

A background image of space debris orbiting Earth. The Earth's horizon is visible on the left, with a bright blue and white light streak representing a satellite or rocket trail. The sun is a bright yellow orb on the right, illuminating the scene. Numerous pieces of space debris, including satellites, solar panels, and fragments, are scattered throughout the dark space.

THE TIME FOR INTERNATIONAL SPACE TRAFFIC MANAGEMENT IS NOW



The New Space Era has brought significant advancements in security, connectivity, prosperity, and collective action. But this growth comes with substantial and increasingly urgent challenges. Along with the expanding number of space objects and activities, new types of near-Earth operations, such as megaconstellations of satellites, space tourism, on-orbit servicing and manufacturing, space tugs, active debris removal, and just-in-time and artificial intelligence–driven collision avoidance maneuvers, have complicated the space domain, resulting in an orbital environment that is substantially more congested and risky.

THE NEED TO MANAGE SPACE TRAFFIC IS BECOMING MORE URGENT

Since approximately 2000, the boom in space accessibility and interest has fueled tremendous growth in the volume and variety of satellites orbiting Earth, as well as the data and services those satellites provide. Governments and companies rely on space for critical services and benefits, including defense and national security activities related to positioning, navigation, and timing; satellite communications; internet service; television and cable broadcasting; international financial transactions; remote Earth sensing; weather monitoring and prediction; and scientific exploration and experimentation.

Unfortunately, the growing number of objects in orbit has significantly increased the potential for overcrowding, debris creation, and, ultimately, collisions as the most-useful orbital altitudes steadily approach their carrying capacities. Space operators must maneuver their satellites to avoid potential collisions, which imposes additional fuel costs and shortens the life span of the satellites. These shortened life spans not only

increase costs but also result in added debris if the defunct satellites cannot be disposed of sustainably. Moreover, studies estimate that tens of thousands of additional satellites will likely be launched into low earth orbit by 2030, which would further increase the risk of collisions and threaten the sustainable use of Earth's orbits.



As of December 2022, space traffic included

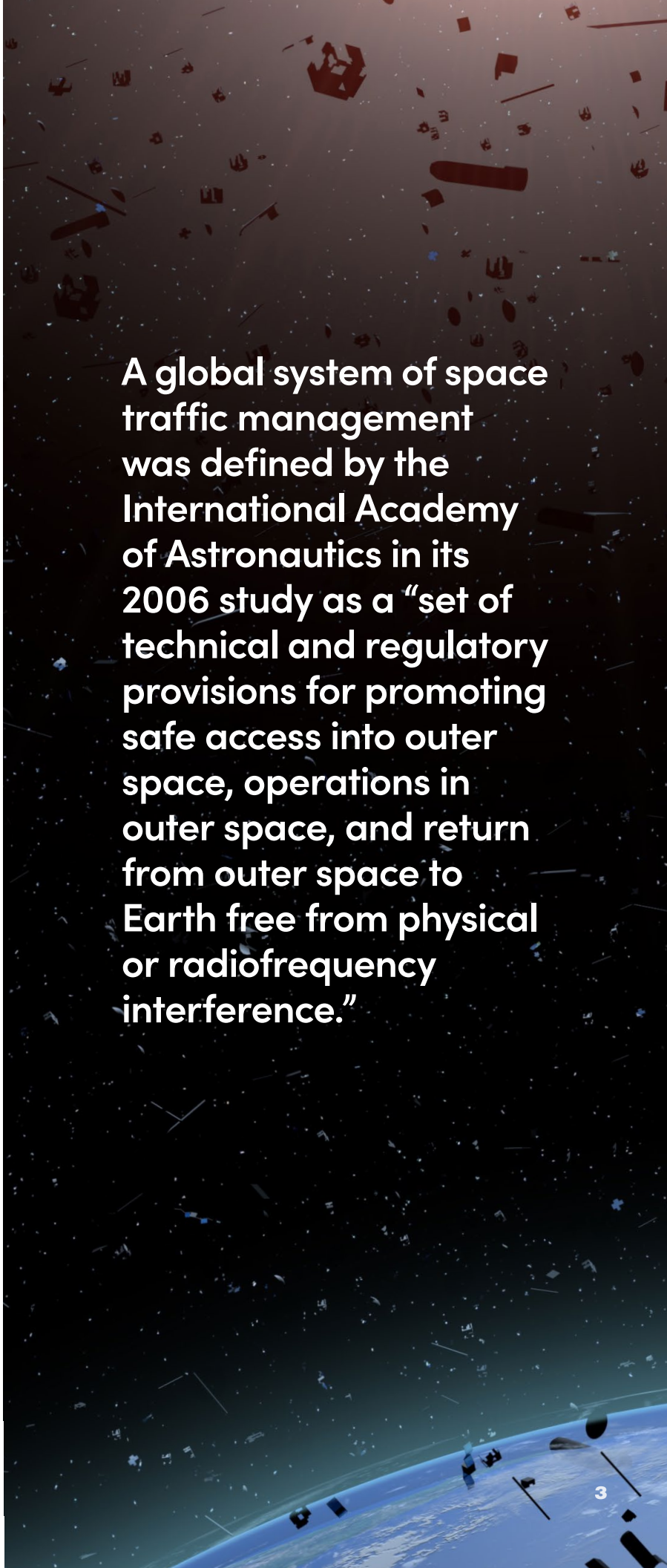
- **approximately 6,900 active satellites**
- **more than 36,500 pieces of trackable debris that are 10 cm or larger**
- **approximately one million objects that range in size from 1 cm to 10 cm.**

