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Key Governance Issues in Space

Author

KAITLYN JOHNSON

CSIS | CENTER FOR STRATEGIC &
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Center for Strategic & International Studies
1616 Rhode Island Avenue, NW
Washington, DC 20036
202-887-0200 | www.csis.org

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Project Scope

This paper analyzes the views of nations on key governance issues in the space domain, focusing on countries other than the United States, Russia, and China. It examines how existing and proposed international mechanisms define and regulate space sustainability and debris mitigation, rendezvous and proximity operations, and insurance requirements for private and national space missions.

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List of Abbreviations

Abbreviation	Phrase
ADR	<i>Active Debris Removal</i>
ASAT	<i>Antisatellite</i>
CONFERS	<i>Consortium for Execution of Rendezvous and Servicing Operations</i>
COPUOS	<i>Committee on the Peaceful Uses of Outer Space</i>
CSA	<i>Canadian Space Agency</i>
DARPA	<i>Defense Advanced Research Projects Agency</i>
EOL	<i>End-of-Life</i>
ESA	<i>European Space Agency</i>
GEO	<i>Geostationary Orbit</i>
GPS	<i>Global Positioning System</i>
GTO	<i>Geostationary Transfer Orbit</i>
IADC	<i>Inter-Agency Space Debris Coordination Committee</i>
IDA	<i>Institute for Defense Analyses</i>
ISO	<i>International Organization for Standardization</i>
ISS	<i>International Space Station</i>
ITU	<i>International Telecommunications Union</i>
JAXA	<i>Japan Aerospace Exploration Agency</i>
LEO	<i>Low Earth Orbit</i>
LTS	<i>Long-Term Sustainability</i>
MILAMOS	<i>Manual on International Law Applicable to Military Uses of Outer Space</i>
NOTAM	<i>Notice to Airmen</i>
OOS	<i>On Orbit Servicing</i>
OST	<i>Outer Space Treaty</i>
PNT	<i>Positioning, Navigation, and Timing</i>
QZSS	<i>Quasi-Zenith Satellite System</i>
RFID	<i>Radio-Frequency Identification</i>
RPO	<i>Rendezvous and Proximity Operation</i>
SIA	<i>Satellite Industry Association</i>
SSA	<i>Space Situational Awareness</i>
SSR	<i>Space Sustainability Rating</i>
STM	<i>Space Traffic Management</i>
WEF	<i>World Economic Forum</i>
UN	<i>United Nations</i>
3SOS	<i>Safety, Security, and Sustainability of Outer Space</i>

Executive Summary

Each year, new actors enter the space domain and bring new technologies, practices, and challenges. This paper explores how current international governance structures are keeping pace with the increased activity and diversity of space missions. It dives into three key governance areas for the space domain: sustainability and debris mitigation, rendezvous and proximity operations, and insurance requirements, and it evaluates national, multinational, and industry efforts to develop better norms or operating standards for space governance.

The best developed of these areas is space sustainability and debris mitigation efforts. An indiscriminate issue for the space domain, space debris is a growing problem with almost every launch. Many space experts acknowledge that without norms of behavior or debris removal missions, the space environment may be permanently damaged.

There are several international mechanisms, national policies, multinational activities, and industry efforts to curb the creation and proliferation of space debris. Several organizations, such as the United Nations Committee on the Peaceful Uses of Outer Space, the Inter-Agency Space Debris Coordination Committee, and the Satellite Industry Association have published collaborative guidelines that suggest best practices for operating in the space domain in a sustainable manner. Several nations, especially Japan, have also taken significant steps to reduce debris on orbit.

Despite this progress, few international standards or norms exist. The few that are in place—such as the commonly practiced 25-year deorbit norm—are out of date with today’s technology and the proliferation of commercial satellites. Many in the space community are rightly concerned that without dedicated international action, possibly legal action, there will be a day where a debris-creating event is so significant that it sets off a chain reaction of more collisions on-orbit. This is often referred to as the Kessler syndrome.¹ If such a day arises, the global space economy and services that are built into our everyday life (such as GPS, the global financial system, and daily weather forecasts) will no longer function as they do today.

The second issue area covered in this assessment is rendezvous and proximity operations—intentional maneuvers on orbit that put one satellite in a similar orbit or close to another satellite. Similar to space debris mitigation and the sustainability of the space environment, there are little to no agreed-upon definitions of what constitutes a safe interaction between satellites on orbit. Rendezvous and proximity operations are likely to become more commonplace as on orbit servicing (OOS) and active debris removal (ADR) technologies are tested and proven. Before this occurs, experts are working to develop standards or norms both for technical activities and for communicating movements while on orbit. However, unlike space debris mitigation and sustainability efforts, national and international discussions about rendezvous and proximity operations are either non-existent or at initial stages.

1 “Micrometeoroids and Orbital Debris (MMOD),” National Aeronautics and Space Administration (NASA), June 14, 2016, https://www.nasa.gov/centers/wstf/site_tour/remote_hypervelocity_test_laboratory/micrometeoroid_and_orbital_debris.html.

Lastly, this report addresses national policies and perspectives of space insurance. There are several ways to insure a satellite for both launch and on orbit operations, but insurance options are currently expensive and can cost up to one-third the total cost of a satellite, depending on the risk. There are also minimal national policies requiring any sort of insurance—especially once the satellite is out of the Earth’s atmosphere and therefore in little to no danger of harming civilians or property on Earth.

However, for space insurers, the crowded space domain is making insuring satellites riskier and less profitable. This is already causing insurers to drop out of the space insurance market or reframe their insurance to not cover certain popular orbits. Until significant movement on cleaning and preserving the space domain occurs on an international level, space insurers may put such high premiums on coverage that companies cannot afford to buy insurance.

Through the following discussion and evaluation of national, multinational, international, and industry perspectives on the aforementioned topics, several issues for further action emerge, including:

- Creating international definitions for key space terminology;
- Developing normative rules of the road for satellite behavior, especially for rendezvous and proximity operations; and
- Assessing the stability and sustainability of satellite insurance and how the increasingly crowded space domain might affect satellite lifetime risk.

These options for future pursuit, and others, are elaborated upon in the following report.

Introduction

The global space economy was valued at \$360 billion in 2018 and is only expected to increase as space becomes more accessible through declining costs.² As more countries rely on space for not only national security but also commercial opportunity, global governance and consensus on acceptable behaviors in space are becoming increasingly necessary.

A recent near miss of two satellites on orbit highlights the importance of the key governance issues discussed in this analysis. On September 2, 2019, two active satellites in low Earth orbit (LEO) nearly collided. *Aeolus*, an Earth observation satellite from the European Space Agency (ESA), and *Starlink 44*, one of SpaceX's first satellites for its highly proliferated satellite constellation intended to provide broadband internet, were in danger. As part of its satellite traffic management service, the U.S. Air Force provided both satellite operators with an assessment of the likelihood and timeframe for the collision. Due to the lack of defined international regulations on how to address a potential collision, the choice of how to proceed is left to the satellite operators, as was done during the *Aeolus-Starlink 44* incident.

As the date of collision neared, the chance of collision increased from 1 in 50,000 to 1 in 1,000. This caused the ESA great alarm, and they attempted to reach out to SpaceX. Currently, this process is done through direct email, however, due to a bug in SpaceX's software, the company did not receive the ESA's message. The collision was avoided after the ESA chose to maneuver *Aeolus* away from *Starlink 44*'s orbital path.³ Of course, a collision would have been detrimental to both satellites and significant amounts of debris in LEO would have been created—perhaps to the scale of the *Iridium-Cosmos* collision of 2009 that created almost 2,000 trackable pieces of debris.⁴

In just this single example, it is clear that the lack of agreed international norms and processes for space traffic management (STM) could have caused a devastating event in the space environment. Collisions in space are incredibly damaging to space sustainability and can be equally devastating to companies. While the ESA self-insures its satellites, there is no evidence that SpaceX's *Starlink* satellite was insured. A similar occurrence recently took place in late January 2020. Two satellites were on a collision course, with a 1 in 100 chance of collision, even greater than the *Aeolus-Starlink 44* incident.⁵ However, unlike the *Aeolus-Starlink 44* near miss, these two satellites were not operational, meaning they could not maneuver out of one another's way. All the international community could do was wait and watch as the two satellites nearly collided. Luckily the satellites did not crash; however, this incident throws into sharp relief the increasing danger of on orbit collisions in a crowded space domain.

2. "State of the Satellite Industry Report," Bryce Space and Technology, May 2019, 2, <https://brycetechnology.com/reports>.

3. "ESA Spacecraft Dodges Large Constellation," European Space Agency (ESA), March 9, 2019, https://www.esa.int/Security_Security/ESA_spacecraft_dodges_large_constellation.

4. Brian Weeden, "2009 Iridium-Cosmos Collision Fact Sheet," Secure World Foundation, November 10, 2010, http://swfound.org/media/205392/swf_iridium_cosmos_collision_fact_sheet_updated_2012.pdf.

5. Jeff Foust, "Potential satellite collision shows need for active debris removal," Space News, January 29, 2020, <https://spacenews.com/potential-satellite-collision-shows-need-for-active-debris-removal/>.

Space situational awareness (SSA) and STM are the building blocks for the sustainability of the space domain, including mitigating debris, performing safe rendezvous and proximity operations, and having accurate insurance requirements and assessments. Rather than attempting to provide a comprehensive assessment of all perspectives, this analysis provides highly relevant or unusual cases that may highlight consensus or change in the aforementioned areas of space governance. It examines national and international policies and efforts that may present opportunities for international consensus or contention in the upcoming years in the areas of space sustainability and debris mitigation, rendezvous and proximity operations, and space insurance requirements.

DEFINITIONS

There is little to no consensus on definitions for SSA, STM, space debris mitigation, or space sustainability. In fact, a 2018 Institute of Defense Analyses study on global trends for SSA and STM highlights 14 distinct definitions for SSA and 5 definitions for STM.⁶ While there are no concrete internationally accepted definitions for these terms, this study will attempt to clarify these terms through a few selected definitions.

Most definitions surrounding SSA focus on tracking and identifying objects in space, and they agree that without good SSA, the future of operating in space will become increasingly difficult. The lack of an internationally agreed-upon definition of SSA through the United Nations (UN) was lamented by a recent UN-sponsored working group, which further emphasized the need to define SSA.⁷ For the ESA, SSA is the collective understanding of three main areas: space weather, near-Earth objects, and space surveillance and tracking.⁸

Perhaps a more descriptive SSA definition comes from the Secure World Foundation:

[T]he ability to accurately characterize the space environment and activities in space. Civil SSA combines positional information on the trajectory of objects in orbit (mainly using optical telescopes and radars) with information on space weather. Military and national security SSA applications also include characterizing objects in space, their capabilities and limitations, and potential threats ... It requires a network of globally distributed sensors as well as data sharing between owner-operators and sensed networks.⁹

6. 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)* (Alexandria, VA: Institute for Defense Analyses, April 2018), B-1 – B-4, <https://www.ida.org/-/media/feature/publications/g/gl/global-trends-in-space-situational-awareness-ssa-and-space-traffic-management-stm/d-9074.ashx>.

7. United Nations, "Operating in space: towards developing protocols on the norms of behaviour," Committee on the Peaceful Uses of Outer Space, June 13, 2019, https://www.unoosa.org/res/oosadoc/data/documents/2019/aac_1052019crp/aac_1052019crp_12_0_html/AC105_2019_CRP12E.pdf.

