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(SPACE) SHIPS PASSING IN THE NIGHT: TRANSLATING MARITIME RULES OF THE ROAD FOR THE SPACE DOMAIN

ROBIN DICKEY
THE AEROSPACE CORPORATION

AEROSPACE

ROBIN DICKEY

Robin Dickey is a space policy and strategy analyst at The Aerospace Corporation's Center for Space Policy and Strategy, focusing on national security space. Her prior experience includes risk analysis, legislative affairs, and international development. She earned her bachelor's and master's degrees in international studies at Johns Hopkins University.

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Summary

Collisions in space can be incredibly dangerous for space operations, with the resulting debris posing hazards for satellites for months, years, or decades after an incident. As space gets more crowded, the likelihood of collisions is increasing, and many space stakeholders have begun to propose potential norms or rules to prevent collisions. Analogies are a popular source of ideas for what norms could look like. This paper provides a deep dive into one of many possible documents that could be translated to rules of the road for space, one of which being the Convention on the International Regulations for Preventing Collisions at Sea (COLREGs). While not all the rules in COLREGs apply well to the space domain, several rules and principles could be adapted to help identify collision risks in a conditions-based approach, make decisions on which satellites should maneuver to avoid collision, and facilitate communication between operators to resolve confusion or disagreements. This methodology—which could be repeated with other norms, rules, or principles from any domain—provides an opportunity to get more specific and practical with norm proposals, looking to what has worked already on Earth and translating it to the physical and legal context of space.

Introduction

Imagine there are two ships sailing toward each other on the open ocean. It is nighttime and foggy, so the crews of each ship can only see the other vessel via radar. The ships' horns and radios are also broken, so the best way for the ships to communicate is for the captains to email each other, but they have to find the email address first. Furthermore, both ships were designed so that they cannot be refueled, so every bit of energy they use to maneuver out of the way cuts a chunk out of the operational lifetime of the ship. If you're steering the ship, what do you do? How do you know you are at risk of collision? Who should move out of the other's way? How do you communicate your plans? Satellite operators face these challenges every time one of their satellites are predicted to potentially collide with someone else's satellite. If satellites do collide, the resulting debris travels at thousands of kilometers per hour and can remain in orbit—threatening other satellites—for years or decades after the collision. In other domains, rules of the road help operators make decisions and take action to avoid collision, but these rules do not exist yet for space.

Understandably, many stakeholders have raised the need for some kind of norms, rules, or guidelines for activities in space. The actual creation of such rules of the road has been hard to achieve, and many fear that it will take some kind of catastrophe to generate the necessary political will. While there is broad consensus that norms are needed, there are deep divisions over *how* to develop norms. This in turn means that many existing efforts to define *what* the norms should be are broad, nonoperational, or confined to a single idea at a time.

If policymakers want to get to a broadly accepted set of rules of the road for space, they may need to consider the approach of drawing lessons from other domains. Such analogies can take concepts from norms or rules that already work in one environment and translate them to the physical and legal context of space. While some researchers have conducted broad surveys across many analogies from other domains at once, an alternative approach would be to analyze individual policies and treaties to identify specific principles that are translatable to space.

This paper conducts a deep dive on the Convention on the International Regulations for Preventing Collisions at Sea (COLREGs), providing both a demonstration of the methodology and a potential set of space norms.[1] COLREGs is a uniquely useful document to analogize to space because, unlike broader treaties such as the UN Convention of the Law of the Sea, COLREGs focuses exclusively on guidance for avoiding collisions.[2] This topic is highly significant for space without trying to cover all the challenges in the domain. Furthermore, as a maritime document, COLREGs exists in a legal environment that is more comparable to space than the air domain: While responsibility for air traffic control around the world is divided among states, both sea and space include vast swaths of the domain (for space, the entire domain) where no national actor has sovereignty or responsibility and collision-avoidance decisions are up to the individual operators.[3] This analysis is not a one-for-one translation of COLREGs to space; some rules within COLREGs do not transfer well but those that do are worthy of a closer look.

