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Executive Summary

Background

Global attitudes on norms of behavior for space activities will be increasingly important and dynamic as norms are more frequently discussed in policy, academic, and technical communities. Understanding these international perspectives will be vital to promote norms of behavior that will in turn ensure continued access to and safe operations within space for civil, commercial, and U.S. national security stakeholders. The number of spacecraft from commercial and government entities is growing at an unprecedented pace, as new countries and companies develop space capabilities. While novel space activities and technologies are emerging rapidly, the legal and policy landscape for space is slow to change and lags well behind technology development. The standards, guidelines, and best practices for space operations outpace national policies, government policies and directives, and international law and norm-building efforts. Norms of behavior for on-orbit servicing, assembly, and manufacturing (OSAM), in particular, will be important as both commercial and government entities begin to develop and deploy such capabilities. Outlining norms of behavior will help provide more certainty and accountability for OSAM activities, and OSAM norms may potentially guide space operators as they navigate challenges given the dual-use nature of many of these activities.

Defining OSAM

OSAM is an acronym that has gained traction in the United States, but other countries and regions prefer different acronyms and terms. Some use the terms "on-orbit satellite servicing," "in-space manufacturing," "in-space assembly," and "rendezvous and proximity operations (RPO)." Even within the United States, other terms may be used. For instance, the White House Office of Science and Technology Policy released a national strategy for "ISAM" or in-space servicing, assembly, and manufacturing.

The term OSAM incorporates many activities under one umbrella. We rely on the definition of OSAM from previous studies:

- Servicing is the alteration of a spacecraft on-orbit and includes activities such as remote inspection; relocation or moving a spacecraft from one orbit to another; refueling or adding propellant on orbit; repairing or fixing a spacecraft; replacing or swapping modular parts; and recharging a spacecraft remotely or physically.

- On-orbit assembly involves aggregating components to produce a spacecraft or subsystem on orbit and can be done remotely or with a crew.
- Manufacturing refers to transforming raw materials on orbit into usable spacecraft components or subsystems for use in space.
- RPO is the capability of two independent space objects intentionally maneuvering to close proximity of each other for the purpose of performing some operation, such as inspection or docking. RPO is a prerequisite for nearly all OSAM activities.

Objectives and Approach

The IDA Science and Technology Policy Institute (STPI) conducted a study to better understand how countries regard norms of behavior specifically related to OSAM technologies and how international perspectives may evolve in the next 10 to 15 years. While the U.S. Government was not in scope, the U.S. commercial sector was, as companies can relocate between countries and form international partnerships—either with governments or foreign companies. The study team also examined the drivers and mechanisms that may lead to norms development in the area of OSAM. We delved deeper into attitudes and perceptions of norms by a number of stakeholder groups relying on interviews, literature review, and case studies.

Findings

This study produced several findings related to norms of behavior in space. However, the space community's broader discussions of OSAM norms of behaviors are nascent and mostly focused on satellite servicing or RPO capabilities. Based on our literature review and extensive interviews, the space community's discussions in this area are focused on the need for norms in the domain more broadly, rather than more detailed discussions of specific norms, activities, or mechanisms for norm development.

We outline eight overarching findings of norms in space related to OSAM as well as future trends that will affect progress in developing norms specific to OSAM.

Finding 1: The term *norm* is not well defined for the space domain, inhibiting progress in developing a common understanding.

In our interviews, representatives from governments and commercial entities found it challenging to discuss norms of behavior for OSAM and instead preferred to discuss norms of behavior for space more broadly. For the OSAM capabilities that are more nascent (such as on-orbit manufacturing and assembly), there is not enough flight heritage and experience for norms to emerge. As a result, many findings and assertions of trends are not necessarily unique to OSAM activities and involve discussions of space activities more broadly.

Furthermore, norms of behavior for OSAM activities are anticipated to evolve slowly as newer activities are demonstrated. The only OSAM activity that seemed to resonate when discussing norms of behavior was RPO.

There are increasing calls to establish norms of behavior in space, and more countries and groups are discussing space norms as a solution to a perceived competitive, contested, and unregulated space environment. States, commercial actors, and industry groups will seek to establish norms of behavior in space, both broadly and focused on OSAM. However, the term *norm of behavior*—and the term "norm" which is often used interchangeably—is not grounded nor is there a common understanding or definition. If the definition is not clarified and well understood among stakeholders, the utility of norm building will be limited to the communities that are already working together. That is, individual entities will tend to use the norms developed within their respective communities and partnerships, but other stakeholder groups may use different, perhaps even competing, frameworks. We attempt to bring more clarity to the definition in Figure ES-1 by breaking out norms into three types: legal norms, codified norms and behavioral norms.

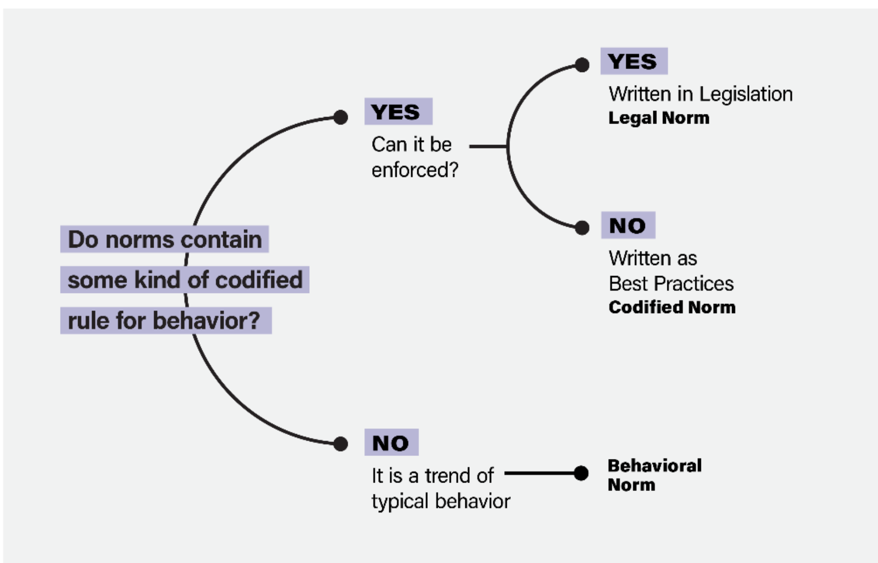

Figure ES-1. How Do Norm Paradigms Differ?

Language matters in developing a common understanding and interpretation of the term "norm" in other countries. The meaning of the term can easily become obfuscated from the original intended meaning upon translation. In Chinese, for instance, the English word "norm" can be translated in several ways, and each translation conveys different levels of codification and enforceability. In one case, norm is 规范 (*guifan*), which means a standard or regulation. Yet in the UN Resolution 75/36, norm is translated as 准则 (*zhunze*), which can also mean a principle or guideline. The former implies some level of enforcement and that there is a firm benchmark or reference—in other words, a codified norm—while the latter implies guidance that is value driven and high level.

Governments and commercial entities vary in their definitions of the term norm. Industry tends to envision written norms in the form of technical standards that are likely voluntary, albeit potentially prone to social pressure. An example is the principles and practices for RPO that are currently being drafted by the International Organization for Standardization. Industry's progress in developing norms may be accomplished in parallel to governments developing norm-building measures at a diplomatic level, through guidelines and perhaps treaties are more binding mechanisms. Unless the commercial sector and the national governments work together to establish a common understanding of the term, the discussions will remain ambiguous and confusion will persist. Actors within, or even each stakeholder group as a whole, may pursue differing or competing frameworks and mechanisms for OSAM norms.

Finding 2: Best practices and guidelines will be developed at the bilateral or multilateral level, but it is unlikely that there will be new legally binding treaties in the future.

International law moves slowly compared to the rate of OSAM technology development. As such, most interviewees indicated that governments and the commercial OSAM actors will continue to see non-binding approaches—such as guidelines, standards, and best practices—as the most viable avenue for building codified norms. That said, Russia, China, India, and most developing or emerging spacefaring nations seem to prefer binding measures, whereas countries like the United States, the United Kingdom, Japan, Canada, and other allies prefer non-binding international agreements and best practices. However, these countries will still use legally binding measures to govern and regulate entities that operate within their borders. Furthermore, due to their limited role in legal and diplomatic efforts, commercial companies will continue to develop guidelines and best practices, or non-binding codified norms. Commercial entities, however, can partner with governments—either their own or internationally—for norm-building efforts, such as the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS), which is industry-led but originally funded by the Defense Advanced Research Projects Agency.

Finding 3: Uncertainty about how liability will be assessed and addressed will persist.

Liability and responsibility are particularly applicable to OSAM because of the risk of damaging another spacecraft. Commercial actors are concerned about liability because paying penalties or insurance claims could affect their revenues and profits. State actors are concerned about liability because it has financial ramifications and it could affect their standing in international forums. Further, the Outer Space Treaty dictates that countries are responsible for actors that launch from or operate within their borders, leaving governments liable for their commercial sector. With increasing activity in space by various space operators, there are more opportunities for potential disputes with respect to liability. In the case of active debris removal, should a state want to move or remove an object, confusion regarding what is "allowed" will continue and technical improvements may be rendered moot due to political and diplomatic barriers limiting the activity. Unless there is clarity as to how liability will be assessed and addressed, uncertainty will persist. This is of concern to all actors, but will be driven in particular by growing commercial activities.

Finding 4: The commercial sector will have a role in identifying best practices and providing input to guidelines, but will continue to operate within the regulatory framework of their states and within the interpretations of the Outer Space Treaty.

Commercial space actors will push the boundaries of technology and innovation. They will continue to demonstrate new OSAM capabilities and will hope that their approach will be adopted by other companies. When a commercial actor successfully demonstrates a new technology, they may have an advantage and concurrently also have the opportunity to set the direction for standards and guidelines that could result in behavioral norms. Similarly, building experience over a long period of time or among technically mature partners, such as with the International Space Station, also provides useful experience to influence best practices and guidelines.

As has been the case for the past 5 to 7 years, government-supported, industry-led coalitions for OSAM activities will identify best practices and guidelines through organizations such as the Space Safety Coalition, CONFERS, and Plan European Roadmap and Activities for Space Exploitation of Robotics and Autonomy (PERASPERA). Countries with active commercial space sectors—in particular the United States, but also Japan, the United Kingdom, and New Zealand—work with commercial entities to provide guidance on existing and new regulations that may impact their business case.

Actors that are "first-movers" or actors that have flight history will have a greater influence on the norm-making process due to the perceived credibility of this experience. In particular, when the rules are ambiguous, the first-movers often have outsized influence on the norms.

Finding 5: Motivations and values for developing norms vary depending on the stakeholder group. The process of norm building is a combination of top-down and bottom-up approaches and will be hastened by greater transparency.

The intersection of motivations, values, and capabilities will affect how different actors behave and create both behavioral and codified norms. OSAM activities are associated with different values, based in part on the activity's maturity level, use cases, and relevant stakeholder groups as shown in Table ES-1.

Table ES-1. Core Values for Norms by Activity

OSAM Activity	Values Emphasized	Maturity Level	Relevant Stakeholder Group
Remote Inspection	Transparency, Accountability	High	▪ National Security
Satellite Servicing and Active and Active Debris Removal (ADR)	Sustainability	Medium	▪ Commercial Entities ▪ Civil Space Agencies
Docking and Berthing	Transparency, Interoperability	High	▪ Commercial Entities ▪ Civil Space Agencies
Assembly and Manufacturing	Innovation	Low	▪ Commercial Entities

Norms for each OSAM activity will be driven by different sets of values based on the activity's maturity level, use cases, and the stakeholders for whom the activity is most relevant. For instance, satellite servicing and active debris removal operators espouse the value of sustainability and view their technologies as a means to advance sustainability by removing debris and extending the life of existing assets. Similarly, docking and berthing can only be conducted when parties have compatible systems and have built trust with each other, creating a need for interoperability and transparency. These values are further emphasized by the stakeholder group that is most relevant. Docking and berthing is of greatest concern to commercial entities and civil space agencies, which use this capability the most and likewise value transparency and interoperability to enable these activities.

An enabler for OSAM and among the most mature OSAM technology areas is RPO. RPO norms that improve transparency of operations may offer the best starting point for OSAM norm development. Many interviewees mentioned that announcing and publicly listing assets would improve transparency among actors and serve as a gesture of goodwill. In addition, undertaking RPO with active consent from the other parties and establishing safe zones around assets would improve stability and, as a result, security. In addition, space situational awareness (SSA) was discussed as a key supporting capability for RPO. A lack of verification in the space domain was often cited as an issue for RPO in particular.

Finding 6: The norm-building process is a combination of top-down and bottom-up approaches and will be hastened by greater transparency.

Norms tend to evolve slowly, iteratively, and require cooperation among stakeholders. This process can occur either top-down, bottom-up, or a blend of the two approaches. Top-down norm building is driven by national space policies, international agreements, government agency space strategies, and similar documents and statements from governments and international bodies. Norms that are created using a top-down approach tend to be value driven and broader in their framing. Bottom-up norm development is spurred by individual or interpersonal behavior, which progresses to group behavior, nationally driven activities, and international acceptance. They can also be developed or promulgated through individual actions. This is particularly true for nascent OSAM activities where innovation is driving new capabilities and informing what norms may be needed. Figure ES-2 idealizes this process, though there are many steps and timescales associated with developing an accepted norm. It should be noted that a norm may not go through the entire cycle, but may remain at one stage. For instance, an individual or interpersonal behavior may be adopted by a group, but may not progress to a nationally led activity.

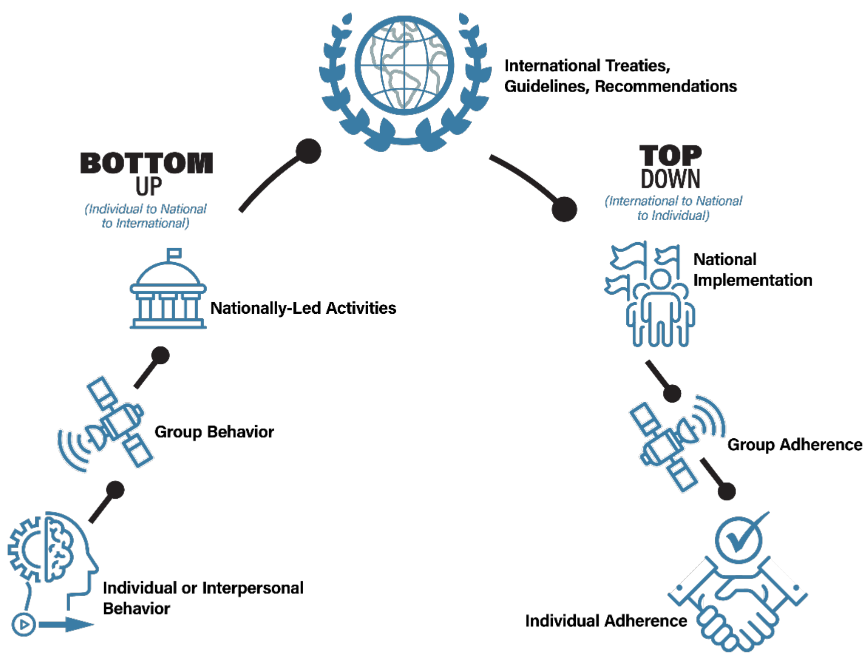

Figure ES-2. Top-down Bottom-up Approach to Behaviors Leading to Written Norms Influencing Behaviors

Finding 7: Technological advances, many driven by the commercial sector, will motivate the adoption of technical standards and influence future design and operations of OSAM.

Technical standards and best practices are a type of norm—namely a codified, non-binding norm—that will be increasingly important as new technological advances emerge. Based on our interviews, the commercial satellite operator community tends to believe that having a family of interfaces and open standards will accelerate the use of OSAM capabilities by providing a shared technical base for operators. Furthermore, interoperability is both a driving value for this stakeholder group and seen as necessary for a commercial OSAM ecosystem to be established. That said, companies will promote the adoption of their preferred technical standards and competing interfaces will likely emerge. Commercial entities will vie for their preferred interface design or practice. Though technical standards are not behavioral norms, they will still play a key role in influencing how actors will eventually behave in space. These standards will be facilitated by industry groups, or consortia between government, industry, and non-profits.

Finding 8: Concerns over dual-use technologies will drive norm-building efforts.

Across stakeholder groups, the space community will continue to call for more clearly delineated norms of behavior in space, particularly due to concerns over dual-use technology. In the case of the defense community, they are looking to maintain security over their missions, deter acts of conflict in space, and prepare to defend their space assets. Civil actors seek to operate their missions without disruption or damage, as do commercial actors. Commercial actors provide services to industry and governments and need to operate in a reliable, safe, and sustainable environment. When the environment is threatened—for example, through activities such as anti-satellite tests or unintended collisions—communities will continue to call for norms of behavior to be established so that all actors behave in a predictable manner. This is even more important in the case of RPO where activities can often be misinterpreted by adversaries as dangerous or nefarious. A lack of transparency regarding intent could lead to concern and confusion—and without notification and verification processes that governments agree to, OSAM activities could be viewed as threatening. Conversely, malicious actors can "disguise" their operations by claiming to be an OSAM activity.

Finally, technical advances in technologies for verification, such as SSA, may eventually provide real-time or better "eyes" on OSAM capabilities and drive progress in determining intent of an action. Should SSA become more ubiquitous and monitor specific actions on orbit, particularly dual-use OSAM activities, space operators will be able to verify or demonstrate intent.

Contents

1. Introduction

A. Background

In recent years, spacefaring countries have been concerned about the lack of globally agreed-upon norms of behavior in space. Space is increasingly congested, as commercial and government actors launch at such a fast and growing pace. Since 2010, the use of space has grown rapidly, from 958 operational satellites in 2010 to 3,371 operational satellites in 2020 (SIA 2021). This growth is due mainly to the advent of CubeSats and small satellites as well as large satellite constellations. The number of assets and actors operating in space has grown, while international law, national policies, and other efforts to regulate or limit behavior have lagged behind, causing some to liken space to the "Wild West" (Everstein 2021).

The term *norms* is often used when discussing space security, particularly as a solution to identify malicious behavior and avoid potentially unintended consequences. While the term features heavily in policy and security discussions, it is not well defined or understood. If norms of behavior in space are not better defined and clarified, the likely result would be misinterpretation that will make it more difficult for countries and stakeholders to build a more coordinated and collaborative space environment.

In the case of on-orbit activities, common practice or a delineation of potential norms is nascent or even non-existent. In low Earth orbit (LEO), spacecraft have traditionally performed few, well-understood functions. Satellites are launched to a specific orbit and remain in that orbit for the duration of the mission, only moving to perform station-keeping maneuvers or to avoid a potential mission-ending debris collision. At the end-of-life of the mission, the satellite maneuvers to a graveyard orbit or reenters Earth's atmosphere. However, new activities in space are emerging—such as satellite servicing missions, satellite inspections, assembly of satellites into space, and even manufacturing spacecraft parts in space, which are far less predictable. Many of these activities have been demonstrated, and some countries and commercial actors are on the cusp of entirely new industries in space (Corbin et al. 2020).

The policy landscape for space is slowly changing and, in general, lags behind technology development (Corbin et al. 2020). Avenues for consensus are beginning to emerge, particularly through standards, guidelines, and best practices. Discussions in the United States, Europe, and Japan have been spurred in large part by technological development in the commercial sector, but these conversations have involved stakeholders across government (both military and civil), commercial actors, and non-profits. The major development internationally is the United Nations (UN) General Assembly Resolution 75/36 entitled, *Reducing space threats through norms, rules and principles of responsible behaviours* (UN 2021a). Put forth by the United Kingdom in August 2020, the resolution directs nations to study and report to the General Assembly space activities the countries interpret as threatening or hostile. As of the writing of this report, 31 countries and 9 other entities including 7 non-governmental organizations submitted responses to UN 75/36 (UN 2021b). These reports also contain ideas for norms, rules, and principles of responsible behaviors in space.

Global attitudes on norms of behavior for space activities will be increasingly important and dynamic as norms are more frequently discussed in policy, academic, and technical communities. Understanding these international perspectives will be vital to promote norms of behavior that will in turn ensure continued access to and safe operations within space for civil, commercial, and U.S. national security stakeholders. Furthermore, such consensus or agreements will enable satellite owners to operate in a more predictable and sustainable space environment.

Norms of behavior for on-orbit servicing assembly and manufacturing (OSAM) will be important as both commercial and government entities begin to develop these capabilities. Outlining OSAM norms of behavior will help provide more certainty and accountability for these activities, and potentially guide space operators as they navigate challenges given the dual-use nature of many OSAM activities. That is, these OSAM activities may also be seen as threatening—and norms of behavior can offer some clarity on the nature of individual operations and capabilities.

B. Objectives

Given the focus and interest in norms of behavior, the IDA Science and Technology Policy Institute (STPI) conducted a study to better understand how countries regard norms of behavior related to OSAM technologies and how that may evolve in the next 10 to 15 years. The study team also examined the drivers and mechanisms that may lead to norms development in the area of OSAM. Building on the *Global Trends in OSAM* study conducted in 2020, STPI extended the work done to examine how country-level policies and legal regimes were adapting and changing in anticipation of newer OSAM space activities (Corbin et al. 2020).

The overall objective of the study is to provide an assessment of space-relevant norms and behavior regimes for countries of interest. The project also examines the relationship between space law in these countries and their approaches to norms of behavior. The focus is on norms that relate to on-orbit activities, particularly on-orbit inspection, RPO, servicing, and assembly.

As such the STPI study team set out to answer the following research questions:

1. How are OSAM norms and behaviors in space defined?
2. How do we anticipate OSAM norms and behaviors in space changing over the next 10–15 years? How do we anticipate OSAM norms and behaviors being shaped by practices, standards, statements, and guidelines over the next 10–15 years?
3. How are countries developing OSAM norms?
    a. To what extent do a country's space laws affect OSAM activities? (top-down)
    b. To what extent do a country's space activities drive the establishment of OSAM norms? (bottom-up)
    c. How are international laws or norms related to OSAM affecting a country's space laws and behaviors?
4. What can analogous regimes (maritime, cyber, drone, etc.) tell us about how OSAM norms may develop over the next 10–15 years?
5. What are future OSAM norms scenarios and forecast drivers of scenarios over the next 10–15 years?

C. Methodology

1. Definitions

This study focuses on trends in norms of behavior related to OSAM activities, rather than broader space activities. OSAM is an acronym that has gained traction in the United States, but other countries have not necessarily adopted the term. Other terms used are on-orbit satellite servicing, in-space manufacturing, in-space assembly, rendezvous and proximity operations, and several others. Even within the United States, other terms may be used. For instance, the White House Office of Science and Technology Policy released a national strategy for "ISAM" or in-space servicing, assembly, and manufacturing.

The term OSAM incorporates many activities under one umbrella. The study uses a definition and taxonomy of OSAM provided in STPI's prior report, *Global Trends in OSAM* (Corbin et al. 2020).

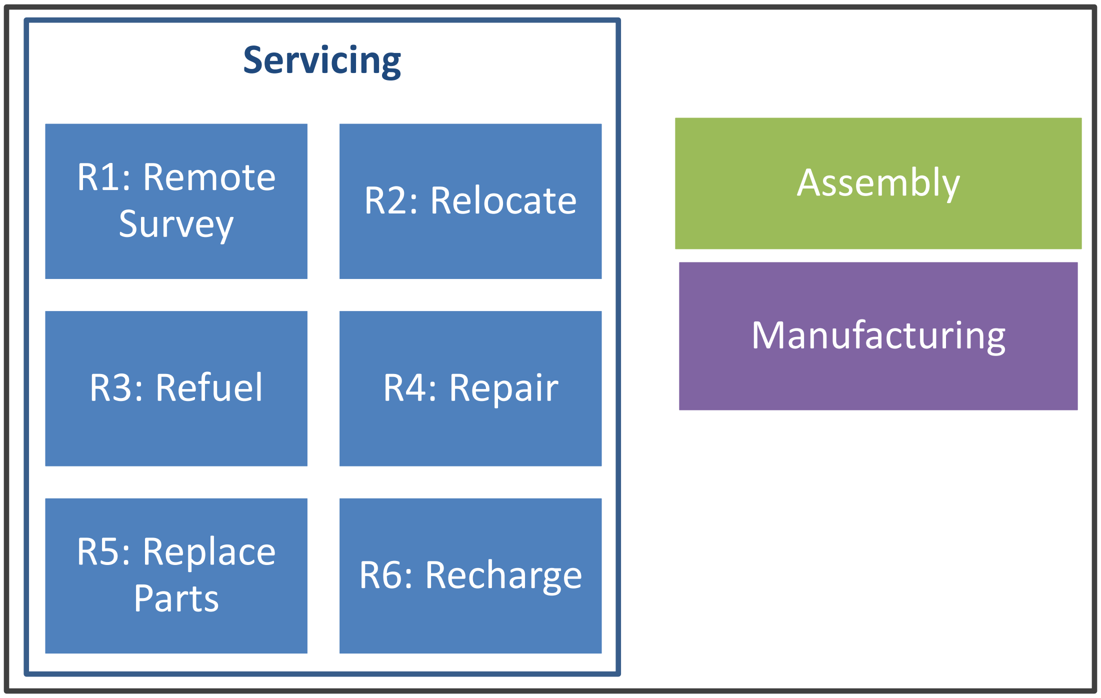

Figure 1. Taxonomy of On-Orbit Servicing Assembly and Manufacturing Activities

Figure 1 describes the taxonomy of OSAM activities. Specific definitions taken from Corbin et al. (2020):

- Servicing is defined as the on-orbit alteration of a satellite after its initial launch, using another spacecraft to conduct these alterations. Servicing includes at least the following six specific activities.
  1) Remote Survey: close or ultra-close inspection of a spacecraft or satellite
  2) Relocation: moving the spacecraft, which includes orbit maintenance, modification, and transportation
  3) Refuel: adding propellant, which includes transfer of fluids from one spacecraft to another
  4) Repair: fixing spacecraft, which includes activities such as untangling deployable systems or realigning optics
  5) Replace Parts: change out parts of a spacecraft, possibly as an upgrade
  6) Recharge: delivering electric power to a spacecraft, remotely or through a physical connection
- Assembly involves the on-orbit aggregation of components to constitute a spacecraft or spacecraft subsystem.

- Manufacturing involves the on-orbit transformation of raw materials into usable spacecraft components. The study focused on manufacturing in space for use in space rather than manufacturing in space for return to Earth (i.e., we included efforts to use the resources of space, but not efforts to manufacture products that will be sent back to Earth).
- RPO is the capability of two independent space objects intentionally maneuvering to a close proximity of each other for the purpose of performing some operation such as inspection or docking. RPO relies on different aspects of OSAM and is a prerequisite for nearly all OSAM activities.

2. Data Collection and Analysis

The STPI study team employed a number of methods to address the study questions. First, we identified countries of interest to be included in the study. We categorized the countries into two groups: countries with OSAM capabilities and countries with space interest and evolving national laws (see Table 1). These countries were chosen based on the OSAM activities in which they are engaged as noted in the previous STPI *Global Trends in OSAM* report (Corbin et al. 2020). Countries that have evolving legal regimes targeting space activities were also selected. The focus of this study is on how spacefaring countries, other than the United States, are developing norms in space related to OSAM; however, the study team included inputs and insights from the U.S. commercial sector as part of the study, given their interest and ability to sell products and services to the commercial sector and governments outside the United States.

Table 1. Case Study Countries

OSAM Capabilities	Space Interest and Evolving National Laws
Australia	Argentina
Canada	Brazil
China	European Space Agency
Germany	European Union
Japan	France
Russia	India
United Kingdom	Israel
	Luxembourg
	New Zealand
	Singapore
	South Korea
	United Arab Emirates

Once the countries were identified, the study team employed a number of methods for data collection. First, we reviewed 150 papers, reports, articles, draft legislation and other written documents on norms of behavior generally, and how norms apply to space. Next, we conducted 71 interviews with experts from academia, industry, and government from around the globe, focusing on experts from the case study countries. See Appendix A for the list of questions, and Appendix B for the list of interviewees. Finally, in addition to conducting 19 country case studies, the team conducted 7 case studies on past and current activities informing how norms have been developed or used in OSAM-related activities. Appendix C includes summarized select responses from the UNGA Resolution. Appendix D contains the country case studies and Appendix E is a summary of findings related to other analogous domains such as maritime, aviation and cyber.

3. Caveats and Limitations

There were some limitations and barriers encountered. First, the term *norm* was unclear and defined differently by many interviewees and stakeholders. As a result, the second chapter of this report is dedicated to defining the term *norm*. Second, many countries are in such nascent stages of developing legal frameworks for space, or even outlining guidelines that it was challenging for interviewees to discuss how norms would develop in the future when specifically discussing OSAM. Finally, there is a temporal limitation to this study given that the discussions on this topic are happening in real time, and the landscape appears to be changing more quickly than anticipated.

D. Organization of Report

The report is organized as follows. Chapter 2 discusses how the term *norm* is defined and differentiates definitions of norms by stakeholder type. In Chapter 3, we focus on written norms, and discuss key legal concepts as well as mechanisms used to develop written norms. Chapter 4 outlines the use of norms—ranging from motivations to values to strategic considerations for norms. Chapter 5 explores future trends in the development of norms for OSAM, drawing upon the analyses conducted in the previous chapters.

2. What Is a Norm?

In order to discuss global and future trends in OSAM norms, we must first examine definitions and shared understandings of the term *norm* to ground the discourse throughout this report.

A. Norms, Rules, and Principles of Responsible Behaviors

Norms are often discussed in tandem with rules or behaviors, but what does norm mean? How are norms different from rules or principles of responsible behavior? Political scientists use the term norm to elucidate aspects of the complex relationship between rules and behavior. Among the political science community, a popular definition of norm comes from Finnemore (1998): "a standard of appropriate behavior for actors with a given identity." The following example illustrates the difference between a norm and a law. The speed limit on Interstate-95 does not change when crossing into Massachusetts from Rhode Island. However, the speed of traffic in this area usually does change. A Massachusetts resident might attribute this to the 10 mile per hour (mph) rule. The unwritten rule is that on a highway the flow of traffic is typically 10 mph above the speed limit; going 10–15 mph above the speed limit is acceptable, approaching 20 mph above the speed limit may get you pulled over, and driving more than 20 mph above the speed limit could risk a serious ticket. While the 10-mph rule is not in Massachusetts Highway Code nor is it Massachusetts law, residents tend to follow it despite the lack of codification. Applying Finnemore's definition to Massachusetts' highways, the 10-mph rule is not law but it is the norm.

Authors in sociology frequently use norm and its cognates. For example, P. Sanyal (2009) talks about "normative influence" in promoting women's social capital, referring to "the capacity to sanction against deviant or undesirable actions and to influence social norms and practices." The normative influence in this definition is broad and could include using any available mechanism to promote certain types of behavior. Under this definition, Sanyal (2009) discusses how groups use their normative influence to redefine ethical boundaries through intentional actions to redefine acceptable behavior. The article also discusses legal mechanisms of normative influence such as annulling underage marriage and anti-liquor laws.

In a review of political corruption, Bidner and Francois (2013) discuss political norms. They state: "Norms are the modes of behavior characterizing a political culture. They are the specific way political actors are incentivized to engage the gray areas left by formal rules..." (Bidner and Francois 2013). Similar to Sanyal (2009) and Finnemore (1998), Bidner and Francois (2013) describe a perceived appropriate behavior.

Some within the political science community discuss two categories of norms: regulative and constitutive norms (Pigozzi and van der Torre 2018). Regulative norms "indicate what is obligatory or permitted," while constitutive norms "are rules that create the possibility of or define an activity" (Pigozzi and van der Torre 2018). The Finnemore (1998) definition falls into the former category, as it is a conditional obligation. On the other hand, constitutive norms, as they were originally used by Searle (1969), describe the link between a physical interaction and something often non-physical. For example, the link between a signature and agreeing to a contract is a constitutive norm (Pigozzi and van der Torre 2018).

There is disagreement among experts on certain aspects of norms, such as enforceability. Bidner and Francois (2013) specify norms govern activity for areas not covered by "formal rules." Florini (1996) explicitly states, "norms are obeyed not because they are enforced, but because they are seen as legitimate." However, Brunnée and Toope (2019) include enforced rules in their descriptions of norms, stating that certain legal norms "prohibit, require, or permit certain conduct" (Brunnée and Toope 2019). These conflicting definitions can be partitioned into legal and behavioral norms, but in practice those attempting to identify norms, such as practitioners and policymakers, do not always specify to which type of norm they are referring. This leads to individuals stating, "The norm is…" and introducing ideas that may be contradictory to how others use the same term. For example, one interviewee stated, "a norm is shared understanding of a behavior or patterns of a behavior that are considered to be rational and legitimate." Conversely, another interviewee asserted: "…[a norm] can be draft resolution and legislation. A norm is a rule of conduct, a rule of behavior." In the case of the UN Resolution 75/36, it is unclear whether the resolution that references "norms, rules and principles of responsible behaviours" is focused on norms as expected behavior, a set of rules, or something else entirely.

In the space community, the term norm is increasingly used—often in ways conflicting with social and political uses of norm or conflicting with the usage by other space experts. Our study focuses on perceived norms for on-orbit activity. Several studies have tried to answer the questions: What is a norm, and how does it apply to space? West et al. found that space experts polled on the definition of the term norm had differing concepts on the meaning (West and Doucet 2021). Relying on interviews and a literature review, this chapter provides an overview of space norms, particularly as discussed in the context of OSAM.

B. Space Experts' Uses of the Word Norm

STPI engaged 71 interviewees with questions designed to allow the interviewee to define their preferred lexicon, uninhibited by STPI's perspective. The goal was for the study team to hear the experts' views without biasing their use and reaction to the word *norm*.[1] In this section, we differentiate and distinguish the varying responses received through the interview process. We focus our assessment on how these norms are communicated or emerge rather than the behavior they are attempting to impact or enforce.

Our interviewees' responses indicate that the space community is relatively divided on whether a norm is something seen and observed; driven through collective behavior; or something used, like a rule for behavior. A second point of disagreement within the interviews was whether a norm could be enforced. Some interviewees asserted that norms are synonymous with best practices, while others disagreed, stating that norms were legal regimes created through resolutions and legislation. To reflect this disagreement, we describe a distinction between these kinds of norms. Throughout this report, we will refer to enforceable rules for behavior as *legal norms* and the written, unenforceable rules for behavior as *codified norms*.[2] Lastly, we classify norms used to describe an observed behavior of a group as a *behavioral norm* (Figure 2).

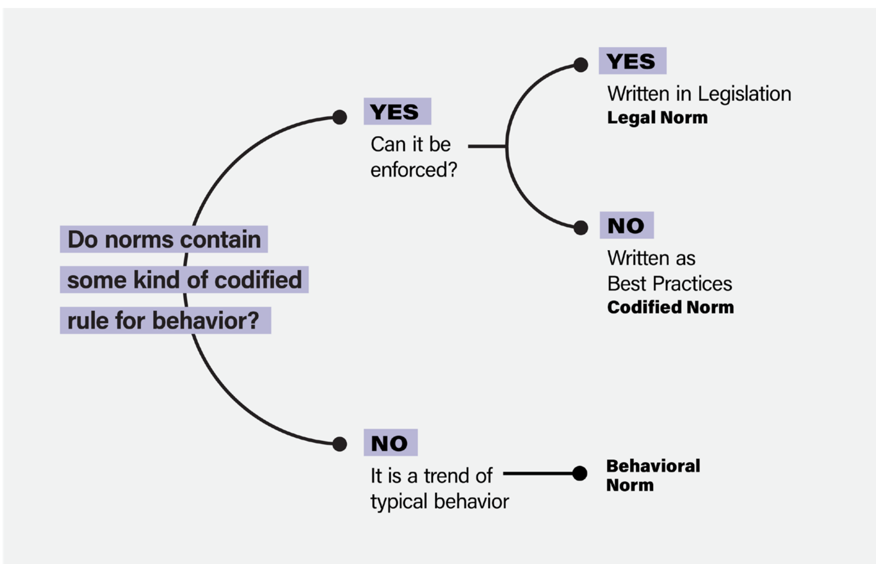

Figure 2. How Do Norm Paradigms Differ?

1. Behavioral Norms

Behavioral norms are trends of behavior observed in a group—often times influenced by the individual's perception of appropriate group behavior. These behavioral norms may not come from legislation but from historical precedent, and may be influenced by an

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[1] See Appendix A for the full interview protocol.

[2] Though the term *codified* can be interpreted as a legal term, we use the term in a different way—a codified norm is one that is written but cannot be enforced, such as a best practice, technical standard, or guideline.

individual's perception of what constitutes "proper behavior." As a result, behavioral norms can result from a reaction to an event that conflicts with an individual's sense of principle. In addition to principle, there is often the identification of a common threat and informal understandings that influence adherence to behavioral norms.

Those who defined norm as being created by behavior used words and phrases such as "common understandings," "trends," or "actions by a group of people." In this context, norm is most similar to Finnemore's definition, describing "a standard of appropriate behavior for actors with a given identity" (Finnemore 1998). The interviewees who use this paradigm describe norms as the observed behaviors of the group, detailing an actor's logic for a specific action. A collective behavior can provide clear rules, transparent operations, or a historical precedent for a behavior. In this way, a behavior can set a rule. These rules, however, are not always clear or easy to enforce because they are based on an individual's interpretation of proper behavior.

A number of factors contribute to behavior. Generally, those who ascribe to behavioral norm paradigms actively discussed good norms and bad norms, the same way a person might say good behavior and bad behavior. From our conversations defining norms, we identified factors that stakeholders, particularly owners and operators, generally consider the drivers of behavior: capability, motivation, and incentives.

2. Codified Norms

In space policy and literature, the term *norm* is frequently used to describe what we have defined as behavioral norms. We assert that an entity or group may codify a norm by writing it down. A norm can be codified through an official statement, non-binding guidelines, best practices, or standards. We refer to this distinct type of norm as a *codified norm*. Codified norms, by virtue of being written, can elucidate gray areas and identify safe forms of behavior with greater clarity and specificity than behavioral norms.

In Space Policy Directive-3 (SPD-3) issued in 2018, the President directed:

> The Secretaries of Defense, Commerce, and Transportation, in coordination with the Secretary of State, the NASA Administrator, the Director of National Intelligence and in consultation with the Chairman of the FCC, shall develop space traffic standards and best practices, including technical guidelines, minimum safety standards, [and] behavioral norms…

In this context, the term *norm* is used to clarify a type of practice, such as standards and best practices. Examples of this paradigm are common in space literature and can take the form of expressions such as "responsible behavior norms" (Hertzfeld et al. 2015) or "norms of behaviour" (West and Doucet 2020). These phrases refer to a common behavior. Norms, in this paradigm, give actors a better sense of what is typical or normal. This further allows actors to better understand the difference between good operations and bad operations. Unlike behavioral norms—which many interviewees explicitly commented are not written—codified norms are always written to clearly highlight good behavior or discourage bad behavior. Identified common behaviors can reduce the risk of misperceptions that could cause conflict (Weeden 2019). For industry-led activities, formalizing behavioral norms might give commercial operators a better sense of what activities are seen by the international community as being to be "good" or appropriate and which activities are "bad" or undesirable. Norms have been viewed as social obligations that have either no enforcement mechanism or only social enforcement mechanisms, such as ostracizing parties that violate the codified norm or otherwise "calling out bad behavior." In a similar study of space norms, the perspective of norms as voluntary non-legal obligations was held by some participants but not others (West and Doucet 2021).

Consortia can play a critical role in the development of codified norms. Multiple interviewees attributed the creation of codified norms to non-government groups such as the Manual on International Law Applicable to Military Uses of Outer Space (MILAMOS), the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS), Plan European Roadmap and Activities for Space Exploitation of Robotics and Autonomy (PERASPERA), and the Space Safety Coalition (SSC) (MILAMOS 2021; CONFERS 2021; PERASPERA 2021; SSC 2021). Statements made by these groups are influential in the space community, particularly for industry, members of the space community, government, and others that follow the community carefully. Interviewees indicated that their perspectives are influenced by the comments made by these groups. In some ways, the advice propagated by these groups can be used by actors to justify or alter their behavior.