8. The ESA defines these three key areas as: (1) space weather (SWE): monitoring and predicting the state of the Sun and the interplanetary and planetary environments, including Earth's magnetosphere, ionosphere, and thermosphere, which can affect spaceborne and ground-based infrastructure thereby endangering human health and safety; (2) near-Earth objects (NEO): detecting natural objects such as asteroids that can potentially impact Earth and cause damage; (3) and space surveillance and tracking (SST): watching for active and inactive satellites, discarded launch stages, and fragmentation debris orbiting Earth. "SSA Programme Overview," ESA, accessed March 03, 2020, https://www.esa.int/Safety_Security/SSA_Programme_overview.

9. Brian Weeden, "Space Situational Awareness Fact Sheet," Secure World Foundation, May 2017, https://swfound.org/media/205874/swf_ssa_fact_sheet.pdf.

This definition highlights the intricacies of what is required of good SSA and why many nations are prioritizing SSA investments.

STM is another building block toward space sustainability, and good STM is foundational in debris mitigation strategies. A 2006 International Academy of Astronautics study defines STM as “the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from outer space to Earth free from physical or radio-frequency interference.”¹⁰ The intent of this definition was to make clear that the purpose of STM is to create safe and appropriate methods for conducting space operations without harmful interference. This supports the free and open use of outer space by any nation or entity, which is the cornerstone of the 1967 Outer Space Treaty (OST).

Space debris mitigation practices and activities are made possible through a solid knowledge of the space environment, such as robust SSA, and effective STM practices to operate safely in the space environment. Space debris mitigation has historically been defined by either the accidental or intentional breakup of objects on orbit, which often produces long-lasting debris, or by debris that is intentionally released from launch vehicles or satellites on orbit—such as payload fairings or lens caps on optical sensors.

The UN Committee on the Peaceful Uses of Outer Space (COPUOS) divides space debris mitigation measures into “two broad categories: those that curtail the generation of potentially harmful space debris in the near term and those that limit their generation over the longer term.” The first involves mitigating or curtailing debris production of ongoing missions and avoiding further breakups. The second category focuses on end-of-life (EOL) procedures that mitigate new debris creation or the potential for safely removing existing debris on orbit.¹¹ Some of these procedures include: ADR; deorbiting a satellite into the Earth’s atmosphere, causing it to break up and incinerate; pushing a satellite into a non-usable or uncommon orbit; and creating reusable launch vehicles that do not contribute debris into orbit.

SSA, STM, and space debris mitigation activities all contribute to the common goal of space sustainability. COPUOS defines space sustainability “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.”¹² Better knowledge of the space environment, more cohesive communication about satellite movements, and either taking harmful debris out of orbit or not creating new debris will all add to preserving the space domain for future use.

With the above definitions in mind, the following analysis evaluates national policies and attitudes toward space sustainability and debris mitigation, rendezvous and proximity operations, and space

10. Corinne Contant-Jorgenson, Petr Lála, and Kai-Uwe Schrogl, eds., “Cosmic Study on Space Traffic Management,” International Academy of Astronautics, 2006; as defined in Claudiu Mihai Taiatu, “Space Traffic Management: Top Priority For Safety Operations,” International Institute of Space Law, 2017, <https://iislweb.org/docs/Diederiks2017.pdf>.

11. Office of Outer Space Affairs, *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space* (Vienna: United Nations, 2010), 1, https://www.unoosa.org/pdf/publications/st_space_49E.pdf.

12. Committee on the Peaceful Uses of Outer Space, *Guidelines for the Long-term Sustainability of Outer Space Activities* (Vienna: United Nations, June 2018), 2, <https://cms.unov.org/dcpms2/api/finaldocuments?Language=en&Symbol=A/AC.105/L.315>.

insurance. The analysis also accounts for work in progress in multinational fora and new industry-led initiatives and standards. With these cases, likely areas for consensus within the next decade emerge, along with possible trigger points where contention among nations or between nations and private entities may arise.

Space Sustainability and Debris Mitigation

At the International Astronautical Congress in 2019, several panels of policymakers, experts, and technicians from around the world discussed the risks of space debris. During these sessions and in private discussions held that week, the international space community collectively called for better SSA and increased coordination for STM and highlighted the need to mitigate debris-creating events in the space domain.

To have a comprehensive debris mitigation strategy or efforts to secure the sustainability of the space domain, one must first have robust SSA. Understanding where objects are in space and projecting their orbital path is a cornerstone of developing a global STM system that encourages economic activity, global space debris mitigation regulations, and sustainability requirements.¹³ These three key elements—SSA, STM, and debris mitigation—will determine the sustainability of the space domain for decades to come.

INTERNATIONAL MECHANISMS

Several international mechanisms exist that play a large role in creating norms, best practices, and guidelines for mitigating space debris. Examples include both UN-based organizations such as COPUOS and other mechanisms such as the Inter-Agency Space Debris Coordination Committee (IADC), an intergovernmental forum for worldwide coordination of activities related to space debris.¹⁴ In general, these international bodies are working to establish clear, internationally-recognized policies and technical frameworks for nations to adopt or use as a basis for their own national space sustainability policies.

UNITED NATIONS COMMITTEE ON THE PEACEFUL USES OF OUTER SPACE

Guidelines for space sustainability were first introduced in 2007 by COPUOS. Twenty-one of these guidelines were approved by all 92 member states in June 2019. While the guidelines are voluntary and not legally binding, they do signify a united effort to better coordinate SSA and STM measures in order to track all objects in space and to limit the amount of new space debris created. These objectives are in line with Article I of the 1967 Outer Space Treaty, which states “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.”¹⁵ While not all of the guidelines are relevant for

13 Brian Weeden and Victoria Samson, “Insight - Improving Space Situational Awareness,” Secure World Foundation, November 11, 2019, https://swfound.org/news/all-news/2019/11/insight-improving-space-situational-awareness?mc_cid=01e8c0ff72&mc_eid=8de9226597.

14 Members include the national space agencies of Italy, France, China, Canada, Germany, India, Japan, South Korea, the United States, Russia, Ukraine, and the United Kingdom. The ESA is also a member.

15 Office for Outer Space Affairs, *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: United Nations, 1966), <https://www.unoosa.org/pdf/gares/>

this analysis, several show consensus between both spacefaring and non-spacefaring nations on initiatives governments and non-governmental entities may take to ensure the sustainability of the space domain for future endeavors.

The first guideline presented encourages states to “adopt, revise and amend, as necessary, national regulatory framework for outer space activities,” particularly in order to ensure the long-term sustainability of outer space.¹⁶ The guidelines that follow recommend additions or revisions that could be made in national frameworks to encourage responsible behavior by the state and its entities (such as commercial industry) to maintain the integrity of the space domain. Specifically, the UN guidelines suggest: limiting debris released during operations; minimizing the potential for breakups on orbit; and avoiding destruction or harmful activities that may further create debris.¹⁷

The guidelines also highlight the need to increase communication between countries and non-governmental entities to better manage potential conjunctions between space assets. To this point, the guidelines also suggest “the establishment of a United Nations information platform” that would serve as a basis for an international SSA system to more effectively manage STM. A later guideline suggests that states require all satellites launched from their territory to use either passive or active on-orbit tracking aids (such as radio-frequency identification, or RFID) in order to have more accurate SSA data. This is especially critical for emerging space programs, who often rely on smaller, less sophisticated satellite designs.¹⁸ These objects are inherently harder to track because of their size and may not have active propulsion components to maneuver in space, which makes the suggestion of including active and passive tracking aids even more critical.

Furthermore, the guidelines encourage pre-conjunction assessments. This is when, prior to launch, a satellite operator will determine the likelihood that the satellite will be at risk for collision with another active or inactive space object. This would help a country or company plan and anticipate the risks a satellite will incur over its lifetime.¹⁹ Several nations have adopted this mechanism in their national policies on space sustainability, as it is also in line with the 1972 UN Convention on International Liability for Damage Caused by Space Objects standards.²⁰ Pre-conjunction assessments are critical for determining risk and evaluating insurance costs for satellites.

The final guideline suggests states and international intergovernmental organizations should investigate debris removal technologies and consider how to effectively reduce or manage space debris in the future. The document is clear that these efforts, however, should not “impose undue costs on the space programmes of emerging spacefaring nations.”²¹

Reception of the COPUOS guidelines has been quite positive in the space community, although some believe more stringent guidelines could have been adopted. However, this international

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16 Committee on the Peaceful Uses of Outer Space, *Guidelines for the Long-term Sustainability of Outer Space Activities*, 5.

17 Office of Outer Space Affairs, *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space*.

18 Committee on the Peaceful Uses of Outer Space, *Guidelines for the Long-term Sustainability of Outer Space Activities*, 10-11, 15-16,

19 Ibid., 12-13.

20 For more on the Liability Convention, see page 25 in chapter on Insurance Requirements for Space Missions.

21 Committee on the Peaceful Uses of Outer Space, *Guidelines for the Long-term Sustainability of Outer Space Activities*, 20.

consensus to protect the space domain and limit debris creation is an encouraging first step for international space policy.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

Often cited in national policies are the International Organization for Standardization (ISO) standards for mitigating space debris. Founded independently of other international organizations in 1947, the ISO crafts and promotes international standardization for a variety of policy areas, including space. Comprising 164 national standards bodies, the ISO has coordinated international standards in food safety, health care, agriculture, and commercial technology. For space safety, ISO standards are notable for providing several technical means or frameworks for evaluating the potential of an object to create space debris or breakup on orbit.²² These include the common 25-year EOL disposal standard for LEO.²³ This is one of the most successful norms in the space domain to date.

In 2019, the ISO updated its primary document on space debris mitigation guidelines.²⁴ In this update, requirements across the board were made stricter, including “the requirement for a spacecraft or orbital stage to exceed a specified threshold for its probability of successful disposal.”²⁵ Several nations follow ISO guidelines and either write ISO standards directly into their national policies or use them as a basis for crafting unique policy.

INTERNATIONAL TELECOMMUNICATIONS UNION

Since many communications satellites populate geostationary orbit (GEO), the UN International Telecommunications Union (ITU) released its own guidelines for sustainable practices in this protected region of near-Earth space. The ITU specifically provides guidance on safe disposal practices for GEO satellites, which includes defining the protected area around GEO so that satellites are disposed of in an orbit no less than 200 km above the geostationary altitude, in order to minimize potential interference. Colloquially, these are often referred to as “graveyard orbits.” The ITU guidelines also address tactics for minimizing radio frequency interference during EOL maneuvers.²⁶ The ITU is composed of 193 member states, “as well as some 900 companies, universities, and international and regional organizations.”²⁷

22 Office of Outer Space Affairs, *Compendium: Space Debris Mitigation Standards Adopted by States and International Organizations* (Vienna: United Nations, February 25, 2019), 70-75, https://www.unoosa.org/documents/pdf/spacelaw/sd/Space_Debris_Compendium_COPUOS_25_Feb_2019p.pdf.

23 Hedley Stokes et al., “Status of the ISO Space Debris Mitigation Standards,” ESA, June 2017, 2-3, <https://conference.sdo.esoc.esa.int/proceedings/sdc7/paper/979/SDC7-paper979.pdf>.

24 “ISO 24113:2019 - Space systems – Space debris mitigation requirements,” International Organization for Standardization, July 2019, <https://www.iso.org/standard/72383.html>.