Although the situation described in the beginning of this paper would be exceedingly rare at sea, COLREGs provides guidance for how to operate in a low visibility environment, highlights multiple paths for communication, and gives directions on how to respond if other safeguards fail, all of which could make similar situations in space less dangerous. The rules in COLREGs could help inform space rules on how to mitigate risks and avoid collisions, providing a model for similar examinations of key norms in various domains and how to apply them to improve space safety and sustainability.

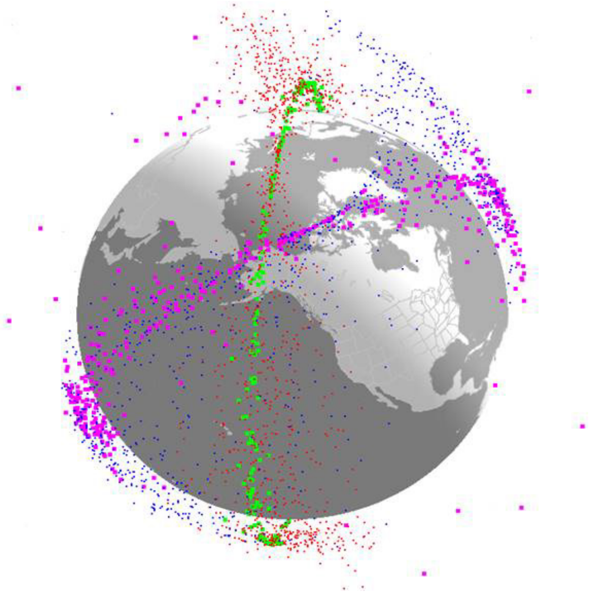

Figure 1: What a "Crash" Looks Like in Outer Space. *This graphic shows the distribution of debris from mid-2009, months after the crash between an Iridium communications satellite and a defunct Russian Cosmos satellite in January of that year. The purple and green dots represent tracked debris larger than 10 centimeters from the two satellites. The red and blue dots represent modeled smaller debris down to one centimeter in size that could still be fatal to spacecraft. The dots are not to scale, representing the amount and position of the debris, not the size.*[4]*.*

COLREGs Lessons Learned for Space

After centuries of human activities at sea and decades of attempts to start codifying some of the widely accepted practices and behaviors in the maritime domain, states gathered under the auspices of the International Maritime Organization (IMO) to negotiate the 41 rules comprising the 1972 COLREGs.[5] This convention, in the midst of the Cold War, updated and replaced the Collision Regulations of 1960 and joined the larger pantheon of international law and regulations related to the maritime domain while being particularly focused on identifying, acting, and communicating to avoid collisions. The rules include sections on steering and sailing, lights and shapes, sound and light signals, exemptions, and verification of compliance. As of 2023, 164 "Contracting States" have signed, ratified, or acceded to the treaty, representing nearly 99 percent of the gross tonnage of the world's merchant ships.[6] The rules are robust, broadly adopted, and have been implemented for decades, all qualities to strive for in developing comparable rules of the road for space. Given the high consequence of accidents in space, it would be unwise to wait centuries for rules to develop, and COLREGs could provide a way to jump ahead in the process. The following section discusses select rules and principles from COLREGs and evaluates how well they could translate to space.

Identifying Risk of Collision

The first step in avoiding a collision in any domain is recognizing that a collision might happen. This is naturally much easier to do in two dimensions than three, easier when an object is traveling 27 kilometers per hour instead of 27,000, and easier when you can look at the other ship to directly observe what is happening than when you have to rely on computer readouts of sensors hundreds or thousands of kilometers away from the objects they are observing. Numerous technical challenges exist to identifying a situation in space with a high risk of collision. (Potential collisions in the space domain are often referred to as *conjunctions*). In fact, the often-discussed proposal of identifying a "minimum safe distance" between satellites is not practical given the way orbits affect movement: Objects that are close to each other may never collide if they are on the same orbit, while objects on other sides of Earth may be minutes away from collision if their paths intersect at the wrong time.[8] "Safe speed" is another term with little meaning in space. Terrestrial notions of acceleration do not apply in space because "speed" in orbit is determined by the altitude and shape of the orbit.

