are most likely to allow progress. The area of space security is also very important and should be addressed. There is even less awareness among the general population of the current intentional and hostile threats to space assets. It is important that the realities of space as a warfighting domain and the potential risk to operating safely in space today and in the future are understood by all nations. Responsible space behaviors work when they are adopted by a critical mass of actors. Eventually, the global community will come to realize that, just like the maritime and air domains before, space is evolving into a domain that has both peaceful and hos-

tile components. Increasing communication and engagement regarding threats to space is an important first step in implementing solutions. The recommended increase in transparency will require more openness about at least the existence of national security platforms on orbit, in much the same way that military aircraft and vessels are generally required to comply with international law during peacetime. This approach will build greater trust where it does not currently exist while allowing nations to maintain their necessary national security capabilities, much as they do in other domains. The geopolitical competition in space is accelerating, and the more the public knows about it, the better.¹¹⁷ However, the major space powers should strike a balanced approach to public discourse about their own activities and competitor activities and should acknowledge the significant impacts that nonsecurity activities have in space and the risks to all of space warfare.

Conclusion

The context of space activities today is vastly different from that of 1967, when the OST was signed. The early space domain was dominated by two superpowers. Today, the world has more than 60 spacefaring nations, multiple commercial space operators, and a global economy that is inextricably linked to space. The Cold War-era architecture for governance is no longer adequate when there are so many more spacefaring actors and the risks of collision and even conflict are growing. There are multiple problems that deserve attention as space becomes more congested and contested and just as many roadblocks to progress that we have summarized as part of a broader information effort. To help address the challenges that humanity faces in space, we offer several key areas for action that our analysis indicates are the most likely to be successful in the near term and are also important for the longer-term development of responsible space norms. It remains to be seen

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whether there is adequate political will to transcend the short-term gains and focus on ensuring long-term sustainability in space.

Areas for Further Research

This Perspective has provided a preliminary look at the status of space norms, hurdles to further progress, and preliminary steps that could be taken to improve space sustainability and governance. The resources available to conduct this research and reporting were limited, and this is by no means a complete analysis of the situation or a comprehensive list of actions. Rather, it is a first step in a longer series of research efforts needed not only to fully understand the problems associated with space sustainability but also to offer solutions. A few, but not all, of the areas in which further research and analysis are needed are discussed in this section.

Further research is needed to study the evolution and structure of governance frameworks for other domains and to consider best practices and approaches for the space domain. This could be framed as a “design brief” that outlines the key characteristics that policies for the New Space Era should contain.

Economic issues, and space resources in particular, are likely to be a central topic of space governance discussions. Although there are clear differences between the space domain and other domains, it would be helpful to examine

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how property rights in other domains have encouraged more-efficient economic use and environmental stewardship of common-pool resources. Further analysis is needed (although the field is growing and more analysis is becoming available) to understand the gaps in space law at the international level.

More-detailed technical analysis is needed to understand the issues associated with data trust for SSA. The United States should assess the historic trends in its policies toward space law and governance and determine the best approach for its interests and overall space sustainability.

Notes

¹ By comparison, the early space era was limited to superpowers and early entrants, mostly at the government level. For a discussion on the definition of *New Space*, see Gourav Namta, “Let’s Talk About NewSpace,” *Satsearch Blog*, last updated November 10, 2020. For an earlier discussion of the concept, see Scott Pace, “Merchants and Guardians: Balancing U.S. Interests in Space Commerce,” Santa Monica, Calif.: RAND Corporation, RP-789, 1999. (Reprinted from John M. Logsdon and Russell J. Acker, eds., *Merchants and Guardians: Balancing U.S. Interests in Global Space Commerce*, Washington, D.C.: George Washington University, 1999.)

² The 2020 National Space Policy lists as a first principle:

It is the shared interest of all nations to act responsibly in space to ensure the safety, stability, security, and long-term sustainability of space activities. Responsible space actors operate with openness, transparency, and predictability to maintain the benefits of space for all humanity. (White House, “The National Space Policy,” memorandum, Washington, D.C., December 9, 2020, p. 3)

One example of a description of strain on the existing systems of space governance comes from the European Union (EU):

The existing governance frameworks and rules that seek to guarantee a sustainable use of space for all nations are increasingly under strain. . . . The European Union therefore calls for increased international cooperation that should help us establish agreed standards of responsible behaviour in outer space. (Judit Körömi, “EU Statement” presented before the 71st Session of the United Nations General Assembly, First Committee Thematic Discussion on Outer Space, New York: United Nations, October 15, 2016, p. 2)

³ Our workshops included 37 individuals from 11 countries and current and former government officials from the United States serving in the U.S. Department of Defense, U.S. Department of State, U.S. Department of Commerce, and National Aeronautics and Space Administration (NASA). Countries involved in the workshops were Australia, France, India, the United Kingdom, the United States, and others. We also participated in similar workshops and held discussions with officials in the UN, select countries, and companies and with subject-matter experts in academia and nongovernmental organizations (Bruce McClintock, Katie Feistel, Sarah MacConduibh, and Stephen Flanagan, unpublished RAND Corporation research, 2020).