25 Hedley Stokes et al., “Evolution of ISO’s Space Debris Mitigation Standards,” Universities Space Research Association, 2019, <https://www.hou.usra.edu/meetings/orbitaldebris2019/orbital2019paper/pdf/6053.pdf>.

26 Office of Outer Space Affairs, *Compendium*, 76.

27 “About the International Telecommunications Union,” International Telecommunications Union, accessed March 20, 2020, <https://www.itu.int/en/about/Pages/default.aspx>.

INTER-AGENCY SPACE DEBRIS COORDINATION COMMITTEE

The IADC is a voluntary collection of 13 of the world's space agencies, which collectively work to provide technical recommendations “for the worldwide technical/scientific coordination of activities related to space debris in Earth orbit issues.”²⁸

The IADC's Space Debris Mitigation Guidelines were developed in 2002, updated in 2007, and became the backbone on which the COPUOS long-term sustainability guidelines were built. The IADC guidelines focus on limitation of debris creation in normal operations over a satellite's lifetime, the minimization of the probability of breakup on orbit, plans for EOL disposal, and the prevention of on orbit collisions with other spacecraft.²⁹ However, like the COPUOS guidelines, the IADC guidelines are non-binding, but several countries have policies that enforce these guidelines nationally.

NATIONAL POLICIES

While there are few officially stated national policies on space sustainability and debris mitigation, there are several indications of what nations are prioritizing within SSA, STM, debris removal, and sustainability efforts. In a 2018 study entitled *Global Trends in Space Situational Awareness (SSA) and Space Traffic Management (STM)*, the Institute for Defense Analyses (IDA) presents several key findings from its case studies that shed light on national priorities and perspectives on sustainability and debris removal activities. Some countries demonstrated “concerns that if they do not participate in global discussions (e.g., long-term sustainability [LTS] guidelines), their national interests will not be appropriately reflected in the rules, and they will miss out on critical opportunities.” The IDA suggests that this indicates countries' willingness to work toward sustainable operations in space to keep the domain safe and clear of debris for future endeavors. The IDA further concluded that Europe, in particular, needed to work cohesively—between EU member countries' national space agencies and the EU's European Space Agency—in order to affect decisions on future STM regulations.³⁰

Many countries are looking to be leaders and responsible actors in space and therefore support growing international efforts to develop responsible behaviors and norms for space operators. The IDA found that countries such as Brazil, China, France, Japan, and South Africa all prioritize the effort to establish norms of behavior in space. Many countries are looking to protect their assets in space through better SSA and STM. This may include advocating for responsible behaviors. The following selection of national policies from 10 different countries demonstrates this breadth and highlights some unique cases.

28 The 13 IADC space agencies include: ASI (Agenzia Spaziale Italiana), CNES (Centre National d'Etudes Spatiales), CNSA (China National Space Administration), CSA (Canadian Space Agency), DLR (German Aerospace Center), ESA (European Space Agency), ISRO (Indian Space Research Organisation), JAXA (Japan Aerospace Exploration Agency), KARI (Korea Aerospace Research Institute), NASA (National Aeronautics and Space Administration), ROSCOSMOS (State Space Corporation “ROSCOSMOS”), SSAU (State Space Agency of Ukraine), and UKSA (United Kingdom Space Agency). Alberto Tuozi, “The Inter-Agency Space Debris Coordination Committee (IADC) an overview of IADC's annual activities,” International Committee on Global Navigation Satellite Systems, November 4-9, 2018, 2, https://www.unoosa.org/documents/pdf/spacelaw/sd/IADC-2002-01-IADC-Space_Debris-Guidelines-Revision1.pdf.

29 Tuozi, “The Inter-Agency Space Debris Coordination Committee (IADC) an overview of IADC's annual activities,” 6, 9.

30 Lal et al., *Global Trends in Space Situational Awareness*, 20-21.

There is a wide spectrum of national space debris mitigations standards and guidelines. Some nations are just starting their evaluation processes to inform their national perspective and potential policies or regulations, while others have well-developed and exacting guidelines for both national and commercial space missions. Several additional nations were surveyed but did either not have enacted national policies or only had minimal language addressing space debris mitigation. These include Brazil, New Zealand, Saudi Arabia, South Africa, and the United Arab Emirates.

AUSTRALIA

Australia has agreed to prioritize the debris mitigation guidelines laid out by COPUOS but has no specific national policy toward space debris creation or the mitigation of existing debris. However, Australia has official guidelines for applicants seeking to apply for an overseas launch license that include developing a debris mitigation strategy in line with COPUOS guidelines.³¹ Australia also recently brought a C-band space surveillance radar system online that will track space debris as part of its operations.³² This is one step toward building out Australia's SSA and debris monitoring capabilities—a national priority, according to the country's new civil space strategy.³³ Better SSA data, especially from the Southern Hemisphere, will help with STM and sustainability practices globally.

AUSTRIA

Despite not having a strong space presence, Austria has detailed official policies to curtail the creation of space debris. The Austrian Outer Space Regulation states that as a condition for authorization of launch the operator must submit a detailed plan showing that provisions have been made for the mitigation of space debris, including mitigating on-orbit debris creation, preventing on-orbit collisions or breakups, and removing space objects at EOL, and that non-maneuverable objects operators must show that the orbit chosen will ensure the reentry of the object within 25-years post-mission.³⁴

CANADA

Canada also has a regulatory framework to mitigate the creation of space debris. For remote sensing satellites, operators must provide an assessment of the expected debris created on orbit and a plan for disposal after EOL.³⁵ The Canadian Space Agency (CSA) has adopted the IADC Space

31 Office of Outer Space Affairs, *Compendium*, 7.

32 “Western Australia ready to start tracking space debris,” Engineers Australia, accessed March 20, 2020, <https://www.engineersaustralia.org.au/News/western-australia-ready-start-tracking-space-debris>.

33 Australian Space Agency, *Advancing Space: Australian Civil Space Strategy 2019 – 2028* (Canberra: Government of Australia, April 2019), <https://publications.industry.gov.au/publications/advancing-space-australian-civil-space-strategy-2019-2028.pdf>.

34 “Regulation of the Federal Minister for Transport, Innovation and Technology in Implementation of the Federal Law on the Authorisation of Space Activities and the Establishment of a National Space Registry (Outer Space Regulation),” Government of Austria, 2015, 2, <http://www.spacelaw.at/wp-content/uploads/2016/05/Austrian-Outer-Space-Regulation-2015.pdf>.

35 *Remote Sensing Space Systems Act*, Government of Canada, November 25, 2005, <https://laws-lois.justice.gc.ca/eng/acts/r-5.4/page-1.html#h-427028>.

Debris Mitigation Guidelines and intends to apply it to all CSA activities. Additionally, within licensing procedures for spacecraft that use the radio spectrum, the Canadian government requires that licensees submit a space debris mitigation plan. If the satellite will be in GEO, the plan must be in accordance with the ITU guidelines.³⁶

FINLAND

In 2018, Finland enacted the Act on Space Activities, which governs any space activities on the territories or vessels registered in Finland. One of the conditions for authorization of space activities is that the operator “shall restrict the generation of space debris during normal operations” and has a plan for EOL or termination of the mission.³⁷ The same act also details that space activities should be carried out in a sustainable manner for the space environment. This includes that a space object must be maneuvered to a non-crowded orbit or deorbited into the Earth’s atmosphere within 25 years of its EOL.³⁸

FRANCE

French policies on space debris mitigation can mainly be found within the Decree on Technical Regulation issued in 2011, which focuses on launch and orbital licenses. For launch systems, the vehicle must be “designed, produced and implemented in such a way as to minimize the production of debris during nominal operations, including after the end-of-life of the launcher and its component parts.”³⁹ However, for each payload launched, a single launcher element (such as a faring component or rocket stage) may be placed into orbit. Initially, this may seem like a limitation, but the Ariane-5 is capable of launching several payloads to orbit simultaneously. In the past five years, it has never launched less than two payloads at the same time.⁴⁰ Additionally, since the Ariane vehicles are operated by a joint venture between the ESA and France’s national civil space agency they do not fall under these national restrictions.⁴¹ The ESA is the owner of all launch infrastructure out of French Guiana, the European spaceport, including the launch site and vehicle.⁴²

For orbital systems, the Decree on Technical Regulation states that these systems must also be designed, produced, and implemented in a way that avoids generating debris during nominal operations. The probability of breakup on orbit at the time of launch must be less than 1 in 1,000. Additionally, the regulations demand that once a space object has completed its mission, it must be able to safely deorbit with controlled atmospheric reentry. If it cannot deorbit, it must be sent

36 Office of Outer Space Affairs, *Compendium*, 17.

37 *Act on Space Activities*, Ministry of Economic Affairs and Employment, Government of Finland, 2018, 6, <https://tem.fi/documents/1410877/3227301/Act+on+Space+Activities/a3f9c6c9-18fd-4504-8ea9-bff1986fff28/Act+on+Space+Activities.pdf>.

38 Office of Outer Space Affairs, *Compendium*, 24.

39 *Ibid.*, 25.

40 “Ariane-5,” Gunter’s Space Page, accessed March 25, 2020, https://space.skyrocket.de/doc_lau/ariane-5.htm.

41 About 63 percent of Arianespace’s capital is held by France. The rest is unequally held by Germany, Switzerland, Sweden, Italy, Spain, Norway, the Netherlands, and Belgium. “Company Profile,” ArianeSpace, accessed March 24, 2020, <https://www.arianespace.com/company-profile/>.

42 “Who does what?,” ArianeSpace, accessed March 24, 2020, <https://www.arianespace.com/spaceport-facility/who-does-what/>.

into a non-usable orbit, or graveyard orbit, by 25 years after the EOL of the spacecraft.⁴³ This is in accordance with the ITU's protections for GEO.

INDIA

Despite being one of the foremost launching states, with six orbital launches in 2019, India does not have any specific language in national policy documents promoting space sustainability.⁴⁴ Despite this, India is focusing on further building out national SSA capabilities through developing an SSA control center dedicated to “protecting high valued space assets from space debris close approaches and collisions.”⁴⁵ India is a founding member of COPUOS and a signatory to the long-term sustainability guidelines.⁴⁶

JAPAN

In 2016, Japan published the Space Activities Act, which gives guidance on regulation and licensing of varied space activities for the Japanese commercial sector. For both satellite launch and control, non-governmental organizations need government approval. This includes pre-launch examinations for compliance and safety reasons. To obtain a license, the company must have space debris mitigation measures in line with those from the Outer Space Treaty. However, unlike some national laws, Japan has limited its scope to only launches from Japanese territory. In contrast, many other nations regulate businesses registered in their country but launching elsewhere.⁴⁷ Satellite licensees must also include plans for EOL in their application. The steps for EOL must be one of the following choices, barring any accidental explosion or malfunction on orbit: “(1) de-orbiting and re-entry to Earth, with public safety at landing ensured; (2) deploying the satellite into ‘graveyard orbit’; or (3) deploying the satellite into the orbit of another celestial body or allowing the satellite to fall into the celestial body.” These measures are in line with modern norms for limiting the creation of space debris.⁴⁸

In 2017, Japan's Committee on National Space Policy, which reports directly to the Japanese prime minister, established a new task force focused on space debris. The Task Force for Space Debris is composed of Japan's state ministers and the president of the Japan Aerospace Exploration Agency (JAXA). The task force convened twice in 2019.⁴⁹

43 Office of Outer Space Affairs, *Compendium*, 27.

44 “Space Environment: Total Launches by Country,” Aerospace Security Project, last updated January 2, 2020, <https://aerospace.csis.org/data/space-environment-total-launches-by-country/>.