To provide clarity to the ongoing space traffic solution debates, RAND researchers reviewed the literature and conducted workshops with international experts from government, academia, research organizations, and industry to better understand the leading conceptions of the space traffic problem and identify possible solutions. The findings from the literature review and workshops helped the research team determine the most-advantageous features of a potential international space traffic management (STM) system and the optimal and most-feasible pathways to implement that system going forward.

STM IS A GOVERNANCE CHALLENGE MORE THAN A TECHNICAL ONE

Research and analysis show that STM is primarily a governance challenge rather than a technical one. To operate safely and sustainably in space, operators must coordinate and communicate; exchange data and information; enable situational awareness; avoid, mitigate, and resolve conflict; and define processes and procedures to determine and adjudicate who will maneuver, when that maneuver will occur, and how the maneuver will be executed to ensure safety.

Management of space objects is an informal, ad hoc, and often ill-coordinated process. But as orbital danger and complexity have increased in the New Space Era, so have calls from academics, members of civil society, policymakers, and industry leaders for improved governance of space traffic—particularly on an international level—to ensure the continued safety and sustainability of the final frontier. Heightened awareness of STM needs and the urgency of worsening orbital conditions have escalated global space traffic debates from purely academic circles to the highest levels of government. STM is now an annual topic at United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) Legal Subcommittee proceedings. However, little agreement exists on what structure international STM should eventually take or even what new steps, if any, should be taken in the short term in pursuit of reliable, global STM.

A background image of space debris in orbit above Earth's horizon. The image shows a dense field of small, dark objects (space debris) against a dark blue and black sky. The Earth's horizon is visible at the bottom, showing a blue and white curved surface. The debris includes various shapes, sizes, and colors, representing a significant threat to space operations.

A global system of space traffic management was defined by the International Academy of Astronautics in its 2006 study as a “set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space, and return from outer space to Earth free from physical or radiofrequency interference.”