Codified norms are seen as a mechanism to address certain challenges that might be difficult to incorporate into a treaty or piece of legislation. This is because codified norms are less stringent than treaties but also are likely easier to negotiate with international partners (Rose 2018). The challenge with codified norms is that they have limited enforcement mechanisms attached to them. However, codified norms may lead to practices that are adopted in legally binding ways.

3. Legal Norms

Some of the experts interviewed suggested that norms could be further formalized into national or international legislation. We refer to this resulting regulation, rule, or law as a *legal norm*. Our interview findings are consistent with other space literature. As shown in previous research, space experts look to international laws, adopted guidelines, industry standards, and national laws to identify norms in space (West 2020). Deviating from the behavioral norm paradigm, a number of sources described norms as the rules: "rules of the road" (Rose 2018); "rights balanced with obligations or prohibitions" (Johnson 2018); and "high-level principles intended to inform the development of new international legal regimes…" (Schaffer 2017).[3] This use of norm is more in line with Brunnée and Toope's (2019) use of legal norms. The legal norms paradigm was not common among the experts we interviewed, although legal scholars made up a small portion of our interviewees.

4. Interpreting the Term *Norm* by Interviewee

This study conducted 71 interviews, each for at least 1 hour, with experts across disciplines and nationalities. Of the 71 experts interviewed, 59 provided their definition of the term *norm*.[4] The way interviewees interpreted the term *norm* varied given the interviewee's background (Figure 3). We categorized interviewees by their occupation and region of expertise. Interviewees' were coded into five mutually exclusive stakeholder groups: academics, consultants, governments, non-profits, and private sector. Region of expertise was distributed through three continents: North America, Europe, and Asia. Some interviewees had expertise outside of these regions; we exclude these comments from the regional analysis to prevent attribution.

a. Definition of *Norm* by Occupation

Non-profit interviewees tended to view norms as behavioral norms. This contrasts with government interviewees who tended to view norms as codified norms with minimal enforcement. The implication of this is: when asked the same question (e.g., what is the future of OSAM norms?), many of our non-profit interviewees spoke about observed behavior and what behaviors we might see in the future while most government interviewees spoke about mechanisms to guide behavior, namely the guidelines and policies needed for the future.

Private sector interviewees were mixed in their responses. Some private sector interviewees viewed norms as observed behaviors in space, but many viewed norms as mainly guidelines and best practices. Private sector interviewees often described competing norms within industry as a battle for market space. They discussed wanting their technology to be adopted on a large scale and to be viewed as the common method for an activity, either as a standard or codified norm. Some interviewees referenced the Universal Serial Bus (USB), a technology seen as the standard for transferring digital information from computer to computer as an example of a competing technical standard in industry that reached market saturation. In these discussions, the private sector interviewees identified the importance of the role of industry groups such as CONFERS in communicating standards that guide operations.

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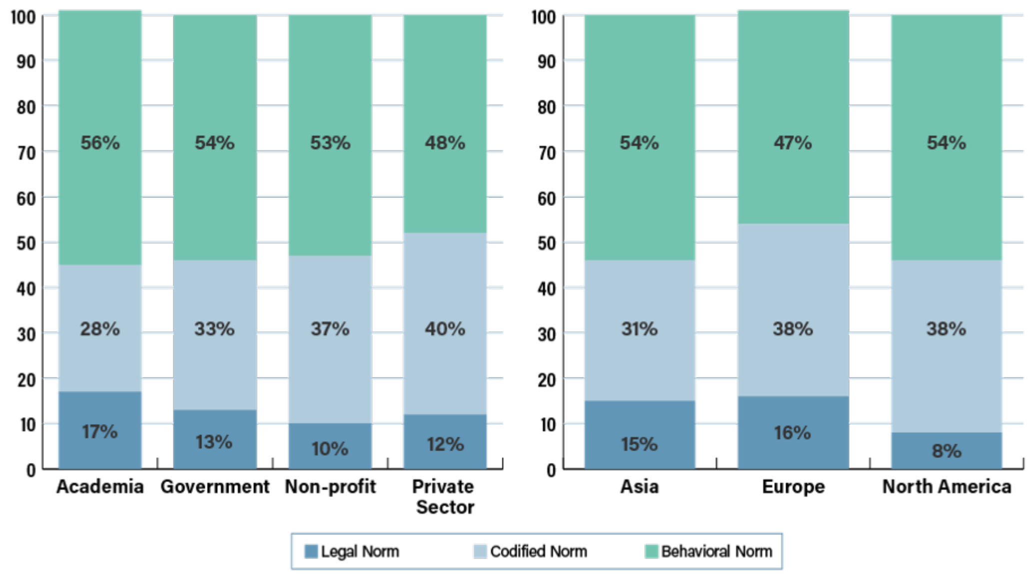
[3] A full account of the legal mechanisms associated with the legal norms paradigm will be detailed in Chapter 3.

[4] Interviews were designed to provide the space expert flexibility to direct the conversation of OSAM norms to the direction of their choosing. As a result, only 59 of the 71 experts explicitly defined *norm*.

Across all stakeholder groups, interviewees discussed national and international law as norms, but this categorization was less frequent than discussions of codified norms or behavioral norms. Unlike private sector interviewees, the government interviewees tended to identify national and international governing bodies as mechanisms for norm development, and less often industry standard organizations.



Note: Australia and Oceania are included within the Asia subgroup. Respondents from South America are not shown due to an insufficient number of interviews conducted with experts in this region.

Figure 3. Distribution of Interviewees Using Social, Codified, and Legal Norms by Region and Background

b. Definition of *Norm* by Region

Examples of behavioral, codified, and legal norms were used across interviews in all regions in which interviews were conducted. Interviewees offered examples of places where norms are codified and provided rules for behavior, but these examples varied significantly in their enforceability. Few interviewees indicated that norms could be readily enforced. Regionally, there were only minor differences in the scoping of norms between Asian, European, and North American experts. Interviewees from all three continents were divided over whether a norm was behavioral or whether norms could be something written.

c. Variation in Interpretation of *Norm* Based on Language

Several interviewees noted that China and Russia have a legalistic interpretation of norms; there is some evidence to support this claim in the Russian and Chinese literature. This legalistic interpretation of norms could be due to both linguistic differences and geopolitical interests.

As mentioned earlier in the chapter, experts do not agree on a precise definition of norm even within the same language. As the term *norm* is discussed in other languages, the meaning can easily become obfuscated or changed from the original intended meaning. In Chinese, for instance, the English word "norm" can be translated in several ways, and each translation conveys different levels of codification and enforceability. In English we use the word "norm," stemming from the Latin word "norma," to mean something that is a model or something typical. However, Chinese experts have translated norm in a number of ways with distinct differences in meaning and usage. One Chinese expert translated norm as 规范 (*guifan*), which can take the form of a noun—meaning a standard or regulation—or a verb, meaning to standardize or to regulate. Similar to English, a Chinese example sentence for *guifan* is "Ambiguity is the fundamental reason for the existence of abstract legal concepts, *norms*."[5] However, the same word can also be translated in the following manner: "Section III is about how to *regulate* connected transactions of the listed corporation."[6] Likely for this reason, searching the internet for "on-orbit norms" in Chinese resulted in documents such as *Specifications of Engineering Designs for the Domestic Satellite Communication Earth Station* rather than discussion of behavioral norms for on-orbit activity.[7] To an English speaker, this translation of norm seems to imply some level of enforcement and that there is a firm benchmark or reference for the norm. Chen and Xie, Chinese social scientists whose work mirrors Finnemore (1998) and Sanyal (2009), translate "social norm" as 社会规范 (*shehui guifan*) (Chen and Xie 2018). Similar ambiguities can occur for other Chinese translations of norm. For example, *norm* in UN Resolution 75/36 is translated as 准则 (*zhunze*), which can also mean a principle or guideline. This translation seems to have contrasting connotations compared to *guifan,* as a high-level, value-driven guidance rather than an enforceable, concrete measure. In our literature review we also understand that *norm* can be translated as 标准 (*biaozhun*), a word that can also be translated into English as "a standard." In essence, language matters when it comes to understanding and interpreting the term *norm*.

Similarly, the Russian delegation's use of *norm* in their response to UNGA Resolution 75/36 mentioned earlier in this chapter is different from how English language speakers use the term *norm*.[8] Russia called for "a mandatory norm of the national policy of UN Member States and a generally recognized international obligation" to prevent an arms race in outer space. The letter submitted by Russia also references "legal norms" such as the

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5 The Chinese version of this text is: "法律概念的抽象性、规范性、模糊性是其存在的根本原因" (source: https://www.youdao.com/w/eng/%E8%A7%84%E8%8C%83/#keyfrom=dict2.index)

6 The Chinese version of this text is: "第三部分提出如何规范上市公司关联交易". (source: https://www.youdao.com/w/eng/%E8%A7%84%E8%8C%83/#keyfrom=dict2.index)

7 The Chinese language version of this source is "国内卫星通信地球站工程设计规范" and can be viewed here: https://max.book118.com/html/2018/0619/173505214.shtm.

8 See Appendix C for a full discussion of national responses to UNGA Resolution 75/36.

Outer Space Treaty. The less enforceable codified agreements were described as an "international initiative" or a "political commitment," or what STPI has characterized as a codified norm.

Further, the values and driving concepts espoused within norm-building conversations may be altered in translation as well. For instance, an interviewee described difficulties in translation between Russian and English during discussions of the Guidelines for the Long-term Sustainability of Outer Space Activities (LTS Guidelines), which were released in 2018 after an 8-year development process. The interviewee noted that at some point in these discussions, the delegations from English-speaking countries realized that the Russian language uses the same term for security and safety (безопасность), while in English each of those words have distinct connotations. In addition, while English has distinctions between sustainability and stability, the same word may be used for both in Russian (устойчивость). Those partaking in international discussions should carefully consider how words are translated across languages and offer examples of their meanings to clarify and prevent misinterpretation. When English speaking nations talk about *norms*, they should specify whether they mean regulatory action, guidelines, or influencing perceived behavior so as to avoid confusing foreign language audiences who may be unaware of other meanings of the term and assume a literal translation (Figure 4).

Figure 4. Examples of a *Norm* Identified by Interviewees and Grouped by Paradigm

C. The Norm Lifecycle: Connecting Social, Codified, and Legal Norms

Based on the literature review and interviews, we posit that the activities described as behavioral norms and legal norms are related in that the creation of one may inform the creation of the other. Figure 5 describes the process by which norms may develop. At the start, we identified a chain of actions serving as a catalyst for space behavior (Figure 5a). The cycle is as follows:

- First, a unique behavior is observed.
- The unique behavior is observed more broadly within a group, forming a behavioral norm.
- Entities discuss what behaviors are acceptable and unacceptable; the consequences for unacceptable behavior may vary from no consequences to the use of force in extreme cases, to additional discussions that generate codified norms and legal norms.

This cycle continues, iterating between group behavior and the laws, guidelines, and standards. Actors continue to operate, observing group behavior and written laws and guidance, but making their own decision to comply or not comply with the discussions of behavior. Similar to how the cycle started, the ecosystem changes again when a new behavior emerges (Figure 5b). The secondary first-mover often uses this information to inform their behavior. For some, this is a catalyst for similarly unique group behavior and laws, guidelines, and standards to govern this behavior (Figure 5c). However, this is not always the case; in certain circumstances a unique behavior may not affect group behavior and it will just remain an isolated unique behavior (Figure 5d).

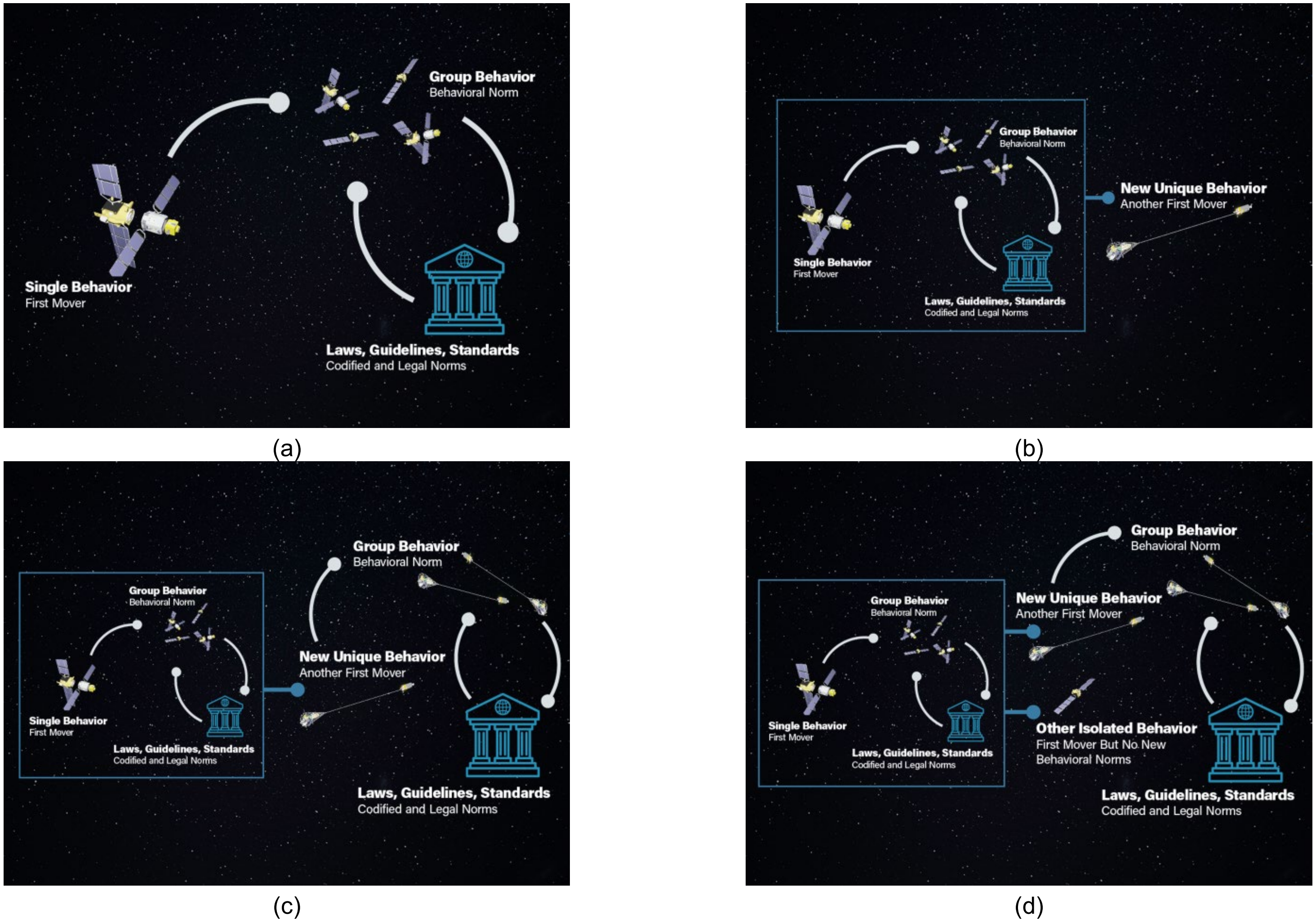

Figure 5. Norms Lifecycle (a) Unique behavior could influence group behavior and written norms, (b) New action is observed by a first-mover, (c) New action could spur a similar cycle to (a), (d) Action could be an isolated behavior that does not lead to multiple actors behaving similarly

The norm cycle connects behavioral, codified, and legal norms. Previous authors have described this evolution as a norms life cycle. An operator introduces a new activity; the activity may then be adopted by a group and become institutionalized, informing new activities (Finnemore and Hollis 2016). Within this process, the group may oppose individual activities, influencing which norms are adopted by the larger group (Finnemore and Hollis 2016). Some experts with whom we spoke referred to themselves as first-movers. Those who discussed first-movers indicated that first-movers may be part of multiple stakeholder groups, and the behavior may only be a first for a particular stakeholder group. What some people see as being different and unique, others might see as being similar to something else. In this sense, the Orbital ATK Mission Extension Vehicle (MEV), for instance, could be considered as an extension of U.S. RPO activity in space. Others may instead see this as a unique activity, possibly setting norms for commercial servicing in space.

Case Study: Mission Extension Vehicle (MEV)

In April 2016, Orbital ATK Inc., now SpaceLogistics and a subsidiary of Northrop Grumman, entered into an agreement with Intelsat to provide the first commercial life extension service (EoPortal 2020). Launched on October 9, 2019, MEV-1 rendezvoused with IntelSat-901 roughly 22,000 miles above Earth, beginning the first commercial servicing mission on February 25, 2020 (Northrop Grumman Newsroom 2020a). The commercial servicing vehicle uses the client satellites' existing structure and allows the client satellite to remain in a passive state during the servicing mission. MEV-1 captures the client satellite by docking to its liquid apogee engine cone. Once the MEV is attached to the client satellite, MEV's chemical and electric propulsion systems provide the client satellite with propulsion and altitude functions (EoPortal 2020). MEV-1 used both chemical and electric propulsion systems over a 3-month period to raise IntelSat-901 to the same altitude as MEV-1, docked and then returned the combined spacecraft into service (Northrop Grumman Newsroom 2020a).

MEV-1 is contracted to provide IntelSat-901 with 5 years of life extension services. Upon conclusion of this mission, MEV is designed to move IntelSat-901 into a graveyard orbit. After that mission is completed, SpaceLogistics plans to service other satellites over MEV-1's 15-year lifetime (EoPortal 2020). SpaceLogistics and Northrup Grumman purport to have developed a scalable methodology for commercial servicing. Northrup Grumman estimates 20 satellites per year are prematurely lost because they run out of fuel (Northrop Grumman Newsroom 2020a). Furthermore, Northrup Grumman asserts that the liquid apogee engine cone capture method used by MEV-1 is scalable to 80% of communication satellites (Northrop Grumman Newsroom 2020a). A second mission, MEV-2, was successfully completed in April 2021. In contrast to MEV-1, the docking took place in the active GEO belt without the client satellite raising its orbit to meet the life extension vehicle (Northrop Grumman Newsroom 2021b).

Overall, IntelSat and Northrop worked to establish their shared values of safety and sustainability and devised their mission plan in a way to ensure the safest possible mission. A major obstacle was obtaining a remote sensing license for non-Earth imaging from the U.S. Government. The majority of interviewees said that the successful MEV missions may set a norm regarding satellite servicing. Yet beyond a potential norm of "companies should conduct mission extension missions," no one could point to a particular practice or technical aspect learned from MEV and neither Intelsat nor Northrup Grumman have publicly identified any lessons learned. Finally, given intellectual property concerns, commercial entities are more reluctant to share data about how the mission was successful, thus depriving the OSAM community of learning from the mission.

D. Consideration of the Term *Norm*

The space community uses the term *norm* in multiple ways: to describe rules, to refer to behaviors, and a mix of the two. The space community's application of the term *norm* differs from the use of *norm* in the social sciences. Irrespective of whether the word is being used correctly, norms are gaining new meaning through their applications in space topics and their codification in UN resolutions. Considering these trends, we choose to describe the term *norm* through three different paradigms, doing our best to encompass the three unique ways in which norms are discussed within the space community but accepting that our paradigms do not perfectly describe every definition. The norms we will describe in the report are the three types described in Table 2: (1) behavioral norms, (2) codified norms, and (3) legal norms. The drivers of norms, behaviors, statements, guidelines, standards, or treaties are tangible even if the community's definition of norm is unclear. Behavior, whether or not we consider it a norm, can affect the broader space environment. Legal mechanisms, whether or not we consider them to be norms, can influence behavior. As such, it is important to outline all of the elements that may be considered *norms* as defined by our interviewees. Based on the identified related functions, we can provide observations, indicating how communities might view the norm activity. The following chapters of this report will discuss in detail the mechanisms, drivers, and uses for these three norms.

E. Chapter Summary and Future Trends

Norms are interpreted in several different manners. Interviewees typically did not accept other definitions of norms and attributed to them different names. Interviewees whose definitions did not fit within the classification of norm paradigms referred to behavioral norms as observed practices, codified norms as non-binding written documents such as best practices or technical standards, and legal norms as laws.

At the continental scale, there are minor differences between the different uses of norms. Behavioral and codified norms are most commonly used by space experts. The legal norm paradigm was less commonly held. This study did observe some linguistic differences in the application of norm. Behavioral, codified, and legal norms inform one another. Table 2 provides our definitions of these three terms. The cyclical norm development process is often begun by first-movers who perform a novel and unique activity. The cycle continues until a new first-mover is spun off from previous norm cycles.

Table 2. Classification of Norm Paradigms

Term	Definition
Behavioral Norms	Behavioral norms are uncodified, observed group behavior with limited enforcement mechanisms, other than social ostracism and similar social instruments. There may be a sense of responsibility attributed to behaviors by a group within a given identity, drawing from the definition of norm used by Finnemore (1998).
Codified Norms	Codified norms are non-binding statements, standards, and best practices explicitly stating what behaviors are suitable or unsuitable.
Legal Norms	Codified legal norms, often synonymous with *rules* or *laws*, attribute significant consequences to certain identified unsuitable behaviors.

Notes: These three definitions do not perfectly capture all of the ideas put forward through the interview process. These terms do overlap in certain cases, depending on an individual's legal worldview. *Behavioral*, *codified, and legal* are terms this study uses to classify the paradigms used by experts. During the interviews, experts referred to the term they identified with as *the* definition of norm.

In the remaining chapters, we rely on these more precise definitions of norms as we discuss the findings and trends for OSAM norms of behavior in space. In the future, unless stakeholders work to clearly define what a *norm* is and use a common definition, we believe that the term may be overused and actions to develop norms of behavior will continue to be called for. We assess that while calls for norms will be amplified, coordination to define what a norm is and how it may be understood, adopted, and adhered to will remain challenging.

3. Written Norms: Key Concepts, Mechanisms, and Effects on OSAM Behavioral Norms

In contrast to behavioral norms, written documents—as either codified or legal norms—can influence and create boundaries for the behaviors. These documents can take a number of forms, including international treaties, laws, guidelines, and industry documents outlining guidelines and best practices. This chapter will explore key legal concepts related to OSAM behavioral norms and the mechanisms through which written norms can affect behaviors.

A. Key Legal Concepts for OSAM Norms

To classify the ways in which the law intersects with norms, STPI developed a framework of major legal concepts that affect OSAM activities, the three pillars of which are: international law, liability and responsibility, and licensing. This legal framework does not include the specific mechanisms (e.g., contracts, national regulations). Instead, those mechanisms will be addressed in the following section. Likewise, this legal section does not address the behavioral norms described in Chapter 2 on the definition of norms.

1. International Law

International law is the "rules and principles governing the relations and dealings of nations with each other, and includes the relations between states and individuals, and relations between international organizations" (Cornell Law School 2021). International law is particularly pertinent to space activities because many of the major stakeholders are national space and defense programs and, thus, are extensions of their national governments. Interactions between two states occur within the boundaries of international law.

a. United Nations Entities Related to OSAM

Through the UN, member states convene and discuss issues pertaining to international peace and security. Within the UN General Assembly, there are six Main Committees. Two are particularly relevant to OSAM: The First Committee on Disarmament and International Security, and the Fourth Committee on Special Political and Decolonization (UN 2021).

Within the First Committee, the UN Office for Disarmament Affairs (UNODA) has equities relating to OSAM within the Conference on Disarmament (CD) Secretariat &

Conference Support Branch, which supports the broader CD, based in Geneva. The CD is a "single multilateral disarmament negotiating forum of the international committee."

Within the Fourth Committee, space activities are addressed by the UN Office for Outer Space Affairs (UNOOSA) and the Committee on the Peaceful Uses of Outer Space (COPUOS). COPUOS has two subcommittees: The Legal Subcommittee, and the Scientific and Technical Subcommittee.

The division between the First and Fourth Committee delineates discussions between national security and peaceful use. Because OSAM technologies are inherently dual use (i.e., have military and non-military applications), they do not fit neatly into this dichotomy. Several interviewees pointed out that this structure limits discussions of OSAM activities.

The First and Fourth Committees, as well as the CD, operate on consensus. Decisions must be made without any disagreements from any participants, although the consensus is not established through voting. While consensus was originally seen as a successful and desirable process because it allowed groups to come to a unanimous agreement (Galloway 1979), it has since been criticized as an inefficient means of discussion. If all participants must agree, that means that each participant also has the unilateral power to stop any decision with which they disagree. In 2012, the UN Secretary General at the time, Ban Ki-moon, released a statement about the CD saying, "Consensus rule, which has served this body so well in the past, is currently used as a de facto veto power to stall every attempt to break the impasse" (UN 2012). Many interviewees for this report echoed that sentiment, saying that the political tensions and lack of consensus in the First Committee make it difficult to discuss topics effectively. Some interviewees feared that if discussions on OSAM are moved from the First Committee to the Fourth Committee, then the disagreements would spread. However, other interviewees noted that the consensus rule in the Fourth Committee already makes it difficult to create codified norms.

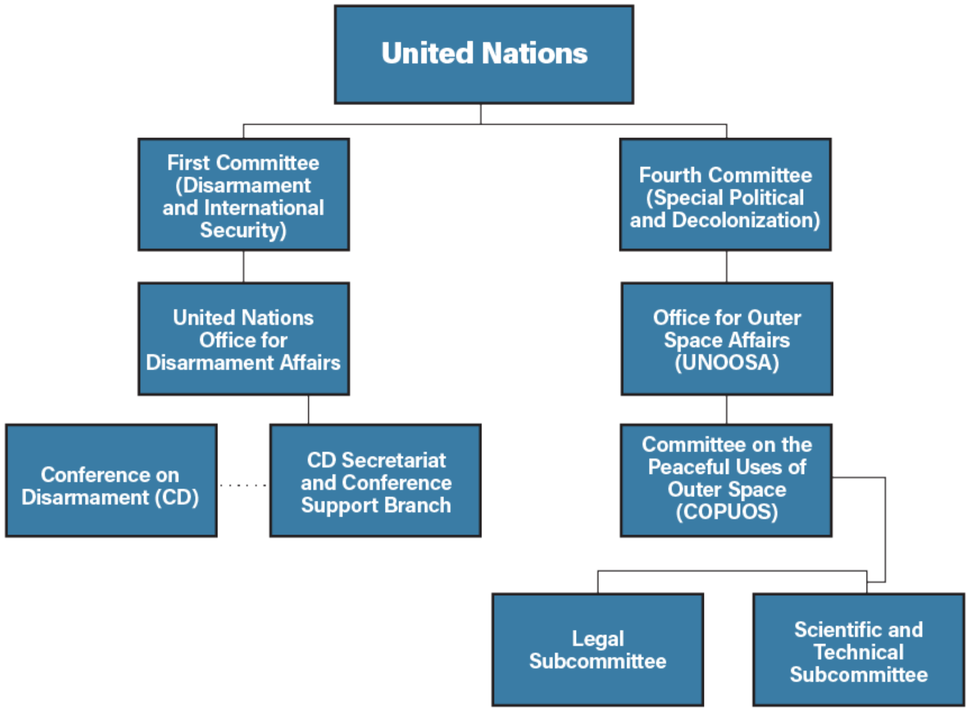

Figure 6. United Nations Structural Components Relevant to Norms of Behavior in Space

b. Customary International Law

Customary international law is another component of international law that "refers to international obligations arising from established international practices, as opposed to obligations arising from formal written conventions and treaties" (Cornell Law School 2021a). Unlike the treaties and guidelines published by the UN, this component of international law is more akin to the "behavioral norms," described in Chapter 2, in that there is not clear guidance governing behavior and limited mechanisms for enforcement.

For something to become customary international law, states need to accept that it is law (*opinio juris*) and behave accordingly, or make explicit exception through declaration and practice. Customary law has historically been the process by which maritime law has been established. To create binding international customary law, there must be a pattern of behavior and a sense of obligation to follow that pattern (Koplow 2008). One interviewee said that others within the OSAM community believed that the practices set forth by the Artemis Accords would eventually become customary international law for lunar activities; another interviewee disagreed because the Artemis Accords have not been universally accepted. As of December 2021, 13 countries have adopted the Artemis Accords (Foust 2021d).

c. Differences in National Preference for International Law

Interviewees indicated that there are varying preferences and perspectives among spacefaring nations with respect to international legal mechanisms versus non-binding and non-codified norms. Many interviewees commented that for space, China, Russia, and India appear to prefer binding measures, whereas countries such as the United States and other Western countries prefer to use non-binding agreements and practices.[9]

From the Chinese and Russian perspective, there is concern that without legally binding mechanisms, stakeholders—particularly other countries and their commercial entities—are less likely to adhere to desirable behavior. Even for the foundational binding international treaties such as the Outer Space Treaty (OST), however, enforcement mechanisms—or more aptly the lack thereof—present a challenge. Enforcement typically is implemented on the national level, as countries adopt the contents of treaties into their national law. However, there is no international mechanism to ensure that this occurs. This lack of enforcement mechanisms is an existing issue for all international law, not just space law. In some instances, a lack of adherence may be met with backlash in the form of international opinion or, in extreme situations, sanctions, but this does not consistently occur. Further, many interviewees suggested it is unlikely there will ever be another international treaty created to govern space.

d. Insufficiency of International Law for Addressing OSAM Needs

One reoccurring response among interviewees was that international law moves too slowly when compared to the rate of technology development. As a result, international law insufficiently addresses the needs of OSAM operators or the concerns of other stakeholders. This is true of the UN, which runs on consensus, and customary international law, which needs time to develop and become adopted as law. As such, most interviewees felt it is necessary to consider alternative concepts and mechanisms for developing OSAM norms. Future efforts to govern OSAM technologies will not likely be clarified through international law.

2. Liability and Responsibility

The legal concepts of liability and responsibility have particular applicability to OSAM issues and are pertinent across all stakeholders. OSAM activities present a risk of damage to other spacecraft, both to those participating in an on-orbit maneuver and to other nearby assets. This threat will only increase as the technology for spacecraft servicing

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9 There is further evidence supporting this statement in the responses to UN resolution 75/36. For more information on responses to the resolution, see Appendix C. For country specific responses, see: https://www.un.org/disarmament/topics/outerspace-sg-report-outer-space-2021/.

matures. Interviewees expressed concerns regarding liability and ultimately responsibility around OSAM activities in space.

a. Liability

Liability is "a legally enforceable claim on the assets of a business property of an individual. In business, liability results from a breach of duty or obligation by act or failure to act" (Cornell Law School 2021b). In regard to OSAM, the concept of liability is particularly drawn upon at a high level in two of the major space treaties: the OST and the Liability Convention.

In the OST, the concept of liability for space objects is addressed in Article VII, which states that countries that have launched or procured the launching of a spacecraft are liable for damage done to another state party to the Treaty by those objects in outer space.[10] This clearly relates to OSAM, in that the missteps would trigger international liability measures, regardless of whether the misstep was intentional or accidental.

Liability for space objects is further described in the 1975 Liability Convention.[11] Article III notes that a country will be held liable for any damage beyond the surface of the Earth done to another launching state's space object. Likewise, Article IV says that when two states cause damage, they "shall be jointly and severally liable" (UN 1975). Both of these articles include the state and "persons for whom it is responsible" as parties who can be held liable for damages. The Liability Convention also describes the process for making claims for damages done. Apart from claims, under Article IX of the OST, a state party to the Treaty that believes a planned activity or experiment could cause potentially harmful interference with peaceful space activities "may request consultation concerning the activity or experiment" (UN 1967). Such a consultation has never been invoked.

Liability is a major consideration for commercial stakeholders. If a commercial company is liable for damages done and cannot cover the costs, then it could damage or even ruin their business, depending on the financial penalty invoked. According to interviewees, this makes commercial stakeholders less likely to pursue operations that could incur financial penalties. However, it is worth noting that the Liability Convention has only been invoked once, when the Russian satellite Cosmos 954 disintegrated over Canada in 1978. In this instance, the case was settled out of court, but the Soviet Union agreed to pay $3 million Canadian to the Canadian government (von der Dunk 2009).

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[10] Full text of Article VII: "Each State Party to the Treaty that launches or procures the launching of an object into outer space, including the moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air or in outer space, including the moon and other celestial bodies."

[11] Full title: Convention on International Liability for Damage Caused by Space Objects

Further, the final settlement itself did not mention the Liability Convention. The cost of liability is quantified in insurance costs and liability limits, which will be discussed further in the Legal Mechanisms section of this chapter.

Liability is a concern for both commercial and state actors, albeit in different ways. For state actors, liability is tied to national security. For example, if a state actor conducted an anti-satellite (ASAT) test that caused harmful debris in orbit, if the debris was tracked to the launching state, the country could pursue invoking the Liability Convention, although this has not been the case historically. In a worst-case scenario, an ASAT test conducted on another nation's satellite could be interpreted as an act of war, although historically countries have conducted ASAT tests on their own spacecraft. Further, state actors consider their resources relative to other nations. Smaller, less financially stable countries may be more likely to propose regulations and may be more risk-averse. On the other hand, for commercial actors, liability is tied to their economic "bottom line." If a commercial company behaved recklessly and caused harmful orbital debris, they would face the risk of litigation and a loss of current and future revenue.

Even countries that do not currently have OSAM capabilities think about liability and how it can be used to encourage safe on-orbit practices. An interviewee noted one specific emerging spacefaring nation that wanted to encourage safe activities without doing the activities itself, but, at the same time, was already thinking about the role that liability would play in the efforts to deter behaviors it deemed unsafe. Liability was described as an incentive to encourage safe space activities in a feedback loop.

Separate but related to liability is the concept of responsibility. For OSAM and all space activities, responsibility is rooted in Article VI of the OST, which indicates that states "bear international responsibility" for their national activities in space, regardless of if they are carried out by government on non-government entities.[12] This article is particularly important because it establishes that commercial entities are not separate from their national governments.

b. Jurisdiction and Control

Jurisdiction is key to the concepts of liability and responsibility. This has become a key issue for OSAM, which relies on the interaction between two space objects, potentially from different countries. Article VIII of the OST states that "A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a

[12] Exact text from Article VI: "States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty."

celestial body" (UN 1967). This further increases the responsibility that states have over their space objects and provides another barrier for OSAM activities. This article could disincentive states from performing active debris removal on spacecraft or debris that is either not their own, cannot be verified to be their own, or could unintentionally damage other assets (Anzaldua 2021).

3. Licensing

Licensing is the final legal concept that is fundamental for shaping OSAM norms. This concept is related to liability because it is the main tool of national governments to regulate on-orbit activities, within certain limitations. On-orbit licenses are currently being used and developed in the UK and Japan. Interviewees from one country expressed that the lack of licensing for RPO is a gap in their legal system.

The concept of licensing for space activities is introduced in the OST. Article VI of the Treaty states that "the activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty" (UN 1967). Most states implement these requirements by creating a national licensing framework, although the details of each framework can vary widely between states.

Licensing is fundamental to the development of commercial activities in space. Therefore, the ease and clarity in the licensing process could make one country more attractive to a commercial entity than another. Conversely, a lack of oversight may be appealing to some commercial actors. One interviewee expressed that licensing in the UK and Japan is less complicated than licensing in the United States.

B. Mechanisms for OSAM Norm Development

While the legal concepts described in earlier sections are important for understanding how the law can affect OSAM behaviors, there are also concrete mechanisms through which stakeholders can directly influence behaviors. These mechanisms fall into five broad categories: international treaties and guidelines, national regulations and policy, insurance policy, contracting terms, and technical standards.

These five mechanisms are discrete but not independent of each other. For instance, one nation's laws and regulations can be introduced in international forums and adopted as international standards, thus influencing the national regulations of other countries. Likewise, technical standards can make their way into contracting terms, or set a guide for responsible behavior that affects insurance policies, national policies, or international discussions. These mechanisms also provide a way for governments and the private sector to interface with each other.

Looking ahead to the future of OSAM norms, some mechanisms may be preferable to others. Several interviewees asserted that it is unlikely that there will be another legally binding space treaty, and the international community as a whole tends to instead favor non-binding guidelines. This is not true across all nations, with countries such as Russia, China, and India preferring legally binding mechanisms.

1. International Treaties and Guidelines

The concept of international law is formed and informed through the mechanisms of international treaties and guidelines from the UN, as well as the outputs of collaborative efforts from groups of multinational actors, such as CONFERS and PERASPERA. Each of these mechanisms produces written documents that then form guardrails in the development of behavioral norms. Behaviors from spacefaring actors occur in response to these international efforts, whether actors decide to comply with them or not.

a. Treaties

Five UN space treaties form the foundation of international space law, three of which are most relevant to OSAM: the 1967 OST,[13] the 1972 Liability Convention, and 1973 the Registration Convention.[14] As discussed in the Concepts section above, the OST is the basis for establishing the legal concepts of responsibility, liability, and the roles of government and non-government spacefaring actors in the space domain. As of May 2021, there are 110 states party to the treaty and 89 signatory states, including all major spacefaring countries discussed in this report (UNODA 2021). As described in the previous section on the concept of liability, the Liability Convention describes different scenarios and clarifies which party is liable. It also describes when and how claims should be made and fulfilled, if necessary. The Registration Convention reinforces the OST in that space objects need to be registered.

The last space treaty, the Moon Agreement, was enacted in July 1984. The Moon Treaty is largely viewed as a failed treaty, however, because it has not been as widely adopted as the other space treaties. The United States, China, and Russia—the countries that have conducted successful lunar missions to date—are not signatories. There has not been another space treaty opened for signature in the UN since the Moon Agreement was enacted, and interviewees generally agreed that it is unlikely that there will be another space treaty—largely attributed to the shift in cultural attitudes by some countries away from space treaties and preference for non-binding guidelines. This attitude is mostly held by Western countries and is not universal. Some countries, such as China and Russia,

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[13] Full title: Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies

[14] Full title: Convention on International Liability for Damage Caused by Space Objects

would prefer a new space treaty to non-binding instruments. The lack of agreement about this, as well as the consensus requirements for the UN, makes it unlikely that a new space treaty will be produced. Thus, only the interpretation of existing space treaties is likely to affect OSAM norms in the future.

b. Guidelines

There are a variety of actors, including the UN, that have released internationally-focused guidelines for space activities. Unlike the treaties, these guidelines are not legally binding and can also apply to more than just states. One of the most notable and recent sets of guidelines are the Guidelines for the Long-term Sustainability of Outer Space Activities (LTS Guidelines), which were released in 2018 after an 8-year development process. One interviewee referred to these as an example of how delegates from the major spacefaring nations could codify best practices for the civil space sector. These guidelines address the following topic areas, as defined within the LTS Guidelines: the policy and regulatory framework for space activities; safety of space operations; international cooperation, capacity-building, and awareness; and scientific and technical research and development. As their name suggests, they are focused on maintaining a space environment that can sustain space activities, and, thus, are generally related to OSAM activities. For example, Guideline D.2.4 encourages states to investigate new "methods for the extension of operational lifetime, novel techniques to prevent collision with and among debris and objects with no means of changing their trajectory, advanced measures for spacecraft passivation and post-mission disposal" (UN 2018).

International collaboration between academic institutions has also produced guidelines and manuals in an attempt to define and influence norms of behavior, namely MILAMOS and the Woomera Manual. The MILAMOS Project was launched in 2016 by McGill University (Canada) and has participation from the Beijing Institute of Technology (China), University of Cologne (Germany), the Institute for Defence Studies and Analyses (India), the Secure World Foundation (USA), St Petersburg State University (Russia), Western Sydney University (Australia), and St. Thomas University (USA). The goal of MILAMOS is to clarify "the fundamental rules applicable to the military use of outer space in peacetime" (MILAMOS 2021). In short, this manual will offer an interpretation of ways to comply with the OST and clarify the existing international law with respect to defense applications. It was slated for publication in early 2021, but has yet to be released.

The Woomera Manual project has a similar mission, to "develop a manual that objectively articulates and clarifies existing international law applicable to military space operations" (University of Adelaide 2021). This international project is led by the University of Adelaide (Australia), the University of Exeter (UK), the University of Nebraska (USA), and the University of New South Wales – Canberra (Australia). The Woomera Manual's focus on defining unlawful space operations is relevant to OSAM because of the dual-use nature of OSAM technology and potential for misinterpretation of actions.