> ***"Every vessel shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. If there is any doubt such risk shall be deemed to exist."***
>
> —Part B. Steering and Sailing Rules
> Section I. Conduct of Vessels in
> Any Condition of Visibility
> Rule 7. Risk of Collision[7]

However, COLREGs does not attempt to define a "safe distance" or a "safe speed." Those terms are mentioned but are not assigned a specific number. Instead, the convention establishes a series of criteria to help the operators of vessels decide which situations are at high risk of collision or not. These conditions include, but are not limited to, the state of visibility and the effectiveness of radar equipment, the maneuverability of the vessels in question, and the presence of navigational hazards (including those that may not be detectable given the available equipment). Many of these conditions are directly translatable to relevant concerns in space. Just like mariners, space operators must contend with problems related to "visibility," maneuverability, and environmental hazards.

- The state of "**visibility**" could easily be compared to the operator's space situational awareness (SSA) and the accuracy, precision, and reliability of the sensors and algorithms the operator is using to maintain SSA. Situational awareness can be limited if operators do not have access to sensors or data on where satellites are and how they are moving. Furthermore, SSA is still a technically challenging field as sensors are observing objects of varying sizes, moving incredibly quickly, from hundreds or even thousands of kilometers away.
- The **maneuverability** of any satellite is limited because, historically, satellites have not been refuellable, and maneuverability can vary based on how efficient a satellite's propulsion technology is and how much fuel the satellite has onboard. Even if a satellite has the capability to conduct a given maneuver, operators must consider how that maneuver may detract from their ability to operate or maneuver in the future, which can make operators reluctant to move if they think the risk is low enough. The capacity to maneuver can have a major effect on operator decisions on whether a potential collision is risky enough to move to avoid, and this issue may become more acute as orbits become more crowded. Maneuvering a satellite whenever a conjunction has a mild probability of collision becomes less feasible if thousands of conjunctions reach that probability every year.
- Finally, as vast as space is, plenty of **environmental hazards** exist, ranging from space weather to orbital debris, that could disrupt or damage a satellite, and many fast-moving, potentially destructive debris objects are too small to track given current technology. It is also important to note that the geometries of potential collisions and the degree of crowding varies in different orbital regimes, so the conditions and concerns may need to be treated differently between low Earth orbit (LEO), geostationary orbit (GEO), cislunar space (operations beyond the GEO belt in the Earth-moon system), and other regimes.

The COLREGs conditions-based approach, instead of a distance- or speed-based approach, also complements the metric used to determine collision risk in space today. Operators currently look for a probability of collision based on where and when the paths of two space objects are expected to intersect and the margin of error for their predictions. If the probability is higher than a certain percentage, the operator determines the risk of collision is high enough to maneuver. For example, the International Space Station considers a probability of collision greater than 1 in 100,000 to require mitigating action.[9] Incorporating factors that affect risk of collision into rules of the road for space agree with both the maritime rules and current space practices. Clarifying and communicating what those factors are can ensure sound decisionmaking by individual operators and improve understanding between them. Even when operators have different tolerances or preferences, a set of rules of the road could help operators speak the same "language" and could help set prioritizations to guide dispute resolution.

The key takeaways from COLREGS and potential space translation of those rules for identifying risky situations or potential collisions are summarized in Table 1.

Table 1: Identifying Risk of Collision

Maritime Rule	Space Translation
No universal defined safety distances	No common “minimum safe distance”
Conditions-based approach to identify collision risks: ◆ State of visibility and radar equipment ◆ Maneuverability of the ship ◆ Presence of hazards	Conditions-based approach to determine risk of collision: ◆ Space situational awareness capability ◆ Spacecraft maneuverability ◆ Presence of debris and space weather hazards

Deciding Who Moves and How to Move

After recognizing that two satellites are at enough risk of collision that at least one has to maneuver, the following questions must be addressed: Which satellite should maneuver? Are there any requirements or constraints on how the maneuver should be conducted?