⁴ To narrow our options from a much more extensive list, we used the following criteria: Actions must be achievable in the near term (three to five years), actions must be things that cannot be blocked by any one nation, and actions must have been predominant in the responses received from workshop participants and additional discussions.

⁵ Michael Sheehan, “Defining Space Security,” in Kai-Uwe Schrogl, Peter L. Hays, Jana Robinson, Denis Moura, and Christina Giannopapa, eds., *Handbook of Space Security: Policies, Applications and Programs*, New York: Springer, 2015.

⁶ R. Cargill Hall, “The Origins of U.S. Space Policy: Eisenhower, Open Skies, and Freedom of Space,” Washington, D.C.: Ballistic Missile Defense Organization, January 1, 1992, pp. 4–13.

⁷ UN Office for Disarmament Affairs, “Outer Space,” webpage, undated.

⁸ We note that the United States and other nations did not use the launch of Sputnik to argue against the use of space for overflight operations, and this developed into the customary international law principle of allowing the use of space objects in this regard. See Myres McDougal, “The Emerging Customary Law of Space,” *Northwestern University Law Review*, Vol. 58, 1963.

⁹ The 1963 Limited Test Ban Treaty states, in part, that its signatories undertake “to prohibit, to prevent, and not to carry out any nuclear weapon test explosion, or any other nuclear explosion . . . in the atmosphere; beyond its limits, including outer space . . .” (Government of the United States of America, Government of the United Kingdom of Great Britain and Northern Ireland, and Government of the Union of Soviet Socialist Republics, Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space, and Under Water, Moscow, Russia, August 5, 1963).

¹⁰ See UN, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, New York, 610 U.N.T.S. 205, January 27, 1967.

¹¹ See the UN introduction to the OST (UN Office for Outer Space Affairs [UNOOSA], “Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies,” webpage, undated e).

¹² UNOOSA, undated e.

¹³ Two of the many examples of discussion of deficiencies (whether intentional or unintentional) in the OST can be found in Christopher D.

Johnson, “Deficiencies and Pressing Issues in the Existing Legal Regime of Outer Space: The Incompleteness of the Legal Order for Space,” briefing at APSCO Conference on Space Law and Policy in Istanbul, Turkey, Vienna, Austria: United Nations Office for Outer Space Affairs, September 24, 2019; and Michael Beaver, *Current Space Law Limitations and Its Implications on Outer Space Conflicts*, thesis, St. Louis, Mo.: Webster University, June 16, 2015. According to Beaver, the limitation of the OST “is its largely ambiguous and idealist nature, indicative on the drafters’ intention for future generations to clarify emerging space related issues as the years passed” (p. 3).

¹⁴ Nuclear Threat Initiative, “Proposed Prevention of an Arms Race in Space (PAROS) Treaty,” webpage, last updated April 23, 2020.

¹⁵ In addition to scholarly articles and briefings on this subject cited earlier (such as Beaver, 2015; and Johnson, 2019), the majority of workshop participants expressed this view, and it was also expressed in multiple interviews with representatives inside and outside the governments of China, Russia, the United Kingdom, the United States, and several other countries. Interviewees’ names are withheld to preserve their anonymity. For a summary of views on the subject, see Stephen Flanagan and Bruce McClintock, “How Joe Biden Can Galvanize Space Diplomacy,” *Politico*, January 15, 2021.

¹⁶ UN, “Prevention of an Arms Race in Outer Space,” resolution, A/RES/36/97C, December 9, 1981, p. 71.

¹⁷ U.S.-China Economic and Security Review Commission, *China’s Position on a Code of Conduct in Space*, Washington, D.C., September 8, 2017.

¹⁸ Robert Wood, “Ensuring the Long-Term Sustainability and Security of the Space Environment,” remarks delivered at the Conference on Disarmament Plenary, September 9, 2014. For a shorter summary, see Jeff Foust, “U.S. Dismisses Space Weapons Treaty Proposal as ‘Fundamentally Flawed,’” *SpaceNews*, September 11, 2014.

¹⁹ The number of “Yes” votes for PPWT in the UN General Assembly has increased from 126 in 2014 to a high of 132 in 2020. However, the number of “No” votes has increased from only four between 2014 and 2017 to a high of 32 in 2020 (UN Digital Library, “No First Placement of Weapons in Outer Space: Resolution / Adopted by the General Assembly,” 2014–2020 voting data, 2020).