Efforts to enable more international cooperation for OSAM and space activities are also taking place. Two examples of this type of international mechanism are CONFERS—which was started in the United States by the Defense Advanced Research Projects Agency (DARPA)—and PERASPERA, which is led by the European Union (EU). CONFERS brings together government and industry representatives from a number of countries to discuss the development of norms and standards for RPO.

PERASPERA is a European collaboration between stakeholders of the EU member states, and invites perspectives from both national space agencies and industry. When PERASPERA began, it initially wanted to focus on collaborating with CONFERS, but now has "the goal of enabling major advances in strategic key-points of Space Robotics Technologies, in order to improve the European competitiveness" (PERASPERA 2021). The effort was initially called Horizon 2020, and is in the process of being continued under Horizon Europe. One of PERASPERA's major goals is to produce OSAM guidelines, called the European Operations Framework, which would clarify OSAM activities and allow new stakeholders to easily enter the European market.

Finally, there are other international mechanisms that are not directly related to space, but that could influence space operations. For example, one interviewee noted that OSAM behaviors of countries in South Asia could be influenced by their involvement in the South Asian Association for Regional Cooperation (SAARC); the BRICs (Brazil, Russia, India, China, and South Africa); and the Shanghai Cooperation Organization (SCO).

c. Failed Efforts of International Treaties and Guidelines

There have been two notable efforts to create codified boundaries relevant to OSAM norms and behaviors, both of which have been unsuccessful (at least to so far). They are: the proposed Treaty on the Prevention of the Placements of Weapons in Outer Space, the Threat or Use of Force Against Outer Space Objects (PPWT) and the European Draft Code of Conduct for Outer Space Activities.

The PPWT was introduced by Russia and China to the CD in 2008. Efforts to work on this treaty were a part of the Ad Hoc Prevention of an Arms Race in Outer Space (PAROS) committee, a subsidiary body to the CD. PAROS was established by a UN resolution in 1981 (NTI 2021). The PPWT is specifically designed to ban placement of weapons on orbit that could be used to attack the Earth and it does not ban terrestrial ASAT weapons that can be used to attack satellites. Interviewees said that this new proposed treaty was unsuccessful because Western countries, like the United States, did not want to commit to a binding space treaty that did not ban terrestrial ASAT weapons that could be used to attack satellites. Thus, it is seen by many as an attempt by Russia/China to hamstring future

US space-based missile defense while allowing their own ASAT weapons programs to proceed. One interviewee indicated that when treaty mechanisms are proposed by China and Russia, other countries that have a different world view will automatically discard them, a practice that the interviewee cited as an issue. In 2014, the U.S. representative to CD, Ambassador Robert Wood, dismissed the PPWT as "fundamentally flawed" and proposed non-binding agreements instead of legally binding treaties (Foust 2014).

Concurrent with the introduction of the PPWT, there was an effort to propose non-binding guidelines within the CD. The European Draft Code of Conduct for Outer Space Activities (hereafter the Code of Conduct) was introduced to the CD in February 2009 (NTI 2021). It was discussed over the next few years, with the intention of conducting a discussion at the UN Headquarters in July 2015. However, the Code of Conduct did not reach broader acceptance because of two procedural concerns, both the potential lack of UN mandate and allowance of other countries to propose alternative text. Interviewees said that one of the major oppositions to the Code of Conduct was not to its contents, but rather that it had been written without sufficient input from other states. The Code of Conduct was also continually rejected by Russia and China, who instead focused on promoting the PPWT (Listner 2015). According to literature and our interviewees, the procedural issues brought up at the UN in 2015, as well as the lack of buy-in from other countries, effectively caused the Code of Conduct to fail (Listner 2015; Krepon 2015).

The failure of the PPWT and the Code of Conduct demonstrates the geopolitical divide in expectations for how to create written norms that may affect OSAM. Countries like China and Russia prefer to have a binding treaty and focus their attentions on banning space-based missile defense and space-to-Earth weapons, while the United States, EU countries, and allies are focused on protecting satellites from ASAT attacks. Interviewees suggested that the United States is reluctant to sign a binding document that may restrict its interests or flexibility in future space activities. The differences between these two mindsets have effectively caused a stalemate in international negotiations in the UN regarding the development and creation of new written OSAM norms.

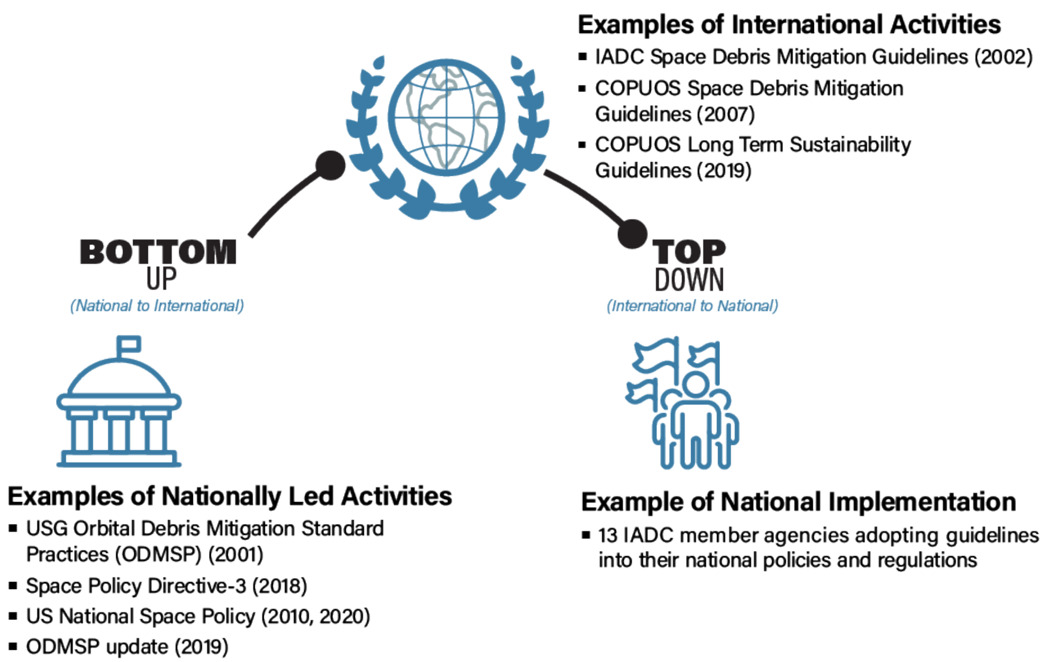

Figure 7. Top-down and Bottom-up Approaches to Address Orbital Debris Mitigation Policies

2. National Regulations and Policy

As demonstrated in Figure 7 for the case of orbital debris, international policies often influence or become national regulations. Figure 7 is not meant to be a timeline, rather an example of how orbital debris policies have been influenced by activities from individual agencies or activities at the national level and lead to informing international activities. As international policies are discussed in multinational forums, like CONFERS or the UN, individual governments may adopt certain measures into their own national space laws and policies. Likewise, national policies can also become incorporated into the international forums, thus creating a cyclical cause and effect. At least one interviewee indicated that, when determining the national space policies of their particular country, they consider not only the international policies and standards made by COPUOS and other organizations, but also their own local laws and the general attitude of the international community. This helps them to decide whether an international measure is likely to be followed and thus become a norm. Another interviewee said that developing national regulations is easier and more flexible than international guidelines, because nations can do so in a way that best suits their own national interests.

The mechanisms for creating and implementing national regulations include national legislation, decisions of governmental organizations, political statements and press releases, and responses to international documents (e.g., proposed UN Resolutions). A current example of this is governments' responses to the UN Resolution 75/36 entitled, *Reducing space threats through norms, rules and principles of responsible behaviours*.

Other national regulations and policies that are not related to OSAM can still influence OSAM behavioral norms. For example, requirements for importing and exporting new technologies influence partnerships between countries when developing OSAM technologies.

a. Import and Export Requirements

Interviewees from private entities described import and export requirements as one of their major considerations when determining what technology they could build and with which countries they could collaborate. Import and export requirements are especially relevant to emerging OSAM technologies because OSAM technologies tend to be dual use in nature. Import and export requirements apply not only to the development of robotics, but also to data sharing. For multinational companies, import and export requirements can vary by the nations in which they are based, and they must navigate the export regimes of two or more nations.

Import and export requirements can impact other mechanisms for the creation of norms, such as insurance policies. Within the United States, import and export regulations occur through the International Traffic in Arms Regulations (ITAR). One of the provisions of ITAR is that insurance companies outside the United States must be granted a license in order to obtain data for risk assessment for insurance policies (Malinowska 2017).

b. Licensing Requirements

One of the strongest tools for national governments to influence the OSAM behaviors of private entities is licensing requirements. Licenses are generally required for launch and reentry. Licensing requirements tie into nations' OST Article VI requirements to provide "authorization and continued supervision" to the space activities of non-governmental entities that operate within their borders. Licensing relates back to the key concept of liability, because it is the mechanism that governments use to ensure supervision of their national space activities.

Governments have the deciding power on whether to grant a license, which gives them a mechanism to establish norms. For example, a government could set a requirement that 90% of a company's spacecraft must deorbit after a certain period of time. If the company cannot demonstrate that they can do this, the government can withhold their launch license. Global companies can respond to this power by deciding where their company operates and does business. One interviewee said that they chose their specific company head-quarters because of the perceived clarity and ease of their licensing process. Therefore, not only flexibility, but also the clarity of the launch license process is key for attracting companies that wish to conduct OSAM activities. To encourage the future development of OSAM technologies, countries may replicate a licensing process similar to that developed by the UK. UK requires space operators to indemnify the government for any potential claims. The UK Space Industry Act of 2018 discussed setting the, "satellite operator's liability to third parties would be limited at the same level as the launch operator's using the same calculation method (if launched from the UK, otherwise the liability would be set at €60m)."

Case Study: Rendezvous and Proximity Operations Licensing

While it is common for launching states to have regulations and requirements for launch and/or radio frequency spectrum use licenses, both the UK and Japan are going one step further and developing licenses for RPO. In March 2021, the End-of-Life Services demonstration (ELSA-d) by Astroscale was licensed by the UK as the first approval for RPO and active debris removal. Under the UK Outer Space Act, the UK Space Agency issued two licenses: one to the ELSA-d servicer, and one to the client spacecraft (Astroscale 2021). In addition to the RPO license, Astroscale also had to obtain a space station radio frequency license from Japan for the ELSA-d servicer and client satellite, as they own and operate a ground station on Totsuka, Japan. Their UK Mission License included authorization to launch from the Baikonour Cosmodrome, which is owned and operated by Roscosmos (Weeden et al. 2019). As of January 2022, the United States has adopted a different approach of adapting its existing licensing frameworks to include OSAM and no new authorities for OSAM have been pursued.

3. Insurance Policies

Another mechanism for commercial implementation of liability is insurance policies. Insurance companies can calculate risk and assign liability for certain space operations and then quantify that risk through the cost of the policy. Insurance companies are able to influence the behaviors of operators by defining which behavior is "responsible" and which behaviors contradict the norm. The price of an insurance policy can especially influence the behaviors of commercial entities. This introduces a significant power that insurance companies have and that can be leveraged within, even in the absence of national regulation or international law. This is termed “insurance as governance” (Harrington 2020). That said, the vast majority of satellite operators do not buy insurance beyond launch. In some cases, this is because insurers do not offer such products, but it other cases they choose to “self-insure” and incur the costs of loss on orbit themselves.

One interviewee from a private company related how insurance coverage is necessary for operators who wish to do RPO because there is a relatively high risk of damaging the spacecraft. It would not be financially sound for them to operate without insurance. National governments can also play a role by requiring insurance for commercial actors to influence insurance policies and calculations of private companies, by determining minimum coverage requirements. For example, Australia requires a minimum insurance of either 750 million UAD or the maximum probable loss of a mission (Harrington 2020). To address issues of liability compensation, Anzaldua (2021) suggests that the space industry adopts protection and indemnity insurance, as the maritime industry does. In this type of insurance, a protection and indemnity club collects dues from its members to use for compensation for an insurance payout. The fund is then replenished or members can pay less the following year, depending on how much was used in the prior year. In the same article, Anzaldua also suggests that an independent, international entity could create an actuarial index to calculate the risk for states and space actors (Anzaldua 2021).

4. Contracting Terms

One way that national governments can directly interface with and influence the behavior of the private sector is through contracting terms. One interviewee asserted that contracting allows national governments to wield the most influence on commercial actors, even more so than international law. The terms of a contract can either explicitly or inadvertently create norms of behavior for operators. They can set technical standards or specify how certain operations should be completed. However, specifications in contracts can be negotiated during the acquisition process.

The majority of contracts within the space domain have been government-to-commercial, which was the case for Astroscale and Clearspace. One notable exception to that is MEV-1, which was a commercial-to-commercial contract. One interviewee said that commercial actors can sometimes feel that they do not have input for government contracts for which they are typically competing with other commercial actors to receive.

Referring back to the major legal concepts, contracting terms are also a mechanism for defining liability for government and commercial actors. Within contract terms, governments can specify caps on the amount of money for which a company could be held liable. For example, in 2015, the United Kingdom established a liability limit of 60 million euros on spacecraft operators as a way to encourage growth in its private space sector (de

Selding 2015). Contracts can also influence insurance, which was discussed in the previous section. Insurance can sometimes be required within a contract (Harrington 2017), and contracts are a mechanism for creating an insurance agreement.

5. Technical Standards

Technical standards can be specified in contracting terms or in the policies of national space programs. These technical standards are often prescribed by the International Organization for Standardization (ISO). The standard ISO/CD 24330 for "Space Systems-RPO and On Orbit Servicing-Programmatic principles and practices" is under development, and, as of April 2021, in the stage of a committee draft closed for voting and comments (ISO 2021). ISO 24330 began as a draft provided to ISO by CONFERS, based on the experience and input from CONFERS members. To relate back to the previous section on contracting, ISO standards can often be used within contracts to reference how a contractor should behave. First-movers and heritage technologies influence the standards used, which will be discussed further in Chapter 4.

Renewed interest in going to the Moon has also brought about the development of standards. These emerging standards could have implications for OSAM activities, especially if spacecraft are designed to be interoperable across national space programs. Multiple interviewees expressed their belief that the Artemis Accords are a strong influence in OSAM norms because they require that partners that sign the bilateral agreements address the principles set by the United States. The Moon Village Association is a different non-governmental organization committed to involving global stakeholders in the exploration and, in their view, eventual settlement of the Moon. A major component of their implementation plan includes best practices and interoperability guidelines, and in 2020 they released their own *Best Practices for Sustainable Lunar Activities* (Moon Village Association 2021). Another lunar-focused organization, For All Moonkind, aims to promote the development of standards for protection of cultural heritage sites in outer space.

Technical standards are not interchangeable with behavioral norms, although many interviewees conflated the two. For the purposes of this report, technical standards are a form of codified norm and are one mechanism through which behavioral norms can be influenced.

C. United Nations Resolution on Responsible Behavior in Space

We analyzed the state responses of UN Resolution 75/36, which can be found in detail in Appendix C. We found that many member states discussed the challenges posed by OSAM activities but they were not consistent on how to address the problem. Implicit within the responses were two themes: either voluntary action must precede a legally binding action, or voluntary actions are insufficient and the international community should pursue other avenues. Countries such as Canada, EU member states, the UK, and Korea posited that voluntary action or non-binding written norms should come before binding agreements. In contrast, implicit among some of the responses is the idea that norms and rules of behavior are not appropriate for the UN given the time constraints posed by the forum and the UN's focus should instead be on legally binding mechanisms.

D. Chapter Summary and Future Trends

The key legal concepts of international law, liability and responsibility, and licensing form a framework to understand how written documents can influence behavioral norms. These concepts are distinct from the mechanisms by which written norms may be developed or established. We identify five different mechanisms for written norms—treaties, national policy, insurance policies, contracting terms, and technical standards—that national governments, industry, and international non-governmental organizations may utilize to influence the behaviors of OSAM operators.

Relevant future trends in OSAM norms of behavior in space associated with this chapter include:

- New legally binding treaties developed through the UN process need to address issues in OSAM behavioral norms that are unlikely to occur. Bilateral and multilateral non-binding written agreements will be more likely.
- The commercial sector will provide input for non-binding guidelines, through organizations such as CONFERS and PERASPERA. National policies, like the UK's RPO license process, will likely be a more effective way for governments to provide clarity to the private sector about OSAM operations. These national policies can eventually be adopted within international forums such as the UN and then become law in other nations. As a result, future codified and legal norms for OSAM activities are more likely to start from the bottom-up rather than from the top-down.
- Liability is a major consideration in carrying out OSAM activities for operators, especially commercial actors. Unless there is clarity surrounding how liability will be assessed and addressed, uncertainty will persist and bring instability to OSAM operators, particularly commercial actors.

4. Capabilities, Motivations, and Incentives Driving Use of Norms for OSAM

In Chapters 2 and 3, we discussed the definition of norms and described how written norms influence behavioral norms including the mechanisms by which they are developed. This chapter pivots towards describing how different actors typically use norms, what motivates different actors, and how technology and incentives influence the use of norms.

Motivations and values are combined with technical capabilities to influence and drive the behavior of space operators and the codified norms they create. Motivations and values may be common among various actors or unique to a specific stakeholder group, country or region, or activity. The intersection of motivations, values, and capabilities will affect how different actors behave and create both behavioral and codified norms as described in Figure 8.

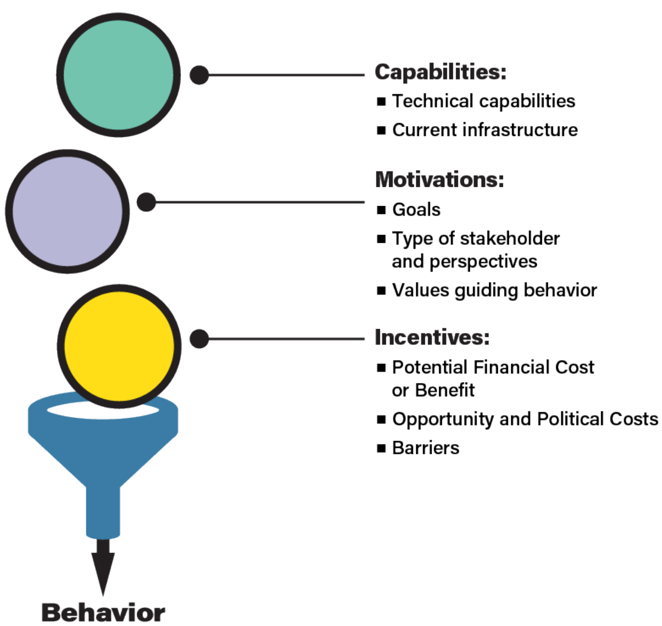

Figure 8. Factors Affecting an Actor's Behavior in Space

A. Motivations' Effect on the Use of Behavioral Norms

A single OSAM actor operating in space drives their own actions and behavior within the guardrails of international and national policy. These actors already have internal mechanisms to modify their own behavior within their respective organizational structures.

Therefore, those who wish to create a new or alter an existing norm of behavior do so to influence the behavior of other actors. While an actor or group of actors may model the behavior they wish to see more widely adopted, their intent is to encourage others to adopt that behavior rather than altering their own. That is, actors' motivation in the norm creation process is to encourage other actors to adopt their own preferred patterns of behavior, whether through behavioral, codified, or legal norms. While all types of actors approach norms with the intent of affecting the behavior of others, each type of actor plays a different role in the norm creation process, which in turns influences the specific ways they utilize and understand norms.

More so than any other type of actor, governments have a voice and influence in international forums. In addition, governments may create binding measures within their own countries, encouraging desirable behavior and discouraging bad behavior. Government actors therefore value codified and legal norms due to the power that can be exerted on both other countries and commercial actors to shape behavior. While some governments may want to place boundaries on the behavior of others, they still value their own flexibility in their actions and discretion in applying those norms, particularly in defense sectors. In such instances, governments may prefer encouraging behavioral norms through the use of guidelines and best practices, rather than binding agreements. Interviewees explained that some countries place a lower value on flexibility of behavior, but the United States has placed a much higher value on this flexibility. The U.S. Department of Defense (DOD) has historically been reluctant to adhere to or develop concrete norms in space due to fear of limiting their own ability to respond to perceived threats (Eisenhower Center 2014; Hitchens 2021a; Hitchens 2021b). Recently, however, national security actors have begun to see norms as potentially useful in establishing boundaries to the actions of other entities, even if their own flexibility is lost. Countries that have less developed space programs or are not currently spacefaring have differing concerns over the use of norms. Interviewees indicate that such countries tend to be concerned that legal and codified norms developed now will be used to further existing international inequality, especially if they are not included in the process of creating those norms. The opposite is also true; some countries are concerned that they will be perhaps unfairly bound in the future by legal and codified norms they were not able to influence. Due to the concern over their own flexibility, we understand from interviewees that many Western governments have shown a preference for non-binding measures, like guidelines or best practices, at the international level.

Discussions regarding norms are largely driven by countries' concerns over the actions of other geopolitical actors. As discussed in Chapter 3 on the framework and mechanism for written norms, some countries—most notably China, Russia, and India—are concerned with the on-orbit activities of foreign governments and their commercial actors. Interviewees from European countries, Russia, and China indicated that U.S.

commercial actors were of particular concern, a sentiment that was intermittently echoed by other interviewees. Therefore, some such countries have stated that they prefer written norms with "more teeth."

Conversely, interviewees from all stakeholder groups, but particularly commercial actors, indicated that commercial entities do not have a direct role in the process for creating international legal norms and may only be involved in providing input within their respective country of operation. At the national and industry-wide level, commercial entities are represented within industry groups and other dialogues that may produce non-binding, codified or written norms such as guidelines and best practices. Commercial entities may also attempt to promote their preferred behavioral norm by simply using their preferred codified or behavioral norm consistently and encouraging their peers to do so. As discussed in Chapter 3, interviewees explained that governments and commercial entities may also use contracts to enforce proper behavior for commercial entities. In some ways, this only affects the actors who participate in the contract, but over time, this approach may influence the behavior of more commercial actors, particularly if space contractors continue to use the same contract terms for other projects, a certain behavior or design is perpetuated. This is especially true if the contract is with the government, and language from one contract persists in the next contract.

In general, commercial actors may be more motivated to codify their operations through contracts, standards, and guidelines to ensure stability and interoperability. However, commercial actors may also be more inconsistent in their use of codified norms perpetuated by guidelines and best practices, due to their non-binding nature. Even for contracts, behaviors are established between a set of actors for a specific mission or maneuver. As a result, behavioral norms may not be consistent from mission to mission.

Some interviewees indicated that commercial entities are more concerned with the actions of their peer organizations than those of geopolitical actors. As such, commercial actors tend to focus on the norm-building efforts oriented towards industry, such as best practices and standards. Possible exceptions are potential scenarios wherein geopolitical actors conduct missions that threaten the broader space environment, such as ASAT testing.

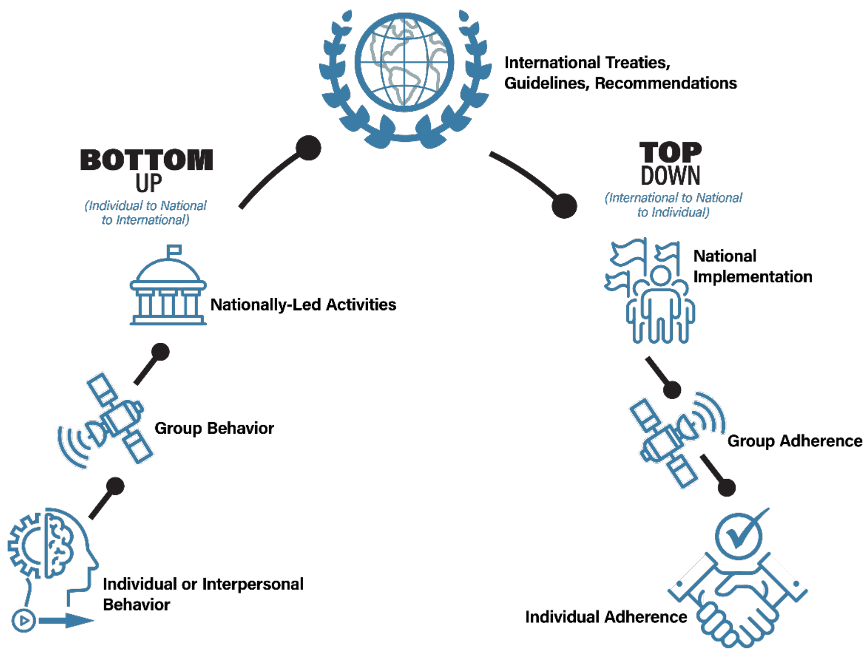

Figure 9. Top-down Bottom-up Approach to Behaviors Leading to Written Norms Influencing Behaviors

Regardless of the type of actor, the process by which norms develop may affect the nature of the norms and how they are used. In particular, the progression of norms from the international to the individual (top-down), or vice versa (bottom-up), can heavily affect the norms that result. As illustrated in Figure 9, top-down norm development is driven by international efforts that filter down to the national, group, and individual level. Conversely, bottom-up norm development is spurred by individual or interpersonal behavior, which progresses to group behavior, nationally driven activities, and international acceptance. The progression of norms in these avenues may not reach every level. For instance, a norm may go from the interpersonal level to the group level, such as a behavior resulting from a contract being adopted by an industry group, but may not progress to the national level.

Norms that are created using a top-down approach tend to be value driven and broader in their framing. These norms tend to be used to guide missions and maneuvers at a high level, often before there is significant activity in the area of concern. Conversely, norms created using a bottom-up approach tend to be driven by specific missions and challenges of ongoing activities. As a result, these norms may resemble stipulations more than guidelines and affect a smaller portion of missions.

Case Study: International Space Station (ISS)—Understanding Intergovernmental Dynamics[15]

While the public largely associates Russian and American collaboration in space with the ISS, this partnership stretches back to 1975, with the Apollo-Soyuz program (Dunn 2021). Coordination for these programs was largely conducted on the technical level between engineers. The ISS, however, required greater communication and collaboration at all levels due to the high level of technological sophistication of this program.

Due to the complexity of this project, it was essential that all parties maintained continuous iteration and coordination on technical, administrative, and executive levels. Construction of the ISS involved several RPO and dockings with both the Space Shuttle and Mir Space Station—complex maneuvers despite their established flight history—and development of new techniques and mechanisms (OTA 1995). To facilitate these efforts, collaboration between the Russian and American space programs occurred on multiple levels, rather than exclusively a top-down or bottom-up approach. Top-down cooperation originated from the highest levels of both governments, led by the American Vice President and the Russian Prime Minister. Collaboration from the engineering and operator level would fall into the category of "bottom-up" norm development. Both approaches proved key to this program.

Complex technical mechanisms require continuous coordination to allow iteration over time. American and Russian engineers worked and trained together, developing standards, operating procedures, and best practices from their routine collaboration. For any specific maneuver to become routine, it had to be executed in a variety of configurations and with extensive contingency analyses (Goodman & Reichert 2011). Coordination from the technical staffs of these organizations was vital, and decisions from technical staff were then codified at higher levels.

The Russian and American leadership addressed the organizational and political barriers, although more technical and procedural aspects were also evaluated at this level. To guide this international collaboration from a leadership level, a task force was established, led by Gen. Thomas P. Stafford (USAF Ret.) (NASA Advisory Council 1995). This task force evaluated these efforts, created recommendations for the National Aeronautics and Space Administration (NASA) Advisory Council, and addressed topics that ranged from technical and operational to administrative and organizational. A similar task force was established for the Russian Space Agency, and these two task forces interfaced with one another. Eventually, Russian Prime Minister Chernomyrdin and U.S. Vice President Al Gore directed the Russian Space Agency and NASA to establish a

[15] This case study considers developments in Russian and American space collaborations until January 2022.

process to review and coordinate with each other. In response, a joint committee was formed, headed by Gen. Stafford and Vladimir F. Utkin, Director of the Central Institute for Machine Building (TsNIIMash). The resulting Task Force Reports included various behavioral, operational, and technical recommendations (General Thomas P. Stafford Task Force et al. 1996).

While some aspects of the partnership between Russia and the United States were addressed more heavily at one level than others, it should be noted that many aspects were discussed, evaluated, and produced norms at both the "top" and the "bottom." For instance, RPO and docking were driven at the engineer and operator level, but the task force leadership led the examination technical information, production of recommendations, and development of contingency plans. Language and cultural issues were addressed at both levels, as engineers and leadership alike identified the need for improved translations of manuals and technical information.

B. Values and Equities as Drivers for Norm Adherence

Interviewees regularly discussed that an actor's values drive both their perception of behavioral norms and the extent to which these behavioral norms are followed and viewed as legitimate. Across all actors, the most commonly mentioned values discussed by interviewees were sustainability, security, stability, reliability, transparency, and innovation. The extent to which actors emphasized these values varied by both the type of actor and the actor's regional origin.

Different types of actors espouse and emphasize different values, and this in turn guides their behavior, as illustrated by Table 3. National security actors emphasized stability first and foremost, and, to a lesser extent transparency and sustainability. Governments of different nations also have varying values. Interviewees from countries such as Japan and those within the EU more heavily emphasize sustainability, while interviewees from the United States and Russia cite stability and security more frequently. Countries that are not yet spacefaring or those still developing their capabilities instead place more value in equity and inclusion. Interviewees indicated that these countries tend to fear that space norms will not include their input or will be used as a mechanism to prevent equity in space.

Table 3. Stakeholder Core Values for OSAM Activities

Core Values by Stakeholders Vary			
Type of Stakeholder	**Core Value**	**Supporting Values**	**Key OSAM Activites**
National Security Actors	Security	Stability, Accountability	Satellite inspection co-orbital ASATs + Servicing
Civil Space Agencies	Stability or Sustainability	Transparency, Reliability, Interoperability	Docking, Berthing, ADR, Servicing
Commercial Entities	Innovation or Sustainability	Interoperability, Transparency, Stability	ADR, Servicing, Assembly, Manufacturing

Commercial actors primarily emphasized innovation and interoperability. To a lesser extent, commercial actors listed sustainability as a guiding principle. Again, this trend was regional. European and Asian commercial entities more often cited the importance of sustainability in space, while American commercial entities placed the most value in innovation and interoperability. In addition, the degree to which a company is established affects the values preferred. Large, established space primary contractors more often listed interoperability and sustainability as guiding values. Meanwhile, smaller companies more often indicated that innovation guides their use of norms. Civil space agencies and those within international forums heavily emphasized transparency, and with less frequency sustainability and reliability. Nonetheless, all actors report being driven by common interest and understanding amongst their peers.

Different values were also emphasized with respect to different OSAM activities. For space situational awareness (SSA) and RPO, transparency was the most commonly cited guiding value. This emphasis is likely because SSA and RPO are the most established and most often performed activities within OSAM. Sustainability was more frequently emphasized in relation to Active Debris Removal (ADR) and satellite servicing. Those developing ADR and satellite servicing capabilities were motivated primarily or solely by this value. For the least mature of the OSAM technologies, assembly and manufacturing, innovation was mentioned most frequently as a motivator for behavioral norms, or more aptly a lack thereof. Interviewees in this area often expressed concern that norms at this stage would hinder the development of assembly and manufacturing technologies.

Case Study: Active Debris Removal

ADR is guided by sustainability as a driving value, and this can be seen in the efforts of two prominent companies working this area: ClearSpace and Astroscale. Both of these efforts are examples of values shaping operations and norms. Each company seeks to encourage other actors to adopt this value using their missions as a model.

The European Space Agency (ESA) has contracted with the company ClearSpace to develop an ADR mission by 2025. Leadership at both ESA and ClearSpace has indicated in public interviews that these efforts are driven by a desire for a more sustainable space environment (Matthewson 2021). It is notable that while ClearSpace has received a grant from ESA, they are also seeking commercial investment. The motivation for this is to pioneer "capture forms [as] the foundation of a recurring business case," as described by Luisa Innocenti of ESA's Clean Space Office (Matthewson 2021). This mission, therefore, is intended as a technological model for other actors, but also as a means to encourage sustainability as a key value in the commercial sector. Should this effort succeed, sustainability may become a more prominent value for the commercial sector and may in turn guide more missions and the resulting behavioral norms.

Astroscale tested their End-of-Life by Astroscale-demonstration (ELSA-d) in 2021. Similar to ClearSpace, this company's primary value is sustainability and it hopes to validate ADR as a viable business activity. Astroscale's efforts are distinct, however, in that their leadership hopes to also "propel regulatory developments," as stated by Astroscale founder and CEO Nobu Okada. In this way, Astroscale is attempting to use their missions to spur national efforts, which would be an example of individual action intentionally spurring national efforts—exemplifying bottom-up norm development. As of December 2021, Astroscale plans to conduct further demonstration missions in 2022.

C. High-Level Considerations for the Use of Norms

As discussed in Chapter 2, norms can manifest as either binding or non-binding measures, depending on an individual's definition of norms. Interviewees discussed that codified norms might be used as a substitute when legally binding mechanisms are not possible, either due to inertia at the international level or those actors' particular lack of leverage in the creation process. In addition, as discussed earlier within this chapter, actors may prefer non-binding measures to retain flexibility in their own actions. The line between these two types of measures, however, is not always clear and can change easily. A non-binding codified norm may be promoted by an individual actor through either usage or the actor promulgating the norm in a forum. That individual actor will continue to promote their norms in the hope that other actors may adopt this norm, and in turn codify this norm in whatever method available to them.

The first-mover principle can be a powerful force in the creation of norms. Interviewees often relayed that behavioral, codified, and legal norms could not or should not precede an action—that is the first-mover. Behavioral norms come from actions, from which legal and codified norms typically follow. In addition, the degree to which a first-mover creates a behavioral norm is highly variable. The first mission to use new technology could set an example for the space community, but intellectual property concerns may limit information sharing and thus the creation of a new behavioral norm or industry document, such as guidelines or standards. Further, even in instances that missions are conducted with transparency, there may not be a common understanding of the technical information shared. That is, different actors may not share a lexicon or may view the same data in different ways. As a result, a behavioral or codified norm may not be developed and perpetuated for every novel action taken in space despite the first-mover principle. Similarly, both behavior and codified norms if and when established based on this principle may not be long lasting. Commercial actors in particular view norms as iterative and may use a norm developed using the first-mover principle as a starting point.

Historically, there has been a key stipulation of the first-movers principle; actors who develop a greater amount of flight history will have greater ability to set behavioral norms. That is, those who have performed a higher number of missions, in more configurations, and have overcome more obstacles, may be seen as a superior source of norms and may have more influence in creating norms. This does not necessarily mean that a more established entity will overshadow a less established one—simply that whoever develops the most flight experience with a certain maneuver or activity has historically had greater influence than the entity that just first performed the action. The operational norms set by the ISS are a prime example; interviewees repeatedly noted that NASA had set norms through the ISS due to their expertise generated over dozens of missions, despite Russia having constructed and operated space stations first, both modular (Mir) and monolithic (Salyut 1). Further interviewees noted Russia as a source of norms—again, not because they were first, but due to the number of space stations they had operated over the past 50 years. Regardless of whether a norm is developed based on the first-mover principle or after more flight experience is established, a norm derived from earlier missions may be inherited across a broader group of stakeholders and for longer than anticipated. The ISS, again, serves as a key example. The docking standards developed for users of the ISS will serve as the foundation for the Lunar Gateway.[16] Further, the operational norms adopted by governmental and commercial actors alike will likely endure for other missions.

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[16] It is unclear whether future Chinese spacecraft will be International Docking System Standard (IDSS) compatible. Early reports on China's new lunar spacecraft indicate that the docking mechanism may be IDSS compatible (Jones 2020). In addition, China's docking mechanisms have been influenced by collaborations with Russia, which has signed onto IDSS (Cook et al. 2011). China may ensure its systems are IDSS compliant in order to work with ISS partner countries.

The development of behavioral and codified norms can be used as an extension of competition between stakeholders, both geopolitically and commercially. This is true geopolitically in particular. For instance, the lack of cooperation between the United States and China could create opposing behavioral and codified norms for OSAM as an extension of their strained relationship. This phenomenon is not limited to the international level, however, and also affects commercial operators. Commercial entities each want to set the standard for operations, particularly in hardware and interfaces that benefit their own products. Interviewees indicated that each commercial entity will likely advocate for or use their own standard until one standard has sufficient traction within the community. Their hope is that once the broader community adopts their operating method, it will become a behavioral norm. Depending on how a behavioral norm is developed, different portions of the community may use different versions of that norm, or even opposing norms.

D. OSAM Norms Considerations by Actor

Each actor's mission and priorities affect the ways that actor behaves and thus the behavioral norms that derive from the actor's activity. The rules for behavior vary significantly depending on the stakeholder group to which the operator belongs: commercial, civil, or national security.

The respective equities and motivations of each type of actor will affect their adherence to and attitudes towards norms. Within this section, national security actors, civil space agencies, large commercial actors, and small commercial actors are all considered.

1. National Security Actors

Some interviewees indicated that the national security community might view norms as useful in setting boundaries for the behavior of other geopolitical and national security actors. National security actors are militaries, defense contractors, the intelligence community, and other organizations responsible for a country's security interest. The norms that national security actors prefer tend to be purely behavioral and non-binding (e.g., guidelines, best practices, standards). National security actors, however, do not want to alter their own behavior for strategic reasons, and as a result, have been historically reluctant to create codified norms in space. This trend has changed in recent years, as national security actors have begun to see the potential value in creating boundaries for broader behavior, particularly using non-binding mechanisms. While national security actors may want to perpetuate rules to influence the behavior of others, interviewees noted that national security communities are more likely to create exceptions to the rules for themselves. Their adherence, or lack thereof, to behavioral and codified norms will not be as visible as that of other actors.

Interviewees noted that the majority of national security actors view space deterrence and its related norms as connected to terrestrial norms and activities, rather than unique to the space domain. As General John E. Hyten noted at the 34th Space Symposium: "It's not space for space's sake. There's no such thing as war in space, there's just war" (Hirsch 2018). A similar conclusion was reached by NSI's Virtual Think Tank (ViTTa) report "Space and US Deterrence," which was produced in support of the Strategic Multilayer Assessment Office (Joint Staff, J39). This report similarly finds that the majority of national security actors believe that space "is so indelibly intertwined in all national security activities that the idea of a separate 'space deterrence' is nonsensical" (Astorino-Courtois 2017). Further, this report describes two schools of thought regarding the defense of space assets. The first believes that sustaining superior capabilities in space is key to protecting American freedom of action in the space domain. The other school of thought prefers American leadership in collective international management through the creation of international security norms as a mechanism for managing the space domain. Our data collection identified a similar dichotomy in the thinking of U.S. national security actors. Given the nature of their work, we were unable to conduct conversations with foreign national security actors, so it is unclear as to whether there are similar dynamics internationally.

National security actors tend to value security, stability, accountability, and reliability as guiding principles. More specifically, national security actors view security and stability as inextricably linked, believing that security allows stability and stability allows security. Accountability and reliability are supporting values that are emphasized as essential to ensure stability and security. National security actors, according to interviewees, view a lack of transparency and accountability on the part of other geopolitical actors as threats to their equities and values in the space domain. This concern is most commonly cited by national security and diplomatic actors. As a result, national security actors view codified norms as potentially providing value by placing boundaries on behavior and clarity on "bad actors."

2. Civil Space Agencies

Interviewees suggested that civil space agencies will be the most likely to adhere to codified and behavioral norms out of all other stakeholder groups. Civil space agencies were noted as more likely to codify the behavioral norms to which they adhere into their internal regulations. Interviewees perceived that civil space agencies would more consistently adhere to their codified norms (e.g., contracts and internal procedures) than other stakeholder groups. Furthermore, they observed that national space agencies proliferate their own norms through contracts with outside entities. This in turn encourages partner agencies and the commercial entities that contract with the civil agencies to adopt these norms. Norms codified by civil space agencies may also be adopted by other departments and agencies within their country.

Interviewees also noted that once a civil space agency had codified a norm, they may be more reluctant to alter or discontinue use of that norm. This is partially due to the fact that civil space agencies tend to codify their norms; once a norm has been adopted into internal regulations and contracts with commercial providers and peer space agencies, the process of altering or discontinuing a particular norm can be burdensome. Interviewees also tended to believe, however, that this perceived lack of flexibility is due to the internal cultures of civil space agencies.