45 Indian Space Research Organization, “Foundation stone of Space Situational Awareness Control Centre by Chairman, ISRO,” Government of India, August 03, 2019, <https://www.isro.gov.in/update/03-aug-2019/foundation-stone-of-space-situational-awareness-control-centre-chairman-isro>.

46 Office of Outer Space Affairs, “Committee on the Peaceful Uses of Outer Space: Membership Evolution,” United Nations, accessed March 20, 2020, <https://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html>.

47 Setsuko Aoki, “Domestic Legal Conditions for Space Activities in Asia,” *AJIL Unbound* 113 (2019): 103–108, doi:10.1017/aju.2019.14.

48 Hiroko Yotsumoto and Daiki Ishikawa, “Japan,” *The Space Law Review*, December 2019, accessed February 4, 2020, <https://thelawreviews.co.uk/edition/the-space-law-review-edition-1/1211969/japan>.

49 Charity Weeden et al., “Development of global policy for active debris removal services,” First International Orbital Debris Conference, 2019, 4, <https://www.hou.usra.edu/meetings/orbitaldebris2019/orbital2019paper/pdf/6077.pdf>.

Furthermore, JAXA was among the world's first space agencies to define national space debris mitigation guidelines. Its primary space debris mitigation standards document includes the following requirements:

- Preventing on orbit breakups of space systems after mission completion;
- Transferring GEO spacecraft into a graveyard orbit at EOL;
- Reducing the orbital lifetime in which a stage in geostationary transfer orbit (GTO) may interfere with the protected GEO region;
- Minimizing objects released on orbit during normal operations; and
- Reducing orbital lifetime after mission completion of LEO spacecraft.

JAXA applies the above guidelines and more to its own space missions and contractors on JAXA projects, but the agency does not have authority over non-JAXA space missions.⁵⁰ JAXA recently selected an emerging ADR company, Astroscale, as a commercial partner for the space agency's first debris removal demonstration.⁵¹

JAXA is mostly focused on civil space missions, while the Japanese Ministry of Defense focuses on military space missions. There is a great deal of technology sharing across the two agencies, and the two also share a common concern for space debris.⁵²

The government of Japan is currently pursuing new programs for space debris monitoring and has established a data-sharing agreement focused on SSA between the Japanese Self-Defense Forces, JAXA, and the United States.⁵³ As part of this initiative, Japan has agreed to host SSA payloads from the United States on its Quasi-Zenith Satellite System (QZSS)—a national positioning, navigation, and timing (PNT) satellite constellation.⁵⁴ The QZSS program is run by the Cabinet Office rather than JAXA or the Ministry of Defense.⁵⁵

NIGERIA

An emerging space nation with a relatively nascent space agency and only nine national satellites to date, Nigeria enacted basic national regulations to mitigate the creation of space debris. In order to obtain a license for any space activities in Nigeria, the licensee in question

50 Office of Outer Space Affairs, Compendium, 37-38; and "Space Debris Mitigation Mechanism: The Case of JAXA," UNCO-PUOS Legal Subcommittee, March 23-April 3, 2009, <https://www.unoosa.org/pdf/pres/lsc2009/pres-05.pdf>

51 For more on Astroscale, see page 16. "Astroscale Selected as Commercial Partner for JAXA's Commercial Removal of Debris Demonstration Project," Astroscale, Press Release, February 12, 2020, <https://astroscale.com/astroscale-selected-as-commercial-partner-for-jaxas-commercial-removal-of-debris-demonstration-project/>.

52 "Japan to assign 100 personnel to new satellite monitoring unit," *Japan Times*, May 14, 2019, <https://www.japantimes.co.jp/news/2019/05/14/national/science-health/japan-assign-100-personnel-new-satellite-monitoring-unit/#.Xg-pvbEdKiUk>.

53 "Japan, US to collaborate on space surveillance," *The Mainichi*, March 30, 2019, <https://mainichi.jp/english/articles/20190330/p2a/00m/0na/002000c>.

54 "Joint Statement: The Sixth Meeting of the U.S.-Japan Comprehensive Dialogue on Space," Government of Japan, July 24, 2019, 2, <https://www.mofa.go.jp/mofaj/files/000501699.pdf>.

55 "Basic Policy on the Implementation of the Operational Quasi-Zenith Satellite System (QZSS) Project," Government of Japan Cabinet Decision, September 30, 2011, <https://www8.cao.go.jp/space/english/basicpolicy.html>.

must show that it can conduct its space operations in such a way as to mitigate the creation of space debris and govern the disposal of the spacecraft at its EOL. However, there are few specifics on exactly what constitutes safe operations in space or how and when to dispose of dying spacecraft.⁵⁶

UKRAINE

Ukraine also has specific laws addressing space debris mitigation. In the Law of Ukraine on Space Activity, the government institutes several technical regulations in order to mitigate the creation of space debris. This includes: eliminating or minimizing space debris creation during normal operations of a spacecraft; minimizing the possibility of breakups on orbit, including at EOL of a spacecraft; removal of a spacecraft and launch vehicle from orbit at completion of mission; and preventing in-space collisions in near-Earth space.⁵⁷ While Ukraine is not a member of COPUOS, nor has it adopted the recent COPUOS guidelines for space sustainability, there were Ukrainian representatives present at the final working session to adopt the guidelines for the long-term sustainability of outer space activities.⁵⁸

THE UNITED KINGDOM

For the United Kingdom, the national policy mechanism for space activities, which includes measures for space sustainability, is the Outer Space Act of 1986. In order to obtain a license from the secretary of state, the licensee must conduct operations in a way that will prevent or mitigate the creation of space debris. The license applicant must show quantitative and qualitative analysis on the potential hazards for not only the launch and on-Earth operations but also hazards posed to other on-orbit spacecraft. Applicants are also required to demonstrate that they are in line with the current best practices relating to space debris mitigation, including several international mechanisms, such as the IADC Space Debris Mitigation Guidelines, the COPUOS guidelines, and other international standards for space debris mitigation.⁵⁹

MULTINATIONAL ACTIVITIES

THE EUROPEAN SPACE AGENCY

In 2014, the ESA updated its Space Debris Mitigation Policy, which was originally released in 2008. The 2014 update focused on minimizing the impact of operations in the space environment, reducing the risk of collision on orbit, and ensuring safe reentry of spacecraft. This document sets forth specific technical standards for risk of reentry.⁶⁰

56 Office of Outer Space Affairs, *Compendium*, 42.

57 Ibid., 54.

58 Office of Outer Space Affairs, *Report of the Committee on the Peaceful Uses of Outer Space: Sixty-second session* (New York: United Nations, June 2019), https://www.unoosa.org/res/oosadoc/data/documents/2019/a/a7420_0_html/V1906077.pdf.

59 "Licence to operate a space object: how to apply," Government of the United Kingdom, April 16, 2014, last updated September 3, 2019, <https://www.gov.uk/guidance/apply-for-a-license-under-the-outer-space-act-1986>.

60 "Space Debris Mitigation Policy for Agency Projects," ESA's Director General's Office, March 24, 2014, https://www.iadc-home.org/documents_public/view/id/121#u.

A year later, the ESA released the ESA Space Debris Mitigation Compliance Verification Guidelines. These guidelines provide detailed information on verification methods and implementation of mitigation measures for ESA projects.⁶¹

The ESA lays out future space sustainability goals on their website. These goals include: having a fleet of spacecraft by 2030 that are resilient to the threat of space debris; having the ability to monitor and safely manage traffic in space, including being able to clean or dispose of existing debris in popular orbits; and developing an “Automated Collision Avoidance System” to ensure no damage is caused that creates new debris. The ESA also plans on developing an ADR system that can act as both an OOS satellite, possibly extending the life of spacecraft on orbit, and as a cleaning unit that will be able to deorbit or move satellites into non-popular orbits for the safety of other space missions.⁶²

One ADR system sponsored by the ESA is through a Swiss company called ClearSpace. Their first demonstration satellite, *ClearSpace-1*, is scheduled to launch in 2025. *ClearSpace-1* will perform proximity operations to approach its target, extend tentacle-like arms to grab the target, and use its own propellant to deorbit both itself and the target—burning up both systems in the Earth’s atmosphere on descent.⁶³

ESA Director General Jan Woerner recently announced that he strongly believes all satellite operators—including nation states and companies—should act to mitigate the creation of new debris now and not wait for international regulations. Woerner is particularly concerned about the amount of planned mega constellations, such as those planned by SpaceX and OneWeb.⁶⁴ Specific direction from the director general may push the ESA, and its member states, to take stronger actions to prevent the creation of space debris or to mitigate the amount of debris already on orbit.

EUROPEAN UNION

Through the European Union’s multinational foreign policy and security service, the European External Action Service, the European Union is also focusing efforts on mitigating space debris. This effort is known as the Safety, Security and Sustainability of Outer Space (3SOS) initiative and intends to promote ethical conduct, particularly focused on limiting and mitigating the amount of debris in space.⁶⁵ Special Envoy for Space and Head of the European External Action Service Space Task Force Carine Claeys stated in early September 2019 that she believed the commonly-

61 Ibid.

62 “Plans for the Future,” ESA, accessed March 20, 2020, http://www.esa.int/Safety_Security/Plans_for_the_future.

63 Andrew Jones, “European Space Agency Targets Orbital Debris, Solar Storms,” IEEE Spectrum, January 22, 2020, <https://spectrum.ieee.org/tech-talk/aerospace/satellites/european-space-agency-esa-mission-news-orbital-debris-solar-storms>.

64 Debra Werner, “ESA Director General calls for aggressive action on space debris,” Space News, November 19, 2019, <https://spacenews.com/woerner-debris-regulation/>.

65 “SOS SOS SOS: EU calls for ethical conduct in space to avoid collision and orbital debris,” European External Action Service, September 19, 2019, https://eeas.europa.eu/headquarters/headquarters-homepage/67538/sos-sos-sos-eu-calls-ethical-conduct-space-avoid-collision-and-orbital-debris_en.

practiced norm of deorbiting 25 years post EOL, especially in LEO, was outdated.⁶⁶ This echoes sentiments from much of the space policy community and could be one of the first items on the docket for this new task force.