²⁰ Massimo Pellegrino and Gerald Stang, *Space Security for Europe*, Paris, France: European Union Institute for Security Studies, No. 29, July 2016, p. 59. See also EU, “Draft: International Code of Conduct for

Outer Space Activities,” Version 31, March 2014. After four rounds of consultations, the EU included language from the United States, and the Code was revised to recognize a state’s right to self-defense against another state’s actions, although the actions must be for a legitimate defense. China and Russia have expressed their resistance to the Code, stating that it is too “EU-driven and insufficiently inclusive.”

²¹ EU, 2014.

²² Christopher D. Johnson, “Draft International Code of Conduct for Outer Space Activities Fact Sheet,” Secure World Foundation, last updated February 2014; and Rajeswari Pillai Rajagopalan, “Op-ed: Keep Space Code of Conduct Moving Forward,” *SpaceNews*, July 21, 2015.

²³ UN, *Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities: Note by the Secretary-General*, New York, A/68/189, July 29, 2013.

²⁴ Space subject-matter experts involved in the original GGE discussions, responsible space behavior, Responsible Space Behavior Workshops, Microsoft Teams, July–August 2020; space subject-matter experts involved in the original GGE discussions, UN progress since 2000, email and phone interview with the authors, September 2020; and space subject-matter experts involved in the original GGE discussions, responsible space behavior, email discussion with the authors, January 2021.

²⁵ COPUOS, *Guidelines for the Long-Term Sustainability of Outer Space Activities*, Vienna, Austria: United Nations, A/AC.105/2018/CRP.20, June 27, 2018b. Adoption by COPUOS of the report does not carry the same legal weight as an adopted agreement. For the full list of the reports, see “A/74/20, para 163 and Annex II” in UNOOSA, “Long-Term Sustainability of Outer Space Activities,” webpage, undated b.

²⁶ UNOOSA, undated b.

²⁷ COPUOS, 2018b.

²⁸ UN, “Decisions and Actions by the Committee on the Peaceful Uses of Outer Space and Its Legal Subcommittee Taken by Written Procedure,” United Nations General Assembly Official Records, A/75/20, New York, 2020a.

²⁹ Peter Martinez, “Challenges for Ensuring the Security, Safety and Sustainability of Outer Space Activities,” *Journal of Space Safety Engineering*, Vol. 6, No. 2, June 2019.

³⁰ Daniel Oltrogge, “Opinion: It’s Time for Comprehensive Space Traffic Management,” Aviation Week Network, February 25, 2020.

³¹ COPUOS, *Guidelines for the Long-Term Sustainability of Outer Space Activities*, Vienna, Austria: United Nations, A/AC.105/L.315, 2018a, p. 2.

³² Our analysis in this paper is based on the prevailing view of international legal analysts that space should be viewed as a “commons” (much as the high seas and the Antarctic are). See Article I of the OST (“province of all mankind”) and Article II’s prohibition on national appropriation (UN, 1967). See also the legislative history of the adoption of the OST (UNOOSA, undated e). For the position of the UN, as represented by five key agencies, see UN System Task Team, *UN System Task Team on the Post-2015 UN Development Agenda: Global Governance and Governance of the Global Commons in the Global Partnership for Development Beyond 2015*, New York: United Nations, January 2013. For the consensus expressed in academic and subject-matter expert literature, see Ram Jakhu and Joseph Pelton, eds., *Global Space Governance: An International Study*, Cham, Switzerland: Springer International Publishing, 2017; and Cassandra Steer, “Global Commons, Cosmic Commons: Implications of Military and Security Uses of Outer Space,” *Georgetown Journal of International Affairs*, Vol. 18, No. 1, Winter–Spring 2017. However, we acknowledge that the “commons” view is not universally accepted, particularly by the United States and other academic and subject-matter experts. See, for example, Section 1 of Executive Order 13914, “Encouraging International Support for the Recovery and Use of Space Resources,” *Federal Register*, Vol. 85, No. 70, April 10, 2020, p. 20381; and Henry R. Hertzfeld, Brian Weeden, and Christopher D. Johnson, *How Simple Terms Mislead Us: The Pitfalls of Thinking About Outer Space as a Commons*, Paris, France: International Astronautical Federation, IAC-15-E7.5.2x29369, 2015.

³³ William Forster Lloyd, *Two Lectures on the Checks to Population*, Oxford: J. H. Parker, 1833. This Perspective refers to the tragedy of the commons, even though there is debate about whether space is a global commons.