FINDINGS

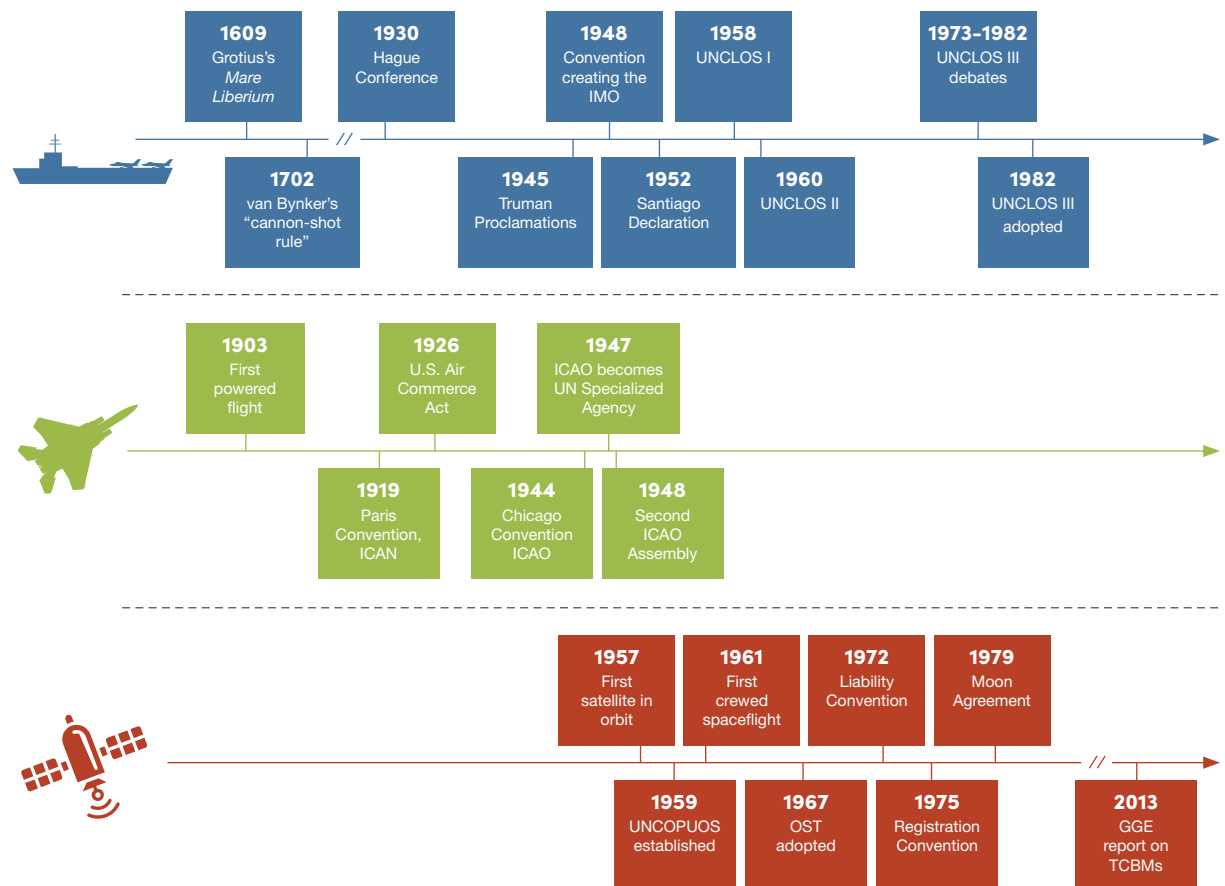
The World Is Approaching a Space Traffic Management Tipping Point

It appears that the world is approaching a tipping point for STM. Chronologically, one could argue that space is already overdue for the creation of an international governance system. The rapid growth of the space domain, especially since the early 2000s, is reflective of the accelerating trends in technology and domain usage that catalyzed the development of similar governance systems in the maritime and air domains, as shown in Figure 1. Furthermore, the research into the need for, process to implement, and options for STM organizations is already extensive. More than a dozen major

conferences, reports, and papers published in the past 40 years have discussed the necessity of an STM system and options for its implementation.

At the same time, there remains a spectrum of views internationally regarding the feasibility and advisability of an actual international space traffic management organization (ISTMO), as shown in Figure 2. Some RAND workshop participants found the ISTMO concept more potentially feasible than did other participants. There was also a lack of consensus among participants on whether an ISTMO was an advisable solution. Overall, European experts