INDUSTRY EFFORTS

Without coherent international attention until recently, several space companies have been leading voices in sustainability and debris removal best practices. Planet, a U.S. satellite company, has spoken publicly about its commitment to a sustainable space environment and the requirement for the company to produce no long-lasting space debris. Planet ensures its constellations of Earth observation satellites are in low orbits so that they will deorbit easily and burn up in the Earth's atmosphere. Additionally, the company pledges that no debris from their products will be created during launch or on-orbit operations.⁶⁷

American company OneWeb announced in December 2019 its intent to place grappling fixtures on its constellation of LEO communications satellites. These fixtures, developed by Altius Space Machines, will allow for the OneWeb constellation to engage in both satellite-servicing and EOL disposal. OneWeb executive Tim Maclay stated, "It is critical we do all we can to employ responsible design and operational practices to ensure a sustainable environment for future generations."⁶⁸

Iridium Communications also wants to be a leader in space sustainability efforts. The company is particularly responsible in its deorbiting and EOL measures.⁶⁹ Iridium often deorbits satellites within 30 days of the end of the mission. Recently, Iridium CEO Matt Desch also acknowledged that Iridium would be willing to pay for ADR services for its existing and future fleet of satellites.⁷⁰

Space sustainability and the threat of space debris impacting future space operations has also led to several new space companies focused on ADR or EOL maintenance. For Astroscale, a Japanese company, the desire to mitigate debris in space is foundational for its business case. Astroscale is developing a fleet of satellites to perform ADR and EOL deorbiting services. The company plans to launch an initial test in 2020 that includes two satellites—a retriever satellite and a target. The retriever satellite is capable of performing rendezvous and proximity operations and carries a magnetic plate in order to dock with the target satellite carrying a matching magnetic plate.⁷¹

66 "3SOS initiative: a new public diplomacy initiative for safety, security and sustainability of outer space activities," European External Action Service, October 18, 2019, https://eeas.europa.eu/headquarters/headquarters-homepage_bg/69068/3SOS%20initiative:%20a%20new%20public%20diplomacy%20initiative%20for%20safety,%20security%20and%20sustainability%20of%20outer%20space%20activities.

67 "Code of Ethics," Planet, accessed March 2, 2020, <https://www.planet.com/ethics/>.

68 "OneWeb and OneWeb Satellites bolster commitment to Responsible Space with advanced grappling technology from Altius Space Machines," OneWeb, December 10, 2019, <https://www.oneweb.world/media-center/oneweb-and-one-web-satellites-bolster-commitment-to-responsible-space-with-advanced-grappling-technology-from-altius-space-machines>.

69 Jeff Foust, "Iridium to complete next-generation satellite deployment by this fall," Space News, May 14, 2018, <https://spacenews.com/iridium-to-complete-next-generation-satellite-deployment-by-this-fall/>.

70 Caleb Henry, "Iridium would pay to deorbit its 30 defunct satellites – for the right price," Space News, December 30, 2019, <https://spacenews.com/iridium-would-pay-to-deorbit-its-30-defunct-satellites-for-the-right-price/>.

71 "ELSA-d," Astroscale, accessed March 5, 2020, <https://astroscale.com/missions/elsa-d/>.

This indicates that Astroscale's technology may only be able to "clean-up" satellites that have been outfitted with one of its magnetic plates prior to launch. However, the company acknowledges that a market exists to remove debris already on orbit, and it is working with national space agencies and international bodies to assist with a solution.⁷²

In October 2019, the Satellite Industry Association (SIA) released its own space sustainability guidance entitled the Principles of Space Safety for Space Actors. The SIA is a U.S.-based trade association representing dozens of leading satellite companies. These principles are dedicated to cooperating and communicating with national space agencies, key regulatory agencies, and the United Nations. It also recommends implementing measures such as designing geostationary objects that are trackable, providing a 24/7 point of contact in the case of a potential collision of satellites, and minimizing the intentional creation of debris on launch and on orbit.⁷³

Finally, a coordinated effort led by the World Economic Forum (WEF) has brought together several stakeholders in order to create a Space Sustainability Rating (SSR), including the ESA, Massachusetts Institute of Technology's Media Lab, University of Texas at Austin, and Bryce Space and Technology. This initiative is in the early stages, with these organizations working to define the technical elements and operation of the SSR.⁷⁴ The rating is likely to include the physical elements of a satellite as well as its concept of operations for avoiding potential collisions and EOL disposal. The SSR has had positive feedback from the international space community, including the space industry.⁷⁵

PRESSING CONCERNS

A concern expressed by several in the space community is that real efforts to protect the space domain will not occur until another major debris-creating event occurs. It is possible that the next collision that creates hundreds or thousands of pieces of debris on orbit could resemble the Iridium-Cosmos collision in 2009. In that incident, an active commercial satellite, *Iridium-33*, collided with an inactive Russian satellite, *Cosmos-2251*, creating 1,875 pieces of debris large enough to track (greater than 10 cm).⁷⁶ To date, about 1,300 pieces of trackable debris remain on orbit from this collision.⁷⁷ But without international standards and norms to build on, even a devastating debris-creating event may not be enough to spur international action.

However, there is a strong industry and multinational consensus that protecting the space environment and focusing on efforts to mitigate the creation of new space debris should be an international priority. This can be seen in the strong support of the recent COPUOS guidelines for

72 "Active Debris Removal (ADR)," Astroscale, accessed March 5, 2020, <https://astroscale.com/missions/active-debris-removal-adr/>.

73 "Principles of Space Safety for the Commercial Satellite Industry," Satellite Industry Association, October 22, 2019, https://sia.org/space_safety/.

74 "Space Sustainability Rating," World Economic Forum, accessed March 24, 2020, <https://www.weforum.org/projects/space-sustainability-rating>.

75 Jeff Foust, "Work advances on space sustainability rating," Space News, January 20, 2020, <https://spacenews.com/work-advances-on-space-sustainability-rating/>.

76 Weeden, "2009 Iridium-Cosmos Collision Fact Sheet."

77 Author analysis using T.S. Kelso's Celestrak Visualizer. "Celestrak Orbit Visualization," Celestrak, accessed March 26, 2020, <https://celestrak.com/>.

space sustainability. Ninety-one world powers have agreed to follow these guidelines and best practices. This includes the largest spacefaring nations—the United States, Russia, and China—which notoriously disagree on many UN space resolutions.

The last guideline in the UN Guidelines for the Long-term Sustainability of Outer Space Activities hits on the contentious issue of who, if anyone, is responsible for cleaning up existing space debris. The guideline does not suggest responsibility, but the burden of cleaning up a polluted environment would certainly be a sizable cost for any nation or company and lead to higher insurance costs. Therefore, a likely area of contention is exactly who is responsible for clearing the growing debris cloud.

Rendezvous and Proximity Operations

Rendezvous and proximity operations, commonly referred to as RPOs, often refer to a spacecraft intentionally maneuvering to dock or operate in close proximity to a target space object. According to an Aerospace Corporation report, an “RPO generally refers to orbital maneuvers in which two spacecraft arrive at the same orbit and approach at a close distance. This rendezvous may or may not be followed by a docking procedure.”⁷⁸

However, like SSA and STM, there is no international consensus on a definition or homogenous concept of activities that can be classified as an RPO.⁷⁹ A U.S.-led group called the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) has defined rendezvous as the “process wherein two space objects (artificial or natural body) are intentionally brought close together through a series of orbital maneuvers at a planned time and place.” The group also defines proximity operations as a “series of orbital maneuvers executed to place and maintain a spacecraft in the vicinity of another space object on a relative planned path for a specific time duration to accomplish mission objectives.”⁸⁰

RPOs are foundational for several key space activities, such as on-orbit servicing and refueling, docking with space stations for human spaceflight, and ADR. In the next decade, RPO maneuvers will likely become commonplace due to several OOS and ADR projects planned both by governments and private industry. Furthermore, two of the largest spacefaring nations are both planning long-term projects that will rely on RPOs to fully function: the new Chinese space station and the American Lunar Gateway project. With the projected increase in frequency of these activities, there have been calls for international standardization of RPO interactions.

Another consideration is that the RPO technology needed for OOS activities or EOL disposal is similar to the technology needed for an effective co-orbital antisatellite (ASAT) weapon. Co-orbital ASATs may perform RPOs in order to physically collide or detonate near a satellite or maneuver near enough to interfere with the target’s electronics or communications.⁸¹ Normalizing RPO behaviors may help build trust or confidence in satellite operators’ RPO intentions or to

78 Rebecca Reesman and Andrew Rogers, *Getting in your Space: Learning from Past Rendezvous and Proximity Operations* (El Segundo, CA: Aerospace Corporation, May 2018), 2, <https://aerospace.org/sites/default/files/2018-05/GettingInYourSpace.pdf>.

79 Committee on the Peaceful Uses of Outer Space, “Meeting hosted by Switzerland on possible further work on the long-term sustainability of outer space activities: Background and Chair’s Summary,” United Nations, June 12-21, 2019, 4, https://www.unoosa.org/res/oosadoc/data/documents/2019/aac_1052019crp/aac_1052019crp_16_0_html/AC105_2019_CRP16E.pdf.

80 “Guiding Principles for Commercial Rendezvous and Proximity Operations (RPO) and On-Orbit Servicing (OOS),” CONFERS, November 7, 2018, 2, https://www.satelliteconfers.org/wp-content/uploads/2018/11/CONFERS-Guiding-Principles_7Nov18.pdf.

81 Todd Harrison, Kaitlyn Johnson, and Thomas G. Roberts, *Space Threat Assessment 2019* (Washington, DC: CSIS, April 2019), 2-7, <https://aerospace.csis.org/wp-content/uploads/2019/04/SpaceThreatAssessment2019-compressed.pdf>.

discriminate between a planned and peaceful RPO and one that may have nefarious intent. Despite the increasing need, no national or international policies explicitly regulate RPOs.⁸²

REACTIONS TO RUSSIAN RENDEZVOUS AND PROXIMITY OPERATIONS

A Russian satellite in GEO has become notorious for skirting the line between acceptable and unacceptable behavior on orbit when it comes to RPOs. *Olymp-K*, commonly also known as *Luch*, frequently performs maneuvers in GEO, a region often characterized by its “stationary” attributes. Thus far in its operational lifetime, *Luch* has stopped at 19 orbital locations in the GEO belt.⁸³ To have more than two or three orbital locations on the GEO belt throughout a satellite’s lifetime is uncommon for any GEO satellite.

In 2015, *Luch* positioned itself between two satellites operated by a U.S. communications company, Intelsat.⁸⁴ According to SSA data, the two Intelsat satellites were likely in the same orbital slot and only separated by approximately 150 km in the geostationary belt.⁸⁵ This close approach could allow for the observation or inspection of the Intelsat satellites or the interception of cross-link or uplink communications to the satellites. At the time, Kay Sears, president of Intelsat General, commented that this was not “normal behavior” and that the company was “concerned.”⁸⁶ Later, in September 2015, *Luch* approached a third Intelsat satellite.⁸⁷

In 2017, *Luch* again caused international outcry for maneuvering near a French-Italian military satellite, *Athena-Fidus*. This RPO caused French Minister of the Armed Forces Florence Parly to accuse Russia of performing espionage on *Athena-Fidus*. Similar to the Intelsat incident, it is possible *Luch* was observing or intercepting communications.⁸⁸ Space expert Jonathan McDowell tracked *Luch*’s RPO in GEO and concluded that in reality *Luch* was parked nearer to a Pakistani satellite dubbed *Paksat-1R*. However, unlike France, there was no official outcry from the Pakistan government about the abnormal behavior.⁸⁹

France responded to the *Luch* rendezvous with a national refocus on space. The nation created a new space command within the French air force focused on defending national space assets. This includes developing active defense measures, such as investing in “bodyguard” satellites

82 Reesman and Rogers, “Getting in your Space,” 4.

83 This data was updated as of January 2020. Todd Harrison, Kaitlyn Johnson, Thomas G. Roberts, Tyler Way, and Makena Young, *Space Threat Assessment 2020* (Washington, DC: CSIS, March 2020), 24, <http://aerospace.csis.org/sta2020>.

84 Mike Gruss, “Russian Satellite Maneuvers, Silence Worry Intelsat,” *Space News*, October 9, 2015, <https://spacenews.com/russian-satellite-maneuvers-silence-worry-intelsat/>.