³⁴ NASA, “Frequently Asked Questions: Orbital Debris,” webpage, last updated September 2, 2011.

³⁵ According to a U.S. Government Accountability Office report, “Over more than three decades, DoD’s efforts to improve its space command and control capabilities—commensurate with the space threats that have continued to grow in frequency and type—have been fraught with development problems” (U.S. Government Accountability Office, *Space Command and Control: Comprehensive Planning and Oversight Could Help DoD Acquire Critical Capabilities and Address Challenges*,

Washington, D.C., GAO-20-146, October 2019, p. 26). See also 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, D.C.: Institute for Defense Analyses, D-9074, April 2018.

³⁶ Lal et al., 2018.

³⁷ “World’s Smallest Satellite Launches Today,” BBC Newsround, January 24, 2019.

³⁸ Lal et al., 2018, p. B-1. Even in the United States, the definitions are evolving. The U.S. Department of Defense defines SSA as “cognizance of the requisite current and predictive knowledge of the space environment and the operational environment upon which space operations depend” (Lal et al., 2018, p. B-1). The Federal Aviation Administration’s Office of Commercial Space Transportation states, “STM focuses on making decisions before and during space operations for those operations within a nation’s responsibility, such as near and long term safety issues, and actions for which you have authority and responsibility” (Lal et al., 2018, p. B-4). STM is most commonly defined as the active part of taking information gained from SSA and deciding on a course of action, while SSA is the data used to inform that decision process. A new term for SSA was formally adopted by the U.S. military space community in 2019: *Space Domain Awareness* (SDA). Because space has been identified as a warfighting domain by the United States, the SSA term was deemed insufficient because it reflected a benign environment instead of the current, contested environment. The United States defines SDA as the “identification, characterization and understanding of any factor, passive or active, associated with the space domain that could affect space operations and thereby impact the security, safety, economy or environment of our nation” (Sandra Erwin, “Air Force: SSA Is No More; It’s ‘Space Domain Awareness,’” *SpaceNews*, November 14, 2019).

³⁹ We cite a case with active satellites because it provides an example in which two operators could take some action to avoid a collision.

⁴⁰ According to NASA’s *Best Practices Handbook*, the owner or operator “plans, and perhaps executes, a collision avoidance maneuver or other mitigation solution to reduce the collision risk to an acceptable level” (NASA, *NASA Spacecraft Conjunction Assessment and Collision Avoidance Best Practices Handbook*, Washington, D.C., December 2020, p. 12).

⁴¹ Kaitlyn Johnson, *Key Governance Issues in Space*, Washington, D.C.: Center for Strategic and International Studies, September 2020.

⁴² There are regularly examples of similar occurrences, and the lack of clear norms makes it unclear how space actors should respond. One example is the recent (November 2020) case of Russia complaining about an Indian satellite passing within 224 m (M. P. Sidharth, “ISRO and Russian Satellites Come Within 224 Meters of Each Other; How Dangerous Is This?” Zee News, 2020.)

⁴³ Quentin Verspieren, “The United States Department of Defense Space Situational Awareness Sharing Program: Origins, Development and Drive Towards Transparency,” *Journal of Space Safety Engineering*, October 2020.

⁴⁴ The International Scientific Optical Network “is an open international non-government project mainly aimed at being a free source of information on space objects for scientific analysis and other applications. It was initiated in framework of the program of the GEO region investigations started by the Keldysh Institute of Applied Mathematics (KIAM) of the Russian Academy of Sciences in 2001” (Igor Molotov, Vladimir Agapov, Zakhary Khutorovsky, Vladimir Titenko, Vasily Rumyantsev, Vadim Biryukov, Nasredin Minikulov, Makhmud Gulyamov, Bakhodur Abdulloev, Sergei Andrievsky, et al., “Faint High Orbit Debris Observations with ISON Optical Network,” 2009, p. 1).

⁴⁵ The Space Data Association “is an international organization that brings together satellite operators to support the controlled, reliable and efficient sharing of data critical to the safety and integrity of the space environment. The SDA membership includes the world’s major satellite communications companies” (Space Data Association, homepage, undated). For information on the EU Space Surveillance and Tracking Support Framework, see European Commission, “Space and Security,” webpage, undated.

⁴⁶ Peter Stubbe, “Space Traffic Management as an International Legal Regime,” presentation slides, 3rd ICAO/UNOOSA Aerospace Symposium, August 30, 2017.

⁴⁷ Lal et al., 2018, p. 2.

⁴⁸ Since 1957, there have been more than 5,000 rocket launches. Currently, it is estimated there are more than 170 million pieces of debris in space (Michael Byers, “Cold, Dark, and Dangerous: International Cooperation in the Arctic and Space,” *Polar Record*, Vol. 55, No. 1, January 2019).