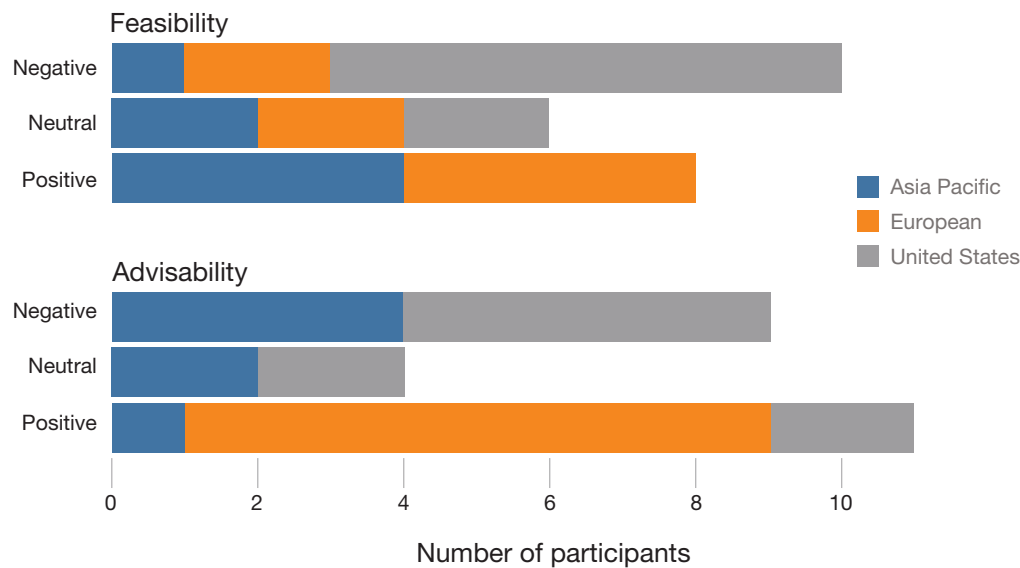
FIGURE 1 Maritime, Air, and Space Governance Development Timelines



SOURCE: Dan McCormick, Douglas C. Ligor, and Bruce McClintock, *Cross-Domain Lessons for Space Traffic Management: An Analysis of Air and Maritime Treaty Governance Mechanisms*, RAND Corporation, RR-A2208-2, 2023, p. 10.

NOTES: IMO = International Maritime Organization; UNCLOS = United Nations Conference on the Law of the Sea; ICAO = International Civil Aviation Organization; UN = United Nations; ICAN = International Commission for Air Navigation; UNCOPUOS = United Nations Committee on the Peaceful Uses of Outer Space; OST = Outer Space Treaty; GGE = Group of Governmental Experts; TCBM = transparency and confidence-building measure.

FIGURE 2 **Feasibility and Advisability Ratings from Workshop**



were the most optimistic about the feasibility and advisability of an ISTMO and U.S. experts were the most pessimistic. History in other domains and areas indicates that an international organization is likely to eventually emerge out of necessity and because the negative consequences of waiting—such as a major collision or incidence of conflict in space resulting from an STM failure—would be significant.

A Future Space Traffic Management Governance System Needs Legitimacy to Endure and Be Effective

For an ISTMO to be successful, it must be chartered with a set of authorities to which the international community, particularly spacefaring nations, will defer. But those authorities cannot be so broad or ill-defined that they create persistent opposition or lack of compliance. To effectively influence STM, member states must accept an ISTMO's exercise of authority related to

- space situational awareness (SSA) and STM measurement
- the institutionalization of STM expertise
- rules development and establishment via an accepted voting regime

- compliance and enforcement mechanisms
- building a strong bureaucratic organization that can deliver quality outputs
- conflict adjudication mechanisms.

As shown in the cases of the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO), lasting intergovernmental organization (IGO) systems need data, information, and measurements that are reliable and trustworthy to ensure situational awareness, inform decisionmaking, and help resolve disputes. These characteristics can be achieved only if members of the IGO work together on technical aspects. Moreover, successful IGOs have established and maintained domain expertise that informs rulemaking through sustained technical cooperation and collaboration.

Finally, and perhaps most critically, ISTMO legitimacy will necessitate buy-in from key space powers, such as the United States, China, and Russia; the inclusion of extant regional bodies, nonspacefaring nations, and low- and middle-income countries; and the eventual connection of all groups via an IGO structure. The air and maritime domains have shown how international norms and customs preceded the



The goal should be an international STM convention within the next five years that sets specific milestones for implementation within the next ten years.

hard codification of actual regulations, a process that has been underway in the space domain since the 1950s. An ISTMO with strong legitimacy must be able to convert current norms of behavior and activities that support STM into a coherent body of rules and regulations by which space actors will abide.

It is important to note that other international governance systems, such as the Internet Corporation for Assigned Names and Numbers (ICANN) and the Society for Worldwide Interbank Financial Telecommunication (SWIFT)—offer examples of IGOs that grew in new but legitimate ways. The space community should explore and consider such examples in its establishment of an ISTMO.