85 This approximation was derived from 0.2 degrees longitude on the geostationary belt. The formula used was distance = 2 * orbital radius * Sin (0.5 * angular separation). In this particular case, the orbital radius is 42,164 km at GEO and the angular separation is 0.2 degrees.

86 Gruss, “Russian Satellite Maneuvers, Silence Worry Intelsat.”

87 Harrison, Johnson, and Roberts, *Space Threat Assessment 2019*, 21.

88 Ibid., 21-22.

89 Jonathan McDowell, Twitter Post, September 7, 2018, 3:30PM, <https://twitter.com/planet4589/status/1038147610073341953?lang=en>.

to protect national space assets, such as *Athena-Fidus*.⁹⁰ These bodyguard smallsats would be responsible for monitoring and observing the space around French satellites and reporting or taking pictures of an object that enters into their proximity.⁹¹ Florence Parly announced that she had also requested cameras be integrated on France's two new military communications satellites, destined for GEO in the early-2020s. France is also investing in a new space academy to coalesce space-focused military training courses, promote space careers, and develop a new cadre of military space professionals. They expect to one day have a space-focused military general.⁹²

However, the geostationary belt is not the only place where Russia is conducting extensive RPOs. Russian satellite *Cosmos 2543* launched on November 25, 2019. *Cosmos 2543* was described as entering an orbit "from which the state of domestic satellites can be monitored" by the Russian Ministry of Defense.⁹³ Within two weeks after launch, the Ministry of Defense announced that a subsatellite had been deployed from *Cosmos 2543*, dubbed *Cosmos 2542*. This is not the first time Russia has deployed a subsatellite.

Only three days later, *Cosmos 2542*, the subsatellite, performed an orbital maneuver in order to synchronize its orbit with a U.S. government satellite, *USA 245*. Amateur satellite trackers observed and shared orbital observations online that *Cosmos 2542* appeared to be trailing *USA 245*. *USA 245* soon performed its own irregular maneuver, possibly to drop *Cosmos 2542* off its tail.⁹⁴ However, in January 2020, *Cosmos 2542* maneuvered once again toward *USA 245*, coming as close as 50 km from the American satellite.⁹⁵ After this flyby, *USA 245* maneuvered once more to distance itself from the Russian subsatellite.⁹⁶ General John Raymond, commander of U.S. Space Command and chief of space operations of the U.S. Space Force, indicated in a later press interview that he believed the actions of *Cosmos 2542* were intentional.⁹⁷

What these two encounters highlight is that there is little to no definition of what is a normal RPO behavior or how satellite operators may discriminate between a normal maneuver and a nefarious one.

90 Brian G. Chow and Henry Sokolski, "The United States should follow France's lead in space," Space News, September 9, 2019, <https://spacenews.com/the-united-states-should-follow-frances-lead-in-space/>.

91 Gosnold, "Space Situational Awareness news from the Paris Airshow," SatelliteObservation.net, June 20, 2019, <https://satelliteobservation.net/2019/06/20/space-situational-awareness-news-from-the-paris-airshow/>.

92 Florence Parly, "Présentation de la stratégie spatiale de défense," (speech, Paris, France, July 25, 2019), <https://satellite-observation.files.wordpress.com/2019/07/discours-de-florence-parly-prc3a9sentation-de-la-stratc3a9gie-spatiale-de-dc3a9fense-c3a0-lyon-le-25-juillet-2019.pdf>.

93 "Orbital Launches of 2019," Gunter's Space Page, 2020, https://space.skyrocket.de/doc_chr/lau2019.htm; Ministry of Defence of the Russian Federation, "Russian Aerospace Forces successfully launches Soyuz-2 launch vehicle from Plesetsk Cosmodrome," Russian Federation, November 26, 2019, http://eng.mil.ru/en/news_page/country/more.htm?id=12263690@egNews.

94 Anatoly Zak, "Soyuz-2-1v Launches Classified Payload," Russian Space Web, January 29, 2020, accessed on February 2, 2020, <http://www.russianspaceweb.com/cosmos-2542.html>.

95 Jonathan McDowell, Twitter post, January 31, 2020, 8:37 p.m., <https://twitter.com/planet4589/status/1223420130576818176>.

96 Michael Thompson, Twitter post, January 31, 2020, 11:40 p.m., https://twitter.com/M_R_Thomp/status/1223466202967760896.

97 Sandra Erwin, "Raymond calls out Russia for 'threatening behavior' in outer space," Space News, February 10, 2020, <https://spacenews.com/raymond-calls-out-russia-for-threatening-behavior-in-outer-space/>.

INDUSTRY STANDARDS

As more commercial companies build their business plans around RPO capabilities, the need for defined and internationally accepted norms of behavior grows. RPOs are foundational for OOS and ADR missions, and companies such as Surrey Satellite and Astroscale are developing technologies without guidance from the international community on accepted behavior or even reporting of RPO maneuvers.

Although there are not many international industry-led initiatives focused on RPOs, a successful ongoing mechanism in the United States may illuminate particular industry concerns. CONFERS is an industry-led initiative supported by the U.S. Department of Defense's Defense Advanced Research Projects Agency (DARPA). CONFERS "aims to leverage best practices from government and industry to research, develop, and publish non-binding, consensus-derived technical and operations standards for OOS [on-orbit servicing] and RPO."⁹⁸ CONFERS is working with over 30 global industry corporations to develop these technical and operations standards.⁹⁹ In October 2019, CONFERS released Recommended Design and Operational Practices as a first step to implementing the CONFERS Guiding Principles for Commercial Rendezvous, Proximity Operations and On-Orbit Servicing (OOS).¹⁰⁰ CONFERS guiding principles focus on consensual operations, compliance, responsible operations, and transparency.¹⁰¹ However, no national governments have officially commented on recommendations from CONFERS thus far, likely because the effort is still ongoing.

INTERNATIONAL ENGAGEMENT

There has been little engagement in the United Nations or other international mechanisms focused on defining standards or norms of behaviors for RPOs. The UN sustainability guidelines encourage states and international intergovernmental organizations to consider providing timely and appropriate information on changes in operating status of their satellites. This includes providing information about changes on orbital position, but not specifically RPOs.¹⁰² In a COPUOS meeting hosted by Switzerland in June 2019, meeting notes indicate that part of the discussion on long-term sustainability of outer space activities focused on RPOs. While discussion indicates that there may be interest in developing multinational efforts focused on better monitoring and regulating RPOs to include sharing information about RPO activities on-orbit, including notification, the details from the meeting are minimal, and there is no indication which countries may support these efforts. However, "[t]he modalities of such notifications (by who? to whom? including which information? according to which timing?) would need to be discussed by COPUOS."¹⁰³

98. David A. Barnhart et al., "Using Historical Practices to Develop Safety Standards for Cooperative On-Orbit Rendezvous and Proximity Operations," 69th International Astronautical Congress (IAC), October 1-5, 2018, 1, https://www.isi.edu/sites/default/files/centers/serc/CONFERS_IAC_Paper_PUBLISH.PDF.

99. "Current Members," CONFERS, accessed January 8, 2020, <https://www.satelliteconfers.org/members/>.

100. "Guiding Principles for Commercial Rendezvous and Proximity Operations (RPO) and On-Orbit Servicing (OOS)," CONFERS; and "CONFERS Recommended Design and Operational Practices," CONFERS, October 1, 2019, https://www.satelliteconfers.org/wp-content/uploads/2019/10/CONFERS_Operating_Practices.pdf.

101. "Guiding Principles for Commercial Rendezvous and Proximity Operations (RPO) and On-Orbit Servicing (OOS)," CONFERS.

102. Committee on the Peaceful Uses of Outer Space, *Guidelines for the Long-term Sustainability of Outer Space Activities*, 9.

103. Committee on the Peaceful Uses of Outer Space, "Meeting hosted by Switzerland on possible further work on the

One ongoing effort of international engagement for normalizing operations in space—which could potentially include RPOs—is the Woomera Manual on the International Law of Military Space Operations. The Woomera Manual is an ongoing academic effort to “articulate and clarify extant law applicable to military activities associated with the space domain, especially that which is relevant in periods of tension (when States and non-State actors may consider using force) or outright hostilities.” These efforts are being undertaken by researchers from the University of Adelaide, University of Exeter, University of Nebraska College of Law, and University of New South Wales in Canberra.¹⁰⁴

Another international ongoing academic effort to better define the legal structure of operating in space is the Manual on International Law Applicable to Military Uses of Outer Space (MILAMOS) project. This effort is led by McGill University, supported by the Canadian government, and is partnering with international institutions from China, Germany, India, the United States, Russia, and Australia.¹⁰⁵ Similar to the Woomera Manual, the MILAMOS project is not solely focusing on RPOs but on a wide range of international law that may include norms of behavior for missions involving RPOs.¹⁰⁶

In late 2019, the ESA announced a contract for independent organizations to bid on a project that will “define requirements and guidelines for close-proximity orbital operations to ensure safe rendezvous and capture operations.” The overall goal of this new Safe Rendezvous and Proximity Operations’ Technology Research Programme is to take into account all possible aspects of RPO activities and create consistent guidelines to ensure safety and sustainability of the space environment. Despite the bid closing date in August 2019, there has been no announcement regarding which organization will lead the program.¹⁰⁷

The ISO is also currently working on a draft for review on programmatic principles and practices of RPOs and OOS missions. This is in part to contribute to the UN Sustainable Development Goals.¹⁰⁸ As of February 2020, the draft was under review by experts from Brazil, France, Germany, Japan, Russia, Ukraine, the United Kingdom, and the United States. The expectation at that time was for a vote to occur in April 2020 to move the draft to a full committee draft stage.¹⁰⁹ Despite this initial work, there is little further detail on what the draft may contain or how it might evolve in the ongoing process.

long-term sustainability of outer space activities.”

104. “The Woomera Manual on the International Law of Military Space Operations,” University of Adelaide, October 2018, <https://law.adelaide.edu.au/woomera/system/files/docs/Woomera%20Manual.pdf>.

105. “Manual on International Law Applicable to Military Uses of Outer Space: Partner and Collaborating Institutions,” McGill University, accessed January 10, 2020, <https://www.mcgill.ca/milamos/partner-institutions>.

106. Ibid.

107. Jessica, “Writing the rules on close-proximity orbital operations,” ESA, July 8, 2019, <http://blogs.esa.int/clean-space/2019/07/08/writing-the-rules-on-close-proximity-orbital-operations/>.

108. “ISO/AWI 24330: Space systems — Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) — Programmatic principles and practices,” International Organization of Standardization, accessed March 24, 2020, <https://www.iso.org/standard/78463.html>.

109. Brian Weeden, “Update on the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS),” United Nations Office of Outer Space Affairs, February 6, 2020, <https://www.unoosa.org/documents/pdf/copuos/stsc/2020/tech-15E.pdf>.

LIKELY OUTCOMES

Unlike space debris mitigation, national and international conversations on best practices surrounding RPOs appear to be in the initial stages. Most of the focus is on the offensive and defensive effects of RPO activities, and little movement to create standards or norms of behavior has progressed. One area where the international community—along with the United States—could make headway is to have a consensual definition on what an RPO is and what kinds of boundaries need to be set to protect one's assets in space. With increasingly transparent satellite activities due to worldwide investments in SSA, it may be possible to develop a standard operating procedure to make the international community aware when one country or company is conducting a cooperative RPO. Additionally, setting distance guidelines for intentional maneuvers by satellite operators for uncooperative or uncoordinated RPOs could help protect satellites and distinguish between an attack and a necessary or routine space operation.