The most commonly cited values for civil space agencies, as reported by interviewees, are sustainability, reliability, and transparency. More specifically, sustainability is viewed as the primary guiding value for these agencies, with reliability and transparency as values that contribute to providing a sustainable domain. Concerns over orbital debris and congestion of the space domain were noted as significant threats to their vision of the space domain. Interviewees also viewed both national security and commercial actors as the primary drivers of those perceived threats, and as a result, they view norms as potentially useful in deterring what civil space agencies understand to be harmful activities and practices.

3. Large Commercial Actors

The values of larger commercial entities may differ from those of their smaller peers. For the purposes of this section, large commercial actors are defined as defense contractors and large space contractors with strong governmental ties and established technological heritage. This may include those typically considered "New Space" entities, as well as "Old Space." Interviewees noted that large commercial actors value stable environments in which to operate, allowing greater reliability and protecting their ability to conduct their missions. This is partially driven by the fact that larger, more established entities tend to have less risk within their business model. In addition, due to their close relationships with civil space agencies, large commercial actors will adopt and potentially codify norms before other organizations, in order to align themselves with their primary customers. Large commercial actors tend to use contracts as their primary method of implementing norms, particularly contracts with civil space agencies.

Conversely, commercial actors of any size may be concerned that norms may stifle innovation and place limits on their operations. Intellectual property concerns further complicate large commercial actor's relationships with norms. Intellectual property is of high value to such companies, and commercial entities may limit what they share with their peers. As a result, other actors may only have an approximate understanding of the internal norms of other companies, which in turn limits the degree to which these norms are disseminated. However, civil space agencies tend to be consistent in their behavior and in transparency, providing somewhat of a common basis for the behavior of large commercial entities.

Large commercial actors tend to value sustainability, stability, and reliability in their norms. Given that these companies are more risk averse, stability tends to be the overarching value. Sustainability provides value in allowing greater stability, with reliability as a supplementary value within. These actors tend to view liability as a potentially serious hurdle in the space domain.

4. Small Commercial Actors: Startups and Small Businesses

Interviewees noted that small commercial actors may be the most reluctant group to adopt norms, out of concern that it may stifle innovation. Innovation was the most commonly cited value for these actors. These actors tend to view norms as being in opposition to this value. Concerns over intellectual property further complicate this relationship.

A smaller subset of these commercial actors also expressed concerns that they are underrepresented in the norm creation process, at both the international and industry levels. Government officials are more likely to confer with larger commercial entities in this process, although interviewees noted that many countries may not confer with any commercial actors at all. At the industry level, small commercial actors tend to have less power and fewer resources to participate in these dialogues.

E. OSAM Norms Considered by Activity

For all OSAM activities, interviewees conveyed that actions drive norms. Most actors are hesitant to create codified or legal norms before an activity is conducted. Commercial actors in particular believe that a mission must be completed in varying configurations and multiple instances before a norm can be created. National security actors tend to differ, likely due to the nature of both their equities and concerns. Although, one interviewee indicated that even in the case of norms for terrestrial weapons, the use of the weapon must be understood before boundaries can be made.

For the majority of interviewees, guidelines are preferable to stipulations, which are viewed as heavy-handed and stifling. In practice, a guideline would provide boundaries for a type of behavior, while stipulations would be more prescriptive. Commercial actors in particular strongly prefer guidelines to stipulations. Civil agencies, however, have historically promoted more prescriptive norms, but are now trending towards guidelines with increasing frequency. The ISS docking standards are an example of this trend and are discussed later in this chapter.

Each OSAM activity is associated with different values, based in part on the activity's maturity level, use cases, and relevant stakeholder groups, as described in Table 4. For instance, docking and berthing activities are largely driven by the values of transparency and interoperability. In order for two spacecraft to dock with one another, they must have interoperable systems and be able to trust the parties with whom they are coordinating—creating a need for interoperability and transparency. These values are further emphasized by the type of stakeholder group most relevant. Docking and berthing is of greatest concern to commercial entities and civil space agencies, which use this capability the most and likewise value transparency and interoperability.

Table 4. Core Values for Norms by Activity

Core Values by Activity				
OSAM Activity	**Values Emphasized**	**Maturity Level**	**Relevant Stakeholder Group**	**Additional Notes**
Remote Inspection	Transparency, Accountability	High	▪ National Security	▪ Most discussed ▪ Foundational to all other OSAM
Satellite Servicing and Active and Active Debris Removal (ADR)	Sustainability	Medium	▪ Commercial Entities ▪ Civil Space Agencies	▪ National security actors concerned with dual-use risk
Docking and Berthing	Transparency, Interoperability	High	▪ Commercial Entities ▪ Civil Space Agencies	▪ Flight history of U.S. and Russia has lasting effect
Assembly and Manufacturing	Innovation	Low	▪ Commercial Entities	▪ Commercial entities fear norms could hinder tech development

1. Rendezvous and Proximity Operations

When asked about OSAM activities, interviewees were most familiar with and most frequently discussed RPO. As the most mature and foundational OSAM capability, more actors are capable of RPO than other OSAM areas. Interviewees indicated that norms can be useful for RPO to indicate to others their intent and to improve transparency regarding the activity. One interviewee noted that problems arise when an object is seen and interpreted, as disagreements tend to arise not because of the action but due to the assumptions made, particularly when an object is not listed or publicly acknowledged. As more actors develop this capability, the dual-use nature of RPO will drive further discussions, as described in Section F on Co-Orbital and Direct Ascent ASATs.

Interviewees indicated several norms that may provide utility in this area. Many discussed that announcing and publicly listing assets would improve transparency among actors and serve as a gesture of goodwill. Numerous interviewees also said that only undertaking RPO with active consent from the other party would improve stability. These interviewees also often noted that established perimeters or safe zones around assets would improve both stability and safety. Norms may be more developed in this area because this is the most mature of all OSAM activities.

SSA was described as a key supporting capability for RPO. A lack of verification in the space domain was often cited as an issue for RPO in particular. Interviewees tended to characterize national security actors, particularly those in the United States, as reluctant to announce their assets. In addition, they indicated that identifying and monitoring maneuvers can be difficult on the ground.

2. Satellite Servicing and Active Debris Removal

Satellite servicing and ADR are discussed together, as they both require similar technical capabilities and are guided by sustainability as a foundational value. Interviewees often stressed the importance of interoperability and transparency. Some interviewees valued these independently, others as ways to enable sustainability.

Interoperability is vital to satellite servicing and ADR. Both operations require some level of interaction between two spacecraft. As a result, compatible designs and a common set of technical standards are seen as integral to the broader success of these activities.

In addition, transparency was discussed by interviewees as important, as many may believe that these capabilities represent a threat. Interviewees discussed that capabilities could be adapted as weapons, and some within the space community may be wary or disapproving of these activities as a result. Interviewees have stressed the importance of outreach to dissuade other actors from this concern.

Interviewees did not address some topics areas within norms that will need to be addressed within satellite servicing and active debris removal. In particular, interviewees did not discuss frameworks to gain consent to service assets that the operator does not own and may be owned by a foreign country. Organizations developing satellite servicing and ADR capabilities often state their intention to remove or repair ailing or defunct assets as a service. Current international legal frameworks do not provide a way for the owner of that asset to consent for such servicing and ADR activities and, further, prohibit states from interfering or harming each other's assets. Without a framework to establish consent, such activities may be severely hindered due to liability concerns. In addition, interviewees did not discuss whether norms were needed to allow for servicing and for ADR entities to provide post-mission disposal services. While these may have been valuable conversations, they were not observed in the course of interviews.

Case Study: Docking Plates

Companies such as OneWeb and Astroscale have begun to promote behavioral norms that they believe allow for interoperability and sustainability, as well as facilitate the continued development of their OSAM activities of interest. Astroscale encourages satellite operators to include a ferromagnetic docking plate on their spacecraft (Pool 2021). Such docking plates will allow for ADR and servicing missions to detect, approach, capture, and manipulate their target body. In advocating for this behavior, Astroscale undoubtedly is serving their own business interests; they are also, however, encouraging behavior that is aligned with their values of sustainability and interoperability.

OneWeb has committed to including a ferromagnetic docking plate on each satellite in their constellation. Further, OneWeb has invested in future Astroscale missions, primarily the End-of-Life Services by Astroscale-Multi (ELSA-M) servicer. This mission was publicly described as, "specifically designed for servicing of constellation satellites that are fitted with a compatible docking plate, including OneWeb's Joey-Sat" (Astroscale 2021).

Astroscale and OneWeb are attempting to set a norm by using their behavior as a model for a behavioral norm. This interaction is an example of "bottom-up" norm development, in that two organizations are using their interpersonal interactions and agreements to advocate for a broader norm. This instance also highlights the relationship between values, as interoperability is key for sustainability more broadly.

3. Docking and Berthing

Docking and berthing have a comparable amount of flight history as RPO, as missions for this activity similarly begin in the Apollo era. These capabilities were first developed by Russia and the United States, and were routinized in each country's missions as well as in their collaborative international missions. Docking and berthing capabilities are no longer limited to the U.S. and Russian governments, and commercial entities and international space agencies regularly conduct these maneuvers. Other countries developed their capabilities under the guidance of the U.S. and Russian space agencies. In general, the transfer of knowledge was accomplished through partnerships with other nations' space agencies, and the technical and operational standards generated were then written into contracts.

Many interviewees discussed that a common standard for docking systems would be beneficial by enabling numerous operators to have compatible systems. Interoperability was seen as important because an effort must be made by many actors to design and operate their spacecraft in a way that allows interactions between spacecraft. Interviewees from commercial entities also indicated that they would prefer to set that standard themselves or promote the system that they prefer.

Case Study: International Docking System Standard (IDSS)

The International Space Station Multilateral Coordination Board (ISS MCB) created an international standard for spacecraft docking mechanisms. The ISS MCB is the highest-level coordinating body for the ISS and includes representatives from all ISS partner space agencies: NASA, Roscosmos, Japanese Exploration Agency (JAXA), Canadian Space Agency (CSA), and ESA. The ISS MCB led this effort to "establish a standard docking interface to enable on-orbit crew rescue operations and joint collaborative endeavors utilizing different spacecraft" (ISS MCB 2016).

The result of this effort is the IDSS, which has since been signed and accepted by all ISS partner countries. Establishing a standard docking interface will enable greater collaboration for future missions beyond the ISS, between not only international partners but also non-governmental entities. A commonly defined interface will serve as a key element in enabling dissimilar spacecraft to "mate" for crew and cargo exchange, as well as enabling spacecraft assembly.

IDSS provides common design parameters, rather than a more prescriptive blueprint for docking mechanisms. IDSS describes functional needs and interfacing, but is intentionally agnostic to the specific technologies driving the system (Hatfield 2012). In other words, these standards identify the features with which a system must be compatible, but do not specify how precisely that must be achieved. These standards were intended to ensure "commonality of function, not commonality of design" (ibid).

In several senses, IDSS is distinct from other norms in OSAM. Historically, norms for docking and berthing have manifested as contracts between two entities or as technical standards adopted by an entity. As such, these codified norms were binding, specifically with respect to the desired technical mechanisms and operations. Further, these codified norms were generated with a "bottom-up" approach. That is, these written practices were determined on an interpersonal level and proliferated to higher levels. IDSS is distinct in that it provides high-level rather than prescriptive guidance, and these standards—while informed by earlier maneuvers—were generated from the upper echelons of international leadership in this area: a top-down approach. However, IDSS is similar to its predecessors in that it is a binding mechanism. All entities that wish to dock with the ISS must adhere to these standards. It is unknown to what degree IDSS will be binding for future missions, other than the Lunar Gateway, which is publicly noted to require its partners to be IDSS compliant.

The IDSS has guided collaboration with the ISS since its implementation in 2010. Initially, IDSS was primarily relevant to governmental partners, but in recent years, commercial entities have begun to dock with the ISS—and, as a result, have had to comply with IDSS. Commercial entities interface with their country's space agency for such missions. To comply with IDSS, each space agency has developed its own internal technical standards. NASA's is the NASA Docking System (NDS). Commercial providers working with the ISS are given an NDS data package, at which point they decide to either build a compliant design, "build to print" the NDS design, buy a compliant system from another vendor, or require NASA provision the NDS.

This commercial interface is noteworthy. These commercial entities are likely performing these maneuvers for the first time under NASA guidance and supervision, adhering to IDSS. As a result, their capabilities will likely be strongly shaped by IDSS, even beyond the conclusion of the company's ISS partnership. This highlights two key aspects of the norm creation process. Contractual agreements can be a tool to determine a broader norm. Secondly, with respect to norms relating to hardware and technology, actors who both make their specifications public and closely collaborate with new actors can increase adherence to their preferred norm.

One should also note that the creation of IDSS was heavily informed by not only earlier ISS missions, but also Russian, U.S.-Russian, and U.S. missions. This highlights the reverberating effect of flight history in norms. A first-mover can establish behaviors and approaches that can be used for years to come, even extending beyond the original parties involved. However, it should be noted that the first action itself does not necessarily carry enough weight to determine a norm. Interviewees identified the United States and Russia as respected sources of information not due to their status as the first to conduct such maneuvers, but due to the significant amount of experience amassed.

4. Assembly and Manufacturing

The OSAM activities discussed the least were assembly and manufacturing, likely because these are the least developed of the OSAM technologies. Given that these capabilities are in the most nascent stages, innovation and flexibility in implementation were the most commonly cited values in this area. Interviewees had very little commentary or ideas on emerging assembly and manufacturing norms other than those already mentioned regarding RPO and interfaces.

F. National Security Activities and Perspectives

A key challenge with OSAM activity is the civil and military applications of similar technologies. Western space experts on multiple occasions have described the threat of Chinese or Russian OSAM activity as having military applications. Several Chinese RPO maneuvers have been described as potential tests for offensive capabilities, in particular TJS-3 and TJS-3 AGM in 2019; the SJ-17 in 2016; SY-7, Cx-3, and SJ-15 in 2016; and others, as is documented by the Secure World Foundation (SWF 2021). For Russia, several incidents suggest a clearer view of military applications of OSAM technologies. In 2019, Russia announced the launch of a military payload. The payload, Cosmos 2542, released a secondary payload, Cosmos 2543. The secondary payload later rendezvoused to a position where some believe the satellite could observe a classified U.S. intelligence satellite, USA 245 (SWF 2021). Non-western delegations have similarly expressed the same concerns with the United States. In 2021, the Chinese delegation to UNODA referenced the MEV-1 commercial satellite servicing demonstration and the X-37B spaceplane as an example of American efforts to militarize space (UNODA 2021).

Increased transparency may affect global response but regardless of the level of transparency associated with a mission, the civil and military application of OSAM activity may generate unease among an operator's adversaries. According to the Secure World Foundation, only the United States, Russia, and China have some or a significant co-orbital ASAT capability (SWF 2021).

G. Anti-Satellite Weapons

Co-orbital and direct ascent ASAT are both forms of space warfare that can destroy or damage space assets. Both of these capabilities have a long history and have been demonstrated as early as the 1970s (Grego 2012). While co-orbital ASATs fall under the OSAM umbrella, direct ascent ASATs are not an OSAM activity. Nonetheless, they are similar in that they both are offensive space capabilities. Both co-orbital and direct ascent ASATs have been the subject of great scrutiny as the number and variety of actors operating in the space domain grows. Tests of these capabilities are polarizing among the international space community due to their perceived threat to the sustainability and safety of the space domain, albeit each in distinct ways.

Direct ascent ASATs use a rocket, launched from the ground, air, or sea, to place a kinetic kill vehicle (KKV) into space. Once the KKV has separated from the rocket, it will track and approach its target, creating a hypervelocity collision (Pfrang & Weeden 2021). As such, direct ascent ASATs do not fall under OSAM. China, Russia, the United States, and India have all tested direct ascent ASATs (SWF 2021).

Despite the relatively small number of actors with current or developing direct ASAT capabilities, ASAT tests reduce the stability of the space environment for all operators, not only national security actors, by generating orbital debris (SWF 2021). This threat is of particular concern in LEO. Our interviewees across all stakeholder groups expressed concern for risks presented by direct ascent ASAT tests, stating that the proliferation of debris caused by these tests could harm access to and ability to operate within space.

A co-orbital ASAT is a satellite or spacecraft that is placed into an orbit near its target, and, upon approach, the co-orbital ASAT will attempt to destroy, damage, or otherwise interfere with their target (Martin et al. 2021). The co-orbital ASAT may attempt this through direct collision; releasing objects or other spacecraft that collide with the target; using robotic systems to damage the target; or directed energy or electronic warfare (Martin et al. 2021). Co-orbital ASAT capabilities have been tested by or are under R&D in Russia, the United States, and China (SWF 2021).

Unlike its direct ascent counterpart, co-orbital ASATs require or overlap with many OSAM activities. At the most basic level, co-orbital ASATs require RPO capabilities (Harrison et al. 2021). The 2020 IDA STPI report on OSAM identifies 23 technology areas as critical, desired, or enabling for OSAM activities (Corbin et al. 2020). While the amount of overlap between OSAM and co-orbital ASATs varies based on the specific type of co-orbital ASAT, the technology areas required by these activities have commonalities. At a minimum, both activities require rough-control or fine propulsion; advanced guidance, navigation, and control; and some degree of automation. Various co-orbital ASATs may require basic or advanced robotic arms; intra-space mobility; cutting tools; space welding; wireless power transfer; or other technologies.

Further, the specific capabilities and technologies required for some OSAM activities overlap with technologies needed for co-orbital ASATs. For instance, repairing (R4), replacing parts (R5), or recharging (R6) a satellite as part of a servicing mission requires the same technologies as a co-orbital ASAT. In our interviews, commercial users repeatedly expressed concern that their satellite servicing activities may appear to be co-orbital ASATs and indicated that they want to alter public perception, drawing a line between these two activities, pointing to norms as a way to approach this challenge. From our interviews and in the literature review, we learned that government actors are concerned that ambiguity between satellite servicing and co-orbital ASATs provides deniability for malicious actors.

In fact, China expressed concern over Northrop Grumman’s MEV-1 satellite servicing mission as having potential defense applications. China’s response to UN General Assembly Resolution 75/36 states that MEV-1 was an example of technologies that “can be diverted to offensive military use, thus posing a serious threat to the security of outer space assets of other countries” (UNODA 2020). This point was further underscored by the close approach of a high-speed projectile released from Russian Cosmos-2543 to a National Reconnaissance Office (NRO) asset in February 2020. The U.S. Space Command condemned this as a test of co-orbital ASATs, while the Russian Ministry of Defense asserted that this maneuver was an experiment to “continue work on the assessing of the technical condition or domestic satellites” (Harrison 2021; Tass 2019).

Given the tension caused by these two activities, the international space community has engaged in many discussions on the need for norms to provide boundaries in this area. These conversations have not been fruitful as of March 2022, and ASAT tests continue to occur. Even during the creation of this report, Russia conducted a direct ascent ASAT test on November 15, 2021 that destroyed one of its defunct satellites. This test occurred at a higher altitude than earlier U.S. and Indian ASAT tests, but lower than China’s notorious 2007 ASAT test (Gohd 2021). Notably, the debris cloud generated by this event forced the

ISS Flight Control team to undertake emergency procedures to protect the astronaut and cosmonauts onboard (NASA 2021). This event can be interpreted in two ways: either as evidence that norms have yet to be developed or that the norm is that direct ascent-ASATs, particularly low debris causing once, are permissible. In either case, the severity in terms of impact and public reaction underscores the significance of these maneuvers to the space domain.

Since relatively few actors can perform either of these maneuvers, norms developed for either of these activities will likely be developed by the governments that have ASAT capabilities—India, China, Russia, and the United States. Norms in this area could be developed jointly, with all parties reaching an agreement to place limits on or even cease either type of ASAT test. However, due to the political dynamics between these actors, it is also possible that these norms may be developed in opposition to norms proposed by their counterparts. That is, a country or group of countries may propose a norm that another country or group of countries dismisses in favor of a different norm. As such, norms themselves may become another means to compete internationally. Further, should a norm be developed by this select group of countries, it may be accepted or discarded by other actors that develop ASAT capabilities later.

STPI identified several drivers of future trends in this area. National security actors have historically been reluctant to establish norms of behavior in space relating to such militaristic activities, as they do not want to limit their own behavior or ability to react to perceived threats (Eisenhower Center 2014; Hitchens 2021a; Hitchens 2021b). However, this historic trend may be countered by growing calls for norms for direct ascent ASATs. In response to Russia's November 2021 direct ascent ASAT test, the Council of the European Union "strongly condemn[ed]" the test and called upon "all States, including the Russian Federation, to refrain from further such tests and to contribute in a constructive manner to ongoing efforts in the United Nations on the development of norms, rules, and principles of responsible behavior in outer space." This call was echoed by DOD: U.S. DOD Deputy Secretary Kathleen Hicks said at a National Space Council meeting in November 2021 that the DOD "would like to see all nations agree to refrain from anti-satellite weapons testing that creates debris" (Sheetz 2021). At this same meeting, State Department Deputy Secretary Wendy Sherman echoed this sentiment, saying that the UN will be creating a process to establish "national security space norms of behavior" (Sheetz 2021).

As the number and variety of actors in space grows, orbital debris becomes a greater concern and may result in pressure on actors thought to be behaving recklessly. Actors may perceive that the space communities' efforts to mitigate orbital debris—through improving satellite designs, improving tracking and characterization, and developing remediation technologies—are rendered insignificant if direct ascent ASAT tests continue. This trend has been strongly accentuated by the international reactions to the November 2021 Russian ASAT test.

The last notable driver is that more actors are developing RPO and other capabilities that enable or resemble co-orbital ASATs. Growing capabilities may drive the need for norms to place boundaries on this behavior. Conversely, national security actors may begin to utilize co-orbital ASATs more often if growing pressure from the international community or broadly accepted norms limit or prevent the use of direct ascent ASATs.

Based upon the drivers described, STPI identified three possible scenarios for norm development with respect to direct ascent and co-orbital ASATs: (1) continuation of status quo, (2) treaty limiting direct ascent ASATs, and (3) co-orbital ASATs over direct ascent.

Both co-orbital and direct ascent ASAT tests may continue unaltered, due to either a lack of norm development or consensus. This scenario may be enabled by actors' reluctance to adhere to norms of behavior, as actors may value their freedom of action over the personal restriction and the potential broader stability a norm may provide. A lack of consensus in norm development—either due to disagreements over substance or forum—may also contribute to a continuation in co-orbital and direct ascent ASATs. For instance, China and Russia have historically preferred written, binding norms through international treaties, while the United States has historically preferred behavioral norms over binding mechanisms. Conversely, a lack of trust between actors may hinder norm development in this area. For example, our interviewees indicated that India may view emerging norms as efforts to limit their still developing capabilities in favor of more established space powers.

A treaty may be formed that limits direct ascent ASATs, either broadly or at particular orbits or altitudes. Limits to direct ascent ASATs may be driven by the perception in the international space community that certain direct ascent ASAT tests have been more problematic than others have. The public reaction to the 2007 Chinese and 2021 Russian ASAT tests compared to the 2019 Indian ASAT test provide an example of varying public reactions. The 2007 Chinese ASAT and 2021 Russia ASAT tests occurred at higher altitudes, and experts anticipate that the debris generated by these events will be longer lasting than the 2019 Indian ASAT (Gohd 2021). Consequently, the broader community has reacted more strongly to the 2007 and 2021 tests.

STPI anticipates that it is unlikely that a treaty is formed, as interviewees repeatedly indicated that treaties will take too much time and that it is difficult to get the broad approval necessary. This is further reinforced by differences in the views of Russia, the United States, and China on binding legal mechanisms. Procedural hurdles can prevent or delay treaties as well. Countries may agree on content, but the identity of the originating party may heavily affect who supports the treaty. Lastly, national security actors may not want to limit themselves to such an extreme degree, even if they wish to prevent what they view as bad behavior from other actors.

Mounting pressure from the international community may cause ASAT-capable countries to rely more heavily on co-orbital ASATs, as they are more ambiguous and allow for plausible deniability. In this scenario, there is no binding or codified mechanism to prevent use or tests of direct ascent ASATs, but strong international pressure influences the decision to rely more heavily on co-orbital ASATs. International pressure may come from allied countries and the commercial sector, which particularly value sustainability in the space domain.

Should limits on direct ascent ASATs emerge—whether as treaties or as societal pressure—co-orbital ASATs may become more prevalent, fulfilling national security actors' need for counterspace capabilities that are less damaging to the broader space domain and allow for greater ambiguity in action.

- Several countries espouse "security" first and foremost—particularly from their military departments; however, other values also are important to recognize. Japan and Europe value sustainability. Russia and the United States value stability and accountability. However, that is tempered by the desire for freedom of action and movement in the space domain.
- More stakeholders in space and more congestion will ensure that orbital debris continues to be a growing concern and may result in pressure on actors perceived as behaving recklessly. All the work to mitigate debris creation through better satellite designs, more maneuverability, and improved tracking and characterization in the space environment will be rendered insignificant if debris-causing ASAT tests continue.
- More actors are developing RPO capabilities, and activities that resemble co-orbital ASATs will become more prevalent. This seems to be driving the need for codified or legal norms in order to differentiate responsible actors from those that may have malicious intentions.

H. Chapter Summary and Future Trends

Motivations and values are combined with technical capabilities to influence and drive the behavior of OSAM operators. Additionally, the intersection of motivations, values, and capabilities will affect how different actors behave and create both behavioral and non-binding written norms or codified norms. We found that values vary across OSAM stakeholders with national security actors valuing security first, civil space agencies valuing stability and sustainability, and commercial operators valuing innovation and sustainability (particularly those looking to develop a service). Furthermore, commercial actors indicated in interviews that to develop codified or behavioral norms, a significant amount of flight history was needed for perceived credibility. In contrast, national security actors tended to prefer behavioral norms earlier in the process, even preemptively.

We identify some future trends on the use of norms:

- Technical advances, many driven by the commercial sector, will motivate the adoption of technical standards and influence future design and operations of OSAM activities. In the case of docking standards, it is likely that when a critical mass of companies converges and adopts a particular docking standard, a technical approach and likely a behavioral norm for docking will be developed.
- Given the dual-use nature of technologies, norms of behavior will continue to be called for and steps such as notifying the space community as well as sharing plans and maneuvers will result in greater transparency and hopefully more trust among actors.
- Should there be advances in technologies such as SSA and on-orbit verification, national security and commercial actors' intent with OSAM activities will be clearer to the world.

5. Future Trends

Norms of behavior for OSAM activities are anticipated to evolve slowly as newer activities are demonstrated. This final chapter is an analysis across all previous chapters and synthesizes what we see as the future trends related to OSAM norms of behavior. Many findings and assertions of trends are not necessarily unique to OSAM activities and involve discussions of space activities more broadly.

1. **The space community will continue to call for norms of behavior in space, including norms related to OSAM activities, as the variety of activities and the diversity of actors in space grows.**

In this study, an overarching finding from all stakeholders was that discussing norms of behavior for OSAM activities seemed premature. Given different perceptions of norms of behavior and varying definitions, stakeholders often struggled to think about the idea of OSAM and norms being related. Furthermore, while interviewees were comfortable discussing norms of behavior in space generally, they struggled to think about norms of behavior related to OSAM. The only OSAM activity that seemed to resonate when discussing norms of behavior was RPO.

There are increasing calls for establishing norms of behavior in space, and more countries and groups are talking about norms of behavior as a solution to a perceived growing competitive, contested, and unregulated space environment. States, commercial actors, and industry groups thinking about OSAM will seek to establish norms of behavior in space.

However, the term *norm of behavior* in space is not grounded nor is there a common understanding or common definition. If the definition is not clarified and well understood among stakeholders, the utility of norm building will be limited to the communities that are working together. For example, if the commercial sector builds a common understanding around written norms in the form of technical standards—such as through ISO, which is drafting the principles and practices for Rendezvous and Proximity Operations and On Orbit Servicing (RPO/OOS)—then the commercial sector may begin to drive the behavior of other commercial actors. Industry may move forward to adopt those standards, but this progress may be done in parallel to governments developing norm-building measures at a diplomatic level. These two discussions may make progress within their own spheres, but the norms developed may contradict or compete with each other, or actors may follow the norms created by their own community, but not others. Unless the commercial sector and the national governments work together to establish a common understanding of the term, the discussions will remain ambiguous and confusion will remain.

Furthermore, while the conversations may remain distinct as discussed in Chapter 4, stability will remain a core value amongst all actors—be it commercial or state actors. Stability will continue to drive each sectors' norm-building activities even if the conversations between different communities do not take place.

2. **Best practices and guidelines will be developed at the bilateral or multilateral level, but it is unlikely that there will be new legally binding treaties in the future.**

Most interviewees indicated that international law moves slowly compared to the rate of OSAM technology development. As such, governments and the commercial OSAM actors will continue to see non-binding approaches—such as guidelines, standards, and best practices—as the most viable avenue for building codified norms. That said, Russia, China, India and many developing/emerging spacefaring nations seem to prefer binding measures whereas countries like the United States, the United Kingdom, Japan, Canada, and other allies prefer non-binding agreements and best practices. Furthermore, due to their limited role in legal and diplomatic efforts, commercial companies will continue to develop guidelines and best practices, or non-binding codified norms. Commercial entities, however, can partner with governments—either their own or internationally—for norm-building efforts, such as the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS), which is industry-led but originally funded by the Defense Advanced Research Projects Agency (DARPA).

3. **Uncertainty on how liability will be assessed and addressed will persist.**

Liability and responsibility are particularly applicable to OSAM because of the risk of damaging another spacecraft. State actors are concerned about liability because it has financial ramifications and it could affect their standing in international forums, while commercial actors are concerned about liability because paying costs or insurance claims could affect their revenues and profits. Furthermore, with increasing activity in space by various space operators, there are more opportunities for potential disputes with respect to liability. In the case of active debris removal, should a state want to move or remove an object, confusion around what is "allowed" will continue and technical improvements may be rendered moot due to political and diplomatic barriers limiting the activity.

OSAM operators are skeptical that changes to Article VII of the Outer Space Treaty and the Liability Convention will happen in the next 5 years. They also understand that best practices and guidelines will not replace more modern legal norms needed to elucidate liability. Unless there is clarity as to how liability will be assessed and addressed, uncertainty will persist. This is of concern to all actors, but particularly commercial actors.

4. **The commercial sector will have a role in identifying best practices and providing input to guidelines, but will continue to operate within the regulatory framework of their states and within the interpretations of the OST.**

Commercial space actors will push the boundaries of technology and innovation. They will continue to demonstrate new OSAM capabilities and will hope that their approach will be adopted by other companies. In particular, when a commercial actor successfully demonstrates a new technology they may have an advantage and concurrently also have the opportunity to set the direction for standards and guidelines that could result in behavioral norms. Similarly, building experience over a long period of time among technically mature partners, such as with the ISS, also provides useful experience to influence best practices and guidelines.

As has been the case for the past 5–7 years, government-supported, industry-led coalitions for OSAM activities will identify best practices and guidelines through organizations such as the Space Safety Coalition, CONFERS, and PERASPERA. Countries with active commercial space sectors—in particular the United States, but also Japan, the United Kingdom, and New Zealand—work with commercial entities to provide guidance on existing and new regulations that may impact their business case. In countries with an active commercial OSAM industry, governments will likely continue to seek input from the commercial sector.

Finally, actors that are "first-movers" or actors that have flight history will have a greater influence on the norm-making process due to the perceived credibility of this experience. In particular, when the rules are ambiguous, the first-movers often have outsized influence on the norms. In the case of those actors with heritage, we have seen that NASA has clearly established docking standards for the ISS, which has influenced commercial actors that continue to dock to the station. The ISS example shows that rules adopted by entities for one maneuver or activity that results from collaboration and communication among many different actors may last long beyond that initial mission.

5. **Technological advances, many driven by the commercial sector, will motivate the adoption of technical standards and influence future design and operations of OSAM.**

Technical standards and best practices are a type of norm—namely a codified, non-binding norm—that will be increasingly important as new technological advances emerge. Based on our interviews, the commercial satellite operator community tends to believe that having a family of interfaces and open standards will accelerate the use of OSAM capabilities by providing a shared technical base for operators. Furthermore, interoperability is both a driving value for this stakeholder group and seen as necessary for a commercial OSAM ecosystem to be established.

That said, companies will promote the adoption of their preferred technical standards. However, interviewees shared that they believe competing interfaces will likely emerge. Commercial entities will vie for their preferred interface design or practice. Competition of interfaces will end when a critical mass of companies adopt an interface, at which point that interface will become the norm. The volatility of the commercial sector—mergers and acquisitions or companies failing—will affect this competition and add some uncertainty until that critical mass is reached.

While technical standards are a form of codified norm rather than behavioral, they will play a key role in influencing how actors will eventually behave in space. These standards will be facilitated by industry groups, or consortia between government, industry, and non-profits.

6. Concerns over dual-use technologies will drive norm-building efforts.

Across stakeholder groups, the space community will continue to call for more clearly delineated norms of behavior in space, particularly due to concerns over dual-use technology. In the case of the defense community, they are looking to maintain security over their missions, deter acts of conflict in space, and prepare to defend their space assets. Civil actors seek to operate their missions without disruption or damage as do commercial actors. Commercial actors provide services to industry and governments and need to operate in a reliable, safe, and sustainable environment. When the environment is threatened, for example through activities such as ASAT tests or unintended collisions, communities will continue to call for norms of behavior to be established so that all actors behave in a predictable manner. This is even more important in the case of RPO where activities can often be misinterpreted by adversaries as dangerous or nefarious; conversely, malicious actors can "disguise" their operations by claiming to be performing another activity. A lack of transparency regarding intent could lead to concern and confusion—and without notification and verification processes that governments agree to, OSAM activities can be viewed as threatening. For example, China views the recent satellite servicing missions by Northrop Grumman, MEV-1 and MEV-2, as threats. In contrast, U.S. allies in the West view the demonstration as groundbreaking and a sign that government and commercial reliance on OSAM capabilities to conduct their missions will continue and flourish in the coming years.

The UN Resolution, *Reducing space threats through norms, rules and principles of responsible behaviours,* introduced in August 2020 to the UN First Committee on Disarmament, is a renewed effort to develop norms for OSAM capabilities—first focusing on RPO. Spacefaring nations will continue to call for the development of norms of behavior in space and a commitment from other nations to adhere to these norms, but the process must be transparent and achieve sufficient buy-in from different countries. The UN processes will continue to be an international body that has hopes of building trust and transparency among spacefaring nations, but to make real progress in the area of international norms of behavior building in space, the process must learn lessons from the failed efforts from the UN Code of Conduct measures led by the EU. While the content of Code of Conduct was likely not a source of disagreement itself, the process was seen as being largely EU-led and some other nations felt excluded and resentful and thus rejected the Resolution.

Finally, technical advances in technologies for verification, such as SSA, may eventually provide real-time or better "eyes" of OSAM capabilities and drive progress in determining intent of an action. Should SSA become more ubiquitous and monitor specific actions on-orbit, particularly dual-use OSAM activities, space operators will be able to verify or demonstrate intent.

Appendix A.
Interview Protocol

What Is a Norm?

- How would you define a norm?
- What other words would you use to describe a "norm"?
- What contributes to the development of a "norm"?
- To what extent are norms created from a top-down approach (i.e., norms influencing actions)?
- To what extent are norms created from a bottom-up approach (i.e., actions establishing norms)?
- Is there anything specific you would want to add about a norm related to On-Orbit Servicing Assembly and Manufacturing (OSAM), not just general to space norms?

Use of Norms

- Which stakeholders are most involved in the development of norms?
- To what extent do different stakeholders buy into norms?
  - Do different stakeholders view norms in different ways?
  - Or are some stakeholders more inclined to follow norms than others?
- In what on orbit-activity scenarios do you think norms would be useful?
- In what on orbit-activity scenarios do you think norms would *not* be useful?
- What are the challenges, if any, in establishing norms?
- What are the mechanisms by which norms are established?

Norms versus Actions

- To what extent are codified (i.e., written down) norms followed?
- To what extent are there behavioral norms (i.e., norms that are not written down) for on-orbit activities?

Country-Specific Space Law

- What specific space laws or legislation that affects OSAM activities does your country have, if any?
- What makes up your OSAM legal framework (e.g., laws, agreements, international treaties, MOUs, bilateral agreements)?
- Which countries do you think are good examples of having established OSAM norms?
- How do you see any laws, regulations, or policies related to OSAM developing in your country?
- How are international laws or norms related to OSAM affecting your country's space laws or behaviors?

(Optional) Commercial

- How do you establish your norms of behavior? What sources do you use?
- How do you interface with your national government, if at all? With the international community, if at all?
- What challenges do you face that could be solved with clarified norms?

Analogous Norms

- What domains (other than space) are there in which norms have been developed?
- How were these norms established?
- What were challenges in establishing these norms?
- To what extent are these norms follow? In which cases are they not?
- How applicable are these norms to the space domain?

Future Trends

- What are the ongoing efforts that may influence or establish OSAM norms in the next 10–15 years?
  - What are the drivers of those efforts?
  - What are the mechanisms by which you foresee these norms being developed?
- What are any future OSAM challenges that could be addressed by norms?