Existing Activities Show That a Bottom-Up Approach Is Already Underway for Space Traffic Management

The space community should learn from the past and find a way to make progress on the very likely future that includes an STM governance system. The recent emphasis of STM in various regions, such as the European Union's approach to STM, demonstrates that there might already be some movement toward broader STM governance structures. Leveraging the existing approach could be the optimal entry point for kick-starting an STM governance effort. It is important to note that bottom-up approaches require state-led governance efforts, such as the creation of bilateral or multilateral agreements and organizations. Evidence from the commercial spaceflight industry indicates that commercial or industry-led standard development efforts alone are unlikely to produce agreement on and implementation of regulatory standards.

A Viable International System Requires Adequate Expertise and Funding

Management organizations in other domains have adequate member state participation and appropriate staffs and resources for the tasks assigned to them. ICAO's budget for 2020 to 2022 was 322 million (Canadian dollars), with a total staff of 908 individuals in 2021. IMO's budget for 2021 was 44.29 million British pounds with a total staff of 320. The necessary budget and staffing level to effectively operate an ISTMO would need to be determined through further study. IMO and ICAO, which are primarily funded by member nations, could be starting points for this research.

Another potential starting point is the International Telecommunication Union, which has a total budget of \$165 million and relies on fees paid by participating companies, nongovernmental organizations (NGOs), academic institutions, and member governments. As state buy-in grows, so will the level and amount of expertise required to run any new organization and to develop technical rules that will allow the eventual adjudication of conflicts and establishment of compliance mechanisms.

RECOMMENDATIONS

Four recommendations to jump-start the establishment of an ISTMO are described in the following sections.

1

Key Space Powers Should Formally Start the Discussion to Establish an ISTMO

The time has passed to just study the problem of STM, and it is now time to convene the appropriate organizations to decide on the path forward. **The goal should be an international STM convention within the next five years that sets specific milestones for implementation within the next ten years.**

The time to actively develop STM is now, rather than waiting for the loss of key orbital shells because of collision-generated debris that limits the use of valuable orbits for decades or longer. Past studies and recommendations have been helpful but have not generated the necessary momentum for more-significant progress.

Key space players could use the example of the UN Resolution 75/36 process to kick-start the international discussion and move from lower-level discussions to international discussions that avoid claims of lack of coordination or regional bias. Early discussions should include not only major space powers but also key regional stakeholders and representatives from nonspacefaring nations, industry, academia, and NGOs. Regional circles of trust (i.e., groupings of allies or like-minded nations) can be the key input node for developing an ISTMO while maintaining participation and buy-in from nations that might not participate autonomously because of lack of resources or fear of marginalization from other multinational blocs. This start-in-the-middle approach could be employed to build SSA and STM capacity at the regional level before feeding into the ISTMO.

The role of industry and NGOs is important because of the extensive contributions of both to the development of SSA and STM technology, frameworks, and proposals. This approach would gain the full benefit of representation from diverse stakeholders, nations, and regions while mitigating potential capture of the ISTMO by elite, powerful, and well-resourced spacefaring nations and entities.

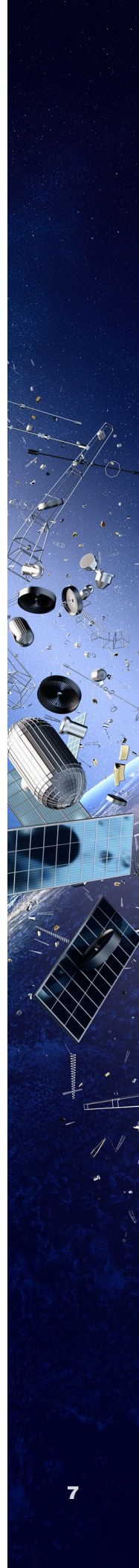
2

The STM Convention Should Learn from Past Successes

Although there is not one perfect model for an ISTMO, there are some clear best-practice considerations that should be incorporated.

First, the organizational design should be cooperative, collaborative, and inclusive, and its creation and design should be based on consensus to ensure legitimacy. IMO and ICAO have participation from most states across the globe. Each has an assembly of all members and a council that draws membership from three categories to ensure diversity of representation. In both cases, the structures of the councils incorporate both geographic and financial interest diversity while having processes and procedures to bring about convergence and agreement on rules.