> ***“Any action taken to avoid collision shall, if the circumstances of the case admit, be positive, made in ample time and with due regard to the observance of good seamanship.”***
>
> —Part B. Steering and Sailing Rules
> Section I. Conduct of Vessels in
> Any Condition of Visibility
> Rule 8. Action to Avoid Collision[10]

As with identifying collision risk, COLREGs provides a multifaceted approach to determining right of way. Besides the clearly maritime-specific rules pertaining to wind direction for sailing vessels and two-dimensional angles of approach, one particularly useful rule is the concept that the more maneuverable vessel should give way for the less maneuverable vessel and for any ships that are actively fishing. This is determined not by a technical, specific measurement of maneuverability but by identifying overall classes of ships: power-driven vessels should move for sailing vessels, which should move for fishing vessels, which should move away from any non-maneuverable “vessel not under command.”[11]

This approach, categorizing ships by maneuverability and activity, can and already has been applied to space. In March 2023, the Space Safety Coalition updated its “Best Practices for the Sustainability of Space Operations,” including a matrix of which spacecraft should move to avoid a potential collision. There are five categories: (1) non-maneuverable, (2) minimally maneuverable, (3) maneuverable, (4) automated collision avoidance, and (5) crewed.[12] Nonmaneuverable objects, which include orbital debris such as meteoroids, defunct satellites, used rocket bodies, and pieces remaining from broken-up spacecraft, always have the “right of way” from a physics standpoint. The choices facing any satellite on a path to collide with a non-maneuverable object are to move or get hit. For the other categories of maneuverability, the more maneuverable objects or those with automated collision avoidance are expected to move. The one exception to the maneuverability matrix is the crewed station category, which tends to move out of the way, regardless of relative maneuverability, out of an abundance of caution to protect the people onboard.

Defining “minimally maneuverable” is particularly important for space rules of the road because the reduced likelihood of having to maneuver could be seen as an incentive for operators to claim their satellites are less maneuverable than they are. The Space Safety Coalition attempts to resolve this by using a fairly technical definition in its Best Practices document: "Only able to perturb one's orbit to a very small degree, e.g., using low duty cycle low-thrust maneuvers or differential drag perturbations."[13] Creating broad capability categories like these reduces the need for precise information to calculate which of a pair of satellites is more maneuverable; instead, it narrows down the number of conjunctions that require "negotiation" or decisionmaking. It is only when both satellites are in the same maneuverability category and both are either in transition or in their operational orbit that the operators need to come to a new agreement on who should move.

Parallel to the recognition of fishing boats as a category requiring different right-of-way practices, the "maneuver rules" matrix in the Space Safety Coalition Best Practices document also accounts for how certain mission or activity types may require different right-of-way practices. The document recommends that satellites moving into or out of their mission orbit should yield to those already in their mission orbits. This framework for yielding could help minimize disruption to satellites that are actively performing their missions. The Best Practices also recognize that crewed vehicles with humans onboard are often more risk-averse than non-crewed satellites, so that crewed vehicles typically prefer to move out of the way, even of more maneuverable vehicles, or to create bilateral agreements with satellite operators determining who moves.

That last point, prior agreement, is not recognized in COLREGs but is worth noting here. The predictability of orbital movements and the increasing use of automation in collision avoidance means that right of way does not always need to be determined on an individual incident level. NASA and SpaceX, for example, signed a memorandum of understanding stating that Starlink satellites will maneuver to prevent collisions with NASA science satellites.[14] Limitations on space situational awareness mean that these agreements cannot necessarily be taken for granted: even those satellites designated to not maneuver may still need to watch closely to ensure that conjunctions are being identified and avoided. However, provisions for prior agreements can help to provide the flexibility needed when creating rules of the road based on categorical distinctions for maneuverability and mission.