Appendix B.
List of Interviewees

Agency/Entity Name	Name of Interviewee	Country Expertise	Date of Interview
AGI	Dan Oltrogge	USA	1/4/2021
Astroscale	Aya Iwamoto	Japan	2/2/2021
Astroscale	Charity Weeden	USA	1/6/2021
Astroscale Israel	Arie Halsband	Israel	2/2/2021
Astroscale UK	John Auburn	UK	2/11/2021
Beihang University	Fabio Tronchetti	China	12/8/2020
Brazil's Consul-General	Guilherme de Aguiar Patriota	Brazil	1/26/2021
Brookings Institution	Frank Rose	USA	1/25/2021
Canadian Space Agency	Eleanora (Elle) Agnew	Canada	2/4/2021
Catholic University of Santos, Brazil	Olavo Bittencourt	Brazil	1/25/2021
Center for Naval Analyses	Kevin Pollpeter	USA	12/2/2020
Cislunar Development Co	Dallas Bienhoff	USA	1/11/2021
Clear Space	Luc Piget	EU, Switzerland	1/13/2021
Consultant (former OneWeb)	Tim McClay	USA	12/31/2020
DLR Project Support and Standardization	Daniel Schiller	Germany	2/25/2021
DLR Robotics	Bernd Sommer	Germany	3/10/2021
DLR SSA	Uwe Wirt	Germany	3/4/2021
DLR, PERASPERA	Daniel Noelke	Germany	2/11/2021
DOC	Diane Howard	USA	12/4/2020
DOC	Diane Howard	USA	12/11/2020
DOD	Audrey Schaffer	USA	10/5/2020
Dua Associates (Law firm)	Ranjana Kaul	India	2/17/2021

Agency/Entity Name	Name of Interviewee	Country Expertise	Date of Interview
European Space Policy	Claudiu Mihai Tăiatu	Romanian	5/2/2021
Federal Ministry of Economic Affairs and Energy	Regina Peldszus	Germany	12/18/2020
Former Astronaut	Pam Melroy	USA	9/23/2020
Former ISRO	Chandrashekar Srinivasan	India	2/10/2021
French Government (Retired)	Philippe Clerc	France	1/8/2021
George Washington University	Martha Finnemore	USA	3/1/2021
Gitai	Taguchi Yuske	Japan	1/6/2021
Hokkaido University	Kazuto Suzuki	Japan	12/29/2020
iBoss, JKIC	Joerg Kreisel	Germany	1/5/2021
IDA	Peter Levine	USA	11/4/2020
IDSA	Ajey Lele	India	2/5/2021
Independent	Gordon Roesler	USA	1/4/2021
Independent	Namrata Goswami	India	1/5/2021
JAXA	Kikuchi Koichi	Japan	1/27/2021
JAXA	Masami Onoda	Japan	1/6/2021
Lift Me Off	Michel Poucet	UK, Luxembourg	1/7/2021
Lockheed Martin	Rob Chambers	USA	1/29/2021
Lunar Resources	Alex Ignatiev	USA	4/5/2021
Made in Space Europe	Jaroslaw Jaworski	Luxembourg	12/3/2020
McGill University	Ram Jakhu	Canada	4/5/2021
MDA Corporation	Dan King	USA	1/7/2021
MIT	Danielle Wood	USA	2/24/2021
Momentus	Rob Schwarz	USA	12/22/2020
NASA	Deborah Tomek	USA	1/5/2021
NASA	Sean Fuller	USA	1/22/2021
NASA OIIR	Mike Gold	USA	1/13/2021
National Institute of Advanced Studies	Rajaram Nagappa	India	2/12/2021
National Security Council	Troy Endicott	USA	9/18/2020

Agency/Entity Name	Name of Interviewee	Country Expertise	Date of Interview
New Zealand Space Agency	Isaac Hollis	New Zealand	3/3/2021
New Zealand Space Agency	Jonathan Mitchell	New Zealand	3/3/2021
New Zealand Space Agency	Marta Mager	New Zealand	3/3/2021
OneWeb	Maurizio Vanotti	UK, USA	1/14/2021
Orbit Fab	Daniel Faber	USA	12/23/2020
ORF	Rajeswari Rajagopalan	India	2/4/2021
Professor of International Space Law/Environmental Law	Anna Hurova	Ukraine	1/26/2021
Project Ploughshares	Jessica West	Canada	9/30/2020
RAND	Bruce McClintock	USA	10/1/2020
Romanian Space Agency	Claudiu Mihai Tăiatu	Romanian	2/19/2021
Secure World Foundation	Brian Weeden	USA	12/2/2020
Secure World Foundation	Daniel Porras	USA	12/22/2020
Secure World Foundation	Victoria Sampson	USA	2/2/2021
Secure World Foundation, Beijing Institute of Technology	Guoyu Wang	China	1/26/2021
Singapore Space and Technology Limited	Jonathan Hung	Singapore	2/1/2021
Singapore Space and Technology Limited	Lynette Tan	Singapore	2/1/2021
Space Logistics, LLC	Joe Anderson	USA	12/23/2020
State Dept.	Josh Wolny	USA	2/1/2021
State Dept.	Richard Buenneke	USA	10/9/2020
State Dept. (Retired)	Don Planty	USA	10/26/2020
The Heritage Foundation	Dean Cheng	USA	1/8/2021
Western Sydney University	Steven Freeland	Australia	

Agency/Entity Name	Name of Interviewee	Country Expertise	Date of Interview
Wilton Park	David Edmondson	UK	3/9/2021

Appendix C.
Summary of Select Responses to UNGA Resolution 75/36

Background to the Resolution

On December 7, 2020, the United Kingdom sponsored United Nations General Assembly (UNGA) Resolution 75/36, *Reducing space threats through norms, rules and principles of responsible behaviours*, to foster discussion of space threats and norms with the international community. The UNGA passed Resolution 75/36 with the United States and other European spacefaring nations among the 164 votes in favor, Russia and China among the 12 against, and 17 Member States that either abstained or did not vote. Among other things, the Resolution adopted by the general assembly:

> Encourages Member States to study existing and potential threats and security risks to space systems… and share their ideas on the further development and implementation of norms, rules and principles of responsible behaviours and on the reduction of the risks of misunderstanding and miscalculations with respect to outer space.

The legislation also requests the Secretary-General submit a report on Member States' responses to the Resolution. In the early summer of 2021, Member States submitted their comments to the Secretary-General. On July 2021, the Secretary-General distributed his report: *Reducing space threats through norms, rules and principles of responsible behaviours*. The Secretary-General's report, which included comments from 25 Member States' comments and the European Union (EU), provides another opportunity to learn about nations' perceived space threats and what role norms have in ameliorating these threats.

The comments submitted to the Secretary-General identify threats with a direct connection to OSAM. The United Kingdom cited the Secure World Foundation Counter-space Report claiming China, Russia, and the United States have all done research on co-orbital ASATs. The EU mentioned on-orbit servicing and debris removal could be misunderstood to be hostile actions if a state is unaware of the intention of the maneuver. China mentioned they perceived a threat from the Northrup Grumman Mission Extension Vehicle (MEV), which they claim could be diverted to military use. The United States dedicated a section to the dual-use challenge, which discusses several OSAM activities like on-orbit servicing and active debris removal.

Norms-Based Solutions Offered in Member State Responses

Many Member States discussed the challenges posed by OSAM activities but they were not consistent on how to address these problems. Implicit within the responses were two themes: either voluntary action must precede a legally binding action or voluntary actions are insufficient and the international community should not waste their time.

Voluntary Action Must Come Before Legal Action

Some states characterized Resolution 75/36 as a new way forward. In the past decade, the UN First Committee on Disarmament has failed to pass a comprehensive treaty on the weaponization of space despite the best efforts of Russia and China to put forward the draft treaty Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Space Objects (PPWT). Considering this impasse, delegations led by the United Kingdom proposed an alternative approach: norms.

The United Kingdom's approach is based on the view that without understanding normal, non-threatening behavior, states may misinterpret or miscalculate—which could lead to conflict. They note that space is a more complex domain than when the Outer Space Treaty was written, and countries have concerns about new capabilities that are not adequately addressed in international law. The United Kingdom viewed the proposed Russian and Chinese treaty to prevent the weaponization of space as "fatally flawed." Instead, the United Kingdom has listed a series of security threats and suggested ways they could be voluntarily resolved. The list includes a description of "unacceptable" activities, and things states "should" and "should not" do.

In the EU's response to the Resolution, EU and its Member States posited that voluntary measures such as norms, rules, and principles of responsible behaviors are the most pragmatic way forward. Among the recommendations, the EU asked nations to not conduct RPO without the consent of all parties involved. The EU and its Member States also endorsed sharing space doctrines, policies, and strategies among states. They also recognized the utility of pre-launch notifications and cooperation on SSA services internationally.

Canada suggested that non-binding measures of responsible behavior are the first step towards binding measures in international law, emphasizing the idea that states can act responsibly and lawfully. Canada outlined specific actions that can be taken to promote responsible behavior and increase predictability and transparency, and they suggested countries commit to exchange information in a timely manner and communicate the intent of their activities with other states. Canada viewed responsible behavior as a commitment to not intentionally test or use ASAT capabilities. Commitments to responsible behavior may take the form of a ban on ASATs that cause debris in the Conference of Disarmament. Canada stated that there is progress to be made in Transparency and Confidence-Building

Measure (TCBMs) such as international communication protocols. These protocols could take the form of advanced launch notifications or making domestic space policy available to the international community. Canada noted that the dual-use nature of space requires nations to be better about communicating intent. A commitment to Space Domain Awareness (SDA) and space surveillance and tracking would help nations better understand the status of space activities.

The Republic of Korea delegation commented their view that previous international legal regimes failed because they force states to regulate weapons or capabilities themselves. The Republic of Korea endorsed an approach based on "mitigating the possibility of misperceptions of threats that may provoke unnecessary tensions between States." The South Korean response included a reference to "legally-binding norms," which they said are the ultimate goal but not achievable at this time. Instead, the delegation recommended increased communication between nations on national space policy, military space expenditures, and notifying other countries of orbital parameter and planned launches, among other communication-based recommendations.

Voluntary Agreements Are Not Enough, and Maybe a Waste of Time

Implicit among some of the responses—particularly from Russia, India, China, and Iran—is the idea that norms and rules of behavior are not worth the UN's time.

Russia stated interest in building transparency and confidence building measures for outer space and codifying these measures through legally binding instruments. The delegation noted that an international treaty would prevent the placement of any weapon in outer space and codify safe operational behavior. Russia specifically called for a "complete and comprehensive ban on space-based strike weapons as well as on any land-, air-, or sea-based systems designed to destroy objects in outer space." Russia noted that they have consistently tried to promote negotiations on an international legally binding instrument to prevent an arms race in space, citing the 2008 Treaty on the Prevention of the Placement of Weapons in Outer Space introduced by Russia and China. Russia called on the UN to advance multilateral agreements that promote appropriate verifiable and binding agreements.

The Chinese delegation stated that a legally binding instrument is imperative to prevent an arms race in space, and the international community should conclude the instrument at an early date. Within this statement, the Chinese delegation specifically recommended another Group of Governmental Experts (GGE) or open-ended working group on Prevention of an Arms Race in Outer Space (PAROS). These efforts, like TCBM's, are a starting point, but the Chinese delegation indicated they did not believe they go far enough. In addition to supporting a space arms control treaty, China called for the "suspension of rendezvous proximity operations and space-based tests of technologies that endangers other countries' spacecrafts" to enhance mutual trust.

India, which abstained on Resolution 75/36, called on all nations to ensure space is used for cooperation and not conflict. India noted that it is the responsibility of nations to ensure that their government organizations and citizens are adhering to practices contributing to transparency and sustainability. Specifically, India called on states to improve the accuracy of orbital data and increase the sharing of information on objects. India also has stated a desire to work towards legally binding measures in PAROS. They commented that TCBMs and guidelines can be constructive, promoting transparent practices, but they cannot replace legally binding instruments.

The Iranian Government disagreed with the Resolution's fundamental assumptions. Iran did not support the coining of new "vague" legal terminology. In particular, Iran described the term "responsible behavior" as "fundamentally flawed," expressing concern that it is an appealing term but falls short when it comes to operationalizing the principles and likely covers nations real political ambitions. Iran felt responsible behavior inadequately addressed the prevention of a space arms race and called for a legally binding treaty on preventing an arms race instead. In the opinion of the Iranian delegation, codifying certain behaviors would work to the benefit of space powers that have already developed advanced space technologies and hinder the technology development of countries with less space heritage. Iran urged the international community to refrain from setting high standards that would negatively affect developing countries hoping to use space for peaceful and exploratory purposes.

Impact on the Future of Norms

It is unclear whether the 164 UN Member States that voted in support of Resolution 75/36 were in support of using norms as a mechanism to address space security or if nations were more interested in a discussion of threats in the space environment.[17] Those who endorsed voluntary actions before legal measures often identified practices that can make activities in space more transparent and reduce misperceived threats. Many but not all of these actors grouped these functions under the category of "norms." The United Kingdom and Canada provided a list of voluntary rules most similar to codified norms. The Republic of Korea recommended a series of behaviors that others described as norms and indicated they could lead to "legally-binding norms." Each Member State interpreted "norms, rules and principles of responsible behavior" a little differently. The difference in recommendations might lead to misinterpretation but might also allude to a preference among actors supporting the Resolution for different solutions. This preference for different solutions will likely lead to different desires for a future space treaty.

The United Kingdom's norms-based approach still faces several obstacles. The most significant obstacle is states—Russia, China, India, among others—that play a significant

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[17] Depending on an individual's norm paradigm, these may be indistinguishable things.

role in the future of space voted against the Resolution or abstained. Their responses indicate a lack of trust that voluntary guidance will be effective in constraining antagonistic behavior. At the same time, some of their responses do indicate a common desire for certain actions. China and India did endorse short-term actions similar to nations supporting the Resolution, such as more information sharing and trust building exercises. In these areas the Resolution appears to have identified a near-term list of activities nations can to together to reduce threats. Those who follow a behavioral norm paradigm might call these activities norm building; however, as shown in responses, there are many others who might not use the word norm to describe these activities.

Appendix D.
Country Case Studies

The country case studies below were completed before January 2022. Developments may have occurred since the time of completion.

Argentina

National Space Landscape

- Argentina has an emerging space sector and has developed launch systems and satellite manufacturing for both GEO and LEO (ESPI 2021).
- Argentina has a small but developing commercial space sector. Private industry in this area is primarily focused on satellite manufacturing (ESPI 2021).

OSAM Activities

- STPI did not encounter evidence of OSAM capabilities or of concerted efforts to develop OSAM capabilities in Argentina.

Guiding Frameworks

Legal and Policy Frameworks

- Argentina's national space strategies are outlined in the Plan Espacial Nacional (PEN). PEN is adopted and conducted for 10-year periods, and the most recent version spans 2016 to 2027 (EPSI 2021).
- The main areas of interest within the most recent PEN do not address OSAM. Rather, use of spatial information, construction of satellites, and investment in human capital and technology are the main focuses (ESPI 2021).
- Argentina has space laws addressing telecommunication activities (ESPI 2021).
- There are no laws addressing OSAM at this time, nor evidence of efforts to develop any.

Notable International Collaborations

- Argentina and Mexico are leading the creation of the Latin American and Caribbean Space Agency (ALCE). This regional space agency is designed to combine the resources—financial, human capital, and technological—of its member countries (Valero 2021).
  - Bolivia, Ecuador, El Salvador, and Paraguay will be members, and Colombia and Peru will be observers (Valero 2021).
  - ALCE intends to have its first satellite in orbit by 2022 (Valero 2021).
  - ALCE will likely have power in establishing norms—particularly behavioral and codified—among their member countries.
- China has operated a deep space center in Argentina. Argentine President Cristina Kirchner and Chinese President XI Jinping signed an agreement to develop this center in 2014. This agreement also provided the Chinese government extensive tax exemptions, discretion over their operations, and relatively unrestricted movement of Chinese personnel operating the center (Watson-Lynn 2020; Garrison 2019).
- The Indian Space Research Organization (ISRO) and Argentina's National Commission for Space Activities (CONAE) have worked to develop a partnership in space. In 2018, the countries developed a bilateral agreement, the Framework Agreement on Cooperation in the Pacific use of Outer Space.
- The Agreement between these two countries addresses coordination in remote sensing, satellite communications, ground infrastructure for space systems, and training in space sciences and technology (Siddiqui 2020).
- Argentina's state-run technology company INVAP and Turkey's partially state-owned Turkish Aerospace Industries have formed a joint venture, Gsatcom Space Technologies, to build and sell small GEO satellites (Henry 2019).
- None of Argentina's partnerships in space has direct ties to OSAM activities at this time, but there is interest in further developing the country's space capabilities.
- International partnerships with China, India, and Turkey may influence Argentina's approach to norms brought to broader forums.

Australia

National Space Landscape

- The Australian Space Agency was established in 2018. In 2019, the Australian Space Agency worked with a $41.2 million budget to promote industry growth supplemented by 19.5 million over 3 years through the Space Infrastructure Fund (Corbin et al. 2020).
- In 2021–2022, another 13.3 million was added to the agency's budget (Lambeth 2021). We are not aware of OSAM specific funding at this point in time.
- Corbin et al. (2020) commented that there was little venture capital available to OSAM entities in Australia forcing some entities, such as LEO Labs, to rely on advance purchases (Corbin et al. 2020).

OSAM Activities

- Active Debris Removal:
  - Australia does have nascent satellite servicing and ADR activity in their private sector.
  - Australian Company Exodus Space Systems is developing a kinetic ADR solution using low-density solids to kinetically remove orbital debris.
  - After being contacted by the low-density solutions, targets in 600km–1200km orbits could be deorbited in an estimated 3 months (Exodus Space 2020).
  - The Exodus method does not rely on RPO technologies and limited space robotics technologies compared to other ADR methods. The Exodus method also does not preclude a multi-target mission, where the spacecraft goes to an orbital cluster to release its low-density particles (which are really "simple fluid consumables") deorbiting multiple targets (Exodus Space 2020).
  - There is no indication of when KiSSD will become operational. The organization does estimate that a space debris cleanup market will be present starting in the mid-2020s (Exodus Space 2020).
  - The company cited an estimate that the space debris industry would be worth $6 billion USD by 2029 supporting the needs of spacecraft operators, entities with liabilities caused by space debris, insurance providers, and national space programs.

  - The low-density solids are intended to slow the debris, deorbiting the object without fragmenting it. Deploying fragments from satellite flying-by is designed to be a cost effective and scalable method for active debris removal.
  - The group has submitted grant applications within the Australian Space Agency's Moon to Mars Demonstrator Feasibility Program. However, STPI has yet to identify any public comments on a demonstration for Exodus's Space Sweeper.
  - Australia-based startup Space Machines has an OSAM servicer called the Optimus Satellite, designed for refueling, lifetime extensions, deorbiting, repairing, and in-space assembly (Space Machines n.d.).
  - Space Machines hopes to launch Optimus-1, an orbital transfer vehicle, in Q2 of 2022. Planning for "limited commercial flight to low Earth orbit (LEO)" in Q1 of 2023, regular flights starting in 2024 (Space Machines 2021).
  - The company hopes to provide commercial satellite relocation and life-extension services (Space Machines n.d.).
- Remote Survey
  - HEO robotics is a first-mover in satellite-inspection services, the first company to provide commercial inspection services. The group provides less than 0.5 m resolution imagery in LEO.
  - As noted by Corbin et al. (2020), HEO Robotics is partnering with partners in Australia's military to provide data on objects in LEO (Corbin et al. 2020).
  - HEO robotics is taking advantage of global legal norms surrounding non-Earth imaging. When compared to the United States, HEO robotics can cut costs because Australia has less stringent non-Earth imaging policies (Corbin et al. 2020).
  - Other Australian companies have expressed interest in remote survey. Inovor’s Hyperion Mission plans to use 12U nanosatellites in low Earth orbit to observe objects in MEO and GEO (Inovor 2021). It is unclear when the Hyperion Mission will be operational.
- Manufacturing
  - Terrestrial Additive manufacturing companies have expressed interest in on-orbit manufacturing but STPI has yet to identify implementation (Corbin et. al. 2020).

Guiding Frameworks

Legal and Policy Frameworks

- Australia has adopted five major international space agreements: The Liability Convention; Registration Convention; The Outer Space Treaty; The Moon Agreement; and the Rescue Agreement (Australian Government 2018).
- In 2018, the Australian government passed the Space (Launches and Return) Act, which amends legislation for launching domestic space objects and an Australian entity returning an object to Australia or overseas.
- The Act defines return as "a space object means return the space object from an area beyond the distance of 100 km above mean sea level to Earth, or attempt to do so."
- The Act provides means of authorized returns. There are still some sources of ambiguity with OSAM implications. For example, it is unclear how a potential ADR company would be treated under this policy. Most debris burns up in the atmosphere and may not fully "return."
- To apply for a launch permit the applicant must include a strategy for debris mitigation; this may strengthen the case of ADR companies and encourage practices limiting debris (Australian Government 2018). Violations of the Launch or return policy may result in civil penalties (Australian Government 2018-2).

Notable International Collaborations

- Australia was part of UN COPUOS' first cohort of members and is a participant in discussions.
- Australia is a member of APRSAF, a regional space technology forum for the Asia-Pacific region.
- Australia has limited influence in CONFERS. HEO Robotics is part of CONFERS but only an observer member (CONFERS 2020).

Additional Topics of Importance

- Australia's Space Strategy to 2028:
  - The Australian Civil Space Strategy describes Australia's national space goals for 2028. The strategy includes several mentions of OSAM technologies. Australia points to "the need to track the orbits of debris and object," likely implying support for commercial remote survey industries currently led by HEO Robotics. However, the strategy also calls for:

"infrastructure driving commercial SSA – including asteroid tracking, and conjunction mitigation-as-a-service" and "On-board satellite anti-collision sensors and autonomous mitigation programs." Technologies that do not necessitate remote survey but could be benefited by remote survey. The Space Strategy also calls out the need for "measures to mitigate and clean-up debris" which could include ADR or preventative measures (CISRO 2018).

  - Beyond 2028, CISRO, the strategy advisory arm of Australia's national science agency, indicated plans to print 3-D solar panels in space to support ISRU. This would be done in a lunar context but CISRO commented that the resources would come from recycled satellites and space debris, which would require diverse OSAM capabilities. This is future looking and we do not know of Australian research on recycling satellites or space debris at this point in time (CISRO 2018).
  - Furthermore, to reduce the need for ADR, CSIRO noted a desire to integrate passive onboard deorbiting capabilities into their satellites (CISRO 2018).
  - The 2028 strategy describes on-orbit servicing mentioned as an R&D leapfrog area (Australian Government 2019).
  - The strategy aims to expand SSA capabilities beyond the next decade, specifically aiming for "In-space situational awareness using a range of small-to-large satellites." In the same timeframe, the Australian strategy calls for "Active debris removal and decommissioning of end-of-life satellites, potentially through robotic attachments, tethers, in-orbit recycling" (CISRO 2018).

Brazil

National Space Landscape

- Brazil has become a regional leader in space activities (UNIDR 2015).
- Brazil has developed launch capabilities and a relatively mature satellite-manufacturing sector.
- However, their space program has suffered many setbacks over the past two decades, including launch failures, international partnerships that failed to come to fruition, and competition with the European space port in French Guiana (Hill 2021).
- The Brazilian commercial space sector has grown in recent years and will likely continue to do so (ITA 2021).

OSAM Activities

- STPI did not encounter evidence of OSAM related activities in Brazil nor of concerted efforts to develop OSAM capabilities.

Guiding Frameworks

Legal and Policy Frameworks

- Brazil does not have any laws specific to OSAM.
- Brazil has a regulatory framework that supervises satellite operation and commercial launch activities (Advogados 2020).

Notable International Collaborations

- China and Brazil have developed a strong partnership in space.
  - In particular, the two countries have developed a 10-year plan to collaborate in communications, meteorological, and remote sensing satellites (Xinhua 2019).
  - This partnership began in 1988 and has continued to grow (Xinhua 2019).
- The United States and Brazil have collaborated in the space sector.
  - In June 2021, Brazil signed the Artemis Accords, becoming the first country in Latin America to do so (Foust 2021b).
  - In 2019, the U.S. and Brazil established a Technology Safeguards Agreement (TSA) to protect U.S. licensed technology to support space launch services from the Alcantara Space Center in Brazil. This agreement also allows Brazil to "enter the global market for commercial space launches."
  - Brazil was the first nation to "conduct high-level Space Engagement Talks" with the U.S. Space Force and other relevant agencies (U.S. Embassy in Brazil 2021).

Canada

National Space Landscape

- Canada possesses a strong space sector, particularly in satellite manufacturing and space robotics.

- However, Canada spends less on its space program than other G8 countries in terms of actual dollars—the second lowest per capita (Caiazzo et al. 2016).
- The Canadian Space Agency's (CSA) funding is trending downwards, having received $285 million in FY2021, compared to $388 million in FY2017 (Corbin et al. 2020).
- According to a 2015 Euroconsult report, the Canadian space industry consists of about 150 companies. These companies work in research and engineering services, space systems manufacturing, ground system manufacturing, satellite operations, terminal suppliers, and broadcasting services (Keith 2015).
- By far the largest sectors are research and engineering services and broadcasting services. Broadcasting services drive majority revenue amongst all categories (Keith 2015).

- In March 2019, the CSA released a National Space Strategy that outlined their priorities and challenge areas. Among the priorities identified are joining the Lunar Gateway program, increased utilization of Earth observation data, collaboration on international science missions, and encouraging development within the Canadian space sector (CSA 2019b).
  - The strategy asserts that the private space sector in Canada contributes $2.3 billion to the country's GDP (CSA 2019b).

OSAM Activities

- Canada has an extensive history developing space robotics for in-space assembly and has been a leader in this area for decades.
  - Notably, Canada produced robotic systems used on NASA's Space Shuttles and on the ISS. While these systems were procured by CSA, a private corporation—then Spar Aerospace, since renamed MDA Ltd. — created these systems.
  - Canadarm—retroactively named Canadarm 1—was produced for the Space Shuttle Program. Canadarm 1 used technologies developed in the nuclear power sector. Ultimately, five total "arms" were built for the Space Shuttles (Corbin et al. 2020). These systems were used to manipulate the contents of the Space Shuttle's payload bay (CSA 2018).
  - Canadarm 2 was developed for the ISS and installed in 2001. This robotic arm was an integral tool in the assembly of the ISS (CSA 2019a).

  - Dextre was installed on the ISS in 2008. Dextre is used to maintain the ISS, replacing the need for crew to perform many installation, replacements, and tests for small equipment, tools, and components (CSA 2018c).
- Canada's competency at in-space robotic systems will likely be leveraged for continued growth in OSAM areas, both by Canada's civil and commercial sectors.
  - According to the 2019 Canadian Space Strategy, Canada's will participate in NASA's Lunar Gateway by contributing "AI-enabled deep-space robotic system[s]," which will also "position Canadian firms as global leaders in the future on-orbit servicing market."

Guiding Frameworks

Legal and Policy Frameworks

- Canada currently has a space legal regime that regulates and provides licenses for remote sensing and launch (Jakhu & Koroma 2010).
- Canada does not have any OSAM-specific legislation.
- Interviewees noted, however, that they could not comment on any efforts to address OSAM.
- In the interim, interviewees noted that contracts could help to establish norms and accountability for OSAM activities.

Notable International Collaborations

- Canada has announced that their partnership with NASA through the ISS will continue in the Artemis Program.
  - Canada has pledged to contribute another robotic arm—the Canadarm 3—to perform repairs and maintenance for NASA's Lunar Gateway (Howell 2019).
  - Canada has also pledged to spend $1.56 billion on Artemis over the next 24 years for the development and operations of Canadarm3 and a Lunar Exploration Acceleration Program to encourage small- and medium-size Canadian businesses to develop technologies in health, artificial intelligence, and health (Howell 2019).
- In October 2020, CSA joined the Artemis Accords by signing a bilateral agreement with NASA. The Artemis Accords outline principles to guide

international cooperation in space exploration beyond Earth's orbit (Project Ploughshares 2018).

  - The Artemis Accords address several issues regarding space exploration, including the extraction of resources, interoperability, deconfliction, and the Moon as a heritage site (Project Ploughshares 2018).

Additional Topics of Importance

- More broadly, our interviewees indicate that Canada is engaged within the international community on space norms through the United Nations.

China

National Space Landscape

- The Chinese National Space Administration (CNSA) is responsible for managing China's Civil Space program and facilitating international partnerships (CNSA n.d.). The CNSA is a subordinate agency of State Administration for Science, Technology and Industry for National Defense (SASTIND), which sits in the Ministry of Industry and Information Technology (MIIT). To achieve its goals, the CNSA includes subordinate entities such as the Chinese Lunar Exploration Program (CLEP) to draft technical plans and manage China's lunar ambitions.
- Important for this study is the CNSA's National Space Administration Law Center. Supported through the China Aerospace Science and Technology Corporation (CASC) and Beijing Institute of Technology, the Law Center researches space policy and consults with CNSA leadership on draft laws and regulations. The organization also carries out research on international law and participates in international space law forums (CNSA n.d.).
- The CNSA also supports the Space Law Foundation, which in 2011 proposed updates to China's space law. The Foundation also conducts domestic legislative research and comparative national space law research (CMSE 2011).
- The Chinese Academies of Science (CAS), which consists of many institutions across scientific disciplines, manages the National Space Science Center (NSSC). The NSSC plans, develops, launches, and operates Chinese satellite missions (NSSC 2015).
- CASC is the main contractor for China's space program. CASC has eight subsidiary R&D complexes and a number of affiliated companies and units (CASC 2018). Major subsidiaries include the Chinese Academy of Launch

Vehicle Technology (CALT) and the Chinese Academy for Space Technology (CAST).

OSAM Activities

- China's experience with OSAM begins with its space station ambitions. China's space station is implemented in two stages, space laboratory and space station. The RPO and docking capabilities demonstrated through the Tiangong and Shenzhou demonstrated these capabilities (XUE et al. 2020, 12). China performed its first OSAM-related activity in 2011, conducting rendezvous of two of its own uncrewed vehicles, the experimental laboratory Tiangong-1 and Shenzhou-8 (CMSE 2021a).
- In follow-on missions for the crewed space station, China conducted on-orbit refueling in 2016 between the Tianzhou and Tiangong-2 vehicles, followed by a second refueling demonstration in 2017. The first stage, space laboratory, demonstrated both uncrewed and crewed RPO capabilities including technologies such as the Chinese Space Station Remote Control Manipulator System (CSSRMS) (XUE et al. 2020, 12).
- In April 2021, China launched the Core Module, Tianhe, marking the beginning of their space station construction. This year China plans to launch two Tianzhou cargo spacecrafts and two Shenzhou crewed spacecrafts. This will be followed up by launching the Wentian and Mengtian experimental cabins, two Tianzhou cargo spacecraft, and two Shenzhou manned spacecraft, completing the space station by 2022 (CMSE 2021b).
- The Space Station Mission is run by CAST, CALT, the China Astronaut Research and Training Center, and the CAS Space Application Engineering and Technology Center (CMSE 2021c). CAST is responsible for the research and development of the various compartments of the space station. CALT developed the launch vehicles for the mission. The China Astronaut Research and Training Center and the CAS Space Application Engineering and Technology Center are simulating crewed verification and key technology testing.
- Four researchers from the Shenyang Institute of Automation simulated and experimented with docking structures for an on orbit refueling system. (Liu et al. 2020)
- Researchers publishing with the China Aerospace Science and Technology Corporation ran simulations and analysis on inflatable entry decelerator technology, which would deorbit end of life targets in low Earth orbit (Wang et al. 2021). China does claim to have an active debris removal satellite, Ao’long-1 (Chen 2016). There was media speculation that Ao’long-1 could be used as a

space-based weapon. In the 2 months Ao'long was in orbit, the satellite did not rendezvous with any other objects (Weeden and Samson 2021).

- On Orbit Assembly
  - The Changchun Institute of Optics, Fine Mechanics and Physics, alongside the University of Surrey (UK), are working to develop a space telescope and by so doing are studying assembly technology (Xue et al. 2020, 12).
  - Researchers at Chinese Academy of Military Sciences, Chinese Academy of Sciences, China Academy of Space Technology, China Electronics Technology Group, Harbin Institute of Technology, Xidian University, Sichuan University and Chongqing University have discussed concepts for a space based solar power station (Chinese Society of Astronautics 2021). Site selection and planning was completed in 2019 and Construction for the project began in 2020. For the short term, the group aims to realize a stratospheric solar power station and grid-connected power generation around 2025 (Chongqing University n.d.). Early discussions of the space solar power project include automated assembly processes. University Researchers and researchers from state-owned enterprises have proposed and conducted research on several robots for on-orbit assembly (Cheng et. al. 2016; and Xue et al. 2020, 12)
- Manufacturing
  - For on-orbit manufacturing in May 2020, CASC reported the success of China's and the world's first 3-D printed object in space. The state-owned enterprise printed the company logo and a CubeSat deplorer in a honeycomb structure (Huanqiu 2020).
  - In 2019, the Qian Xuesen lab of CAST signed a cooperation plan for in-space 3D metal material printing (Qian Xuesen Lab 2019).

Guiding Frameworks

Legal and Policy Frameworks

- Planning documents published by the State Council identifies many of China's space ambitions through the *Five Year Plans for Scientific and Technological Innovation* in the 13th Five Year Plan period and Whitepaper on China's Activities in Space. The current whitepaper includes one mention of OSAM: "…plans to build in-orbit servicing and maintenance systems for spacecraft" (SCIO 2016a). Outside of this, there is no direct mention of OSAM activity in

Chinese policy. There are, however, several measures that impact Chinese OSAM activity.

- Registration Management Measures for Space Objects: The *Measures for the Administration of Registration of Objects Launched into Outer Space*[18] (hereafter referred to as the registration measures) is how China implements the registration convention. China's measures require all human-made objects made by China or in cooperation with China to be registered, and this applies to all government departments and organizations launching objects. The Commission for Science, Technology and Industry for National Defense (COSTIND) is charged with registering domestic space objects, with daily affairs managed by the International Cooperation Department of COSTIND. The Launch Measures require the state to register characteristics of the launched materials (Article 6). Article 9 of the Registration Measures has language that likely would impact OSAM activity. Registrants of the space objects are required to register any "major changes, such as orbital changes…". Presumably, through Article 6 and 9, China's Registration Measures require OSAM capable assets to disclose these capabilities to COSTIND within their registration and to disclose to COSTIND any major activity completed in orbit (SCIO 2011).
- Interim Measures for the Administration of Licenses for Civil Space Launch Projects: The *Interim Measures for the Administration of Licenses for Civil Space Launch Projects* has little direct impact on OSAM activity but the Civil Launch Measures do give COSTIND some authorities to prevent the launch of certain assets. Article 5 of the Launch Measures potentially contains some authority over orbit activity. COSTIND confirms the project "does not endanger national security, does not harm national interests, does not violate the country's foreign policy and international conventions that have been signed and become effective" and "[the civil entity] possess the technical strength, economic strength and perfect technical data to engage in the applied project" (COSTIND 2002).[19]
- Interim Measures for the Administration of Civil Satellite Projects: The *Interim Measures for the Administration of Civil Satellite Projects*[20] (hereafter referred to as the Civil Satellite Measures) lays out procedures for civil satellite

[18] Translation of "空间物体登记管理办法" Full text here: http://www.scio.gov.cn/xwfbh/xwbfbh/wqfbh/2011/1227/xgzc/Document/1072494/1072494.htm

[19] Translation of 民用航天发射项目许可证管理暂行办法 for the full text see: http://www.gov.cn/gongbao/content/2003/content_62252.htm

[20] Translation of 民用卫星工程管理暂行办法 for the full text see: http://www.scio.gov.cn/xwfbh/xwbfbh/wqfbh/35861/36552/xgzc36558/Document/1549898/1549898.htm

operation. The Civil Satellite Measures require projects to notify SASTIND within 12 hours of an emergency. Article 38 of the Civil Satellite measures encourages satellites to coordinate monitoring with ground stations to prevent orbital collisions (SCIO 2016b).

- Interim Instrument of Space Debris Mitigation and Management: China's Interim Instrument of Space Debris Mitigation and Management published by SASTIND sets several standards for OSAM activity, including the requirement that operators control debris release and plan for post-mission disposal. Article 9 of the Instrument further requires licensees to constantly monitor the risk of collision (Tronchetti 2019).
- Future Policy: Several reports indicate a Chinese National Space Law could be in development (Tronchetti 2019; Wu 2015, 25). Meetings to draft and discuss the National Space Law have been delayed due to the COVID-19 pandemic. The National Space Law may departmental rulings on licenses, registration, and notification; however, this is subject to change through the drafting process. This report does not expect regulations that directly discuss OSAM activity. The National Space Law will likely have an indirect impact on OSAM activity similar to previous interim measures of the Chinese Government. The National Space Law is being drafted among large drafting groups, including government officials, industry leaders, and academics.

Additional Topics of Importance

- China signed a memorandum with Luxembourg in 2018 on space mining, granting companies the rights to the materials they mine in space (USCC 2019).

European Space Agency

Regional Space Landscape

- Among the countries in Europe, there are four major, interconnected categories of stakeholders in terms of space norms and space activities. For the regional case studies, each is discussed separately.
  - First, there is the international organization of the European Space Agency, with its 22 member states. ESA is the main provider of joint-European space activities.
  - Second, there is the European Union, an economic and political organization with 27 member states. The scientific activities of the EU are coordinated and funded by the executive branch of the EU, the European Commission.

  - Third, there are space-specific collaborative organizations and working groups, such as Europspace, ESRE, etc.
  - Fourth and finally, there are the actions and policies of organizations within individual countries, including national space agencies and private companies.

OSAM Activities

- Space sustainability is a priority area for ESA, and the agency is developing policies and missions focused on debris remediation. One notable example is the Active Debris Removal/In-Orbit Servicing (ADRIOS) mission.
  - In 2019, ESA's Ministerial Council decided to place a service contract with a competitively selected commercial entity to remove an inactive ESA asset (ESA 2019). The company chosen was ClearSpace, a Swiss company developed as a spin-off from orbital debris research at Ecole Polytechnique Federale de Lausanne (EPFL) research institute.
  - In December 2020, ClearSpace announced that they had signed a service contract with ESA for 86.2 million euros for the ClearSpace-1 mission, which is expected to launch in 2025. The total mission cost is expected to be 100 million euros, the remainder of funding will come from sponsor is contributors (ClearSpace 2020).

Guiding Frameworks

Legal and Policy Frameworks

- The European Space Agency was established in 1975, and today includes 22 member states.

Notable International Collaborations

- ESA itself is an international norm building mechanism because it takes in the input from all its member states.

Additional Topics of Importance

- ESA is an active participant in UNCOPUOS.

European Union

Regional Space Landscape

- Among the countries in Europe, there are four major, interconnected categories of stakeholders in terms of space norms and space activities. For the regional case studies, each is discussed separately.
  - First, there is the international organization of the European Space Agency, with its 22 member states. ESA is the main provider of joint-European space activities.
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  - Third, there are space-specific collaborative organizations and working groups, such as Europspace, ESRE, etc.
  - Fourth and finally, there are the actions and policies of organizations within individual countries, including national space agencies and private companies.

OSAM Activities

- PERASPERA
  - The Plan European Roadmap and Activities for Space Exploitation of Robotics and Autonomy (PERASPERA) was originally a Horizon 2020-funded project. It will continue to be funded again by Horizon Europe.
  - The next stage of this project is the PERASPERA In-Orbit Demonstration (PERIOD) project, which will focus on developing technology for on-orbit assembly and manufacturing. Airbus will be leading a consortium to develop robotic OSAM technologies (Airbus 2021).
- SIROM (Standard Interface for Robotic Manipulation of Payloads in Future Space Missions) is a project that is funded by the EU.
  - Interface standardization project, that also forms the building block of on-orbit servicing activities
  - The project was under the Horizon 2020 PERASPERA umbrella
  - Takeaway: policy projects creating technological standards can set the norms that allow for OSAM activities
- MOSAR: Modular Spacecraft Assembly and Reconfiguration

Guiding Frameworks

Legal and Policy Frameworks

- The European Union is an economic and political organization with 27 member states. The scientific activities of the EU are coordinated and funded by the executive branch of the EU, the European Commission.
- European Commission
  - The Commission is the executive arm of the EU, implementing legislation and providing funding.
  - One of the major funding initiatives over the past 7 years has been the Horizon 2020 project, which is now in the process of being succeeded by Horizon Europe.
  - Funded individual projects, at an average of 3 million euros.
- EU Agency for the Space Programme
  - In April 2021, the EU approved an update to its own space program, which is distinct from ESA. The update expanded the European Global Navigation Satellite Systems (GNSS) Agency and renamed it as the EU Agency for the Space Programme. The agency was allocated a 14.8 billion euro budget, most of which would be focused on the Galileo and EGNOS satellite navigation systems, and the Copernicus Earth observation program. Most relevant to OSAM, the program would also finance space security, including their SSA program (European Parliament 2021).
  - The creation of the EU Agency for the Space Program caused tensions between the EU and ESA, and discussions were held in January 2021 about the role of each agency (Foust 2021a).

Notable International Collaborations

- Like ESA, and EU is inherently a mechanism for building international norms because it is made of its individual member states.

France

National Space Landscape

- In July 2019, French President Emmanuel Macron announced that France would be changing its military space operations to include a space command, and in September 2020, the French Air Force was renamed as the French Air and Space Force (Mackenzie 2020).

  - In March 2021, France participated in its first military space exercise, called ASTERX, which simulated international crises, including an attack on a French satellite (Delaporte 2021).
  - France's military space command will likely drive the use of OSAM technologies in the future (Corbin et al. 2020).
- France's private space sector is small and consists of both larger, mature companies and more nascent companies (Corbin et al. 2020).

OSAM Activities

- Little is known about the OSAM activities of CNES or the French Air and Space Force at this time, as there is little information publicly available. Representatives from CNES declined to be interviewed for this report.
- The European Space Policy Institute (ESPI) notes that French policies for on-orbit services are focused primarily on defense.
- CNES is working to develop the CASTOR1 satellite mission (Capacité strAtégique Spatiale de Télécommunication mObile et Résiliente). Through the CASTOR1 satellite, CNES hopes to develop a flexible antenna that can support "on-demand beam shaping" (CNES 2019). This activity may serve as a precursor to future OSAM activities in France (Corbin et al. 2020).
  - The European Space Policy Institute notes that a French parliamentary report indicates that this project appears to be on stand-by, and a lack of interest in the program could "lead French industries to lag behind in the domain of in-orbit services."
- Thales Alenia, a Franco-Italian aerospace manufacturing company that is headquartered in France, is conducting two exploratory studies on OSAM capabilities, for satellite servicing and for assembly in GEO (Corbin et al. 2020).
  - These studies will culminate in a ground demonstration by 2023–2024, and in-space demonstrations by 2025–2026.
- The French government intends to place nanosatellites into orbit near military assets in order to detect hostile approaches and attacks through the ARES project (ESPI 2020).
  - The French Space Commander notes that these systems will deter on-orbit threats (ESPI 2020).