Second, the actual creation of rules and enforcement should be driven by a process that is less restrictive to ensure representation but that also incorporates voting rules (e.g., majority or weighted rules) to prevent gridlock. These voting rules will allow enforcement equality and ensure incorporation of diverse views. Both IMO and ICAO allow bottom-up development of rules and participation by nonstate actors, including private companies. An ISTMO should have similar structures and mechanisms built into its committee, subcommittee, and working group processes to ensure that nonstate actors are effectively integrated. This integration is a critical element because nonstate actors, particularly in industry, are primary operators in space and will be able to provide the most-accurate data, information, analysis, and insights for governance decisionmaking. Civil society groups and academic experts also have important perspectives to offer. Moreover, these structures and mechanisms should allow not only for nonstate actor inputs but also industry feedback on current and proposed regulations or other





aspects of governance to ensure relevance and encourage buy-in and long-term acceptance. Although the STM convention should be responsible for the STM organizational design, it should model that design around these characteristics to build on past successes and garner buy-in from both spacefaring and non-spacefaring nations.

3

The Global Space Community Needs to Gather and Grow the Cadre of Experts to Staff an International Space Traffic Management Organization

The demonstrated value of technology as a tool to make interactions in a domain safer indicates that the ISTMO community will need to gather and grow a cadre of technical space experts. **Institutionalized expertise is a key factor in technology uptake and in the legitimacy, efficacy, and longevity of IGOs.** Without sufficient expertise, ISTMO members are likely to ignore or be apathetic to ISTMO processes, decisions, and rulemaking. To create a centralized pool of expertise, any new international organization will need to have adequate staff size and be appropriately resourced to compensate experts. The STM convention should consider the organizational construct, size, and technical expertise needed for any future ISTMO.

4

Future Research Should Consider Alternative Funding Mechanisms for an International Space Traffic Management Organization

Considering the challenges that other international organizations have faced with state funding, there should be more research to identify potential alternative funding mechanisms for an ISTMO.

Traditional models of funding, such as those

used by IMO, ICAO, and International Telecommunication Union (ITU), apportion contribution amounts between their member states, and IMO specifically accounts for overall use of or access to the domain in determining contributions.

An ISTMO could also consider nontraditional funding mechanisms, such as orbital-use fees (OUFs) or tradeable satellite performance bonds (TSPBs). OUFs are effectively a tax on satellites, although the additional costs associated with the tax are smaller than the averted costs of continued debris accumulation, and they could provide a user-based funding mechanism for a future ISTMO. Similarly, TSPBs are a market-based instrument for limiting the growth of space debris and incentivizing more-sustainable and more-efficient uses of orbital space. Like OUFs, TSPBs price the sustainability of orbital-use behaviors; more-sustainable behaviors incur lower costs. Although these are nascent ideas, they are worthy of further study as the ISTMO concept is developed.

CONCLUSION

If space leaders do not begin the hard work of establishing an ISTMO soon, there is a significant chance that the world will lose key portions of its orbital resources—reducing space's overall value to humanity. Additionally, beginning the work of establishing an ISTMO now might help reduce the possibility of future conflict in space. Rather than wait for a crisis to catalyze action, the space community should seize the moment and begin the work of building the governance structures needed to ensure the safety and sustainability of critical space assets, services, and activities. Acting now will enable the international community to develop solutions for protecting and preserving space now and in the future.

This brief describes work done in the RAND National Defense Research Institute and documented in *International Space Traffic Management: Charting a Course for Long-Term Sustainability*, by Bruce McClintock, Douglas C. Ligor, Dan McCormick, Marissa Herron, Kotryna Jukneviute, Thomas Van Bibber, Katie Feistel, Akhil Rao, Adi Rao, Taylor Grosso, Michael Fenner, Hanjun Lee, Abdullah Ar Rafee, and Tomás Urbina, RAND Corporation, RR-A1949-1, 2023 (available at www.rand.org/t/RR-A1949-1). To view this brief online, visit www.rand.org/t/RBA1949-1. The RAND Corporation is a research organization that develops solutions to public policy challenges to help make communities throughout the world safer and more secure, healthier and more prosperous. RAND is nonprofit, nonpartisan, and committed to the public interest. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors. RAND® is a registered trademark.

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