As the Space Safety Coalition Best Practices indicate, parts of the space community are already drawing from right-of-way models similar to what is established in COLREGs. What has not yet been explored much on the space side is the question: What happens if the satellite that was supposed to maneuver does not appear to be doing so? Given limitations in space situational awareness and the complexity posed by the different data used among space operators, how do the operators of the maneuvering satellite demonstrate to the satellite maintaining course that they have successfully taken action? COLREGs includes a provision that the vessel that is supposed to maintain course still has a responsibility to maneuver if it appears that the other has not moved or has not changed course enough to avoid the collision. This could be an important provision in space rules of the road to ensure that operators remain vigilant even if they expect the other satellite to move. However, because constraints on maneuvering capability can significantly affect how long it takes to initiate or complete a maneuver, the rules of the road may need to include parameters or factors for decisionmaking to help determine whether maneuver plans need to change. This could mean setting an amount of time prior to the predicted conjunction when, if the vehicle that was supposed to maneuver has not yet begun to do so, the other satellite would move.

The three maneuvering factors are highlighted in Table 2.

Table 2: ***Deciding Who Moves and How to Move***

Maritime Rule	Space Translation
The more maneuverable vessel should take action to avoid collision (categorically, in ascending order: vessel not under command < fishing < sailing < powered vessel).	More maneuverable spacecraft should typically maneuver to avoid collision (categorically, in ascending order: debris/non-maneuverable spacecraft < minimally maneuverable < human-operated maneuver < automated collision avoidance).
Vessels may need to maneuver to avoid vessels while they conduct certain activities, like fishing, that make them more vulnerable or less maneuverable.	Spacecraft not in mission orbits should yield to those that are, agreements or identification of spacecraft more or less able to maneuver due to their payload or mission set.
Continued responsibility for any vessel to maneuver if the other does not appear to have taken enough action to prevent collision.	Continued responsibility to monitor and maneuver if the other spacecraft does not appear to have maneuvered to avoid collision, up to or including the provision of a decision time prior to the predicted conjunction.

> ***"When vessels are in sight of one another, a power-driven vessel underway, when maneuvering as authorized by these Rules, shall indicate that maneuver by the following signals on her whistle:***
>
> - ***One short blast to mean 'I am altering my course to starboard';***
> - ***Two short blasts to mean 'I am altering my course to port';"***
>
> —Part D. Sound and Light Signals
> Rule 34. Maneuvering and Warning Signals[15]

Communication Practices

Communication is vital in all domains to prevent misunderstandings and collisions. Yet this category is one of the most difficult to translate to space. Communications in COLREGs are designated for many purposes. Signals, sounds, and lights are used to indicate in which direction a ship might be moving to avoid collision, whether the ship has any difficulties maneuvering and whether the ship is in distress or needs assistance. Most of the communications established in COLREGs are for direct interactions between ships. In space, however, satellites from different constellations or with different operators do not typically communicate directly. Operators in ground stations located around the world must communicate through much more remote means, such as email or phone. Missed connections for space operations could increase the risks of accidents, misunderstandings, or unnecessary maneuvers. Also, it is often difficult to know whether failure to make contact is because of wrong contact information, wrong timing, or a refusal to respond.

Although the direct means of communicating established in COLREGs do not exactly translate to space, the concept of having internationally agreed upon means of contact could provide significant value for preventing satellite collisions. For example, the 1975 Registration Convention is a treaty requiring signatories to send the United Nations information on objects launched into space, including orbital parameters.[16] However, it does not require any information on how to contact the operators of the objects. Provisioning for a "contact list" that is shareable at least among operators could facilitate more direct, efficient, bottom-up approaches to preventing collisions.

Making contact information available does not mean an attempt to contact will be received or even answered. According to senior U.S. defense officials, Russia and China often do not answer calls or emails related to space collision warnings.[17] When Starlink satellites passed by the Chinese space station in 2021, China claimed to have attempted to contact Starlink and the United States, but the United States replied that neither the government nor SpaceX had received any attempts to communicate.[18] A norm on providing contact information could at least make it easier to identify whether a failure to respond is deliberate.