Guiding Frameworks

Legal and Policy Frameworks

- The French Space Operations Act was adopted in May 2008. A summary of the Act says that "technical regulations shall be based on international norms and standards."
- France's 2019 Space Defense Strategy noted the growing role of on-orbit services, highlighting the dual-use aspects and inherent risks of these technologies (ESPI 2020). The report states: "Under cover of civilian objectives, States or private actors can thus openly finance potential anti-satellite technologies" (ESPI 2020; Ministère des Armées 2019).
- However, a 2019 parliamentary report discussed the benefits of RPO and on-orbit servicing for military purposes through refueling and orbit correction (ESPI). This report encourages France to invest in both ESA demonstrations for on-orbit services, as well as demonstrations for the French Armed Services.

Notable International Collaborations

- France is a member of ESA and a participant at COPUOS.
- In 2020, France became the second largest financial contributor to the European Space Agency (ESA), contributing nearly 19% of ESA's total budget. (ESA 2019)
- CNES partners with ESA on many missions, including the robotics strategic research cluster PERASPERA, which is funded by the European Commission and coordinated by ESA.
- Thales Alenia's studies for on-orbit servicing and assembly are jointly funded by CNES, ESA, and the Italian Space Agency, ASI.

Germany

National Space Landscape

- The German Aerospace Center (DLR) is the main funder and operator of space activities within Germany. DLR works in coordination with 50 research institutes.
- Germany focuses heavily on development of robotics, sensor technology, AI, and satellite communications for their internal space program, as compared to the ESA projects they fund (Corbin et al. 2020).

- Germany's 2010 National Space Strategy indicates that the German government has increased the amount spent on space by about 10% annually (BMWi 2010).
- The 2010 Germany National Space Strategy also places a priority on developing their industry's capabilities particularly in Earth observation and in-space robotics (BMWi 2010).
- Within Germany's 2019 High-Tech Strategy Progress report, aerospace was described as being of "particular importance" (BMBF 2019).
  - In the 2006 High-Tech Strategy, the German government designated space as an area of importance. Within this strategy, space is the "biggest single field in financial terms," as described by the subsequent National Space Strategy (BMWi 2010).

OSAM Activities

- Germany's 2010 National Space Strategy identified on-orbit servicing as an area of future emphasis. In order to strategically develop national capabilities in this area, Germany will focus on further developing its existing space robotics as well as "establish[ing] synergies between space robotics and 'terrestrial' robotics, as well as between various research institutes and various firms."
- Germany has a long history of in-space robotics (Corbin et al. 2020).
  - Germany first demonstrated its in-space robotics through the RObotic TEchnology EXperiment (ROTEX) during a 1994 Shuttle mission (Corbin et al 2020).
  - DLR later launched a Robotics Component Verification on ISS (ROKVISS) mission to qualify robotic joints and arms for flight. These components were successfully demonstrated, mounted on the ISS, and operated for 5 years (Corbin et al. 2020).
- iBoss is a Germany-based company working on developing modular spacecraft designs standard interfaces. They are backed by DLR and a sustaining ember of CONFERS.
- Several departments within the DLR have equities in OSAM: Robotics, Project Support and Standardization, and SSA.
  - According to our interviewees, robotics development receives about 20 million euros per year.
  - Our interviewees noted that Germany sees itself as upholding open data exchange, and contributing to reliable and sustainable space behavior.

- During interviews, DLR reports that they actively seek industry engagement.
- DLR contributed to the ESA ADRIOS mission for ADR and set up a close proximity operation working group to develop technical standards for servicing operations, according to interviews.

- Within the German Institute of Robotics and Mechatronics, the Space Dynamics Department began to develop a satellite servicing mission in 2012, called the "Deutsche Orbitale Servicing" (DEOS) mission. The DEOS servicing mission was planned to demonstrate refueling and module exchange capabilities. However, this project was canceled, despite being ready to launch in 2018.

Guiding Frameworks

Legal and Policy Frameworks

- The 2010 German National Space Strategy identifies a need for a unified legal framework for space activities (BMWi 2010).
  - The strategy says that their government is “currently working on a German Space Act aimed at providing a clear and comprehensive legal framework for non-governmental, especially commercial and private space activities.” The strategy does not specifically address OSAM.
  - The strategy indicates that the effort to develop a space legal framework is in response to obligation under international law (BMWi 2010).
- The 2010 German National Space Strategy prioritizes the prevention of an arms race in outer space, noting it as an “important objective.” However, the strategy acknowledges that binding instruments “currently appear impossible” and states that instead confidence-building measures such as the EU Code of Conduct should be pursued (BMWi 2010).
- As of February 2021, Germany does not have regulations for commercial stakeholders or a national space law.
- According to interviews, Germany has had plans for many years to develop a national space law, but it has not been finalized.

Notable International Collaborations

- In 2018, Germany allocated 3.3 billion euros across 3 years for the ESA’s budget. This amount is nearly four times what the German government allocates for the German Aerospace Center (DLR) (DLR n.d.).

- After 2018, Germany became the largest contributor to ESA's budget, followed by France.
- Germany's financial contributions will be used for ESA's science program, Earth observation, climate missions, Global Develop Aid (GDA), telecommunications, SSA, and new technology development (Corbin et al. 2020).

- According to interviews, Germany participates in both CONFERS and PERASPERA.

India

National Space Landscape

- India's space program appears to be prioritizing launch capabilities, scientific missions, direct-ascent ASAT capabilities, and support for domestic development.
- The Indian Space Research Organization (ISRO) functions as the primary research and development arm under the Department of Space (ISRO 2021a).
  - For scientific missions India plans to send an Indian Astronaut in orbit by 2022, a Chandrayann-3 mission to the sun between 2022–2024, missions to Mars and Venus in 2023, and an independent space station by 2030 (Goswami 2020).
- India's nascent commercial space sector has capabilities in launch, small satellites, and surveillance (Goswami 2020).
- India appears to be setting up a new Defense Space Agency and Defense Space Research Organization (Goswami 2020).
  - China's 2007 ASAT test preceded a reorganization of India's military space structure, including the creation of an integrated space cell within the integrated defense services 2008. This was followed by the country's first military satellites in 2008 and second in 2013, and finally an ASAT test in 2019 (Goswami 2020).

OSAM Activities

- ISRO Chairman Kailasavadivoo Sivan in 2019 announced that India would conduct a Space Docking Experiment (SPADEX) to demonstrate India's docking capabilities for future spaceflight programs. After launch, the target and chaser satellites would demonstrate docking. Original discussions indicated the

SPADEX mission would take place in 2020; however, this study has been unable to find a public facing update on the mission (Singh 2019).

- Other than the above program, STPI did not encounter evidence of efforts to develop OSAM capabilities. According to interviewees, OSAM is not a high priority at this time for ISRO.
- There is evidence that Indian commercial companies are considering OSAM activities; however, at the moment there is no effort underway to conduct OSAM activity.
  - Digantara, a space situational awareness startup plans to deploy a constellation of nanosatellites for real time space debris tracking (Khanna 2020). Digantara has been incubated by the Indian Institute of Science (IISc), receiving a sum of 50 lakhs the Society for Innovation and Development (SID), Ministry of Micro, Small & Medium Enterprises (MSME), and the Department of Science and Technology (DST) for research and development of their SSA platform (Kumar 2020). The group hopes to raise 1 million in seed funding (Kumar 2020). The Digantara plans to deploy their SSA debris tracking nano-satellites in 2021 (Kumar 2020). Digantara' s Space Debris Monitor tracks debris from space and catalogues the space debris to service satellite companies, launchers, insurers and military operators. Tracking from space, without atmospheric interference enables Digantara to track 1 to 10 cm sized debris, 18 times the resolution possible with ground systems (Madanapalle 2021). Space debris tracking is effective compared to ground-based tracking because it does not lose image fidelity due to atmospheric impacts (Madanapalle 2021). Digantara has signed a number of partnerships for their SSA platform including with the Ecuadorian Space Agency (EXA), a Taiwanese technology startup, Tensor Tech with Altitude Determination and Control Solution (ADCS) capabilities, and OKAPI, a German SSA platform (Siddiqui 2020). Following the advancement of the company's debris detection technologies, the company is considering a move into the deorbiting market (Madanapalle 2021).
  - At least one Indian telecom company has expressed interest in on-orbit servicing. Bharti Global, an Indian telecom company acquired by OneWeb, is putting Astroscale compatible docking plates on its satellites (Rainbow 2021).
  - Another Indian startup, Hyoristic Innovations, indicates debris removal ambitions (Hyoristic 2021). However, there is little public information on this company.

- India's existing space startups and launch infrastructure may ignite future commercial OSAM activities.

Guiding Frameworks

Legal and Policy Frameworks

- Space policies and the implementation of the space program are developed within the Space Commission (ISRO 2021b).
  - The Department of Space coordinates and implements these programs through its subsidiaries such as: ISRO, Physical Research Laboratory (PRL), National Atmospheric Research Laboratory (NARL), North Eastern-Space Applications Centre (NE-SAC) and Semi-Conductor Laboratory (SCL) (ISRO 2021b).
- China's 2007 ASAT test preceded a reorganization of India's military space structure, including the creation of an integrated space cell within the integrated defense services 2008. This was followed by the country's first military satellites in 2008 and second in 2013, and finally an ASAT test in 2019 (Goswami 2020).
- India appears to be setting up a new Defense Space Agency and Defense Space Research Organization (Goswami 2020).
- India is considering a Draft Space Activities Act addressing the growing demand from commercial entities for access to space. The Draft Space Activities Act provides language specific to licensing Indian commercial space activities including a call for insurance against liability in India or outside of India (ISRO 2017). The Draft includes an aspect of government oversight of all licensed activities,[21] and charges the central government with maintaining a register of space objects (ISRO 2017). According to interviewees, the bill may take as long as 2024 to pass. Space startups have commented on the gray area for frequency allocation, approval, and licenses for satellites built by commercial entities but hope that these gray areas will be ameliorated with future policy (Siddiqui 2020).

[21] "The Central Government may, for the discharge of its duties under this section, issue such directions from time to time to any licensee, as it may consider necessary: Provided that no direction shall be issued except for ensuring the compliance of terms and conditions of a license" (ISRO 2017).

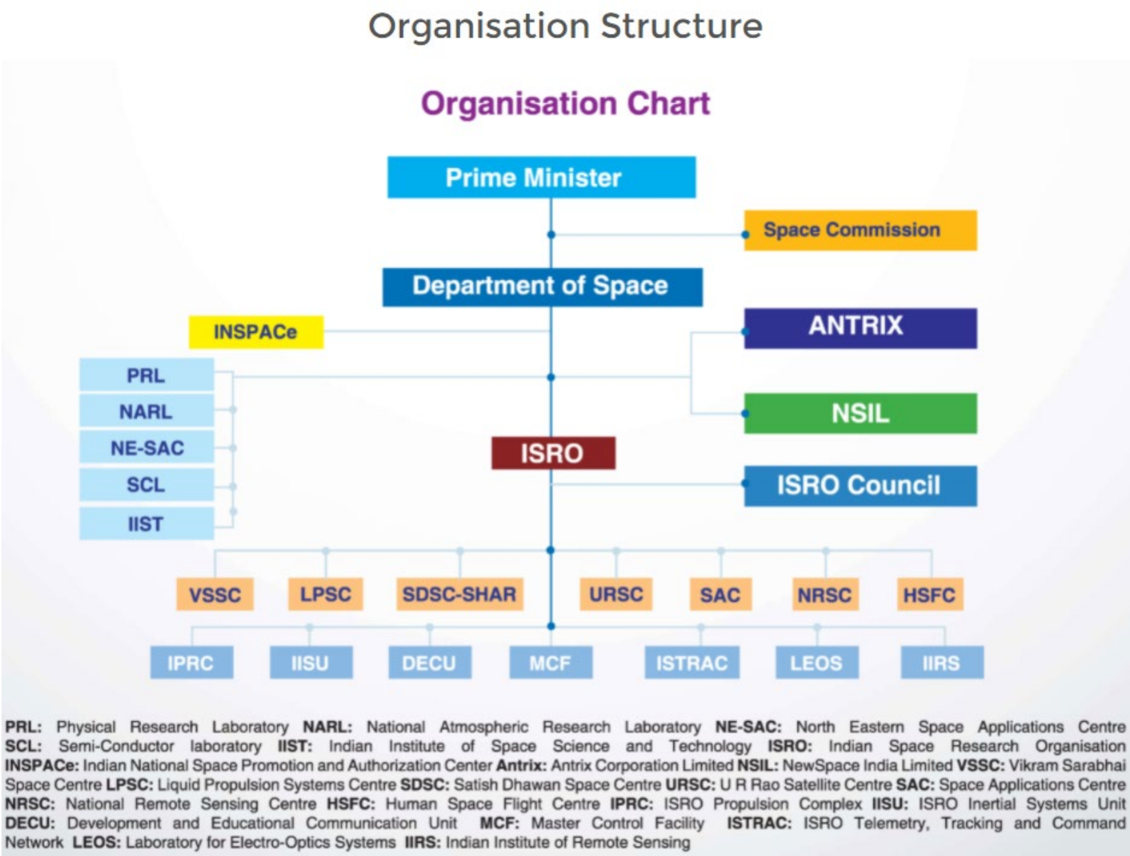

Figure C-1. India Civil Space Organization Chart **(Source: ISRO 2021a)**

Notable International Collaborations

- India is involved in organizations such as SARC, BRICS, and the Shanghai Cooperation Organization. At the moment, these coalitions do not actively propose new measures for space behavior but they represent a forum at which future agreements are sought out. In 2019, BRICS countries negotiated a joint Earth Observation Satellite Sharing Framework (Spacewatch Africa 2019).
- India plays a role in regional space cooperation. India is a member of Asia-Pacific Regional Space Agency Forum (APRSAF). APRSAF hosts working groups on Space Capabilities and Space Policy, Norms, and Law (APRSAF 2021; Global Net Platform 2021).

Additional Topics of Importance

- India provides examples of a nation acting against the grain when it is in the interest of the nation to do so. This was showcased through India's testing of a nuclear weapon in 1998 and through India's ASAT test (Goswami 2020).

- Several interviewees indicated that India has been reactive, but this may be changing. In 1968, countries were negotiating the Nuclear Non-proliferation Treaty, leaving out India who had not yet tested these capabilities. Namrata Goswami (2020) writes that India is working to play a more assertive role in space and they do not want to be left out of a potential future ASAT treaty conversation (Goswami 2020).

Israel

National Space Landscape

- Israel is one of few countries able to build its own satellites and launch its own vehicles (Ben-Israel n.d.).
- Israel's activities in the space domain are focused on Earth observation and imaging satellites in LEO, primarily for military and espionage purposes (Ben-Israel n.d.; Maslow 2018).
- While less developed than the defense space sector, Israel does possess a civilian space program. Israel's space agency has also been investing in their commercial space sector, which is nascent (Rabinovitch 2015).

OSAM Activities

- STPI identified a single organization in Israel, Effective Space Solutions, that is developing satellite servicing technologies for use on GEO satellites. Effective Space Solutions and its intellectual property were acquired by Astroscale in 2020 (Erwin 2020).
- Aside from Effective Space, STPI found no evidence to suggest Israel has developed or has concerted efforts to develop OSAM capabilities.

Guiding Frameworks

Legal and Policy Frameworks

- STPI did not find evidence of any laws governing space activities in Israel. Interviewees suggest, however, that such laws may be under development.

Notable International Collaborations

- The Israeli Space Agency has signed cooperative agreements with the space agencies of the United States, France, India, Canada, Germany, Italy, Ukraine, Russia, Brazil, and the Netherlands.

- In 2021, Israel and the United Arab Emirates (UAE) signed a space exploration and cooperation agreement. In addition to a blanket agreement, Israel and UAE have agreed to coordinate on the Beresheet 2 lunar mission and an Earth-observation program. (Jerusalem Post 2021)

Japan

National Space Landscape

- Role of JAXA
  - JAXA is an R&D agency and has avoided discussions of space security given its history of pacifism. Japan is working on active debris removal with Astroscale; however, ADR capabilities are also seen as a counterspace capability. JAXA lawyers are currently working on the topic (Suzuki 2020, 566). JAXA is responsible for Japan's SSA capabilities and has been since 2017 (Takeuchi 2019, 130).
- Role of MOD
  - As a result of the Space Law, Japan was only recently able to pursue economic and national defense objectives in space. The clauses that impacted this were the changes from "non-military" and "Non-aggressive" to "peaceful purposes." Actions taken in the interest of national security can now be seen as proactive measures to preserve "peaceful purposes" (Wakimoto 2019). Japan's Pacifist constitution forces the Self Defense force to rely on commercial and civilian sectors to provide satellite communication and imagery capabilities (Suzuki 2020, 557). JAXA and MOD continue to have limited cooperation due to the secretive nature of defense work, thus MOD has limited space capabilities (Suzuki 2020, 564). MOD could develop capabilities for self-defense including: telecommunications, surveillance, and navigation (Suzuki 2020, 563).

OSAM Activities

- Japan has a policy interest in space debris mitigation. Japan was a founding member of the Inter-Agency Space Debris Coordination Committee (IADC) and part of the IADC Space Debris Mitigation Guidelines (Takeuchi 2019, 131).
- ETS-VII launched by Japan in 1997 was the first case of RPO, docking and use of a robotic arm for on orbit experiments (Zhao, LIU, and WU 2020, 2190).
- Some of Japans major accomplishments include the Hayabusa Project, which conducted the first ever asteroid return ("Space-Law-Review-1st-Edition")

- Astroscale is a commercial entity headquartered in Tokyo, Japan. Astroscale is supported by Japanese government sources to pursue the development of debris removal services.
  - Astroscale plans to launch Phase I of JAXA's Commercial Removal of Debris Demonstration (CRD2) by 2023 (Astroscale 2021a). Astroscale also received $4.5 million from the Tokyo Metropolitan Government for the Innovation Tokyo Project, which will build a roadmap for commercializing debris removal services (Astroscale 2020a). As part of this project, Astroscale will work with partners to "commercialize its ADR services and develop global sales channels with satellite operators, national agencies and the insurance market" (Astroscale 2020a).
  - Beyond debris removal, Astroscale aims to support on-orbit servicing, life extension, and SSA (Astroscale 2021b). Astroscale is pursuing their ambitions through a mix of public and private capital. In their first five funding rounds of funding, Astroscale raised U.S. $191 million (Astroscale 2020b). Furthermore, in the summer of 2020, Astroscale bought the Israeli company Effective Space Solutions (ESS), which had been developing the SpaceDrone (Astroscale 2020c).
  - In March 2021, Astroscale launched their End of Life Services by Astroscale demonstration (ELSA-d), a commercial space retrieval service. The mission will launch from Baikonur Cosmodrome in Kazakhstan using a Russian Soyuz Rocket (Wall 2020). Astroscale hopes ELSA-d will demonstrate the viability of removing end of life satellites from Earth orbit (Astroscale 2021b). It is the first commercial demonstration of its kind. Astroscale's ELSA-d mission includes two satellites: a larger servicing satellite (~175 kg) developed by Astroscale in Japan and a smaller client satellite (~17 kg) developed by Surrey Satellite Technology Ltd. Both satellites launched from a Soyuz rocket in March 2021.
  - After the launch and commissioning phases, the two satellites demonstrated multiple docks and releases (Astroscale 2021b), increasing the level of complexity to show non-tumbling and tumbling RPO and docking. The servicing satellite uses a magnetic docking tool to rendezvous with the client (Astroscale 2021b). Before performing the tumbling captures, the servicing satellite will simulate a full service in which it flies around the client satellite, performing on orbit-inspection (EO Portal n.d.). The data collected through the inspection phase will be sent to ground operators at the In-Orbit Servicing Control Center National Facility (IOCC), before the mission conducts the tumbling capture (EO Portal n.d.).

Guiding Frameworks

Legal and Policy Frameworks

- Japan has several key documents that comprise their space policy framework.
- Japan's Diet in 1969 passed the "exclusively peaceful purposes resolution" limiting space to civilian actors (Suzuki 2020, 556).
  - The Diet in 1969 passed the exclusively peaceful purposes resolution limiting space to civilian actors (Suzuki 2020, 556). The resolution included language such as "non-military and non-aggressive actions" limiting defense activity in Space (Wakimoto 2019).
- Domestically Japan established the Basic Space Law in 2008.
  - The 2008 Space law was the first to make provisions on the development of Space ("Space-Law-Review-1st-Edition")
  - Prior to 2008 space for national defense was prohibited from using space. As a result of the Basic Space Law Japan was able to pursue economic and national defense objectives in space. The clauses that impacted this were those that changed the language from "non-military" and "Non-aggressive" to "peaceful purposes." Actions taken in the interest of national security can now be seen as proactive measures to preserve "peaceful purposes" (Wakimoto 2019).
  - The Basic Space law created the Strategic headquarters for national space policy part of the cabinet, headed by the Prime Minister with participation from cabinet ministers ("Space-Law-Review-1st-Edition").
  - Space Law establishes Minister for Space and a strategic headquarters of space policy (Suzuki 2020, 561).
  - Japan's Space Law was enacted 1 year after China's ASAT test. It is unclear what impact the event had on the space law, which enables some security behavior in space. The Space Law better enables Japan's threat monitoring capabilities. However, drafting of the Space law began several year prior to the ASAT test, potentially as early as 2004 (Isaia).
- Japan established the Space Activities Act in 2016 ("Space-Law-Review-1st-Edition").
  - Satellite use is reviewed during the launch licensing phase according to the Space Activities Act. This includes any operator launching from Japan. Some of the considerations for launch licenses include: technical aspects of the rocket and satellites; safety; harmonization with international treaties;

and also the use or purpose of the mission ("Space-Law-Review-1st-Edition").

  - The Space Activities Act governs anyone launching a satellite into orbit from a facility in Japan ("Space-Law-Review-1st-Edition").
  - Japan's Space Activities Act includes a provision requiring permission to control satellites. This includes satellites controlled or operated from Japan—meaning that a satellite launched in the United States but controlled by Japan would require authorization. If there are multiple operators, permission is required if Japan will be the main operator ("Space-Law-Review-1st-Edition").
  - Space Activities Act includes a provision providing liability rules for damage suffered by third party collisions after launch ("Space-Law-Review-1st-Edition").
  - Launches are all certified by the Prime Minister. The Prime Minister can decide to certify rocket models or launch sites, which expedites the process if the models are known or sites are reused ("Space-Law-Review-1st-Edition").
  - Japan only grants radio licenses to Japanese Nationals. The process goes through the International Telecommunication Union and the Ministry of Internal Affairs and Communications ("Space-Law-Review-1st-Edition").
  - Satellites require end of life planning. Deorbiting or returning of the satellite to a graveyard orbit are acceptable options. Currently deorbiting is difficult because of the uncertainties associated with public safety ("Space-Law-Review-1st-Edition").
- Japanese commercial activities in space are also guided by the Act on Launching Artificial Satellites and Managing Satellites (Satellite Act, No. 76, 2016) and the Act on Securing Proper Handling of Satellite Remote Sensing Records (Remote Sensing Records Act, Act No.77, 2016) (Wakimoto 2019).
  - Remote Sensing is regulated by the Space Activities Act and The Remote Sensing Act. Any satellite remote sensing device using radio equipment in Japan requires permission from the Prime Minister of Japan for each device. Low-resolution devices are outside the scope of the act. One provision requires operators to cease remote sensing when they are outside of their authorized orbit. ("Space-Law-Review-1st-Edition")
- Foreign Trade is regulated under the Foreign Exchange and Foreign Trade Act of Japan. A number of launch, satellite, or robotic technologies are subject to these

restrictions. Importing the technology may require licensing intellectual property (“Space-Law-Review-1st-Edition”).

- Japan is an original member of the OST and is a member of the Rescue of Astronauts; Return of Astronauts; the Return of Objects Launched into Outer Space; the Liability Convention; and the Registration Convention (“Space-Law-Review-1st-Edition”).

Notable International Collaborations

- Japan has taken a regional leadership role for space affairs and their space law provides direction to this (Suzuki 2020, 563). One example of regional space cooperation is the Asia-Pacific Regional Space Agency Forum (APRSAF). The 2021 APRSAF includes a panel exploring norms in space (Global Net Platform 2021).
- Japan is directly involved with several regions through Astroscale. In addition to their headquarters in Japan, Astroscale has branches in the United Kingdom, United States, Israel, and Singapore. Astroscale launched their ELSA-d mission from the Baikonur Cosmodrome in Kazakhstan (Astroscale 2021a) and plans to launch their 2023 CRD2 mission from New Zealand (Astroscale 2021c).

Additional Topics of Importance

- Geopolitical tensions have influenced Japan's conversations about space and security. The 1998 North Korea Taepodong missile that flew over japan in particular spurred demand for security measures in space. Japan has since launched the information gathering satellite program (Suzuki 2020, 558). To comply with the 1969 Diet resolution Japan considered the Information-Gathering Satellite (IGS) program to be a multipurpose program. One purpose for the program is to monitor the military activities of regional threats (Suzuki 2020, 558). The 2018 National Defense Program Guidelines (NDPG) specifically call out the "Capability to disrupt opponents command, control, communications, and information" counterspace capabilities. Japan is considering jamming capabilities and not kinetic capabilities (Isaia).

Luxembourg

National Space Landscape

- Luxembourg’s national space endeavors are primarily focused on using raw resources in space to facilitate space exploration, also referred to as in-situ resource utilization (IRSU). OSAM technologies will be critical to accessing and utilizing space resources (Corbin et al. 2020).

- The satellite and space sectors make up nearly 2% of Luxembourg's GDP. Approximately 50 companies and 2 public research organizations operate within Luxembourg's space sector (Brennan 2019).
- In 2018, Luxembourg established the Luxembourg Space Agency (LSA) as part of the Ministry of Economy, and much of LSA's mission is focused on fostering cooperation with and developing in industry (Corbin et al. 2020).
  - In support of this mission, the government of Luxembourg set up a venture capital fund of $200 million to support new space companies. The government will be a shareholder of this fund (LSA 2018a).

OSAM Activities

- Made in Space Europe is the sister company to the U.S.-based Made in Space, Inc. Made in Space Europe focuses on the development of a robotic arm and is based in Luxembourg (Made in Space 2021).
  - In September 2020, Made in Space Europe announced an agreement with U.S.-based company Momentous to develop a robotic arm on their Vigoride spacecraft. The arm is being designed to move satellites into different orbits (Werner 2020).
  - The mission is set to perform a demonstration in 2022, based upon our interviews.
  - Interviews described Made in Space's business case as robotic arms that would be able to grab client satellites and move them into a new orbit. Client satellites would have to have a standard interface, and would be able to choose from different models and sizes of robotic arms, based on their needs.
- Cislunar Industries, another company based in Luxembourg, intends to transform orbital debris into raw materials. This company is still in its nascent stages (Corbin et al. 2020; LSA 2019a).
- A small company called Kleos is developing a small constellation of satellites to provide maritime surveillance services. Kleos intends to provide these services using extendable composite booms manufactured in space (Corbin et al. 2020; LSA 2019b).
- Maana Electric is a company researching lunar regolith extraction to use in the in-space manufacturing of solar panels (Corbin et al. 2020; LSA 2019c).

- SES S.A. is a satellite and telecommunications provider based in Luxembourg. SES is one of the largest satellite operators in the world and operates over 70 satellites in GEO and MEO (Corbin et al. 2020). Maxar and SES had entered an agreement for satellite refueling services, but this relationship dissolved when Maxar exited from DARPA's satellite servicing contract. Currently, SES does not have any public connection to OSAM services (Corbin et al. 2020).

Guiding Frameworks

Legal and Policy Frameworks

- There is currently no policy or laws in Luxembourg that are directly relevant to OSAM.
- Luxembourg increasingly been developing space policy and incentivizing commercial space companies to establish a headquarters there, but its focus has been on space resource utilization, rather than OSAM.
  - However, OSAM capabilities will be key to ISRU (Corbin et al. 2020). As such, OSAM specific policy and law is not out of the question should Luxembourg continue to be a leader in space law.
- Luxembourg is a signatory of the OST and a member of COPUOS.

Notable International Collaborations

- The Luxembourg Space Agency (LSA) is a member of ESA.
  - From 2020 to 2023, Luxembourg will provide ESA with 129 million euros, which accounts for 0.9% of ESA's budget (ESA 2019).
- The government of Luxembourg has signed memoranda of understanding with China, UAE, Japan, Portugal, Poland, and the Czech Republic to exchange information on space resources, as well as to promote the adoption of a legal and regulatory framework to facilitate space resource utilization (LSA 2018b).

New Zealand

National Space Landscape

- The New Zealand Space Agency is a department of the Ministry of Business, Innovation and Employment (MBIE).
- New Zealand's Space activities are largely commercial. As of 2020, almost half (27) of New Zealand's 56 launch permits have gone to commercial entities (Martin and Desmond 2020).

OSAM Activities

- New Zealand participates in OSAM activities through their domestic launches and launch policy.
- New Zealand companies have not conducted any OSAM activity but New Zealand will play a role in Astroscale's 2023 ADRAS-J demonstration through Rocket Labs. The ADRAS-J demonstration, funded in part by the Japan Aerospace Exploration Agency (JAXA)'s Commercial Removal of Debris Demonstration Project, will rendezvous with a Japanese upper stage rocket body (Astroscale 2021c).

Guiding Frameworks

Legal and Policy Frameworks

- As noted by Martin and Desmond (2020), commercial space launch pre-dates this policy. Prior to this policy, Rocket Labs USA was governed through Technology Safeguards Agreement between the United States and New Zealand. The agreement set procedures by which Rocket Lab could ensure a responsible launch in New Zealand.
- In 2017, New Zealand passed their Outer Space and High-altitude Activities (Licenses and Permits) Regulations establishing domestic space policy (Parliamentary Counsel Office 2017).
- During the launch application process, the applicant must provide "details of each proposed launch including each launch vehicle" and an "an orbital debris mitigation plan" (Parliamentary Counsel Office 2017).
- As their licensing policy currently is defined as "causing to take off or depart; or releasing…" Under the licensing policy, "any component part of a vehicle" is subject to regulation (Martin and Desmond 2020). This could have two possible implications for OSAM norms from New Zealand: the launch process could be considered overly prescriptive, overanalyzing subcomponents; alternatively, New Zealand's regulators might provide future OSAM entities with better guidance that may encourage OSAM innovation. This being said, interviewees from Corbin et al. (2020) commented on the efficiency of the licensing pipeline and noted that it may increase commercial interest in New Zealand.
- In 2019, New Zealand's Cabinet took another step towards promoting the peaceful use of outer space by prohibiting payloads that intend to harm, interfere with or destroying other spacecraft, payloads intended to cause serious or irreversible harm to the environment (Martin and Desmond 2020).

Notable International Collaborations

- New Zealand has signed the Outer Space Treaty; Rescue Agreement; Liability Convention; and the Registration Convention. New Zealand has not signed the Moon Agreement.
- New Zealand has participated in UN COPUOS since 2016.
- New Zealand and Australia signed a space technology sharing agreement in 2019 to encourage partnerships in the two countries (Australia Department of Industry 2019).

Russia

National Space Landscape

- Russia has been a leader in the space domain for decades, both for interplanetary and Earth orbit missions.
- Unlike NASA or ESA, Roscosmos has a military component. Roscosmos and the Ministry of Defense jointly define Russia's space strategy and compete to control key space infrastructure assets (Vidal 2021).
- The budget for Russian space programs has decreased significantly in recent years. Russia spent $9.75 billion on space in 2013; that number decreased to $4.2 billion in 2018 (Seminari 2019).
- Russia released a 10-year space strategy in 2016. This strategy set the following priorities: increasing telecommunications capacities, replenishing aging Earth observation systems, streamlining launch fleets, and maintaining the GLONASS constellation (Zak 2016).
  - The budget for this was ultimately set at $20.4 billion, which is far less than the original 2014 proposal of $56.4 billion (Corbin et al. 2020).
- In November 2021, Russia conducted a direct-ascent anti-satellite (DA-ASAT) test that destroyed one of its defunct satellites in LEO. This test generated significant amounts of orbital debris and was met with strong negative attention from the broader international community (Raji 2021).

OSAM Activities

- Russia has developed satellites capable of R1: Remote Inspection.
  - In 2017, such a satellite was successfully tested by the Russian Ministry of Defense. This satellite (referred to in Izvestia as a maneuvering military satellite inspector or маневрирующий военный спутник-инспектор) is

capable of approaching other orbiting spacecraft and conducting inspections (Valchenko 2017).

- In 2020, a Russian satellite conducted maneuvers broadly interpreted in the international community as a co-orbital ASAT test.
  - The Russian satellite Cosmos 2542 released a smaller satellite, Cosmos 2542, while on orbit in 2019. Cosmos 2542 then ejected the smaller 2543.
  - On January 20, 2020, Cosmos 2542 came within 160 km of USA 245, an NRO satellite (Corbin et al. 2020).
  - Cosmos 2543 approached and synchronized orbits with several other Russian satellites. In July 2020, Cosmos 2543 fired a small projectile near another Russian satellite. The U.S. Space Command condemned this as a test of co-orbital ASATs (Harrison 2021).
  - The Russian Ministry of Defense asserted that this was an experiment to "continue work on the assessing the technical condition of domestic satellites" (Tass 2019).
- RSC Energia has conducted experiments for transmitting power between satellites or from the ground to satellites, as part of a larger effort to develop "orbital gas stations" to conduct R6: recharging operations (Litovkin 2019).
  - An article in Izvestia describes this as "transmission of electricity in the atmosphere" [провела практический эксперимент по передаче электричества в атмосфере].
  - This capability may allow for the design of satellites with smaller batteries and solar panels, as power can be delivered. This capability also raises concern over potential dual use.
- RSC Energia is partnering with Airbus Defence and Space to develop space tug capabilities for use on commercial communications satellites. The intent is to move commercial communications satellites to geostationary orbit. Airbus and RSC Energia describe this mission as "an autonomous spacecraft whose missions are maintenance, logistics and the cleaning up of Space debris" (Henry 2017).
- Our research suggests that the following OSAM challenges are seen within the Russia space community as requiring norms to address safety and sustainability of space operations; attribution of property rights; protection of ownership; and the role of commercial operators. Commercial actors are understood to be ambiguous within international law, which is a source of concern. Norms were also seen as key to promoting transparency, as they may assist in making

reliable international mechanisms of data exchange and operational cooperation for decision-making, in turn avoiding misinterpretation and tension.

- According to our interviews, the Russian space community expects norms to be of particular importance for ADR, on-orbit servicing, and in-space assembly and manufacturing.
  - With respect to ADR, this activity is expected to be complicated legally due to the number of actors involved. The liability for ADR will be complex and will require norms to navigate; our interviewees suggest that without strong norms in this area, the Russian space community does not expect ADR to become a widespread activity.
  - For on-orbit servicing (OOS), our interviewees noted that guidelines would be helpful for instances in which immediate decisions must be made. By definition, this activity will require flexibility, but guidelines would allow for necessary yet flexible guardrails.
  - Lastly, in-space assembly and manufacturing was noted as being too nascent for norms, although it was noted that individual partnerships will allow for mutual regulation. Interviewees also observed that this activity will fit well into existing space treaties. More broadly, industry was noted as having an important perspective to ensure that norms reflect the real state of technology. Both economic incentives and the creation of new activities were seen as drivers for norms in this area.

Guiding Frameworks

Legal and Policy Frameworks

- Russia has a well-established legal framework for space activities more broadly, and this will likely serve as a foundation for any OSAM specific codified norms that follow.
  - The 1993 Law of the Russian Federation No. 5663-1 (since updated in 1996, 2003, 2004, and 2006) is seen as providing a solid basis for OSAM activities. Within Article 2, "space activities" are broadly and firmly defined, and throughout that law and the others that followed, the Russian government has created a legal framework for space activities.
- In regard to OSAM activities, the current legal status is unknown to the general public. Our research suggests that the most recent State Policy Framework for Space Activities (2020) provides policy tasks and directives relating to OSAM, but this document is not publicly available. The earlier State Policy Framework

for Space Activities in 2013 briefly touches on OSAM, stating: "state policy in the area of space activities is based on the following principles: … accelerated development of advanced space technologies, creation of scientific-technical and manufacturing-technological potential for future projects" (para. 7(ж)). Our research also suggests that there may be specific regulations relating to OSAM that are not available to the public or even to experts within the Russian space industry.

- In general, our research suggests that the Russian space community views norms as necessary to allow for an orderly, predictable, and safe space environment. According to our interviews, however, Russians perceive a critical divide between technical standards (what we have referred to as codified and behavioral norms) and legal norms. Legal norms are strongly emphasized due to a perceived need for boundaries. Technical standards are also viewed as important, but not as strongly emphasized.
- Russia possesses a rigid legal tradition, and therefore, they are partial to creating legal norms before an activity commences. The emphasis on legal norms extends to both the national and international spheres. International legal norms are seen as originating from mutual consent between states, generating bilateral agreements and eventually those involving more states in a bottom-up approach. While interviewees acknowledged the difficulty and prolonged timeline to achieve this, they noted that the Outer Space Treaty is an important and helpful foundation for any future efforts. There is a preference for legally binding mechanisms to establish boundaries, particularly for new activities. New activities were seen as strong drivers for norm creation, as they require "rules of the road" before they move forward.
  - Technical standards are seen as separate but nonetheless crucial. While interviewees noted that legal norms are helpful in providing boundaries, they acknowledged that legal norms cannot and should not address every type and configuration of mission. Conversely, technical standards are thought to be of great value in guiding missions at all stages and in all scenarios.

Notable International Collaborations

- Russia has regularly collaborated with the United States for civil space missions. This partnership in civil space grew over time, but joint missions occurred as early as the Apollo program.

  - The most notable collaborative project is the ISS, which has involved a variety of OSAM activities, including RPO, docking, and in-space assembly (Corbin et al. 2020).
  - This collaboration has long been seen as a powerful symbol of diplomacy, as Russia and the United States' partnership in space has remained untouched by conflict in other sectors.
  - However, in early June 2021, Roscosmos Director General Dmitry Rogozin publicly stated that Russia would withdraw from the ISS Program if sanctions limiting Russian ability to import microchips vital to the space industry were not lifted (Howell 2021).
  - It is uncertain whether these claims are political theater, as Rogozin is known as an ostentatious figure, or if there may be a near term change in U.S.-Russian collaboration in the ISS.
- In the years after the ISS, Russia and China have announced their intent to partner for a lunar base (Pultarova 2021).
  - The Chinese and Russian partnership extends beyond their lunar base. Their space cooperation program for 2018–2022 addresses one cooperation item—a joint lunar and deep space data center—and technical cooperation in special materials development, satellite systems, Earth remote sensing, and space-debris research (Vidal 2021).
  - In addition to technical collaboration, China and Russia have jointly coordinated their diplomatic efforts based on a common vision for the use of space.
    - In 2014, Russia and China submitted a new draft of the "Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects" (PPWT). This effort sought to prevent the weaponization of outer space using a legally binding mechanism (legal norm) (Vidal 2021).
- Russia has sought partnerships in space with other countries, including South Korea, Israel, Japan, Brazil, and India. These efforts are thought to be an attempt to subvert the Russian space sector's strategic dependence on the United States and other Western powers. However, these partnerships are regarded as mismatched in priorities and capabilities, representing "fragile links that fail to tackle Russia's technological and industrial decline" (Vidal 2021).

Singapore

National Space Landscape

- Today, Singapore's Space industry is made up of 30 companies and 1,000 people (News Full Circle 2021).
- Office founded in 2013 by the Singapore Economic Development Board. From 2013–2018, the office offered $90 million in funding to support thematic grant calls for Singapore's nascent small satellite industry.
  - As of 2017, the industry was composed of 215 researchers across 18 satellite technology projects at universities, research institutes, and private organizations (EDB n.d.).
- Singapore Space & Technology LTD does trade initiatives, educational programs, expert workshops, and space camps (SGAC 2021).
  - The Singapore Space & Technology LTD organizes the Global Space and Technology Convention where space industry actors meet and develop partnerships (EDB n.d.). The convention brings together Asia's technology experts together to collaborate and connect (GSTC 2021).