⁴⁹ Emily Kwong, “Space Junk: How Cluttered Is the Final Frontier?” NPR, January 13, 2020.

⁵⁰ Orbital Debris Program Office, “Frequently Asked Questions,” webpage, undated.

⁵¹ “UK to Play Critical Role in Building ‘the Claw’—the First Ever Satellite to Remove Space Junk,” press release, UK Space Agency, November 17, 2020. *Orbital debris* is generally defined as “man-made objects in orbit about the Earth which no longer serve a useful purpose” (Orbital Debris Program Office, undated).

⁵² Lal et al., 2018.

⁵³ Nicholas Johnson, “First Natural Collision of Cataloged Earth Satellites,” *Orbital Debris Quarterly News*, Vol. 1, No. 2, September 1996.

⁵⁴ Johnson, 2020.

⁵⁵ Donald J. Kessler and Burton G. Cour-Palais, “Collision Frequency of Artificial Satellites: The Creation of a Debris Belt,” *Journal of Geophysical Research*, Vol. 83, No. A6, June 1978.

⁵⁶ Joe Schoneman, “Beyond Counterspace: Addressing Debris as a Credible Threat in Low Earth Orbit,” *War on the Rocks*, November 16, 2020.

⁵⁷ NASA, “U.S. Government Orbital Debris Mitigation Standard Practices,” undated.

⁵⁸ UNOOSA, *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space*, Vienna, Austria, 2010, p. iv.

⁵⁹ According to one study, “a 90% global compliance with the 25-year rule could reduce the LEO debris population growth to approximately 110% over the next 200 years. Reducing the 25-year rule to, for example, a 5-year rule, only leads to another 10% debris reduction over 200 years, which is not a statistically significant benefit.” (J.-C. Liou, M. Kieffer, A. Drew, and A. Sweet, “The 2019 U.S. Government Orbital Debris Mitigation Standard Practices,” *Orbital Debris Quarterly News*, Vol. 24, No. 1, February 2020, p. 5). Additionally, we note that although state agencies (e.g., the Federal Communications Commission or the Federal Aviation Administration in the United States) that license companies that launch objects may impose regulations related to debris mitigation, these companies may not be restricted (depending on the state) from moving their launch operations overseas, where there might be less stringent regulations.

⁶⁰ World Economic Forum, “Space Sustainability Rating,” webpage, undated. The SSR initiative is in early development and is limited to platforms on orbit and specific constellations (SSR program management lead at Massachusetts Institute of Technology, SSR implementa-

tion, email and Microsoft Teams interview with the authors, February 17, 2021).

⁶¹ For a concise summary of U.S., Chinese, and Russian ASAT testing, see Brian Weeden, *Through a Glass, Darkly: Chinese, American, and Russian Anti-Satellite Testing in Space*, Washington, D.C.: Secure World Foundation, March 17, 2014.

⁶² Byers, 2019.

⁶³ Ashley J. Tellis, “India’s ASAT Test: An Incomplete Success,” Carnegie Endowment for International Peace, April 15, 2019.

⁶⁴ Rej Abhijnan, “Russia Tests Anti-Satellite Missile: US,” *The Diplomat*, December 18, 2020.

⁶⁵ Anuradha Damale, “Rendezvous Proximity Operations: Not Operating in Isolation,” European Leadership Network, August 12, 2020.

⁶⁶ Ian Christensen, “Norms and Standards to Enable Emerging Industry Segments: Satellite Servicing,” presentation slides for the Global Space and Technology Convention in Singapore, Washington, D.C.: Secure World Foundation, February 1–2, 2018.

⁶⁷ Chris Gebhardt, “Northrop Grumman Makes history, Mission Extension Vehicle Docks to Target Satellite,” NASA Spaceflight.com, February 26, 2020.

⁶⁸ J. D. Harrington, “NASA Releases Best Practices Handbook to Help Improve Space Safety,” press release, Washington, D.C.: National Aeronautics and Space Administration, last updated January 4, 2021. See also NASA, 2020b.

⁶⁹ Johnson, 2020; and Rebecca Reesman and Andrew Rogers, “Getting in Your Space: Learning from Past Rendezvous and Proximity Operations,” El Segundo, Calif.: Aerospace Corporation, May 2018.

⁷⁰ Defense Intelligence Agency, *Challenges to Security in Space*, Washington, D.C., January 2019. Russia combined its air force and Aerospace Defense Force and established the Aerospace Forces in 2015. China created its own space force a few months later (William J. Broad, “How Space Became the Next ‘Great Power’ Contest Between the U.S. and China,” *New York Times*, January 24, 2021).