However, this "point of contact" norm would likely need to be supplemented with standards for communications infrastructure. This could include operator commitments to respond to contact attempts—even if only to acknowledge receipt—in a timely fashion. The definition of "timely fashion" could be different for space than at sea. Potential collisions are sometimes predicted days or weeks in advance in space, so responses would not need to be within minutes so long as there is ample time before the predicted conjunction. The collision avoidance maneuvers themselves can take hours or longer, and the two operators may need to resolve disagreements on the likelihood of collision. Rules related to operator "self-awareness," such as a frequency of updates to operators from their satellites could also help with timely recognition and communication of issues. Additionally, the role of automation versus human-in-the-loop in satellite operation and collision avoidance would need to be considered, but some level of standardization or access to common means to communicate could at least remove one hurdle.

Numerous examples exist of attempts to improve space operator communications. The Space Data Association (SDA) operates the Space Data Center, which provides members of the association with collision avoidance monitoring and maneuver validation, radio frequency interference mitigation, and operations center contact information for participating satellites.[19] The data comes from the Space Data Association members and for the time being is limited to 31 spacecraft operators, including 763 spacecraft across all orbital regimes, indicating significant room to grow in order to span the hundreds of operators and thousands of spacecraft in orbit today.[20] Similarly, the European Union's Space Surveillance and Tracking (EUSST) network not only provides warnings of potential conjunctions to EUSST registered operators via email or telephone but also helps to facilitate communications with operators when maneuvers are required.[21]

Satellite operators can make other efforts when direct attempts at communication fail. Similar to maritime domain distress signals like flares, designated radio frequencies, or "SOS," space backups to direct operator contact could include means of "broadcasting" satellite position and telemetry data or raising the alarm over potential collisions. Some satellite operators have already taken the initiative to publicly share information on their satellites to reduce the risks of noncooperative collision avoidance maneuvers. When Intelsat was unsatisfied with attempts to communicate and resolve concerns about a Russian satellite closely approaching company satellites in 2015, it published planned maneuvers of its satellites online.[22] A new rule of the road could establish a new webpage or expand on existing networks or associations to create a procedure for operators to post maneuvers and location data if they are struggling with direct contact or need to reach a wider group of operators.

Another possibility for "broad" communication would be for satellites to have GPS (or other position, navigation, and timing signal-based) transponders that can transmit the spacecraft's position and minimize the guesswork involved in space situational awareness (SSA).[23] The International Maritime Organization has a requirement for all ships above certain tonnage to carry automatic identification systems (AISs) that can provide information to other ships and coastal authorities.[24] A similar system in space could reduce uncertainty and therefore reduce the number of collision avoidance maneuvers required. Transponders could also improve satellite identification and make it easier to contact and deconflict with the satellites' operators.[25]

There are several obstacles to the implementation of transponders as a rule such as installation costs (given the difficulty of adding hardware to any satellite already on orbit), sensitivity to sharing information on national security satellites, and limited availability of radio frequency spectrum. Because of these limitations it would not be practical to implement a rule that all satellites, especially those already launched or those with sensitive national security missions, must use transponders. However, even maritime regulations on transponders recognize that specific ship types, such as warships, are not required to be fitted with AISs and that rule functions despite these limitations.[26]

Because it is impractical to add transponders late in satellite design or after launch, some level of agreement or norm on transponder use would best be done sooner rather than later due to the projected growth in the number of operational satellites. Alternative or transitional approaches could provide incentives to encourage transponder use. A rule could call for satellites launched in the future to have transponders capable of sharing data with SSA systems in return for easier access to a range of SSA services or normative benefits of being recognized as a civil or commercial spacecraft. Rules of the road could be used to establish these incentives or transponder standards to make such adoption easier and more interoperable.