As more countries and companies create operational OOS and ADR satellites, notification of an imminent RPO may become more necessary. Experts' concerns focus on the lack of normal behavior or standards with RPOs on orbit. Another proposed option for establishing norms of behavior or international standards is to require a notification of maneuvering a spacecraft. This could be similar to a notice to airmen (NOTAM)—a notice filed with an aviation authority to inform aircraft of potential hazards or operations in the area. Some space experts believe this is a smart place to start introducing regulations on RPOs, with international notifications if an operator intends to maneuver its spacecraft.¹¹⁰

Experts at the Aerospace Corporation have expressed similar concerns for the need to establish international norms of behavior or technical standards for RPOs. They assess that with ever-crowded orbits and mission lifetime extension opportunities through OOS, internationally sanctioned rules for safe and transparent interactions are needed. A 2018 report highlights that several technical standards have already been agreed upon by some spacefaring nations through documents for the International Space Station (ISS). For the ISS, there is a 4 km nominal approach ellipsoid for active satellites. This acts as a defined barrier for ISS operators to watch and monitor satellites that might come within that space. Additionally, the ISS has a defined 200 m “keep out zone.”¹¹¹ Only preapproved spacecraft—such as a Soyuz capsule bringing new astronauts to the station—may enter this zone and are carefully tracked and monitored. Even during final approach, spacecraft are required to stay at least 2 m away from the space station. Spacecraft are then manually maneuvered to dock with the ISS with a robotic arm, the CanadArm.¹¹² While the situation with the ISS is different from other proposed RPOs, the Aerospace Corporation suggests that these rules could be a foundation for developing internationally agreed-upon standards. The ISS consortium of nations includes Canada, Japan, Russia, the United States, and 11 countries of the ESA: Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom.

110. James A. Vedula and Peter L. Hays, *Major Policy Issues in Evolving Global Space Operations* (Alexandria, VA: Mitchell Institute for Aerospace Studies, February 2018), 45, https://aerospace.org/sites/default/files/2018-05/Space_Policy_FI-NAL_interactive_0.pdf.

111. The idea of a keep out zone for satellites is often compared to similar standards in the maritime domain.

112. Reesman and Rogers, “Getting in your Space,” 1.

POTENTIAL CHALLENGES

The largest challenge for standards on RPO behavior is perhaps national recognition of the issue. There are currently no explicit national policies or statements on RPO activities for civil, commercial, or military space missions. Thus far, there have only been cases of nations calling out one another for unusual or unwelcomed behavior.

Several nations, including Russia, China, and the United States, may be wary of restricting their sovereignty and current freedom of action in space. These nations may not be willing to sign onto an alert system or keep-out zone for several reasons. For example, it could inhibit technology development or emergency servicing of a satellite. These restrictions may also limit activities these nations see as ensuring their own national security—such as the inspection or verification of satellites on orbit, both their own and others’.

Private companies may also voice similar technology development concerns. Business cases built around RPO maneuvering are still fragile, and the space industry is waiting to see if the technology and use cases can be successfully proven and if the price of these services will be reasonable. OOS only succeeds if the servicing that can guarantee life extension of a satellite already on orbit is less costly than the remaining value of the satellite it is servicing. For large exquisite satellites, this may be an easier case to close. But if a company such as SpaceX is launching 60 Starlink satellites a month, its mass-production line likely means the cost of launching a new satellite to replace an old or non-responsive one is lower than paying for an OOS mission. While there are several suggestions for regulating RPO activities, the hurdles for international barriers are high.

Insurance Requirements for Space Missions

Insurance for space missions is increasingly required in some form or fashion by various nations. The issue of liability in space is challenging and stems from unclear, and in some respects outdated, guidance in the Outer Space Treaty of 1967. In the treaty, states are responsible for “national space activities whether carried out by governmental or non-governmental entities” and are “liable for damage caused by their space objects.”¹¹³ This clause, along with the 1972 UN Convention on International Liability for Damage Caused by Space Objects (commonly referred to as the Liability Convention), makes clear that states are responsible for both their own actions in space and those of private enterprises, if launched from their territory. The Liability Convention makes clear that a nation is liable for damage to third parties arising out of its space activities.¹¹⁴ Most of the national policies described in this section were created to pass along potential costs from the launching state to the private actor in the case of a liability claim. This has led to states self-insuring their own space activities as well as the rise of private insurance for commercial space activities. For a commercial company, purchasing insurance is often the third-highest cost for the satellite operator, after the cost of the satellite itself and the cost of launch.¹¹⁵

FUNDAMENTALS OF SPACE INSURANCE

Like all insurance, the fundamental value of space insurance is to manage risk and protect against financial loss. The space business remains a risky business. There are many critical points of failure, and until new technologies such as OOS emerge, very few mechanisms exist for correcting an on orbit failure on a satellite. Even new technologies designed to reduce risks, such as OOS, can introduce new risks to satellites and the missions they support. Space insurance can cover a variety of these risks, including launch failure, deployment failure, and mission failure. The most common form of independent insurance is “launch plus one,” or the coverage of the launch of the satellite into orbit and one year of its operations. Launch plus one covers the highest-risk phase of a satellite’s lifetime. Using analysis from the Aerospace Corporation, the table below depicts a more detailed assessment of types of space insurance.¹¹⁶

113. Office of Outer Space Affairs, “Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies,” United Nations, <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html>.

114. Office of Outer Space Affairs, “Convention on International Liability for Damage Caused by Space Objects,” United Nations, November 29, 1971, <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introliability-convention.html>.

115. Lindsay D. Chaney and Nicholas S. Hirano, *End of an Era? Satellite Insurance Faces Changing Landscape* (El Segundo, CA: Aerospace Corporation, November 2019), 2, https://aerospace.org/sites/default/files/2019-11/Chaney_SatelliteInsurance_11132019.pdf.

116. Ibid.

TYPES OF INSURANCE COVERAGE FOR SATELLITES			
PRE-LAUNCH	THIRD-PARTY LIABILITY	LAUNCH	ON ORBIT
Coverage includes damage to satellite or space launch vehicle during manufacturing, transportation, assembly, and processing phases. All prior to launch.	Coverage protects satellite operators from claims from third parties for injury or property damages during pre-launch, or on orbit activities.	Launch Plus One Year	
		Coverage includes loss, damage, or failure of satellite. This coverage begins at the initial ignition of the rocket through the separation of the payload from the launch vehicle.	Coverage includes complete or partial failure of the satellite during its operational lifetime. Coverage begins after initial separation of the satellite from the launch vehicle. Coverage is typically renewed annually.

SPACE INSURANCE INDUSTRY

Space insurance originally began as a subset of the aviation insurance industry. However, insurers quickly realized the need for a separate specialized sector of insurance focused on space. The differences between the risk levels and technologies involved in aviation and space were too different for the lines of effort to remain together.¹¹⁷

In 2018, the International Union of Aerospace Insurers reported over 60 percent of commercial launches to orbit were insured. This is in comparison to 2010, when about 36 percent of commercial launches to orbit were insured.¹¹⁸ As of January 2019, 212 of the 492 active satellites in GEO were insured—about 43 percent of active GEO satellites at the time. Of these, only 23 percent of GEO operators buy little to no insurance beyond launch plus one. In LEO, only 95 satellites of 1,715 total active satellites were insured—about 5.5 percent.¹¹⁹

Despite advances in increasing the success rates of launch, the insurance community has been suffering the past few years, paying out more claims than the annual premiums cover. For example, there were about \$600 million in insurance claims in 2018 from failed launches or on orbit failures. According to Seradata, a UK-based firm that tracks international space insurance claims, premiums for 2018 only totaled about \$460 million—a nearly \$140 million loss for the international space insurance market.¹²⁰ A July 2019 launch failure is the largest single claim to date, almost \$415 million for the United Arab Emirates' *Falcon Eye 1* imaging satellite.¹²¹ The International Union of Aerospace Insurers expects this trend to continue.¹²²

117. Katarzyna Malinowska, *Space Insurance: International Legal Aspects* (Alphen aan de Rijn, The Netherlands: Kluwer Law International B.V., 2017).

118. Schenone, "2019 Space Insurance Update," 11.

119. *Ibid.*, 8.

120. Caleb Henry, "Big claims, record-low rates: Reshaping the space insurance game," *Space News*, September 6, 2019, <https://spacenews.com/big-claims-record-low-rates-reshaping-the-space-insurance-game/>.

121. Jeff Foust, "Space insurance rates increasing as insurers review their place in the market," *Space News*, September 14, 2019, <https://spacenews.com/space-insurance-rates-increasing-as-insurers-review-their-place-in-the-market/>.

122. Robert Schenone, "2019 Space Insurance Update," International Union of Aerospace Insurers, June 2019, 15, 19, and

Swiss Re, one of the leading providers of reinsurance and insurance, announced in 2019 that it would be pulling out of the space insurance market. This was due to the “bad results of recent years and unsustainable premium rates.” According to insurance experts, the space insurance market is facing, and will continue to face, rough conditions as new insurance providers get into space insurance, GEO satellite missions transfer to LEO constellations, and the overall prices of satellites and launch services decline.¹²³ Again, an estimated 43 percent of GEO satellites have some sort of insurance, while LEO satellites only average about 5.5 percent. If fewer GEO satellites are being launched, whether due to extended lifespans or technology advancing so that LEO satellites can perform missions typically reserved for GEO, then less insurance may be purchased.

NATIONAL PERSPECTIVES

Most spacefaring nations self-insure national space missions. This means that the government assumes all financial liability and risk if a space mission should fail. Self-insurance by states is predicated on the assumption that “the magnitude of the Government’s resources, with many exposure units and geographic dispersion, makes it more advantageous for the Government to assume its own risks rather than to insure them through private insurers at rates sufficient to pay all losses and operating expenses together with a profit for the insurer.”¹²⁴

Few national space policies require the purchase of insurance for commercial space missions. This may seem surprising since the OST makes states liable for any spacecraft launched from or operated by an entity within their jurisdiction.

Finland is one of the few nations to require satellite insurance, and it recently enacted its national Act on Space Activities in 2018. Section 8 of this act, entitled “Obligation to Insure,” lays out the national requirement for private entities to purchase space insurance for “damage caused by the space activities to third parties.”¹²⁵ This was likely adopted into the national legislature due to the Liability Convention, which is the foundation for space liability worldwide. This requirement may be bypassed if: “the insurance of the launching company or a corresponding insurance substantially covers the operator’s and the State’s liability for damage” or if the official risk assessment required for license determined that “the activities will not cause any particular risk to persons, property or public safety.”¹²⁶

According to the UN Compendium on Space Debris Mitigation Standards, Greece reserves the right to require the provision of insurance for space objects in its licensing processes.¹²⁷ Similarly, the United Kingdom requires a space operator, during the license process, to insure the spacecraft “against liability incurred in respect of damage or loss suffered by third parties, in the United

22, https://iuai.org/IUAI/Study_Groups/Space_Risks/Public/Study_Groups/Space_Risk.aspx.

123. Caleb Henry, “Space insurer Swiss Re leaves market,” Space News, August 1, 2019, <https://spacenews.com/space-insurer-swiss-re-leaves-market/>.

