The Fragile Frontier

Charting Global Space Traffic Management Solutions
Space is becoming extraordinarily congested.

This NASA-generated image represents the object population in the near-Earth environment.

There are no internationally accepted standards or distancing guidelines that define how close is “too close.”

SOURCE: NASA Orbital Debris Program Office.
No real rules of the road exist for spacecraft.

This map shows entities from more than 80 different countries operating active satellites in orbit.

No nations have adopted comprehensive and enforceable space traffic standards, and no common space traffic approach exists between nations.
How might an effective international space traffic management (STM) system be realized?
Bottom-Up
Flexible but Fragmented

Top-Down
Resolute but Rigid
Air Domain Lessons
Maritime Domain Lessons
Global Governance Lessons
What can be learned from the **maritime domain**?
Centuries of **gradual norm development** eased transition to global system

Early **governance failures** fueled state and industry pressure for improvement

Current system supported by **clear territory delineation**, weakest in the high seas

Governance enabled by **widespread, UN-backed** governance structures (International Maritime Organization [IMO] and UN Convention on the Law of the Sea [UNCLOS])

**Representation** of **various interests** (funding and organizational structure) cultivates legitimacy

High **technical expertise** at international level facilitates sound rulemaking
What can be learned from the **air domain**?
Shorter timeline from first flight to international governance organization (International Civil Aviation Organization [ICAO]) than in maritime domain

Bottom-up commercial pressure catalyzed domestic regimes, harmonized via UN Convention

Governance improved through and in response to technological advancements
ICAO evolution proves **industry, or bottom-up demand**, can motivate global traffic norms development

**Flexible regulatory structure** (variances) facilitates widespread adoption of central standards

**Interoperability** and global acceptance of key aviation **technologies** remain critical to ICAO effectiveness
What can be learned from **global governance** in other technical areas and as a whole?
The International Telecommunication Union (ITU): democratic organizational procedures and private participation and financing

Internet Corporation for Assigned Names and Numbers (ICANN): institutional flexibility and the transition toward more multipolar governance

Society for Worldwide Interbank Financial Telecommunication (SWIFT): technical integration and the formative role that private actors could play
Broad international governance research underscores **legitimacy** as key to effectiveness and longevity

**Regional, democratic** organizations that emphasize **technical** cooperation enjoy higher legitimacy

A **large, well-funded** bureaucratic staff is consistently the biggest predictor of intergovernmental organization success

Major issue is in cooperation with **Russia and China**
What are **key insights and recommendations** for international space traffic management?
A bottom-up approach is already underway for STM, but we are approaching a tipping point.

Institutional legitimacy is needed for the effectiveness and endurance of an STM regime.

A viable global STM governance system will require expertise and funding.
Space powers should **kickstart the discussion** to establish an international STM organization (ISTMO) and learn from **past successes**.

The global space community should gather and grow a **cadre of experts**.

Future research should consider **alternative funding** mechanisms.
“If we do not find ways to manage space traffic, our past and present space activities will jeopardize the safety, security and sustainability of outer space and, as a result, our future ability to rely on space as enabler of key services in benefit of humankind.”