Table 3 reviews the multiple paths to improving communications for collision avoidance that could be translated from sea to space.

Table 3: ***Communication Practices***

Maritime Rule	Space Translation
Means of direct contact between ships	Accessible satellite operator contact list; timely response requirements
Emergency flares, "guard channel" emergency radiofrequencies	Procedures for publicly sharing telemetry data in emergencies or if direct contact fails
AIS transponders for civil/commercial ships	Incentives for transponders on civil/commercial spacecraft

What Might COLREGs for Space Look Like and How Might We Get There?

Not all obstacles to translating COLREGs for space are in the difficulties posed by the laws of physics: some challenges revolve more around the laws of humans. While versions of COLREGs prior to 1972 were considered customary international law based on consensus of maritime nations instead of being a formal legal instrument, the 1972 version of COLREGs was established as an actual treaty.[27] When creating rules and principles to prevent collision in space, the space domain faces several issues that could make it difficult to achieve the same status as COLREGs. With the notable exception of international regulations on use of the radio frequency spectrum, space diplomacy has failed to produce a new multilateral treaty with more than 20 signatories in nearly 50 years.

Even if the space diplomacy deadlock was resolved, numerous obstacles exist to creating and implementing international treaties writ large. Treaties require a high level of political will because they represent a binding sovereign commitment, and each country must pass the treaty through its domestic ratification process. The demands on precise translatable language are higher for treaties than for many nonbinding agreements. Furthermore, there are often complex concerns that are weighed in the incorporation of enforcement, verification, or dispute resolution mechanisms.

These challenges are frequently compounded in space due to the technical complexity of space operations, the lack of agreement on definitions for many key terms related to space, and the difficulty of observing and verifying many technologies and behaviors. It is also important to note the increasing role of non-state actors in space, particularly commercial actors. States are ultimately legally responsible for actions in space by private companies according to the Outer Space Treaty, and international treaties are generally negotiated and implemented by states. However, additional steps would need to be taken to ensure understanding and buy-in from diverse commercial actors or else the treaty might not be effective in practice or commercial actors might exert pressure against it. COLREGs addressed this issue by framing the rules around operator-level, not national-level decisions, so that buy-in could be bottom-up as well as top-down. However, any new set of rules would need to ensure that the guidelines for operator-level decisions actually align with operator experience, knowledge, and capabilities. Therefore, any effort to translate COLREGs to space would have to balance what is meaningful for improving space safety and sustainability with what is doable under the constraints of space diplomacy. There are several approaches by which this could be done.

Start With a Less Binding Diplomatic Mechanism: A voluntary set of guidelines, including one enshrined in a United Nations General Assembly resolution, could parallel the Long-Term Sustainability (LTS) Guidelines.[28] The 21 LTS Guidelines cover a wide range of space sustainability activities, including 10 guidelines for the safety of space operations such as “promote the collection, sharing and dissemination of space debris monitoring information” and “take measures to address risks associated with the uncontrolled re-entry of space objects.”[29] The potential rules or recommendations provided by a COLREGs translation to space could parallel and build off of the LTS Guidelines, an approach potentially made more appealing by the fact that the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) already has a working group exploring what the next phase of LTS Guidelines implementations should be and whether any new guidelines would be beneficial. Furthermore, the cornerstone of international space law, the Outer Space Treaty, started as voluntary principles adopted by the UN, indicating that starting with a voluntary UN approach for applying COLREGs to space could potentially lay the groundwork for a more formal legal agreement further down the road.[30]

Demonstration of Best Practices: Another approach would be to lead by example, either individually or in tandem with key partners and allies, instead of trying to build multilateral consensus from the outset. Bilateral partners aiming to establish rules of the road do not even need to be like-minded: The 1972 Incidents at Sea (INCSEA) agreement between the United States and the Soviet Union helped to routinize encounters between the two navies even during the tensions of the Cold War.[31] Partners also do not need to be states, as industry consortia and commercial operator-led efforts to develop standards and best practices have demonstrated.[32] This "lead by example" approach has the benefit of demonstrating which potential rules work in practice, not just on paper. However, the risk of a non-unified approach to rule and norm development is the emergence of multiple, competing visions of what those rules should be. These trends can be seen in Russian and Chinese opposition to the U.S.-led Artemis Accords and their subsequent attempt to make competing partnerships for lunar exploration.[33] In some circumstances, competing rules could be worse than no rules, so the approach of bottoms-up best practices for space rules of the road would need to account for how to encourage broad adoption and implementation down the line.