124. General Accounting Office, *Report to Congress: Extending The Government’s Policy Of Self-Insurance In Certain Instances Could Result In Great Savings* (Washington, DC: U.S. Department of Defense, August 1975), 1, <https://www.gao.gov/assets/120/114854.pdf>.

125. *Act on Space Activities*, Ministry of Economic Affairs and Employment,

126. *Act on Space Activities*, Ministry of Economic Affairs and Employment, 3, 5.

127. Office of Outer Space Affairs, *Compendium*, 33.

Kingdom or elsewhere, as a result of the activities authorised by the licence.” The space operator must also indemnify the UK government against claims brought “against the government in respect of damage or loss arising out of activities.”¹²⁸

Despite not calling directly for space insurance, Sweden’s 1982 Act on Space Activities may give Swedish space operators reason to purchase insurance. The act specifies that if Sweden is liable for damage that has been caused by a space operator, said operator will be held accountable for reimbursing the state for any costs accrued.¹²⁹

In the Law Concerning Japan Aerospace Exploration Agency, JAXA is required to secure proper insurance through the government of Japan in the case that the satellite in question damages a third-party actor. However, when working with a cosigner for a spacecraft, the nation retains the right to require reimbursement of funds from the cosigner if damages are caused by the willful misconduct of said party. In fact, the head of the space agency is liable for a fine if a satellite is launched without proper insurance protocols being followed.¹³⁰

For space launch, Japan’s 2016 Space Activities Act includes a provision focusing on third-party liability for damage “caused by falls, collisions and the explosion of rockets after commencement of the launch operation.” The law is strict and in the favor of the third party, who does not need to prove negligence in order to pursue compensation for damage. The launching party is the only actor liable in any such case. In order to regulate this, Japan may require a launching party to take out liability insurance for each launch. However, satellites are also regulated for third-party liability. Satellite operators are liable for third-party damage for crashes or explosions on orbit.¹³¹ This language currently appears to be unique to Japan.

Other countries have similar language reducing the liability of the state if a non-state actor is responsible for triggering the Liability Convention. Most include language allowing for reimbursement of funds if the damage was due to willful misconduct.¹³² However, the Philippines, with the newest space agency, does not include liability details in its foundational space law, despite being a signatory to the Liability Convention.¹³³ Instead, the state assumes all liability for space operations.¹³⁴

128. Ibid., 56.

129. Office of Outer Space Affairs, “Selected Examples of National Laws Governing Space Activities: Sweden,” United Nations, accessed March 23, 2020, https://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/sweden/act_on_space_activities_1982E.html.

130. “Law concerning Japan Aerospace Exploration Agency,” Government of Japan, 6-7, https://global.jaxa.jp/about/law/law_e.pdf.

131. Yotsumoto and Ishikawa, “Japan.”

132. France is one prominent example for such a state.

133. Committee on the Peaceful Uses of Outer Space, “Status of International Agreements relating to activities in outer space as at 1 January 2019,” United Nations, April 1-12, 2019, 8, https://www.unoosa.org/documents/pdf/spacelaw/treatystatus/AC105_C2_2019_CRP03E.pdf.

134. *An Act Establishing the Philippine Space Development and Utilization Policy and Creating the Philippine Space Agency, and for Other Purposes*, Republic of the Philippines, Republic Act No. 11363, Manila, July 23, 2018, 13, <https://www.officialgazette.gov.ph/downloads/2019/08aug/20190808-RA-11363-RRD.pdf>.

NEAR-TERM ISSUES

The International Union of Aerospace Insurers reported that among its current topics of particular interest, or perhaps concerns, are LEO satellite constellations.¹³⁵ The current projected growth of LEO constellations adds thousands of new satellites into an already crowded and debris-filled domain.¹³⁶ This understandably adds more risk of collision and the possibility of interference. However, many of these large fleets reduce the risk of the service or mission failing. With hundreds of satellites on orbit, the loss of one or a few may not cripple the entire constellation, fundamentally changing the dynamics of the business environment. This is already causing insurers to pull out of the market for LEO. Assure Space, a space insurance underwriter, says that the company will continue to insure launches but will not insure LEO satellites for the near future. The managing director for Assure Space stated at a conference in March 2020 that he believes they are one to two years early but that eventually all space insurers will stop insuring LEO satellites. In his opinion, there is too much risk and too little being done about mitigating space debris or managing space traffic globally.¹³⁷

In CSIS's Space Threat Assessment 2020, cyber trends are highlighted as a more-easily accessible form of counterspace attack than a highly-advanced direct-ascent ASAT missile.¹³⁸ Cyber counterspace operations can have several intrusion points such as the uplink or downlink data transfer to and from the satellite or the ground station itself. Cyber operations are relatively low cost, and though the nature of attack varies by target, the fundamental skills are the same whether it is an attack on a satellite or an electrical grid.

As more companies and non-state actors venture into space with larger constellations or non-maneuverable spacecraft, the risk of liability and damage may increase. This could cause more nations to write regulations requiring insurance or placing liability on the parties involved to protect the state in case the Liability Convention is invoked.

Additionally, states may require insurance for launch or on orbit, just as nations often require car or aviation insurance. This, however, is unlikely to happen soon. With much of space technology in early development stages, countries may be wary of imposing too high of costs, including insurance, on companies in exchange for these companies pursuing innovative ideas and processes.

One thing to watch in the near future is how OOS and ADR missions may affect satellite insurance. The ability to fix, maneuver, or add fuel to a satellite on orbit decreases the cost of a failure and can increase the stability of the business case, if done in a responsible manner. This may allow for insurance premiums for satellites to lower, making insurance more accessible.¹³⁹

135. Schenone, "2019 Space Insurance Update."

136. Analytical Graphics Inc., "10 Years of Planned Satellites - Spacecast 28," YouTube video, 7:15, December 18, 2019, <https://www.youtube.com/watch?v=8sYtPe9ycWQ>.

137. Debra Werner, "Assure Space won't cover collision risk in low Earth orbit," Space News, March 11, 2020, <https://space-news.com/assure-space-leaves-leo/>.

138. Harrison et al., *Space Threat Assessment 2020*.

139. Rebecca Reesman, *Assurance Through Insurance and On-Orbit Servicing* (El Segundo, CA: Aerospace Corporation, February 2018), <https://aerospace.org/sites/default/files/2018-05/OnOrbitServicing.pdf>.

However, OOS also introduces new risks and liabilities that insurance companies will have to analyze and quantify. Since many of the ADR and OOS proposed technologies vary, this may have to be evaluated separately by ADR or OOS companies.

Conclusion

The global landscape of national space policies concerning space sustainability, rendezvous and proximity operations, and insurance requirements is uneven and irregular. This is also reflected in international policies and standard-setting mechanisms. Interestingly, some space nations with less satellites on orbit are defining clearer and more precise policies than more active space nations. While some nations seem to be laying out policies in advance of need in some areas, these same nations may be relatively unengaged in other key areas that need immediate attention. For example, there is a broad lack of dialogue or consensus on defining RPO activities and requirements for satellite and launch insurance.

Without clear national regulations and policies, the challenge to find international consensus and define technical standards for key issues in space governance remains bleak. However, there are a few areas of consensus among nations, such as the need from the global space community for nations to support solutions for space sustainability. Easy first steps may be establishing norms of behavior or updating EOL guidelines to be stricter and more broadly accepted. Moreover, several states have already suggested an international mechanism for STM.

There are several examples of international consensus for traffic or transportation management in the aviation, automobile, and maritime communities. While these frameworks have been suggested by space policy experts in the past as a basis for building an international STM organization, a strong movement from the international community has yet to occur. Even if the international community agreed on a system for STM, it would take years to negotiate and make such a system a reality. The non-binding COPUOS guidelines alone took over a decade to develop.

AREAS REQUIRING FUTURE COOPERATION AND CONVERSATION

Despite the momentum of focus on space sustainability and the broad international concern for space debris, there are no realistic mechanisms for incentives or enforcement of these best practices. Enforcement is a key tenant of arms control agreements and presents an incredible challenge for space systems.

For rendezvous and proximity operations, timely verification is paramount in the face of nefarious behavior. While it may be possible to one day establish clear guidelines or norms of behavior using a keep-out zone or the NOTAM model, especially in the protected region of GEO, accurate SSA is necessary for not only tracking and attributing behavior but also potentially determining intent. This unclassified assessment assumes that in the case of an unfriendly RPO, many target satellites will have no way to defend or maneuver in a timely fashion. In fact, the satellite operators may not be aware of the attack until after it occurs. One challenge in developing an international monitoring SSA system for verification requires that the system will “detect ‘militarily meaningful’ violations before the offending party can gain advantage from the violation.”¹⁴⁰ Through combining the keep-out zone and NOTAM model, it may allow satellite

140. Daniel Porras, “Eyes on the Sky,” United Nations Institute for Disarmament Research, October 2019, 33, <https://www.unidir.org/publication/eyes-sky>.

operators to more easily detect and determine threats and give the operator a chance to respond or protect their space system.

While this may sound like a promising solution, it is predicated on all actors having access to strong SSA capabilities. Currently, many satellite operators rely on the U.S. Air Force to warn them of possible collisions. There would likely have to be international SSA data access from a collective source or an international body responsible for managing STM with access to an international network of SSA data.

Space insurance also represents a global mismatch. While some states require higher levels of liability insurance, requiring start-ups or burgeoning commercial space companies to spend almost 33 percent (on average) of the satellite cost on space insurance is a high asking price. Additionally, there is a flux of insurance providers entering and leaving the market, causing further uncertainty. Liability on the state is the highest concern, but that may be less critical if states want to encourage the development of a national commercial space sector. Some states, such as the Philippines, appear to be assuming liability as an incentive for the growth of commercial and national space activities. Furthermore, countries continue to self-insure because governments can accept higher risk. This trend does not appear to be changing.

One suggestion from the space policy community is that insurance may possibly be used as an incentive or enforcement mechanism for other sustainability goals.¹⁴¹ Thus far, few forums exist—intergovernmental, academic, or otherwise—for discourse on the use of insurance as an enforcement mechanism for responsible state behavior in space. While insurance as an enforcement mechanism could serve as an avenue to ensuring space domain sustainability, several potential challenges may stymie this strategy. For one, requiring space insurance could serve as a barrier to entry for new space nations, and their nascent space industrial bases as the cost of space insurance could be prohibitive for some. As previously mentioned, satellite insurance accounts for approximately one-third of the overall cost to develop and launch a space asset. Such costs are likely untenable for many new space companies and emerging space nations. This idea, and an evaluation of national, industry, and insurance perspectives, may be an interesting topic worthy of further study.

141. This suggestion was made at a Chatham House Rule private workshop held by the Secure World Foundation at the 2019 AMOS Conference. The author was in attendance.

About the Author

Kaitlyn Johnson is an associate fellow and associate director of the Aerospace Security Project at the Center for Strategic and International Studies. Ms. Johnson manages the team's strategic planning and research agenda. Her research specializes in topics such as space security, military space systems, commercial space policy, and U.S. air dominance. Previously, Ms. Johnson has written on national security space reorganization, threats against space assets, the commercialization of space, escalation and deterrence dynamics, and defense acquisition trends. Ms. Johnson holds an MA from American University in U.S. foreign policy and national security studies, with a concentration in defense and space security, and a BS from the Georgia Institute of Technology in international affairs.

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1616 Rhode Island Avenue NW. Washington, DC 20036
202 887 0200 | www.csis.org