OSAM Activities

- Singapore hosts several satellite operators but does not appear to have any experience with OSAM activity at this time.
- One Company, Infinite Orbits, is working to bring life 5 years of life extension services and disposal services to GEO telecommunications satellites. A demonstration mission originally targeted for 2020 (Goh 2018) has been pushed to early 2022 when they will launch their Autonomous Navigation Technology Demonstration with SpaceX (Full Circle 2021).
  - The Autonomous Space Navigation Technology is composed of several optical sensors that can be used for RPO and high-precision Space Situational Awareness (Infinite Orbits n.d.). Infinite Orbits has identified a docking methodology suitable to 90% of satellites (Infinite Orbits n.d.). The company plans to demonstrate this technology in future missions.

Guiding Frameworks

Legal and Policy Frameworks

- Spacecraft's are subject to export control in Singapore under the Strategic Good Order 2019 (Moonshotspace 2019).

- Singapore has the Telecommunications and Satellite Communication Station License to govern some space activity (Moonshotspace 2019).
- The Telecommunication Act covers: tracking, telemetry, and command stations in Singapore (Moonshotspace 2019).
- Singapore provides guidance to insurance entities covering satellites through the Insurance Act. The Insurance Act provides conditions of approval for insurers. The Act mentions satellites as something covered as a mode of transit covered under the act but does little to detail liability for in space activity (Singapore Statutes Online 2021). Nothing in Singapore's current space policy governs on-orbit activity or satellite transfers. The current space law regime lacks a national registry and on-orbit liability obligations (Moonshotspace 2019).
- Singapore ratified the Outer Space Treaty, the Rescue Agreement, and the Liability Convention. Singapore has signed but not ratified the Registration Convention (Moonshotspace 2019). Singapore Space & Technology LTD sponsored multiple events for regional and global conferences. These events help set promote space education and partnerships.

Notable International Collaborations

- Singapore plays a role in regional space cooperation. Singapore is a member of Asia-Pacific Regional Space Agency Forum (APRSAF). APRSAF hosts working groups on Space Capabilities and Space Policy, Norms, and Law (APRSAF 2021; Global Net Platform 2021).
- Infinite Orbits is supported by the European Space Agency, EDB, Stanford Space Rendezvous Lab, and angel investors—and as of April 2021, has received $1 Million in funding (News Full Circle 2021).
- Infinite Orbits claims partnerships around the world (Infinite Orbits n.d.). The Organization includes employees with experiences at MIT and Stanford (Infinite Orbits n.d.).

South Korea

National Space Landscape

- The Korean Aerospace Research Institute (KARI) in 2021 will receive $553 million from Korea’s Ministry of Science for space systems research (Si-soo 2021).
- KARI aims to make South Korea a launching state by developing Korea’s first launch vehicle capable of carrying a 1.5-ton satellite into low Earth orbit (KARI

2021). Korea plans to launch a domestically developed satellite into orbit on a Korean launch vehicle between 2022 and 2027 (KARI 2021).

- One of the goals of the Korean Third Basic Plan for the Promotion of Space Development (2018–2022) is to transition to a private sector led national space program (KARI Administrator 2018).
  - In some countries, inclusion of the private sector into the national space portfolio has led to more discussions of OSAM. However, we have not yet identified commercial OSAM entities in South Korea.

OSAM Activities

- STPI did not discover any evidence of active OSAM activities or of immediate efforts to develop OSAM capabilities.
  - South Korea's Future Vision 2050 initiative may change this. In this initiative, KARI includes Strategic Goal 13, developing a space photovoltaic power generation system. This plan does not mention on-orbit assembly but plans for space solar power systems do commonly require in-space assembly (KARI n.d.a).
  - Secondly, one of the goals of the Korean Third Basic Plan for the Promotion of Space Development (2018–2022) is to transition to private sector led national space program (KARI Administrator 2018). In some countries, inclusion of the private sector into the national space portfolio has led to more discussions of OSAM. However, these activities do not appear to be in South Korea's near future.
  - The Third Basic Plan for the Promotion of Space Development prioritizes six key areas: "self-sufficiency of space launch vehicle technology; advancement of satellite application service and development; starting space exploration; implementation of Korea Positioning System (KPS); establishment of space innovation ecosystem; and the cultivation of the space industry and creation of space-related jobs." None of which directly call out OSAM activities.

Guiding Frameworks

Legal and Policy Frameworks

- In South Korea, the Space Development Promotion Act governs "the promotion of space development and the use and management of space objects…." The policy does not have any OSAM relevant callouts; however, the act provides several mechanisms for the government to extend their authority over future OSAM missions.

- The Act requires launching entities to provide preliminary registration with the Minister of Education, Science and Technology at least 180 days before the scheduled launch date. As part of the launch authorization process, the applicant must demonstrate performance of liability, and provide information on the orbit of the space object among other information.
- The Space Development Promotion Act elucidates liability through article 14: "Any person who has launched a space object in accordance with Article 8 or 11 shall be liable for damages arising from a space accident caused by the space object." The act also goes into detail on the government's right to intervene in their national's activities if there are national security concerns. "Where the head of any relevant central administrative agency requests … to take corrective measures with regard to any space development activities being carried out by a national of the Republic of Korea, he or she may order the relevant national to correct such space development activities…." Similarly, the minister of National Defense during war or upheaval can suspend space development activities.

Notable International Collaborations

- KARI offers a 2-week course for space experts from developing countries to increase the developing nation's space capacity and promote cooperation with Korea (KARI n.d.b). As of 2019, 245 trainees from 34 countries have participated in the KARI international Space Training Program (KARI n.d.c).
- KARI publishes a list of the 24 International Organizations in which they participate. This list includes APRSAF, a regional space technology forum for the Asia-Pacific region; UNCOPUOS; international working group for space environmental test under AIAA among others (KARI n.d.d).

United Arab Emirates

National Space Landscape

- The United Arab Emirates (UAE) has a national space agency that was founded in 2017. Their key goals are to explore Mars and build the first "scientific city" on the planet.
- The UAE's National Space Policy also sets a goal of creating ""create a competitive and sustainable commercial space industry" (Introductions to UAE's National Space Policy).

OSAM Activities

- To our knowledge, UAE does not have any concrete plan to engage in OSAM activity.
  - However, within the UAE's National Space Policy, they do indicate an interest in engaging in activities that would "provide its citizens and the citizens of our region with hope, inspiration and pride," including the "use of robots and three-dimensional printing and manufacturing in space" (Introductions to UAE's National Space Policy).

Guiding Frameworks

Legal and Policy Frameworks

- The UAE published its first National Space Policy in 2016. Within the policy, the government comments that it will continue to develop and coordinate an implementation plan for the National Space Policy. The Policy tasks the National Space Agency with reviewing the national policy every 5 years.
  - For this reason, as the commercial space sector develops in the UAE it is possible that the UAE will implement policy that directly impacts on-orbit behavior. The National Policy also comments that the UAE will work with government, academia, industry, and international partners to develop appropriate standards for the space industry.
  - The guidelines outlined in the National Space Policy, however, do little to restrict types of activities; they only reiterate that the activities should work towards the nation's goals for space.
  - The National Space Policy does include some guidelines for sustainable space activities that might in the future impact OSAM activity. The guidelines of interest include: "Ensure the principle of the right of way, to and from, in space."
  - The policy also suggests support for principles such as "transparency, openness, coordination and exchange of information regarding space operations and activities."
  - The UAE National Space Policy stated that, "government authorities, shall develop and set a national space regulatory framework that seeks to achieve the following in the UAE space sector" including "Provide insurance policies and facilities suitable to various space activities" and "Minimize the

regulatory burden on commercial space activities to the extent necessary to meet domestic and international legal obligations."

- With regard to international agreements, the UAE is a signatory to the Outer Space Treaty, the Rescue Agreement, and the Liability Convention. The UAE has also signed on to the Artemis Accords.

Notable International Collaborations

- The UAE's National Space Policy calls for international coordination and collaboration and the UAE's nascent space program has already cooperated with foreign nations for key services, particularly launch.
- UAE launched its first Earth observation satellite in 2009, DubaiSat-1 (MBRSC 2019a). The Satellite was jointly constructed by an Emirati and South Korean team and launched into LEO orbit on July 29, 2009, supporting scientific and sustainable planning purposes (MBRSC 2019a).
  - Four years later, Dubai Sat-2 launched from Russia with enhanced propulsion and image storing capabilities (MBRSC 2019b).
- The UAE nanosatellite Nayif-1, built domestically by the Mohammed bin Rashid Space Center (MBRSC) and the American University of Sharjah, was launched from Satish Dhawan Space Center in India.
- For the UAE's work on Mars missions, MBRSC oversaw operations and mission execution but launched the satellite from the Tanegashima Space Center in Japan (Bartels 2020).
- The UAE plays a role in regional space cooperation. UAE is a member of Asia-Pacific Regional Space Agency Forum (APRSAF). APRSAF hosts working groups on Space Capabilities and Space Policy, Norms, and Law (APRSAF 2021; Global Net Platform 2021).

United Kingdom

National Space Landscape

- The United Kingdom has begun to significantly increase their investments and develop their regulatory regime in order to further grow their space economy and capabilities.
  - The UK has publicly stated an intention to increase their share in the global space economy from 5% to 10% by 2030 (Sheetz 2018). In pursuit of this goal, the UK has invested in launch companies specializing in small satellites.

OSAM Activities

- OneWeb is a global communications company based in the UK. OneWeb is developing a large constellation of over 600 satellites.
  - While OneWeb is not conducting OSAM activities themselves, the satellites within their constellation will include a docking plate that will ensure their compatibility with satellite servicing or removal efforts.
  - In 2019, OneWeb announced that they were going to advance their OneWeb Responsible Space program by implementing a grappling fixture, developed by Altius Space Machines (UK Space 2019).
- The UK has developed and demonstrated ADR technologies (ESPI 2020).
  - In 2018, the Surrey Space Center launched the RemoveDEBRIS mission, which had a harpoon system developed companies based in the UK, including the Stevenage branch of Airbus (ESPI 2020).
  - Further, the UK is involved in the Clearspace-1 mission and the funding of other initiatives targeting orbital debris (ESPI 2020).
- The government of the UK has created notable space infrastructure in an effort to promote its space economy, most notably the National In-Orbit Servicing Control Centre (ESPI 2020).
  - This center was funded by a £4 million grant from the UK government in partnership with Astroscale. (ESPI 2020)
  - Astroscale used this center in support of their ELSA-d missions, but use of the center will be available to other operators.
- There are several companies in the UK interested in developing or supporting satellite servicing capabilities (Corbin et al. 2020).

Guiding Frameworks

Legal and Policy Frameworks

- Within the UK government, space activities are regulated through the UK Space Agency, but some authority is moving to the Commercial Air Authority, which according to our interviews operates similarly to the U.S. FAA.
- While the UK has left the European Union, our interviewees indicate that the UK will likely still be involved in European-led R&D for OSAM in the same way that other partner countries (e.g., Canada) are.

- Wilton Park—a not-for-profit executive agency of the Foreign, Commonwealth, and Development Office of the UK Government—assists in the development of OSAM policy by convening stakeholders (Wilton Park 2021, interview). In 2019, Wilton Park hosted a 2-day conference with international experts on the topic of "Operating in space: towards developing protocols on the norms of behavior" (Wilton Park 2019).
- The UK recently developed and issued the first RPO license for Astroscale's ELSA-d mission. More information about this can be found in Chapter 3 on Written Norms.
- In 2018, the UK released the Space Industries Act, which lays out a risk-based approach to issuing licenses, which our interviewees noted is an atypical approach. The 2018 Space Industry Act does not explicitly mention OSAM activities (ESPI 2020).

Notable International Collaborations

- The UK has committed to investing 1.655 billion euros to ESA from 2019 to 2024, which will make the UK the fourth largest contributor to ESA.
  - Beyond ESA's required missions, this funding will support the Lunar Gateway, Martian sample return missions, climate satellites, space weather satellites, and space debris removal missions.
- Astroscale, which has several international offices but is headquartered in Tokyo, has both collaborated with UK companies and sought licensing from the UK government.

Additional Topics of Importance

- The UK is proposing UN resolution 75/36. For more information on responses to the resolution, see Appendix C. For country specific responses, see: https://www.un.org/disarmament/topics/outerspace-sg-report-outer-space-2021/.

Appendix E.
Analogous Regimes Relying on Norms

New technologies enable behaviors unforeseen by previous rules and create international environments where there previously has been a challenge in other domains. For example, the Treaty of Westphalia (1648), which is largely regarded as the foundation on which modern notions of sovereignty are set, predates commercial aviation (Oxford Bibliographies n.d.). Following World War II, states reconvened to determine the new rules for flyover based on the new technologies demonstrated during the war, which highlighted the shortcomings of previous rules. Similar to aviation, space technology has opened a new international environment. Earth orbit provides key economic and military services, such as remote sensing/reconnaissance, telecommunications, and navigation. Technological innovation continues to push the boundaries of what activities are feasible in space.

OSAM encompasses a range of on-orbit activities with the potential to transform the space operating environment. This chapter explores the history of technology domains and what current rules, and norms of behavior emerged. In particular, this section will look at how aviation, maritime and the cyber domains divide and bridge the international landscape. The dividers will look at issues of sovereignty and enforcement in extraterritorial environments. The bridges will examine international methods used to communicate and coordinate activities. Space actors could use this context as a backdrop while they work to develop the rules and behaviors for their own space domain technology environment.

Current Status of Space

Countries that do not disclose their assets run the risk of other civilian assets being confused with military assets. Interviewees expressed that this could be the case with several Chinese and Russian satellites. Members of the international community are concerned by a number of proximity operation maneuvers, for example, in 2008 BX-1 flew within 45 km of the ISS without notification (Fisher 2008). China did not announce or explain the maneuver and U.S. analysts' interpretations have ranged from BX-1 exhibiting threatening behavior to China seeking to demonstrate inspection and limited proximity operations capabilities for a Shenzhou-7 capsule (Weeden 2008). Even among amicable operators, such close proximity operation without prenotification runs the risk of an accident. Non-consensual close proximity operations are viewed by some as threatening behavior whether the action was intentional or unintentional (Spacecom 2020). These extraterritorial encounters appear elsewhere and may provide lessons for space.

Transparency and data sharing are among the many ways that actors can build trust, particularly when the data being shared is verifiable and validated. This concept spans a number of domains from aviation to maritime to cyber. The space domain has some notification systems for close approaches between space objects, but the protocols, standards and communication approaches developed over many decades in other domains may help inform how spacefaring states and space operators may consider data sharing in the future. Extraterritorial environments promote cooperation in several areas. Communication can help identify objects in orbit providing useful information on potential conjunctions and improve our understanding of the status of the space environment. For this reason, actors cooperate in a multitude of ways such as data sharing and communicating best practices.

For example, the way the United States and China exchange close approach warnings (conjunction assessments) for satellites is a example of communication. Since 2010, the U.S. military (specifically United States Strategic Command's Joint Space Operations Center) has provided conjunction warnings to all satellite operators of close approach predictions between their satellites and other space objects, including orbital debris. Prior to 2015, conjunction warnings for Chinese satellite operators followed a roundabout procedure: warnings were sent to the U.S. Embassy in Beijing, which then provided them to the Chinese Ministry of Foreign Affairs (Rose 2020), which then passed the warnings through various layers of bureaucracy to reach the Beijing Institute for Telecommunications and Tracking (BITT), where Chinese satellites are managed. Following the June 2015 meeting of the United States - China Strategic and Economic Dialogue, the United States and China established a more direct line of communication between the Joint Space Operations Center and BITT to coordinate collision avoidance.[22]

At the same time, actors may be incentivized to not communicate certain information. Militaries around the world may choose not to disclose their military assets or claim that their military assets have a non-military function. For commercial actors, disclosing too much information may risk the company's intellectual property or trade secrets. Analogous technology domains face similar challenges. Understanding how other technology domains bridge international gaps to communicate and standardize activities may offer useful lessons for space.

[22] For more information, see: https://2009-2017.state.gov/r/pa/prs/ps/2016/10/263499.htm

Maritime Norms

The maritime domain has established agreements on proximity and sovereignty. In the 17th century, the concept of the Freedom of the Seas was established and in the book *Mare Librum* written by Hugo Grotius. The text provides justification for allowing waterways to be free for the transport of people, raw materials and goods (Young 2016). The United Nations Convention on the Law of the Sea (UNCLOS) establishes maritime sovereignty through ocean zones.[23] This law is a result of hundreds of years of practice and conflict.

A state is attributed basic rights within each zone under UNCLOS. These zones are:

- territorial zones, 12 nautical miles off the shoreline where the state has full sovereignty of territory and may introduce legislation concerning environmental preservation, navigation, and pollution;
- contiguous zones, 24 nautical miles of shoreline, where states can still exercise control through patrol and customs;
- exclusive economic zones, 200 nautical miles of shoreline, where states have exclusive right to manage resources but must allow freedom of navigation; and
- the high seas, beyond 200 nautical miles of shoreline, where all countries have access (UN 1982).

These zones originated in the years immediately following World War II. In 1945, President Truman proclaimed by Executive order that the resources on the continental shelf contiguous to the United States belonged to the United States (Hugh 2016). This became a custom that other countries wanted to follow, going against a Eurocentric view of the sea, and led to subsequent resolutions deciding state ownership of seas (Hugh 2016). Sovereignty over the seas was clarified through conventions at The First United Nations Conference on the Law of the Sea (UNCLOS I) in 1958 and continued to be clarified up until 1982 in UNCLOS III, establishing the territorial sea, the contiguous zone, the exclusive economic zone, the continental shelf, and the high sea (Continental Shelf 2014).

Today, the International Maritime Organization (IMO), a specialized agency of the United Nations, influences international maritime governance but has no centralized enforcement mechanism. The provisions of the IMO are enforced by contracting governments (IMO n.d.a). Despite what is outlined by treaties and multilateral agreements, state disputes over sovereignty and proximity still exist.

For example, since the 1970s, Turkey and Greece have disputed ownership of the Aegean Sea, which grew increasingly contested in 1974 with the discovery of oil in the region (Dalay 2021). Considering territorial waters, Greece covers 40% of the sea while

[23] For the full text, see: https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf

Turkey covers 10%. The reason stemming from the many islands making up Greece all over the sea. Greece currently extends territorial waters at 6 nautical miles, but is pushing to the detriment of Turkey for 12 nautical miles. In 2020, Turkey sent a vessel into disputed waters, which drew a reaction from Greece and Cyprus—members of the EU. In retaliation, the EU imposed sanctions on Turkey (Economist Espresso 2021; Global Security n.d.). Furthermore, international decisions may not impact a nation's behavior. In the South China Sea, China's expansion of territory in the region challenges laws outlined in UNCLOS. In 2016, The Hague issued a ruling against China and in favor of the Philippines, finding that China's operation on certain disputed maritime features infringed on the Philippines' sovereign rights based on UNCLOS. Nevertheless, China refused to accept the court's decision and continues to operate in the South China Sea without major consequence (CFR n.d.).

Many of the current maritime rules were developed in the aftermath of World War II. The IMO, established along with the UN in 1948 and originally the Inter-Governmental Maritime Consultative Organization, governed international maritime practices (IMO n.d.b). The body issues regulations and standards agreed upon by the international community to govern maritime practices.

As a result of the Exxon Valdez oil spill—the largest oil spill in U.S. history involving a tanker—the U.S. Coast Guard created a system akin to Air Traffic Control that could communicate and portray the location of other nearby ships. Modern ships include the Automatic Identification System (AIS) (Cutlip 2017). AIS's main purpose is to mitigate collisions, oversee waterway traffic, and perform surveillance. The use of AIS increased after the 9/11 terrorism attack, and eventually in 2002 became a requirement for all tanker and passenger ships (weighting over 150 tonnes) in an amendment to Safety of Life at Sea (SOLAS; Cutlip 2017). AIS provides geographic location and communication between ships. Every passenger or tanker ship weighing over 150 tonnes is expected to have AIS under the amendments to SOLAS (Cutlip 2017).

AIS is a technology ships should use, but it is not actively enforced in international waters. Ships have the option to turn off their AIS, and it is likely to happen in the case of illegal fishing or entering another state's maritime domain. Furthermore, traffic management is not formally organized within the maritime domain. Near highly trafficked ports, ships also use Vessel Traffic Service (Cutlip 2017).

Aviation Norms

The current set of norms and rules for aviation largely arose after World War II. The United States envisioned a new world order and invited the Allied powers to Chicago for another convention on aviation norms and regulations. Based on the framework of the Paris Convention from 1919, the Chicago Convention in 1944 aimed to refine the definition of state sovereignty and establish a more complete set of economic regulations (Dempsey

2008). The Chicago Convention was defined by the clash of regulated enterprise—in which government regulation aims to support private companies in their free operation without disturbing market function, favored by the United States—and participatory enterprise—in which commerce is an enterprise of national policy and companies are owned in part or in full by their governments, favored by the EU, Canada, and Australia (Jönsson 1981). At the time, the United States was the dominant aviation power (Crouch and Bilstein 2020), and the European countries were profoundly concerned about U.S. market dominance as they struggled to rebuild after WWII (Dempsey 2008).

The Chicago Convention established the International Civil Aviation Organization (ICAO) to promote multilateral cooperation among governments in technical fields capable of standardizing air navigation practices. The Chicago Convention was signed by 52 states, coming into effect in 1947. Now, the ICAO includes 193 member states and is a specialized agency of the United Nations (ICAO 2011a). To this day, the ICAO is responsible for developing and establishing international rules and regulations for civil aviation, and the standards and recommended practices established by the organization have continued to evolve as technology matures (Dempsey 2008).Though ICAO has these responsibilities, it is up to the national governments to enforce the rules in their laws and policies. Rules for uncrewed aerial vehicles were adopted into the preexisting documents for aviation. Article 8 of the Chicago Convention details the "conditions for operating a 'pilotless' aircraft over the territory of a contracting state," emphasizing the responsibility of the operators to control the pilotless aircraft to eliminate undue danger to civil aircraft. Article 12 enforces the notion that the rules of the air apply to all aircraft, crewed or uncrewed; uncrewed aircraft must fully comply with these rules (ICAO 2006).

In the air, there is no vertical limit to state sovereignty but the Chicago Convention outlined five basic freedoms for overflying a sovereign state (Reinhard 2007) and established prohibited areas for air services. Additionally, the Chicago Convention put forward the concept of due regard, stating: "The contracting states undertake, when issuing regulations for their state aircraft, that they will have due regard for the safety of navigation of civil aircraft."[24] It is important to note state regulations is directed to non-state aircraft, and military activity have to abide by due regard which.Due regard implores states to be more transparent with their military activity, but is less enforceable than what is imposed on civilian aircraft.

Sovereignty was one of the defining issues of early aviation norms as countries realized the potential impact of civil aviation on national security. During this period, aircraft development was focused primarily on their military impact; it was not until later that aircraft became useful for civilian purposes. As a result, early conventions were based on the concept of state sovereignty over its airspace. The civil aviation industry is highly

[24] For the full text see: https://www.icao.int/publications/documents/7300_orig.pdf.

regulated, with extensive proficiency checklists and guidelines to ensure that operators are behaving in the correct way. When the standards fail—like in the midcentury midair collisions—the contributing factors are closely examined and new standards and best practices are evolved to eliminate the possibility that the same issue occurs again.

ICAO requires networked identification technology such as transponders, Automatic Dependent Surveillance–Broadcast, and the Aircraft Communication Addressing and Reporting System (Deaton and Hansman 2019). The traffic coordination, identification, and close proximity regimes work in concert to make the air travel safe, efficient, and reliable. Air Traffic Management (ATM) is based on the heightened situational awareness provided by automated collision avoidance systems; the visual, verbal, and remote identification techniques provided by onboard communications devices; and the data and information sharing protocols that allow aircraft to communicate. Unlike drones, crewed aircraft use networked communications techniques, in which equipment onboard aircraft picks up signals from other aircraft in the skies and rebroadcasts to surrounding vehicles.

ATM, regulated by ICAO and responsible for traffic flow, prevents collisions and provides additional information (ICAO 2011b). Rules for drones are focused on harmonization, integration, and interoperability with existing crewed aviation systems. Traffic management, identification, collision avoidance, and sovereignty have all had to evolve due to the proliferation of uncrewed technology. New solutions, like the NextGen Unmanned Traffic Management System (FAA 2021), ACAS sXu (Kochenderfer et al. 2012), and Remote ID (Zoldi and Poss 2020), have all had to integrate uncrewed vehicles with existing systems. UAS Traffic Management will be monitored and developed through ICAO and National Air Traffic Management systems.

Cyber Norms

Similar to uncrewed aviation, cyber environments have amended previous agreements in other technology environments to accommodate cyber needs. Physical components of cyberspace (e.g., underwater cables and satellites transmitting data) fall under both UNCLOS and the Outer Space Treaty (CFR n.d.; CCDCOE n.d.). Lines of state sovereignty become obfuscated in cyber environments, where a person residing within one nation can directly connect and affect a person in another nation. Unlike maritime and aviation environments, cyberspace is a recent development, created for public usage in the 1990s when Tim Berners-Lee came up with the idea of a globally connected web system and wrote the first html code. There is yet to be a major cyber treaty to elucidate lines of sovereignty and extraterritorial enforcement.

There has yet to be a cyber treaty. Countries and cyber experts have hosted a number of meetings to discuss acceptable conduct, but there is a divide in the international community when it comes to governing cyber technologies. Currently, Western countries that support the Budapest Convention are at odds with key non-Western countries, including Russia and China, which support the Shanghai Cooperation Organization. These diverging interests force the international community to rely on bilateral and multilateral agreements on proper behavior. Countries have also published bilateral agreements such as the 2015 U.S.-China Cyber Agreement to cease cyberespionage against commercial firms for commercial properties (Rollins 2015). In the absence of international law, these organizations and statements provide guidance for behavior. At the international level, the United Nations Group of Governmental Experts (GGE) delivered a consensus report on cybersecurity. These reports, however, often lack measures to ensure international adherence.

References

Advogados, Pinheiro Neto. 2020. "In review: space law, regulation, and policy in Brazil." *Lexology*, December 17. https://www.lexology.com/library/detail.aspx?g=89ea6b8e-80bc-471b-babf-f074bc7c4fc3

Airbus. 2021. "Airbus pioneers first satellite factory in space." Airbus Press Release. Published March 11, 2021. https://www.airbus.com/newsroom/press-releases/en/2021/03/airbus-pioneers-first-satellite-factory-in-space.html

Anzaldua, Alfred. 2021. "Let's take down the menace to our space dreams." The Space Review. Published May 3, 2021. https://www.thespacereview.com/article/4170/1

Asia-Pacific Regional Space Agency Forum (APRSAF). 2021. "About Working Groups." https://www.aprsaf.org/working_groups/about/.

Astroscale. 2021. "ELSA-d Mission License Approved by UK Space Agency." Astroscale New and Press Releases. Published March 12, 2021. https://astroscale.com/elsa-d-mission-licence-approved-by-uk-space-agency/

———. 2021. "Astroscale UK Signs £2.5 Million Agreement to Develop Space Debris Removal Technology Innovations with OneWeb." Astroscale New and Press Releases. Published May 24, 2021. https://astroscale.com/astroscale-uk-signs-2-5-million-agreement-to-develop-space-debris-removal-technology-innovations-with-oneweb/

Balakrishnan, Asha. 2020. "U.S. Policies Relevant to Orbital Debris (Presentation)." IDA Science and Technology Policy Institute. Published October 2020. https://www.ida.org/-/media/2cae5ff293304c8eac2d1167a03d26f6.ashx

Bartels, M. 2020. "United Arab Emirates launches 'Hope' mission to Mars on Japanese rocket." https://www.space.com/hope-mars-mission-uae-launch.html.

Ben-Israel, I. and Z. Kaplan. n.d. "Out of This World: Israel's Space Program." From: From Modest Beginnings to a Vibrant State. https://mfa.gov.il/MFA_Graphics/MFA%20Gallery/Israel60/ch7-6.pdf

Brennan, L. 2019. "How Luxembourg is positioning itself to be the centre of space business." *The Conversation*. https://theconversation.com/how-luxembourg-is-positioning-itself-to-be-the-centre-of-space-business-120436

Bidner, C., & Francois, P. 2013. "The emergence of political accountability." *The Quarterly Journal of Economics*, 128(3), 1397-1448.

Brunnée, Jutta, and Stephen J. Toope. 2019. "Norm Robustness and Contestation in International Law: Self-Defense Against Nonstate Actors." *Journal of Global Security Studies* 4 (1): 73–87. doi:10.1093/jogss/ogy039.

Canadian Space Agency (CSA). 2018a. "About Dextre." Government of Canada. https://www.asc-csa.gc.ca/eng/iss/dextre/about.asp

Caiazzo, I., S. Gallagher, and J. Heyl. 2016. "A Vision for Canadian Space Exploration." University of British Columbia. https://open.library.ubc.ca/media/stream/pdf/52383/1.0352001/5

CCDCOE. n.d. "International Cyber Norms: Legal, Policy & Industry Perspectives". https://ccdcoe.org/library/publications/international-cyber-norms-legal-policy-industry-perspectives/.

Chen, S. 2016. "Is China militarising space? Experts say new junk collector could be used as anti-satellite weapon." https://www.scmp.com/news/china/diplomacy-defence/article/1982526/china-militarising-space-experts-say-new-junk-collector.

Chen, W.Y., Xie, T. 2018. "The dynamic process of social norm development." *Advances in Psychological Science*. http://journal.psych.ac.cn/xlkxjz/article/2018/1671-3710/1671-3710-26-7-1284.shtml.

Cheng, Z., Hou, X., Zhang, X., Zhou, L., Guo, J., & Song, C. 2016. "In-orbit assembly mission for the space solar power station.". *Acta Astronautica*, 129, 299-308.

China Manned Space Exploration (CMSE). 2021a. "Flight Missions." http://www.cmse.gov.cn/fxrw/

———. 2021b. "Guangming Daily: 'Tianhe' lifts off! The curtain on the construction of China's space station opens" (Chinese). http://www.cmse.gov.cn/fxrw/kjzthhxcrw/mtjj/202105/t20210506_47802.html.

———. 2021c. "Manned space project prepares for space station construction mission across the board." http://www.cmse.gov.cn/xwzx/zhxw/202101/t20210106_47506.html.

Chinese Society of Astronautics. 2021. "The Special Committee of Space Solar Power Plant of Chinese Astronautical Society was established in Beijing" (Chinese). http://www.csaspace.org.cn/n2489262/n2489292/c3169716/content.html.

Chongqing University. n.d. "China's first space solar power station experimental base project launched in Bishan, Chongqing" (Chinese). http://xjy.cqu.edu.cn/info/1013/1381.htm

Consortium for Execution of Rendezvous and Servicing Operations (CONFERS). 2021. "CONFERS: Fostering the Satellite Servicing Industry." https://www.satelliteconfers.org/.

Continental Shelf. 2014. "Background to UNCLOS." http://www.continentalshelf.org/about/1143.aspx

Cook, J., V. Aksamentov, T. Hoffman, and W. Bruner. 2011. "ISS Interface Mechanisms and their Heritage." Paper presented at AIAA Space, Long Beach, CA, January 1. NASA, https://ntrs.nasa.gov/citations/20110010964

Corbin, Benjamin A., Amana Abdurrezak, Luke P. Newell, Gordon M. Roesler, and Bhavya Lal. 2020. *Global Trends in On Orbit Servicing, Assembly and*

Manufacturing (OSAM). IDA Science and Technology Policy Institute: Washington, DC.

Cornell Law School. 2021. “International law.” Legal Information Institute. Accessed April 15, 2021. https://www.law.cornell.edu/wex/international_law

———. 2021a. “Customary international law.” Legal Information Institute. Accessed April 16, 2021. https://www.law.cornell.edu/wex/customary_international_law

———. 2021a. “Liability.” Legal Information Institute. Accessed April 16, 2021. https://www.law.cornell.edu/wex/liability#:~:text=Definition,in%20contrast%20to%20its%20assets.

Council on Foreign Relations (CFR). n.d.a. “Territorial Disputes in the South China Sea.” Accessed March 1, 2021. https://www.cfr.org/global-conflict-tracker/conflict/territorial-disputes-south-china-sea

———. n.d.b. “How Does Cyberspace Work?” https://world101.cfr.org/global-era-issues/cyberspace-and-cybersecurity/how-does-cyberspace-work#:~:text=From%20under%20the%20ocean%20(or,is%20transferred%20across%20the%20internet.&text=A%20global%20network%20of%20cables,be%20transmitted%20across%20the%20internet.

Council of the European Union. 2021. “Statement by the High Representative of the Union for Foreign Affairs and Security Policy on behalf of the EU on the Russian anti-satellite test on 15 November 2021.” Accessed December 9, 2021. https://www.consilium.europa.eu/en/press/press-releases/2021/11/19/statement-by-the-high-representative-of-the-union-for-foreign-affairs-and-security-policy-on-behalf-of-the-eu-on-the-russian-anti-satellite-test-on-15-november-2021/

Crouch, Tom, and Roger Bilstein. 2020. “History of Flight.” Encyclopedia Britannica. November 12, 2020. https://www.britannica.com/technology/history-of-flight.

Canadian Space Agency (CSA). 2018b. “About Canadarm2 - Canadian Space Agency.” Government of Canada. https://asc-csa.gc.ca/eng/iss/canadarm2/about.asp.

———. 2019a. “Canadarm, Canadarm2, and Canadarm3—a comparative table.” Government of Canada. https://www.asc-csa.gc.ca/eng/iss/canadarm2/canadarm-canadarm2-canadarm3-comparative-table.asp

———. 2019b. *Exploration, Imagination, Innovation: A New Space Strategy for Canada.* Ministry of Innovation, Science, and Economic Development. https://www.asc-csa.gc.ca/pdf/eng/publications/space-strategy-for-canada.pdf

Cutlip, Kimbra. 2017. AIS for Safety and Tracking: A Brief History. Accessed Feb 1, 2021. https://globalfishingwatch.org/data/ais-for-safety-and-tracking-a-brief-history/

Dalay, Galip. 2021. *Turkey, Europe, and the Eastern Mediterranean: Charting a Way Out of the Current Deadlock*. Brookings Doha Center. January 2021. https://www.brookings.edu/wp-content/uploads/2021/01/Turkey-Europe-and-the-Eastern-Mediterranean.pdf

De Selding, Peter B. 2015. "UK Agrees to Liability Cap for Satellite Operators." SpaceNews. Published July 27, 2015. https://spacenews.com/u-k-agrees-to-liability-cap-for-satellite-operators/

Deaton, John Logan, and R John Hansman. 2019. "Investigating Collision Avoidance for Small UAS Using Cooperative Surveillance and ACAS X." Cambridge, MA: Massachusetts Institute of Technology. https://dspace.mit.edu/bitstream/handle/1721.1/121165/ICAT-2019-06_John%20Logan%20Deaton.pdf?sequence=1&isAllowed=y.

Delaporte, Murielle. 2021. "ASTERX 2021: French Space Forces Reach for Higher Orbit." Breaking Defense. Published April 9, 2021. https://breakingdefense.com/2021/04/asterx-2021-french-space-forces-reach-for-higher-orbit/

Dempsey, Paul Stephen. 2008. "Multilateral Conventions in International Aviation." *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3295916.

Dunn, Sarah, ed. *U.S.-Soviet Cooperation in Outer Space, Part 1: From Yuri Gagarin to Apollo-Soyuz*. Washington, DC: National Security Archive, 2021.

Eberle, S., A. Ohndorf, and R. Faller. 2010. "On-Orbit Servicing Mission Operations at GSOC." American Institute of Aeronautics and Astronautics, Space Operations 2010. Accessed Dec 9, 2021, from https://core.ac.uk/download/pdf/11144593.pdf

Economic Development Board (EDB). n.d. "OSTIn-Brochure." https://www.edb.gov.sg/content/dam/edbsite/news-and-resources/resources/corporate-publications/OSTIn-brochure.pdf.

Economist Espresso, The. 2021. "Look who's talking: Turkey and Greece." https://espresso.economist.com/aa7bed7356f6705718a75dda26c26614.

Eisenhower Center for Space and Defense Studies. 2014. "Special Report: Space Verification." *Space and Defense,* 7, no. 1: 55-68. Accessed March 4, 2022, from https://inss.ndu.edu/Portals/97/Space_and_Defense_7_1.pdf?ver=2018-09-06-135102-190.

EoPortal. 2020. "MEV-1 (Mission Extension Vehicle-1) and MEV-2." https://directory.eoportal.org/web/eoportal/satellite-missions/m/mev-1.

European Space Agency (ESA). 2019. "Total Subscriptions." https://esamultimedia.esa.int/docs/corporate/Space19plus_charts.pdf

———. 2020. "Funding." https://www.esa.int/About_Us/Corporate_news/Funding

———. 2021. "ESA invites ideas to open up in-orbit servicing market." Published April 1, 2021. http://www.esa.int/Safety_Security/Clean_Space/ESA_invites_ideas_to_open_up_in-orbit_servicing_market

European Parliament. 2021. "MEPs approve update of the EU's space programme." Press Releases. Published April 28, 2021. https://www.europarl.europa.eu/news/en/press-room/20210427IPR02929/meps-approve-update-of-the-eu-s-space-programme

European Space Policy Institute (ESPI). 2021. “Emerging Spacefaring Nations.” https://espi.or.at/publications/espi-public-reports/send/2-public-espi-reports/577-emerging-spacefaring-nations-full-report

———. 2020. “In-Orbit Services—Policy and Business Perspectives.” December. https://espi.or.at/publications/espi-public-reports/send/2-public-espi-reports/557-in-orbit-services-full-report

Everstein, Brian. 2021. “CSO: Space is the ‘Wild, Wild West,’ Requiring New Norms for Operating in Orbit.” Air Force Magazine. Last Modified April 30, 2021. https://www.airforcemag.com/cso-space-is-the-wild-wild-west-requiring-new-norms-for-operating-in-orbit/

Executive Office of the President (EOP). 2018. “Space Policy Directive-3, National Space Traffic Management Policy.” Presidential Memoranda. Issued on June 18, 2018. https://trumpwhitehouse.archives.gov/presidential-actions/space-policy-directive-3-national-space-traffic-management-policy/

Federal Aviation Administration (FAA). 2021. “Unmanned Aircraft System Traffic Management (UTM).” FAA.gov, accessed December 3, 2021. https://www.faa.gov/uas/research_development/traffic_management/.

Federal Register. 2018. “National Space Traffic Management Policy.” https://www.federalregister.gov/documents/2018/06/21/2018-13521/national-space-traffic-management-policy.

Finnemore, Martha, and Duncan Hollis. 2016. “Constructing Norms for Global Cybersecurity.” *The American Journal of International Law*.

Finnemore, Martha, and Kathryn Sikkink. 1998. “International Norm Dynamics and Political Change.” *Int Org* 52 (4): 887–917. doi:10.1162/002081898550789.

Fisher, Richard Jr. 2008. “Closer Look: Shenzhou-7’s Close Pass by the International Space Station”. Accessed January 30, 2021. https://www.strategycenter.net/research/pubID.191/pub_detail.asp

Florini, Ann. 1996. “The Evolution of International Norms.” *International Studies Quarterly* 40 (3): 363. doi:10.2307/2600716.

Forbes India. 2021. “Digantara: Eye in the Sky | Forbes India.” Accessed May 17, 2021. https://www.forbesindia.com/article/innovation/digantara-eye-in-the-sky/64983/1.

Foust, Jeff. 2014. “U.S. Dismisses Space Weapons Treaty Proposal As ‘Fundamentally Flawed.’” SpaceNews. Published September 11, 2014. https://spacenews.com/41842us-dismisses-space-weapons-treaty-proposal-as-fundamentally-flawed/

———. 2021a. “ESA and EU mend relations.” SpaceNews. Published January 22, 2021. https://spacenews.com/esa-and-eu-mend-relations/

———. 2021b. “Brazil joins Artemis Accords.” SpaceNews, June 16. https://spacenews.com/brazil-joins-artemis-accords/

———. 2021c. “Space sustainability makes slow progress at the United Nations.” SpaceNews. Last Modified September 20, 2021. https://spacenews.com/space-sustainability-makes-slow-progress-at-the-united-nations/

———. 2021d. “Mexico joins Artemis Accords.” SpaceNews, December 16. Accessed December 20, 2021, https://spacenews.com/mexico-joins-artemis-accords/

Fuller, L. 1969. “The Morality of Law: Revised Edition.” Yale University Press. http://www.jstor.org/stable/j.ctt1cc2mds.