Adjust Treaty Objectives for Negotiability: One of the key obstacles to negotiating a treaty is lack of trust between the participants and the need for verification and enforcement mechanisms. So, if a treaty is the ultimate goal, adjusting the terms of the treaty to build confidence and reduce verification difficulties will be necessary. This could include using broader terms that are open to interpretation to assuage state concerns about the treaty constraining their behavior. This approach was taken in the broad principles of the Outer Space Treaty, which has allowed the treaty to remain the foundation of international space law until the present but has also left lingering questions of interpretation and the perception of a need for new rules of the road today.

Complementary Approach Focusing on Behavior: Another approach to making a treaty more workable would be to focus on rules for behaviors instead of rules for specific capabilities. The behavioral approach is favored by many countries, including the United States, in the United Nations open-ended working group on Reducing Space Threats through Rules, Norms, and Principles of Responsible Behavior.[34] Particularly in space, it is easier to observe behaviors than to identify the exact capabilities onboard a specific spacecraft, and, as more companies and countries develop SSA capabilities, more opportunities exist for collecting and sharing the information needed to verify space behaviors.[35] Even with these measures, the treaty process can be expected to be difficult, contentious, and not something that can come together quickly, especially because certain countries like China and Iran have objected strenuously to the term *responsible behavior* in space diplomacy.

Consider How and When Rules Would Be Enforced: In many domains, rules of the road are paired with international organizations that have some role in implementation, capacity building, or dispute resolution. The International Maritime Organization (IMO) facilitates COLREGs and other maritime organizations, while the International Civil Aviation Organization (ICAO) implements the Chicago Convention for international air traffic management. The International Telecommunication Union (ITU) already plays a key role in space by helping to coordinate and prevent interference for usage of radiofrequency spectrum by satellites and in allocating orbital slots in geostationary orbit. The lingering question some space policy researchers have raised is whether there needs to be a dedicated organization for international space traffic management.[36]

In the long run, if bottom-up approaches fail to result in unified implementation or if rules alone are insufficient, there may need to be a more robust organization for coordinating space traffic. At a time when multiple states are creating space agencies and military organizations dedicated to space, it may be logical to begin to pursue an IMO, ICAO, or ITU-like organization. However, such an organization, like any international regulatory organization, would require significant buy-in, and resources and would take a long time to establish. Any such effort would also have to account for various national organizations dedicated to space safety or regulations, particularly because the Outer Space

Treaty designates states as being responsible for authorizing and continuously supervising the actions of their nationals in space. An international organization cannot exist unless states are willing to give it authority, money, and staff, so it will be important to ensure that, if an international organization is pursued, those efforts would not conflict with or undermine faster-paced efforts to get common understanding and agreement on rules of the road.

Conclusion

For both the rules themselves and the means of establishing them, it all circles back to finding what is both achievable and meaningful for space safety and sustainability. Although no analogy is perfect, lessons from COLREGs and the maritime domain reveal several possibilities to kick start rules of the road for space. These include principles such as identifying and mitigating risk of collisions based on conditions instead of just distance, using factors like mission type and maneuver capability to determine which satellites should move, and establishing direct points of contact for space operators. These ideas alone are not ground-breaking or unheard of in the space community, but hopefully they can provide the opening bid in a more comprehensive discussion on not only why we need rules and norms for space but what those rules could be and how to develop them. With concerted and cooperative effort, those (space)ships will continue to pass each other in the night.

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