⁷¹ If nations also depend on space for economic and military reasons, there is a notion that their own dependence could act as a deterrent to actions that would make space unusable in the future.

⁷² U.S. Space Force, “United States Space Force History,” webpage, undated.

⁷³ Aaron Bateman, “America Needs a Coalition to Win a Space War,” *War on the Rocks*, April 29, 2020.

⁷⁴ John W. Raymond, *Chief of Space Operations’ Planning Guidance*, Washington, D.C.: U.S. Space Force, November 2020.

⁷⁵ Sandra Erwin, “Raymond Calls Out Russia for ‘Threatening Behavior’ in Outer Space,” *SpaceNews*, February 10, 2020. For a more-descriptive discussion of potential Russian counterspace capabilities, see Defense Intelligence Agency, 2019.

⁷⁶ 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, No. 2, June 2019.

⁷⁷ Martinez, 2019.

⁷⁸ Christopher Ashley Ford, “Whither Arms Control in Outer Space? Space Threats, Space Hypocrisy, and the Hope of Space Norms,” remarks delivered at the Center for Strategic and International Studies Webinar on “Threats, Challenges and Opportunities in Space,” Washington, D.C.: U.S. Department of State, April 6, 2020.

⁷⁹ U.S. Department of Defense, *Defense Space Strategy Summary*, Washington, D.C., June 2020, p. 2.

⁸⁰ Space Security Index, *Space Security Index 2019: Executive Summary*, 16th ed., Waterloo, Ont., Canada: Project Ploughshares, October 2019.

⁸¹ The Space Safety Coalition is an ad hoc coalition of companies, organizations, and other government and industry stakeholders that actively promotes responsible space safety through the adoption of relevant international standards, guidelines, and practices and through the development of more-effective space safety guidelines and best practices. See Space Safety Coalition, homepage, undated.

⁸² Joanne Irene Gabrynowicz, “Space Law: Its Cold War Origins and Challenges in the Era of Globalization,” *Suffolk University Law Review*, Vol. 37, No. 4, 2004; UN, 1968; UN, 1972; UN, 1975; UN, 1979; and UNOOSA, 2020.

⁸³ See, for example, Inter-Agency Space Debris Coordination Committee, *IADC Space Debris Mitigation Guidelines*, IADC Action Item No. 22.4, IADC-02-01, Revision 1, September 2007; International Organization for Standardization, “Space Systems—Space Debris Mitigation Requirements,” Geneva, Switzerland, ISO 24113:2019, July 2019; and UNOOSA, 2010.

⁸⁴ See COPUOS responsibilities at UNOOSA, “Committee on the Peaceful Uses of Outer Space and Its Subcommittees,” webpage, undated a. See also UNOOSA, “Roles and Responsibilities,” webpage, undated c.

⁸⁵ See Article 27 of the UN Charter (UN, Charter of the United Nations, Chapter V, The Security Council, New York, June 26, 1945). Given this high bar, no nation has ever been sanctioned or otherwise penalized by the UN Security Council for violations of the five space treaties.

⁸⁶ See Lal et al., 2018; Emily S. Nightingale, Bhavya Lal, Brian C. Weeden, Alyssa J. Picard, and Anita R. Eisenstadt, *Evaluating Options for Civil Space Situational Awareness (SSA)*, Washington, D.C.: Institute for Defense Analyses, NS P-8038, August 2016; and Joe Pappalardo, “The Pentagon Is Declassifying Lots of Info About What’s in Orbit,” *Popular Mechanics*, December 13, 2018.

⁸⁷ Mike Gruss, “Russian Satellite Maneuvers, Silence Worry Intelsat,” *SpaceNews*, October 9, 2015.

⁸⁸ Laurence Peter, “Russia Shrugs Off US Anxiety Over Military Satellite,” BBC News, October 20, 2015.

⁸⁹ Francis Fukuyama, “What Is Governance?” *Governance*, Vol. 26, No. 3, July 2013, p. 350.

⁹⁰ See Jakhu and Pelton, 2017, p. 341.

⁹¹ Article I(d) of the Liability Convention states: “The term ‘space object’ includes component parts of a space object as well as its launch vehicle and parts thereof” (UN, 1972). See also Jakhu and Pelton, 2017, pp. 343–344. This broad definition has proven insufficient in that nations have adopted their own, typically more detailed, definition of *space object*.

⁹² UN, 1967, Article IX.

⁹³ UN, 1967, Article IX.

⁹⁴ UN, 1967, Article IV.

⁹⁵ See Jason Krause, “The Outer Space Treaty Turns 50. Can It Survive a New Space Race,” *ABA Journal*, April 1, 2017.