Appendix. STM Figures
<table>
<thead>
<tr>
<th>Key Intergovernmental Organizations</th>
<th>Historical Challenges</th>
<th>Collision Environment</th>
<th>Solutions</th>
<th>Limitations</th>
<th>Governance Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>STM might emerge as UN-based entity or amalgamation of regional entities</td>
<td>No formal body or mechanism to standardize space traffic procedures, prevent collisions, or resolve disputes</td>
<td>Vessels vary in size (from toaster-sized to school bus-sized) and move at very high speeds (6,000 to 15,200 knots). Debris avoidance affects fuel margins, shortening mission life.</td>
<td>Potential for centralized agreement with a large buy-in. Dispute resolution can be integrated with International Court of Justice (ICJ) or similar adjudicative body.</td>
<td>All of space faces limitations equivalent to those of the high seas or flight outside of sovereign state airspace.</td>
<td>Will likely require buy-in from even small states with some broad-based voting and deliberative system that includes United States, European Union, China, and Russia.</td>
</tr>
<tr>
<td>ICAO</td>
<td>Lack of standardized air traffic metrics. Lack of formal agreement to permit interstate air travel.</td>
<td>Vessels are generally smaller, but speed is far greater than in maritime domain (75 to 500 knots). No lingering debris created that increases congestion. High-level human involvement.</td>
<td>ICAO agreement involves large buy-in to delineate common metrics and formal agreement to allow for interstate air travel.</td>
<td>No central investigatory body for collisions in international airspace.</td>
<td>Assembly of all states elects council that manages bureaucratic committees. Council structure represents a diversity of regions and domain interests.</td>
</tr>
<tr>
<td>UNCLOS, IMO</td>
<td>Internationally Transferred Mitigation Outcomes.</td>
<td>Waters that are disputed between states. No standardized claims to water similar to those that exist for land. No standardized dispute-resolution mechanisms worldwide.</td>
<td>Vessels vary in size (from couch-sized to the size of five football fields) but have slower speeds (1 to 60 knots), making avoidance easier. Debris usually sinks or drifts with currents. High-level human involvement.</td>
<td>UNCLOS clearly delineates how sovereign waters are divided among states. ICJ, IMO, and ITMOS resolve disputes and enforce standards.</td>
<td>Assembly of all states elects council that manages bureaucratic committees. Council structure represents diversity of regions and domain interests.</td>
</tr>
<tr>
<td>ICJ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Workshop Participants’ Ratings of Feasibility of Governance
About This Slide Deck
These slides are intended to support research that should be of interest to national and international government and military leaders and policymakers, space industry leaders and organizations, public and private interest groups and institutions involved in space, those working in academia, and all those concerned with developing formal government inputs to the issue of space traffic management. The examination of traffic coordination in other domains, as well as the recommendations resulting from an analysis of these domains, will be most useful to established and aspirant spacefaring powers and policymakers, as well as space industry participants and operators. This slide deck accompanies *International Space Traffic Management: Charting a Course for Long-Term Sustainability*, by Bruce McClintock, Douglas C. Ligor, Dan McCormick, Marissa Herron, Kotryna Jukneviciute, Thomas Van Bibber, Katie Feistel, Akhil Rao, Adi Rao, Taylor Grosso, Michael Fenner, Hanjun Lee, Abdullah Ar Rafee, and Tomás Urbina, RAND Corporation, 2023, available at [www.rand.org/t/RRA1949-1](http://www.rand.org/t/RRA1949-1). The research in that report was completed in January 2023 and underwent security review with the sponsor and the Defense Office of Prepublication and Security Review before public release.

RAND National Security Research Division
This research was conducted within the International Security and Defense Policy Program of the RAND National Security Research Division (NSRD), which operates the RAND National Defense Research Institute (NDRI), a federally funded research and development center (FFRDC) sponsored by the Office of the Secretary of Defense, the Joint Staff, the Unified Combatant Commands, the Navy, the Marine Corps, the defense agencies, and the defense intelligence enterprise. This research was made possible by NDRI exploratory research funding that was provided through the FFRDC contract and approved by NDRI's primary sponsor.

For more information on the RAND International Security and Defense Policy Program, see [www.rand.org/nsrd/isdp](http://www.rand.org/nsrd/isdp) or contact the director (contact information is provided on the webpage).

For more information on this publication, visit [www.rand.org/t/RRA1949-1](http://www.rand.org/t/RRA1949-1).

About RAND
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. To learn more about RAND, visit [www.rand.org](http://www.rand.org).

Research Integrity
Our mission to help improve policy and decisionmaking through research and analysis is enabled through our core values of quality and objectivity and our unwavering commitment to the highest level of integrity and ethical behavior. To help ensure our research and analysis are rigorous, objective, and nonpartisan, we subject our research publications to a robust and exacting quality-assurance process; avoid both the appearance and reality of financial and other conflicts of interest through staff training, project screening, and a policy of mandatory disclosure; and pursue transparency in our research engagements through our commitment to the open publication of our research findings and recommendations, disclosure of the source of funding of published research, and policies to ensure intellectual independence. For more information, visit [www.rand.org/about/research-integrity](http://www.rand.org/about/research-integrity).

RAND’s publications do not necessarily reflect the opinions of its research clients and sponsors.

Published by the RAND Corporation, Santa Monica, Calif.
© 2023 RAND Corporation
RAND® is a registered trademark.

Cover photo: © Framestock - stock.adobe.com

Limited Print and Electronic Distribution Rights
This document and trademark(s) contained herein are protected by law. This representation of RAND intellectual property is provided for noncommercial use only. Unauthorized posting of this publication online is prohibited. Permission is given to duplicate this document for personal use only, as long as it is unaltered and complete. Permission is required from RAND to reproduce, or reuse in another form, any of our research documents for commercial use. For information on reprint and linking permissions, please visit [www.rand.org/pubs/permissions](http://www.rand.org/pubs/permissions).