Galloway, Eilene. 1979. “Consensus Decision making by the United Nations Committee on the Peaceful Uses of Outer Space.” *J. Space* L. 7 (1979): 3. https://heinonline.org/HOL/Page?handle=hein.journals/jrlsl7&div=5&g_sent=1&casa_token=&collection=journals

General Thomas P. Stafford Task Force and Academician Vladimir F. Utkin Advisory Expert Council. 1996. “First Joint Report on the ‘Shuttle-Mir’ Rendezvous and Docking Missions.” NASA-TM-112696

German Federal Ministry of Education and Research (BMBF). 2019. “The High-Tech Strategy 2025 Progress Report.” https://www.hightech-strategie.de/SharedDocs/Publikationen/de/hightech/pdf/the-high-tech-strategy-2025.pdf?__blob=publicationFile&v=3

German Federal Ministry of Economics and Technology (BMWi). 2010. “Making Germany’s Space Sector Fit for the Future: the Space Strategy of the German Federal Government.” https://www.dlr.de/rd/en/Portaldata/28/Resources/dokumente/Raumfahrtstrategie_en.pdf

Gleason, Michael P. 2021. “A Short Guide for Understanding and Assessing U.S. Space Sustainability Initiatives.” Aerospace Center for Space Policy and Strategy. Published April 2021. https://aerospace.org/sites/default/files/2021-04/Gleason_SpaceSustainability_20210407.pdf

Global Security. n.d. “Turkish-Greek Aegean Dispute.” https://www.globalsecurity.org/military/world/war/aegean.htm.

Global Space and Technology Convention (GSTC). 2021. “Global Space and Technology Convention.” https://www.space.org.sg/gstc/.

Goh, D. 2018. “Interview: Singapore/UK Infinite Orbits on satellite life extension & tracking space objects.” https://www.spacetechasia.com/interview-singapore-uk-infinite-orbits-on-satellite-life-extension-tracking-space-objects/.

Gohd, C. 2021. “Russian anti-satellite missile test was the first of its kind.” Space.com, Nov 17. Accessed December 9, 2021.https://www.space.com/russia-anti-satellite-missile-test-first-of-its-kind

Goodman, John L. and Christine M. Reichert. 2011. “History of Space Shuttle Rendezvous.” NASA Mission Operations Directorate, Flight Dynamics Division. JSC-63400, Revision 3.

Goswami, N. 2020. “India’s Space Program, Ambitions, and Activities” Edited by John M Logsdon, Kevin Pollpeter, James Clay Moltz, Saadia M. Pekkanen, Hyoung Joon An, Namrata Goswami, Kai-Uwe Schrogl, and Christina Giannopapa. From: “Asia in Space: Race to the Final Frontier.” National Bureau of Asian Research. https://www.nbr.org/publication/asia-in-space-the-race-to-the-final-frontier/.

Grego, L. 2012. “A History of Anti-Satellite Programs.” Union of Concerned Scientists. Accessed December 9, 2021. https://www.ucsusa.org/sites/default/files/2019-09/a-history-of-ASAT-programs_lo-res.pdfGerman Aerospace Center (DLR). N.d. “Facts and Figures (DLR). https://www.dlr.de/EN/organisation-dlr/media-and-documents/facts/facts-and-figures.html.

Hahuta, Hon Nanaia and Hon Stuart Nash. 2021. “Space exploration soars with Artemis Accords.” New Zealand Government. https://www.beehive.govt.nz/release/space-exploration-soars-artemis-accords

Harrington, Andrea. 2020. “Insurance as Governance for Outer Space Activities.” *Astropolitics* 18, no. 2 (2020): 99-121.

Harrison, T., K. Johnson, J. Moye, and M. Young. 2021. *Space Threat Assessment 2021*. Center for Strategic & International Studies, April. https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/210331_Harrison_SpaceThreatAssessment2021.pdf?gVYhCn79enGCOZtcQnA6MLkeKlcwqqks

Hatfield, Caris A. 2012. “Enabling Exploration Through Docking Standards.” Global Space Exploration Conference 2012. JSC-CN-26400. https://ntrs.nasa.gov/api/citations/20120008633/downloads/20120008633.pdf

Henry, Caleb. 2017. “Airbus to challenge SSL, Orbital ATK with new space tug business.” *Space News*. Published September 28, 2017. https://spacenews.com/airbus-to-challenge-ssl-orbital-atk-with-new-space-tug-business/

———. 2019. “Argentina, Turkey wade into tough GEO manufacturing market with joint venture.” *Space News*, Sept 23. https://spacenews.com/argentina-turkey-wade-into-tough-geo-manufacturing-market-with-joint-venture/Hertzfeld, Henry, Brian Weeden, and Chris Johnson. 2015. “How Simple Terms Mislead Us: The Pitfalls of Thinking About Outer Space as a Commons.” (IAC-15 - E7.5.2 x 29369).

Hill, Jeffrey. 2021. “Brazil Taps Virgin Orbit to Establish Nation’s First Orbital Launch Capabilities.” Via Satellite, April 29. https://www.satellitetoday.com/launch/2021/04/29/brazil-taps-virgin-orbit-to-establish-nations-first-orbital-launch-capabilities/

Hitchens, Theresa. 2021a. “DoD Faces Tough Decisions on Space Rules.” *Breaking Defense*, February 2. Accessed March 4, 2022 at https://breakingdefense.com/2021/02/dod-faces-tough-decisions-on-space-rules/

Hitchens, Theresa. 2021b. “Exclusive: In a First, SecDef Pledges DOD to Space Norms.” *Breaking Defense*, July 19. Accessed March 4, 2022, at https://breakingdefense.com/2021/07/exclusive-in-a-first-secdef-pledges-dod-to-space-norms/

Howell, Elizabeth. 2019. “Canada Joins NASA’s Lunar Gateway Station Project with ‘Canadarm3’ Robotic Arm.” Space.com, March 1. https://www.space.com/nasa-lunar-gateway-canada-canadarm3-robot-arm.html

Huanqiu. 2020. “My country completed space ‘3D printing’ for the first time, what has been printed?” (Chinese). https://china.huanqiu.com/article/3y8eUdDUjUn

Hugh, Laura. 2016. “The Truman Proclamation and the Rule of Law.” Accessed January 15, 2021. Rule of Law Education Center. https://www.ruleoflaw.org.au/truman-proclamation-rule-law/

Hyoristic. 2021. “HI Space.” Accessed May 13, 2021. https://hyoristic.com/#.

Hyoung, J.A. 2020. “South Korea's Space Program: Activities and Ambitions.” Project Muse. https://muse.jhu.edu/article/754924/pdf#:~:text=The%20KPS%20is%20another%20key,%2Dmeter%2C%20and%20centimeter%20resolutions.

Indian Space Research Organization (ISRO). 2021a. “Organization Structure.” https://www.isro.gov.in/about-isro/organisation-structure.

———. 2021b. “Department of Space and ISRO HQ.” https://www.isro.gov.in/about-isro/department-of-space-and-isro-hq.

———. 2017. “Seeking comments on Draft ‘Space Activities Bill, 2017’ from the stake holders/public –regarding.” https://www.isro.gov.in/update/21-nov-2017/seeking-comments-draft-space-activities-bill-2017-stake-holders-public-regarding.

Infinite Orbits. n.d. “Our Story.” https://www.infiniteorbits.io/.

Inter-Agency Space Debris Coordination Committee (IADC). 2020. “IADC Space Debris Mitigation Guidelines.” Issued March 2020.

International Civil Aviation Organization (ICAO). 2006. Convention on International Civil Aviation. 9th ed. Vol. Doc 7300/9.

———. 2011a. “The History of ICAO and the Chicago Convention.” https://www.icao.int/about-icao/History/Pages/default.aspx.

———. 2011b. “Air Traffic Management (ATM).” ICAO Safety. https://www.icao.int/safety/airnavigation/pages/atm.aspx.

International Maritime Organization (IMO). n.d.a. “Conventions.” IMO.org, accessed December 3, 2021. https://www.imo.org/en/About/Conventions/Pages/Default.aspx.

———. n.d.b. “Brief History of IMO.” https://www.imo.org/en/About/HistoryOfIMO/Pages/Default.aspx.

International Organization for Standardization (ISO). 2021. “ISO/CD 24330. Space systems — Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) — Programmatic principles and practices.” Accessed May 6, 2021. https://www.iso.org/standard/78463.html?browse=tc

International Space Station (ISS) Multilateral Coordination Board (MCB). 2016. International Docking System Standard (IDSS) Interface Definition Document (IDD) Revision E. October 2016. https://internationaldockingstandard.com/download/IDSS_IDD_Revision_E_TAGGED.pdf

International Space Station (ISS) National Lab. "ISS National Lab Projects Attract Additional Funding and Support." 2020. Accessed December 22, 2020. https://www.issnationallab.org/blog/orbitfab-receives-nsf-grant/.

International Trade Administration. 2021. "Brazil Space Sector." March 15, https://www.trade.gov/market-intelligence/brazil-space-sector.

Jakhu, Ram S., and Koroma Judge Abdul G. *National Regulation of Space Activities*. New York: Springer, 2010.

Jerusalem Post Staff (JPS). 2021. "Israel, UAE sign historic space agreement." Oct 21. https://www.jpost.com/israel-news/israel-uae-sign-historic-space-agreement-682672

Johnson, Chris. 2014. "Draft International Code of Conduct for Outer Space activities Fact Sheet." Secure World Foundation. Updated February 2014. https://swfound.org/media/166384/swf_draft_international_code_of_conduct_for_outer_space_activities_fact_sheet_february_2014.pdf

Johnson, Chris. 2018. "Part I: The Status of Norms Applicable to International Security and the Prevention of an Arms Race in Outer Space." Secure World Foundation. https://swfound.org/media/206199/cjohnson_gge_beijing_jul2018.pdf

Jönsson, Christer. 1981. "Sphere of Flying: The Politics of International Aviation." *International Organization* 35 (2): 273–302.

Jones, A. 2020. "China's new crew spacecraft looks like it could dock with the International Space Station." *Space.com*, March 30, 2020. Retrieved Jan 7, 2022 from https://www.space.com/china-new-spacecraft-dock-space-station.html

Keith, A. 2015. "Comprehensive Socio-Economic Impact Assessment of the Canadian Space Sector." Euroconsult for the Canadian Space Agency. https://www.asc-csa.gc.ca/pdf/eng/publications/2015-assessment-canadian-space-sector-v2.pdf

Khanna, Monit. 2020. "Digantara Space Startup Gets ₹25 Lakh Grant from IISc to Build Space Technology." India Times, July 26. Accessed May 17, 2021. https://www.indiatimes.com/technology/news/digantara-space-startup-low-earth-debris-monitoring-system-518764.html.

Kochenderfer, Mykel J, Jessica E Holland, and James P Chryssanthacopoulos. 2012. "Next-Generation Airborne Collision Avoidance System." *Lincoln Laboratory Journal* 19 (1): 17.

Koplow, David A. 2008. "ASAT-isfaction: Customary international law and the regulation of anti-satellite weapons." *Mich. J. Int'l* L. 30 (2008): 1187. https://heinonline.org/HOL/Page?handle=hein.journals/mjil30&div=35&g_sent=1&casa_token=&collection=journals

Korea Aerospace Research Institute (KARI). n.d.a "Development direction and strategic goals of Future Vision 2050." https://www.kari.re.kr/eng/sub01_06.do.

———. n.d.b "International Cooperation." https://www.kari.re.kr/eng/sub06_01.do.

———. n.d.c "KARIST." https://www.kari.re.kr/eng/sub06_04.do#link.

———. n.d.d "Multilateral Cooperation." https://www.kari.re.kr/eng/sub06_03.do.

———. 2018. "Korea's New Challenge for Space." https://www.kari.re.kr/cop/bbs/BBSMSTR_000000000031/selectBoardArticle.do;jsessionid=779C434B3F9EE3FDAA84C35D6E708D48?nttId=7184&kind=&mno=sitemap_02&pageIndex=1&searchCnd=&searchWrd=.

———. 2021. "Space Launch Vehicle." KARI.re.kr, Accessed December 3, 2021. https://www.kari.re.kr/eng/sub03_04.do.

Korea Law Translation Center. 2010. "Space Development Promotion Act." https://elaw.klri.re.kr/eng_service/lawView.do?hseq=17131&lang=ENG.

Krebs, G. D. n.d. "DEOS." Gunter's Space Page. Accessed Dec 9, 2021, from https://space.skyrocket.de/doc_sdat/deos.htm

Krepon, Michael. 2015. Space Code of Conduct Mugged in New York. August 4, 2015. Arms Control Wonk. https://www.armscontrolwonk.com/archive/404712/space-code-of-conduct-mugged-in-new-york/

Kriening, Torsten. 2020. "Orbit Fab to Develop in-Space Xenon Pumping for U.S. Air Force - SpaceWatch.Global." Accessed December 16, 2020. https://spacewatch.global/2020/08/orbit-fab-selected-by-u-s-air-force-to-develop-in-space-xenon-pumping/.

Kumar, Chethan. 2020. "IISc Co Working on in-Orbit Sat Kill Tech to Aid Defence Forces." Times of India, October 15. Accessed May 13, 2021. https://timesofindia.indiatimes.com/india/iisc-co-working-on-in-orbit-sat-kill-tech-to-aid-defence-forces/articleshow/78688203.cms.

Liou, J.-C. 2020. "The 2019 U.S. Government Orbital Debris Mitigation Standard Practices." Presentation to the 57th Session of the COPUOS Scientific and Technical Subcommittee. Published February 2020. https://ntrs.nasa.gov/api/citations/20200001349/downloads/20200001349.pdf?attachment=true

Listner, Michael J. 2015. "The International Code of Conduct: Comments on changes in the latest draft and post-mortem thoughts." The Space Review. Published October 26, 2015. https://www.thespacereview.com/article/2851/1

Liu, J., Tong, Y., Liu, Y., & Liu, Y. 2020. "Development of a novel end-effector for an on-orbit robotic refueling mission." IEEE Access, 8, 17762-17778.

Luxembourg Space Agency (LSA). 2019a. "Cislunar Industries." https://space-agency.public.lu/en/expertise/space-directory/CislunarIndustries.html.

———. 2019b. "Kleos." https://space-agency.public.lu/en/expertise/space-directory/kleos.html.

———. 2019c. “Maana Electric.” https://space-agency.public.lu/en/expertise/space-directory/MaanaElectric.html.

———. 2018a. “Luxembourg Launches Business-Focused National Space Agency.” September 12. https://space-agency.public.lu/en/news-media/news/2018/luxembourg-launches-business-focused-national-space-agency.html.

———. 2018b. “Luxembourg and the Republic of Poland Agree to Cooperate on Space Activities.” October 12. https://space-agency.public.lu/en/news-media/news/2018/Lux_Poland.html.

Mackenzie, Christina. 2020. “French Air Force changes name as it looks to the stars.” Defense News. Published September 15, 2020. https://www.defensenews.com/global/europe/2020/09/15/french-air-force-changes-name-as-it-looks-to-the-stars/

Madanapalle, Aditya. 2021. “Digantara Is a Local Startup Taking on the Problem of Space Debris.” Digit, March 9. Accessed May 17, 2021. https://www.digit.in/features/startups/digantara-is-a-local-startup-taking-on-the-problem-of-space-debris-58725.html.

Made in Space. 2021. “About Us.” Made in Space. Accessed June 7, 2021. https://www.madeinspaceeurope.com/about-us

Malinowska, Katarzyna. 2017. “Risk Assessment in Insuring Space Endeavours: A Legal Approach.” *Air and Space Law* 42, no. 3 (2017). https://katarzynamalinowska.eu/wp-content/uploads/2021/03/Risk-Assessment-in-insuring-space-endeavours.pdf

Manual on International Law Applicable to Military Uses of Outer Space (MILAMOS). 2021. “What is the MILAMOS Project?” https://www.mcgill.ca/milamos/.

Martin, M., K. Pfrang, and B. Weeden. 2021. “U.S. Co-orbital Anti-Satellite Testing.” Secure World Foundation. April. Accessed December 9, 2021. https://swfound.org/media/207184/swf_us_co-orbital_fact_sheet_asat_apr2021.pdf

Maslow, J. 2018. “Is Israel on its Way to Reach a Five-Year Commercial Space Race Mission?” *The Times of Israel*, Apr 24. https://blogs.timesofisrael.com/is-israel-on-its-way-to-reach-a-five-year-commercial-space-race-mission/

Matthewson, Samantha. 2021. “ESA partners with startup to launch first debris removal mission in 2025.” Space.com. Accessed November 20, 2021. https://www.space.com/esa-startup-clearspace-debris-removal-2025

McGill University. 2021. “Partner and Collaborating Institutions.” https://www.mcgill.ca/milamos/partner-institutions.

Ministère des Armées. 2019. Strategie Spatiale De Défense. [online] Available at: <https://www.defense.gouv.fr/actualites/articles/florence-parly-devoile-la-strategie-spatiale-francaise-de-defense> [Accessed 27 November 2020].

Ministry of Trade, Industry and Energy. 2020. Space Development Promotion Act. https://www.law.go.kr/%EB%B2%95%EB%A0%B9/%ED%95%AD%EA%B3%B

5%EC%9A%B0%EC%A3%BC%EC%82%B0%EC%97%85%EA%B0%9C%EB%B0%9C%EC%B4%89%EC%A7%84%EB%B2%95.

Mohammed bin Rashid Space Center (MBRSC). 2019a. "Dubai-Sat-1". https://www.mbrsc.ae/satellite-programme/dubai-sat-1.

———. 2019b. "Dubai-Sat-2". https://www.mbrsc.ae/satellite-programme/dubai-sat-2.

Moon Village Association. 2021. "Moon Village Implementation." Accessed May 6, 2021. https://moonvillageassociation.org/about/moon-village-implementation/

Moonshotspace. 2019. "Towards a Singaporean Space Act." Accessed May 18, 2021. https://moonshotspace.co/2019/10/towards-a-singaporean-space-act/.

NASA Advisory Council, Task Force on the Shuttle-Mir Rendezvous and Docking Missions. 1995. "Shuttle-Mir Rendezvous & Docking Missions." September 21. NASA-TM-112697.

NASA. 2021. "NASA Administrator Statement on Russian ASAT Test." NASA, Nov 15. Accessed December 9, 2021. https://www.nasa.gov/press-release/nasa-administrator-statement-on-russian-asat-test

———. 2016. "International Docking System Standard (IDSS): Interface Definition Document (IDD), Revision E." October. https://internationaldockingstandard.com/download/IDSS_IDD_Revision_E_TAGGED.pdf

News Full Circle. 2021. "How Infinite Orbits Made A Deal to Launch Satellite Technology with SpaceX." https://www.newsfullcircle.com/2021/04/19/how-infinite-orbits-made-a-deal-to-launch-satellite-technology-with-spacex/.

Northrup Grumman Newsroom. 2020a. "Mission Extension Vehicle: Breathing Life Back Into In-Orbit Satellites." https://news.northropgrumman.com/news/features/mission-extension-vehicle-breathing-life-back-into-in-orbit-satellites.

———. 2020b. "Northrop Grumman's Wholly Owned Subsidiary, SpaceLogistics, Selected by DARPA as Commercial Partner for Robotic Servicing Mission." https://news.northropgrumman.com/news/releases/northrop-grummans-wholly-owned-subsidiary-spacelogistics-selected-by-darpa-as-commercial-partner-for-robotic-servicing-mission#:~:text=Mission%20%7C%20Northrop%20Grumman-,Northrop%20Grumman's%20Wholly%20Owned%20Subsidiary%2C%20SpaceLogistics%2C%20Selected%20by%20DARPA%20as,Partner%20for%20Robotic%20Servicing%20Mission&text=DULLES%2C%20Va.&text=MEV%2D1%2C%20designed%20and%20built,an%20Intelsat%20satellite%20on%20Feb.

Northrup Grumman. 2021a. "SpaceLogistics." https://www.northropgrumman.com/space/space-logistics-services/.

———. 2021b. "Northrop Grumman and Intelsat Make History with Docking of Second Mission Extension Vehicle to Extend Life of Satellite." https://news.northropgrumman.com/news/releases/northrop-grumman-and-intelsat-make-history-with-docking-of-second-mission-extension-vehicle-to-extend-life-of-satellite

———. n.d. “SpaceLogistics Servicing Roadmap.” https://www.northropgrumman.com/wp-content/uploads/D21_13979-SpaceLogistics-Roadmap-Infographic_2-01.jpg.

Nuclear Threat Initiative (NTI). 2021. “Proposed Prevention of an Arms Race in Space (PAROS) Treaty.” NTI Treaties and Regimes. Last updated April 5, 2021. https://www.nti.org/learn/treaties-and-regimes/proposed-prevention-arms-race-space-paros-treaty/

Orbit Fab. 2020. “Products — Orbit Fab.” Accessed December 16, 2020. https://www.orbitfab.space/products.

———. n.d. “RAFTI Brochure.” https://static1.squarespace.com/static/5b7da3f1b40b9dda4d808180/t/5e54254e263fa10371744810/1582572908842/RAFTI+Brochure.pdf.

Oxford Bibliographies. n.d. “Peace of Westphalia (1648).” Accessed, December 3, 2021. https://www.oxfordbibliographies.com/view/document/obo-9780199743292/obo-9780199743292-0073.xml.

Park, Hee S., Katherine A. Klein, Sandi Smith, and Dennis Martell. 2009. “Separating Subjective Norms, University Descriptive and Injunctive Norms, and U.S. Descriptive and Injunctive Norms for Drinking Behavior Intentions.” *Health communication* 24 (8): 746–51. doi:10.1080/10410230903265912.

Pfrang, K, and B. Weeden. 2021. “U.S. Direct Ascent Anti-Satellite Testing.” Secure World Foundation. April. Accessed December 9. 2021.https://swfound.org/media/207180/swf_us_da-asat_fact_sheet_apr2021.pdf

PERASPERA. 2021. “PERASPERA: Space Robotic Technologies.” http://www.esa.int/Enabling_Support/Space_Engineering_Technology/PERASPERA_Space_Robotic_Technologies.

Pigozzi, Gabriella, and Leendert van der Torre. 2018. “Arguing About Constitutive and Regulative Norms.” *Journal of Applied Non-Classical Logics* 28 (2-3): 189–217. doi:10.1080/11663081.2018.1487242.

Pool, Rebecca. 2021. “Space Debris: the scrapheap in the sky.” Engineering and Technology, March 17. Accessed August 15, 2021. https://eandt.theiet.org/content/articles/2021/03/space-debris-the-scrapheap-in-the-sky/

Rabinovitch, A. 2015. “Israel uses military expertise to join commercial space race.” *Reuters*, March 4. https://www.reuters.com/article/us-israel-space/israel-uses-military-expertise-to-join-commercial-space-race-idUSKBN0M016Y20150304

Rainbow, Jason. 2021. “As Astroscale Prepares to Launch Debris-Removal Demo, UK Eyes in-Orbit Servicing Leadership.” SpaceNews, March 18. Accessed May 13, 2021. https://spacenews.com/as-astroscale-prepares-to-launch-landmark-debris-removal-mission-uk-eyes-in-orbit-servicing-leadership/.

Raji, Nivedita. 2021. “Russia’s Anti-Satellite Test Should Lead to a Multilateral Ban.” Stockholm International Peace Research Institute, December 7. Accessed April 18, 2022. https://www.sipri.org/commentary/essay/2021/russias-anti-satellite-test-should-lead-multilateral-ban

Reesman, Rebecca. 2018. *Getting in Your Space: Learning from Past Rendezvous and Proximity Operations*. The Aerospace Corporation. https://aerospace.org/sites/default/files/2018-05/GettingInYourSpace.pdf.

Reinhard, Dean. 2007. “The Vertical Limit of State Sovereignty.” *The Journal of Air Law and Commerce*. https://scholar.smu.edu/cgi/viewcontent.cgi?article=1126&context=jalc.

Rollins, J, W. 2015. *U.S.–China Cyber Agreement*. Congressional Research Service. https://fas.org/sgp/crs/row/IN10376.pdf.

Rule of Law Education Center. 2016. “The Truman Proclamation and the Rule of Law.” https://www.ruleoflaw.org.au/truman-proclamation-rule-law/

Rose, Frank A. 2018. “Safeguarding the Heavens: The United States and the Future of Norms of Behavior in Outer Space.” The Brookings Institution. https://www.brookings.edu/research/safeguarding-the-heavens-the-united-states-and-the-future-of-norms-of-behavior-in-outer-space/.

Russian News Agency Tass. 2019. “Минобороны Провело в Космосе Эксперимент По Отделению Малого Спутника От Другого Аппарата [The Ministry of Defense Conducted an Experiment in Space on the Separation of the Small Satellite from Another Device]” Tass, December 6, 2019. https://tass.ru/armiya-i-opk/7285111

Satellite Industry Association. 2021. “State of the Satellite Industry Report.” June 2021. https://brycetech.com/reports/report-documents/SIA_SSIR_2021.pdf

Sanyal, P. 2009. “From credit to collective action: The role of microfinance in promoting women's social capital and normative influence.” *American sociological review*, 74(4), 529-550. https://journals.sagepub.com/doi/pdf/10.1177/000312240907400402.

Schaffer, Audrey M. 2017. “The Role of Space Norms in Protection and Defense.” JFQ 87. https://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-87/jfq-87_88-92_Schaffer.pdf?ver=2017-09-28-092555-747

Searle, John R., Searle, P.G., and Willis, S. 1969. *Speech acts: An essay in the philosophy of language* (Vol. 626). Cambridge University Press: New York.

Secure World Foundation (SWF). 2021. “Global Counterspace Capabilities: An Open Source Assessment.” Ed. B. Weeden and V. Samson. Accessed December 9, 2021. https://swfound.org/media/207162/swf_global_counterspace_capabilities_2021.pdf

Seminari, S. 2019. “Op-ed: Global government space budgets continue multiyear rebound.” *Space News*, Nov 24. https://spacenews.com/op-ed-global-government-space-budgets-continues-multiyear-rebound/

Shar, S. 2020. “How Orbit Fab Is Building the First Gas Stations in Earth Orbit | Space Bandits.” Accessed December 16, 2020. https://www.spacebandits.io/interviews/orbit-fab.

Sheetz, M. 2018. “The British are coming - for the rocket-launching industry.” CNBC, April 21. Accessed December 9, 2021. https://www.cnbc.com/2018/04/21/uk-space-agency-aims-100-billion-by-2030.html.

———. 2021. “Pentagon calls for stop to anti-satellite weapons testing after Russian demo debris threatened ISS.” December 1. Accessed December 9, 2021. https://www-cnbc-com.cdn.ampproject.org/c/s/www.cnbc.com/amp/2021/12/01/pentagon-calls-for-stop-to-anti-satellite-weapons-testing.html

Siddiqui, Huma. 2020a. “India and Argentina to deepen its cooperation in the space field.” Financial Express, Oct 19. https://www.financialexpress.com/lifestyle/science/india-and-argentina-to-deepen-its-cooperation-in-the-space-field/2109110/

———. 2020b. “Space Startup Develops India’s First in-Orbit Space Debris Monitoring, Tracking System: Anirudh Sharma, Co-Founder and CEO of Digantara.” The Financial Express, July 30. Accessed May 17, 2021. https://www.financialexpress.com/lifestyle/science/space-startup-develops-indias-first-in-orbit-space-debris-monitoring-tracking-system-anirudh-sharma-co-founder-and-ceo-of-digantara/2032993/.

Singapore Statutes Online. 2021. “Insurance (Approved Marine, Aviation and Transit Insurers) Regulations - Singapore Statutes Online.” Accessed May 19, 2021. https://sso.agc.gov.sg/SL/IA1966-RG15?DocDate=20161212.

Singh, Surendra. 2019. “Isro to hold space-docking experiment next year, a step towards setting up space station.” http://timesofindia.indiatimes.com/articleshow/71415073.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst.

Si-soo, Park. 2021. “South Korea to spend $553 million on space projects in 2021.” SpaceNews.com, accessed December 3, 2021. https://spacenews.com/south-korea-to-spend-553-million-on-space-projects-in-2021/.

Space Generation Advisory Council (SGAC). 2021. “Singapore | Space Generation Advisory Council.” Accessed May 19, 2021. https://spacegeneration.org/regions/asia/singapore.

Space Safety Coalition (SSC). 2021. “Best Practices for the Sustainability of Space Operations.” https://spacesafety.org/

Spacewatch Africa. 2019. “BRICS Member States Negotiating Earth Observation Satellite Sharing Framework.” https://spacewatch.global/2019/12/brics-member-states-negotiating-earth-observation-satellite-sharing-framework/.

State Council Information Office of the People's Republic of China (SCIO). 2011. "Measures for the Administration of Registration of Objects Launched into Outer Space" (Chinese).

http://www.scio.gov.cn/xwfbh/xwbfbh/wqfbh/2011/1227/xgzc/Document/1072494/1072494.htm.

———. 2016a. "2016 China Space Whitepaper" (Chinese). http://www.scio.gov.cn/wz/Document/1537090/1537090.htm.

———. 2016b. "Interim Measures for the Administration of Civil Satellite Projects" (Chinese). http://www.scio.gov.cn/xwfbh/xwbfbh/wqfbh/35861/36552/xgzc36558/Document/1549898/1549898.htm.

Tang, T., Hou, X., Xiao, Y., Su, Y., Shi, Y., & Rao, X. 2019. "Research on motion characteristics of space truss-crawling robot." *International Journal of Advanced Robotic Systems*, 16(1), 1729881418821578.

The Commission for Science, Technology and Industry for National Defense (COSTIND). 2002. "Interim Measures for the Administration of Licenses for Civil Space Launch Projects." http://www.gov.cn/gongbao/content/2003/content_62252.htm.

The University of Adelaide n.d. "Woomera Manual on the International Law of Military Space Operations." https://law.adelaide.edu.au/woomera/system/files/docs/Woomera%20Manual.pdf.

———. 2021. "The Woomera Manual." Accessed April 23, 2021. https://law.adelaide.edu.au/woomera/

Tronchetti, F. 2019. "Space Law and China." *Planetary Science*. https://oxfordre.com/planetaryscience/view/10.1093/acrefore/9780190647926.001.0001/acrefore-9780190647926-e-66.

UAE Government. 2016. *UAE National Space Policy in English*. https://space.gov.ae/Documents/PublicationPDFFiles/UAE_National_Space_Policy_English.pdf.

UK Space. 2019. "OneWeb and OneWeb satellites bolster commitment to responsible space with advanced grappling technology from Altius Space Machines." Published December 10, 2019. https://www.ukspace.org/oneweb-responsible-space-altius/

United Nations General Assembly - First Committee. 2020. "Prevention of an Arms Race in Outer Space: Prevention of an Arms Race in Outer Space."

United Nations. 1967. "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies." Signed January 27, 1967. https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html

———. 1975. "Convention on International Liability for Damage Caused by Space Objects."

———. 1982. "United Nations Convention on the Law of the Sea." UN.org, accessed December 3, 2021. https://www.un.org/depts/los/convention_agreements/convention_overview_convention.htm.

———. 2012. “Conference on Disarmament No Longer Living Up to Expectations, Secretary-General Warns, Stressing That Its Future Is in Hands of Member States.” United Nations Meetings Coverage and Press Releases. Published January 24, 2012. https://www.un.org/press/en/2012/sgsm14078.doc.htm

———. 2018. “Guidelines for the Long-term Sustainability of Outer Space Activities.” Published June 27, 2018. https://www.unoosa.org/res/oosadoc/data/documents/2018/aac_1052018crp/aac_1052018crp_20_0_html/AC105_2018_CRP20E.pdf

———. 2021a. “Main Committees” General Assembly of the United Nations. Accessed February 18, 2021. https://www.un.org/en/ga/maincommittees/index.shtml

———. 2021b. “Report of the Secretary-General on reducing space threats through norms, rules and principles of responsible behaviors.” Accessed October 2, 2021. https://www.un.org/disarmament/topics/outerspace-sg-report-outer-space-2021/

U.S. Congress, Office of Technology Assessment (OTA). 1995. *U.S.-Russian Cooperation in Space*. OTA-ISS-618 (Washington DC: U.S. Government Printing Office.)

U.S. Embassy and Consulates in Brazil. 2021. “Fact Sheet: U.S.-Brazil Space Cooperation.” https://br.usembassy.gov/fact-sheet-u-s-brazil-space-cooperation/Valero, Myriam V. 2021. “Latin America’s Moonshot.” *Slate*, May 6. https://slate.com/technology/2021/05/latin-american-caribbean-space-agency-future.html

U.S. Space Command (SPACECOM). 2020. “Russia conducts space-based anti-satellite weapons test.” Spacecom, Accessed, December 3, 2021. https://www.spacecom.mil/MEDIA/NEWS-ARTICLES/Article/2285098/russia-conducts-space-based-anti-satellite-weapons-test/.

UNODA. 2021. “Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.” Accessed May 3, 2021. https://treaties.unoda.org/t/outer_space

Vidal. F. 2021. “Russia’s Space Policy: The Path of Decline?” French Institute of International Relations (Ifri). https://www.ifri.org/sites/default/files/atoms/files/vidal_russia_space_policy_2021_.pdf

von der Dunk, F. 2009. “Too-Close Encounters of the Third Party Kind: Will the Liability Convention Stand the Test of the Cosmos 2251-Iridium 33 Collision.” *Space, Cyber, and Telecommunications Law Program Faculty Publications.* 28.

Wang Liwu, Liu Anmin, Xu Wangjing, Zhang Qingbin, Wang Guangxing, Lu Yuanyuan. 2021. “Research on capture and recovery of low-orbit useless targets” (Chinese). *Chinese Space Science and Technology*, 2021, 41(1): 84-90. http://zgkj.cast.cn/CN/10.16708/j.cnki.1000-758X.2021.0010.

Weeden, Brian. 2008. “China’s BX-1 microsatellite: a litmus test for space weaponization.” *Space Review*. October 20, 2008.

Weeden, Brian. 2019. “The Evolution of Space Rendezvous and Proximity Operations and Implications for Space Security.” United Nations Disarmament Conference New York, NY, April 12, 2019.

Weeden, Brian and Victoria Samson. 2021. "Global Counterspace Capabilities." https://swfound.org/media/207162/swf_global_counterspace_capabilities_2021.pdf.

Weeden, Charity, C. Blackerby, N. Okada, E. Yamamoto, J. Forshaw, and J. Auburn. 2019. "Authorization and Continuous Supervision of Astroscale’s De-orbit Activities: A Review of the Regulatory Environment for End of Life (EOL) and Active Debris Removal (ADR) Services." In 70th International Astronautical Congress. 2019.

Werner, D. 2020. “Orbit Fab to Launch First Fuel Tanker in 2021 with Spaceflight - SpaceNews.” Accessed December 17, 2020. https://spacenews.com/orbit-fab-to-launch-with-spaceflight

———. 2020. “Made in Space Europe and Momentus plan robotic spacecraft.” SpaceNews. Published September 2, 2020. https://spacenews.com/made-in-space-europe-and-momentus-plan-robotic-spacecraft/

West, Jessica, and Gilles Doucet. 2020. “From Safety to Security: Reducing the Threat Environment through the Responsible Use of Outer Space.” https://ploughshares.ca/pl_publications/report-from-safety-to-security-extending-outer-space-norms/

———. “From Safety to Security: Extending Norms in Outer Space. Global Workshop Series Report.” Project Ploughshares Report.

Wilton Park. 2019. “Report: Operating in space: towards developing protocols on the norms of behavior.” Published June 12, 2019. https://www.unoosa.org/res/oosadoc/data/documents/2019/aac_1052019crp/aac_1052019crp_12_0_html/AC105_2019_CRP12E.pdf

Wilton Park. 2021. “What we do.” Wilton Park. Accessed June 14, 2021. https://www.wiltonpark.org.uk/about-us/

Wu, X. 2018. "China's Space Law: Rushing to the Finish Line of its Marathon." *Space Policy*. https://doi.org/10.1016/j.spacepol.2018.03.004.

Xinhua. 2019. “China, Brazil deepen aerospace cooperation.” Xinhuanet, http://www.xinhuanet.com/english/2019-12/20/c_138646447.htm

Xue, a, Z., Liu, a, J., Wu, a, C., & Tong, Y. 2020. “Review of in-space assembly technologies.” *Chinese Journal of Aeronautics*.

Zak, A. 2016. “Russia approves its 10-year space strategy.” *The Planetary Society*, March 23, 2016. https://www.planetary.org/articles/0323-russia-space-budget

Young, Michaela. 2016. “Then and Now: Reappraising Freedom of the Seas in Modern Law of the Sea.” *Ocean Development and International Law*, 47:2, 165-185. April 19, 2016. DOI: 10.1080/00908320.2016.1159088

Zoldi, Dawn M. K., and James Poss. 2020. "3, 2, 1—Done! Remote ID Rule Is Final." Inside Unmanned Systems (blog). December 28, 2020. https://insideunmannedsystems.com/3-2-1-done-remote-id-rule-is-final/.

Abbreviations

ADR	Active Debris Removal
AIS	Automatic Identification Systems
ASAT	Anti-Satellite Test
BITT	Beijing Institute for Telecommunications and Tracking
BRIC	Brazil, Russia, India, China, and South Africa
CD	Conference on Disarmament
CONFERS	Consortium for Execution of Rendezvous and Servicing Operations
COPUOS	Committee on the Peaceful Uses of Outer Space
CSA	Canadian Space Agency
DOD	Department of Defense
ELSA-d	End-of-Life by Astroscale-demonstration
ELSA-M	End-of-Life by Astroscale-Multi
ESA	European Space Agency
EU	European Union
GEO	Geostationary orbit
GGE	Group of Governmental Experts
ICAO	International Civil Aviation Organization
IDA	Institute for Defense Analyses
IDSS	International Docking System Standard
IMO	International Maritime Organization
ISO	International Organization for Standardization
ISS	International Space Station
ISS MCB	International Space Station Multilateral Coordination Board
ITAR	International Traffic in Arms Regulations
JAXA	Japanese Exploration Agency
KKV	kinetic kill vehicle
LEO	Low-Earth orbit
MEV	Mission Extension Vehicle
MILAMOS	Manual on International Law Applicable to Military Uses of Outer Space
NASA	National Aeronautics and Space Administration
NRO	National Reconnaissance Office
OSAM	On-orbit Servicing Assembly and Manufacturing
OST	Outer Space Treaty
OSTP	Office of Science and Technology Policy
PAROS	Prevention of an Arms Race in Outer Space
PERASPERA	Plan European Roadmap and Activities for Space Exploitation of Robotics and Autonomy

PPWT	
RPO	Rendezvous and Proximity Operations
RPO/OOS	Rendezvous and Proximity Operations/On-orbit Servicing
SAARC	South Asian Association for Regional Cooperation
SCO	Shanghai Cooperation Organization
SOLAS	Safety of Life at Sea
SSA	Space Situational Awareness
SSC	Space Safety Coalition
STPI	Science and Technology Policy Institute
UK	United Kingdom
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNODA	United Nations Office for Disarmament Affairs
UNOOSA	UN Office for Outer Space Affairs
USB	Universal Serial Bus

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14. ABSTRACT

Global attitudes on norms of behavior for space activities will be increasingly important and dynamic in the coming years. Understanding these international perspectives will be vital to ensuring continued access to and safe operations within space for civil, commercial, and U.S. national security stakeholders, particularly for new space operations as seen with on-orbit servicing, assembly, and manufacturing (OSAM). This study examines how countries regard norms of behavior specifically related to OSAM technologies and how that may evolve in the next 10 to 15 years. The study team also examined the drivers and mechanisms that may lead to norms development in the area of OSAM. We delved deeper into attitudes and perceptions of norms by a number of stakeholder groups relying on interviews, literature review, and case studies.

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