⁹⁶ COPUOS proposed the following definition of *space debris*:

all man-made objects, including their fragments and parts, whether their owners can be identified or not, in Earth orbit or re-entering the dense layers of the atmosphere that are non-

functional with no reasonable expectation of their being able to assume or resume their intended functions or any other functions of which they are or can be authorized. (COPUOS, *Technical Report on Space Debris*, New York: United Nations, A/AC.105/720, 1999, p. 2)

This definition remains nonbinding.

⁹⁷ See Jack Maxwell, “Standardizing Space,” *Standardization News*, July–August 2019; citing ASTM International’s approved standard ASTM F3377 (ASTM F3377, Standard Terminology Relating to Commercial Spaceflight, West Conshohocken, Pa.: ASTM International, 2020).

⁹⁸ UN, 1967, Article VIII.

⁹⁹ See Jakhu and Pelton, 2017, p. 345. However, it might be that a nation that perceives an object to be a threat to national defense might invoke other principles of international law, or other treaties, to justify seizing and removing such an object or debris. This is an open question.

¹⁰⁰ In addition to the various sources cited throughout this paper, consider the following: Paul B. Larsen, “Minimum International Norms for Managing Space Traffic, Space Debris, and Near Earth Object Impacts,” *Journal of Air Law and Commerce*, Vol. 83, No. 4, 2018; Audrey M. Schaffer, “The Role of Space Norms in Protection and Defense,” *Joint Force Quarterly*, Vol. 87, October 2017; and Jessica West and Gilles Doucet, *From Safety to Security: Reducing the Threat Environment Through the Responsible Use of Outer Space: Survey Report*, Waterloo, Ont., Canada: Project Ploughshares, July 2020.

¹⁰¹ UN, *Report of the Committee on the Peaceful Uses of Outer Space: Sixty-Second Session (12–21 June 2019)*, New York, A/74/20, 2019, p. 4; and UNOOSA, “The Promoting Space Sustainability Project,” webpage, undated d.

¹⁰² UN, “Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours,” draft resolution, New York, A/C.1/75/L.45/Rev.1, October 23, 2020b, p. 3. On December 7, 2020, the UN General Assembly voted on the proposal, and it passed with 164 in favor, 12 against, and six abstentions. Noteworthy votes against included China, Iran, North Korea, Russia, and Venezuela. Notable abstentions included India and Israel.

¹⁰³ A U.S. official announced on February 24, 2021, that U.S. Department of Defense and U.S. Department of State officials are drafting language on the U.S. position for submission to the UN in cooperation with the United Kingdom and with a broader coalition that includes

Australia, Canada, France, Germany, and New Zealand. Of note, one of the officials claimed that the language that will go to the UN will “hopefully result in a binding resolution” (Sandra Erwin, “U.S. to Support International Effort to Set Rules of Behavior in Space,” *SpaceNews*, February 24, 2021).

¹⁰⁴ For an example of UK activities, see Foreign and Commonwealth Office, “Operating in Space: Towards Developing Protocols on Norms of Behaviour,” conference program, London, United Kingdom: Wilton Park, 2019.

¹⁰⁵ We are referring to the broader definition of *maritime domain* awareness from the International Civil Aviation Organization and the International Maritime Organization: “the effective understanding of any activity associated with the maritime environment that could impact upon the security, safety, economy or environment” (International Civil Aviation Organization and International Maritime Organization, *IAMSAR Manual*, Vol. III, Mobile Facilities, 10th ed., Montréal, Que., Canada: 2016, p. xvi).

¹⁰⁶ Verspieren, 2020.

¹⁰⁷ U.S. Space Command provides space surveillance data to registered users through a public website (Space-Track.org). The 18th Space Control Squadron routinely updates the website with positional data on more than 16,000 satellites in orbit around the earth (Space-Track.org, “SSA Sharing & Orbital Data Requests (ODR),” webpage, undated). For more on unacknowledged satellites that even amateur astronomers can track, see Andrea Leinfelder, “From Around the Globe, a Small Cadre of Trackers Document Classified Satellites,” *Houston Chronicle*, last updated January 1, 2021. For more on U.S. government debates about transparency, see Theresa Hitchens, “Intel Community’s Secrecy Culture Frustrates DoD Sat Safety Effort,” *Breaking Defense*, August 26, 2019b.

¹⁰⁸ There are various databases that track satellites and highlight unregistered objects. One noted that, as of 2013, the countries with the most unregistered objects were China, Israel, Saudi Arabia, and the United States (Jonathan McDowell, “Adherence to the 1976 Convention on Registration of Objects Launched into Outer Space,” webpage, undated).

¹⁰⁹ Theresa Hitchens, “SIA Calls for Space Traffic Rules ASAP,” *Breaking Defense*, September 24, 2020.

¹¹⁰ Oltrogge and Alfano, 2019.

¹¹¹ Some example organizations include the Satellite Industry Association (Satellite Industry Association, “Policy,” webpage, undated) and

the Space Safety Coalition (Space Safety Coalition, undated). As an indication of the gap in current international norms, the Space Safety Coalition published its own best practices in 2019 (see Space Safety Coalition, “Best Practices for the Sustainability of Space Operations,” September 16, 2019).

¹¹² Astromaterials Research and Exploration Science, “Debris Mitigation,” webpage, Orbital Debris Program Office, undated.

¹¹³ UN, 2010.

¹¹⁴ Chad J. R. Ohlandt, Bruce McClintock, and Stephen J. Flanagan, “Navigating Norms for the New Space Era,” *National Interest*, February 7, 2021.

¹¹⁵ Although nascent, the Space Sustainability Rating concept is an emerging example of how this kind of measurement and compliance might work. See Minoo Rathnasabapathy, Danielle Wood, Francesca Letizia, Stijn Lemmens, Moriba Jah, Ashley Schiller, Carissa Christensen, Simon Potter, Nikolai Khlystov, Maksim Soshkin, et al., “Space Sustainability Rating: Designing a Composite Indicator to Incentivise Satellite Operators to Pursue Long-Term Sustainability of the Space Environment,” *71st International Astronautical Congress (IAC)—The CyberSpace Edition*, October 2020.

¹¹⁶ This insight was identified in RAND external workshops conducted under the Chatham House Rule with space policymakers and experts in summer 2020 along with various interviews and discussions with policymakers and experts (Bruce McClintock, Katie Feistel, Sarah MacConduibh, and Stephen Flanagan, unpublished RAND Corporation research, 2020). For a public example of similar insights, see Jessica West and Gilles Doucet, *From Safety to Security: Extending Norms in Outer Space Global Workshop Series Report*, Waterloo, Ont., Canada: Project Ploughshares, January 2021.

¹¹⁷ The United States has been more vocal and public about adversaries’ activities that have security implications in the past few years. For some examples, see Mike Gruss, “U.S. State Department: China Tested Anti-Satellite Weapon,” *SpaceNews*, July 28, 2014; National Air and Space Intelligence Center, *Competing in Space*, Wright-Patterson Air Force Base, Ohio, December 2018; and U.S. Space Command Public Affairs Office, “Russia Tests Direct-Ascent Anti-Satellite Missile,” December 16, 2020. For some discussion of how the Russians have characterized U.S. behavior, see Theresa Hitchens, “The Stellar Dance: US, Russia Satellites Make Potentially Risky Close Approaches,” *Breaking Defense*, April 10, 2019a.

Abbreviations

ASAT	antisatellite
CONFERS	Consortium for Execution of Rendezvous and Servicing Operations
DARPA	Defense Advanced Research Projects Agency
ESA	European Space Agency
EU	European Union
COPUOS	Committee on the Peaceful Uses of Outer Space
GGE	Group of Governmental Experts
ICBM	intercontinental ballistic missile
LEO	low earth orbit
LTS	Long-Term Sustainability
NASA	National Aeronautics and Space Administration
OST	Outer Space Treaty
PPWT	Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects
RPO	rendezvous and proximity operation
SSA	space situational awareness

SSR	Space Sustainability Rating
STM	space traffic management
TCBM	transparency and confidence-building measure
UN	United Nations
UNOOSA	UN Office for Outer Space Affairs
USSR	Union of Soviet Socialist Republics

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About This Perspective

This research should be of interest to policymakers and analysts concerned with developing formal government inputs to future space governance norms and responsible behaviors. The brief history of responsible space behavior will be most useful to emergent space policymakers, while the recommendations should be equally useful for established space power policymakers and aspirant space powers.

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umans have explored and exploited near-earth space for more than six decades. More recently, the past two decades have seen the start of a New Space Era, characterized by more spacefaring nations and companies and a growing risk of collisions and conflict.

Yet the basic treaties and mechanisms that were crafted 50 years ago to govern space activities have only marginally changed.

The calls for more progress on space governance and responsible space behavior are growing louder and coming from a larger group. To help address the gap between current space governance and future needs, the authors of this Perspective summarize the development of space governance and key problem areas, identify challenges and barriers to further progress, and, most importantly, offer recommended first steps on a trajectory toward responsible space behavior norms appropriate for the New Space Era. The authors used a review of relevant literature and official documents, expert workshops, and subject-matter expert interviews and discussions to identify these challenges, barriers, and potential solutions.