

## SYMPOSIUM ON THE NEW SPACE RACE

### SPACE TRAFFIC MANAGEMENT: STANDARDIZING ON-ORBIT BEHAVIOR

*P.J. Blount\**

As the number and intensity of space activities increase, so will the need for rules on Space Traffic Management (STM). Emerging technologies such as mega-constellations, which are satellite constellations consisting of hundreds or even thousands of satellites, may stretch the limits of the current informal coordination system. The goal of this essay is to discuss the critical elements of a system of STM that would, through standardization, establish trust in the resulting system. The standardization elements will be divided into three categories: data standards, processing standards, and legal standards. I argue that a system of STM requires standardized practices that are based on a strong technical foundation in order to enhance trust among space actors. After discussing the types of standards that are needed for STM, I turn to possible paths for achieving a globally effective STM system.

#### *What is STM?*

STM is a concept similar to air-traffic control. The goal of STM is to use technical and legal mechanisms to reduce the likelihood of incidents such as collisions in Earth orbit. There are various definitions, but all of them center on technical standards and legal rules that facilitate the coordination of space operations. For example, the International Academy of Astronautics defines STM as “the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from outer space to Earth free from physical or radio-frequency interference.”<sup>1</sup> U.S. policy on STM defines it as “the planning, coordination, and on-orbit synchronization of activities to enhance the safety, stability, and sustainability of operations in the space environment.”<sup>2</sup> At present, STM does not exist in any real sense. Outside of geosynchronous orbit, which is coordinated by the International Telecommunications Union, there are no formal procedures for the coordination of space activities.

#### *What is the Risk?*

Risk is central to our understanding of the law. One of the core roles of law in society is to reduce risk to individuals and entities by standardizing interactions for increased predictability. The regularity that the law provides in social interactions reduces risk by defining rights and obligations, which in turn set the parameters of responsible social conduct. The standardization function of the law helps to remove the guesswork from what other actors are

\* *Postdoctoral Researcher, University of Luxembourg; Adjunct Professor, University of Mississippi School of Law, and Montclair State University; Board of Directors, International Institute of Space Law.*

<sup>1</sup> INT'L ACAD. OF ASTRONAUTICS, [COSMIC STUDY ON SPACE TRAFFIC MANAGEMENT](#) 10 (2006).

<sup>2</sup> White House, [Space Policy Directive 3: Space Traffic Management](#), Sec. 2 (June 18, 2018).

likely to do in certain regulated interactions. In short, standardized behavior creates trust in transactions among entities.

With that basic function of law in mind, the outer space environment and the issue of STM comes into sharper focus. Space is governed by an overarching international treaty framework that sets out general principles for human activities in the space environment.<sup>3</sup> This framework has been elaborated by a patchwork of domestic laws, which vary in their comprehensiveness.<sup>4</sup> The resulting regime is loose and ambiguous in nature. From a military and strategic perspective, states often prefer the freedom of action that ambiguous regimes provide, but ambiguity translates into risk when viewed from a commercial perspective. As a result, one of the problems for commercial space activity is a lack of standardized interactions in the space environment. This is complicated by the fact that space is a strategic domain with deep military implications, which means that there is conflict between the ambiguity prized by military actors and the predictability needed by commercial investors.

This is not to say that military operators do not also benefit from standardized interactions. While states may prefer ambiguity in international law, military operators have long seen the value in standardized interactions that provide operators with reduced risk to their capabilities, reduced risk of inadvertent conflict, and a metric with which to judge whether certain behavior may be hostile based on nonconformity with accepted norms. Strategic thinking as a result requires military actors to balance freedom of action with the benefits that come from regulation. During the Cold War, this was achieved in space by coupling a loose legal regime with a strategic self-restraint built on mutual interest in the space environment.<sup>5</sup> While the Cold War showed the power of such mutual restraint, the post-Cold War era has seen the proliferation of new military, civil, and commercial actors in space. While the physical realities of space remain the same, the proliferation of space actors creates a situation in which there is no longer parity among the interests of states.<sup>6</sup> Additionally, as new technologies emerge, these various actors are beginning to engage in new space activities that have no baseline for standardized behavior. Further, the space environment lacks a regime to integrate new activities and new actors.

The space environment depends on cooperation and coordination in the space domain to avoid the degradation of that environment resulting from miscommunication among space actors. The concept of Space Traffic Management is centered around these needs, and it seeks to establish technical, legal, and normative rules for the operation of space objects. Such rules have the ability to standardize space operations and settle disputes before possible accidents on orbit occur.

### *The Elements of Effective STM*

There are three critical elements of effective STM: data, algorithms, and law. Each of these will be examined in turn.

The first element of STM is data. In order to effectively manage space activities, it is essential to have information about what is in orbit, where it is at a given time, and who (if anyone) controls it. This information is known as Space Situational Awareness (SSA) data. Currently, SSA data are collected through a variety of systems and by a

<sup>3</sup> Tanja Masson-Zwaan, *New States in Space*, 113 AJIL UNBOUND 98 (2019).

<sup>4</sup> Setsuko Aoki, *Domestic Legal Conditions for Space Activities in Asia*, 113 AJIL UNBOUND 103 (2019); Brian R. Israel, *Space Resources in the Evolutionary Course of Space Lawmaking*, 113 AJIL UNBOUND 114 (2019); Paul B. Larsen, *Commercial Operator Liability in the New Space Era*, 113 AJIL UNBOUND 109 (2019).

<sup>5</sup> See generally JAMES CLAY MOLTZ, *THE POLITICS OF SPACE SECURITY: STRATEGIC RESTRAINT AND THE PURSUIT OF NATIONAL INTERESTS* 44–47 (2008).

<sup>6</sup> Saadia M. Pekkanen, *Governing the New Space Race*, 113 AJIL UNBOUND 92 (2019).

number of different actors, but the U.S. Space Situational Network (SSN) is the most comprehensive and accessible of these systems.<sup>7</sup>

The SSN system is a network of sensors that collect on-orbit data. It is managed by the Combined Space Operations Center (CSpOC), which is part of the U.S. military's Joint Force Space Component Command. The primary mission of the SSN system is to protect military space assets and assure military access to space. However, CSpOC has been statutorily authorized to share these data globally.<sup>8</sup> This sharing is designed to protect national security by making available the most sensitive SSA data only to other U.S. government entities and allies. The most widely available data, on the other hand, only contain what is known as the Two-Line Element sets, which carry the most basic information on the location of an object in orbit, and are publicly available through Space-Track.org with the creation of a user account.<sup>9</sup>

While the SSN system is the most comprehensive source of SSA data, there are other states, notably Russia and China, that also collect SSA data. Some nonstate entities such as the Space Data Association (SDA) collect these data as well. SDA is an organization of satellite operators that share SSA data with each other. Notably, SDA has signed an agreement with CSpOC for bilateral sharing of data between the two. There is, however, no comprehensive data pool for SSA data, and much of the data is still considered sensitive and restricted.

Foundational to any proposed STM project are data, and the data must be standardized so that actors within the system can access them and contribute their own data. Further, data integrity must be maintained within the system to avoid mistakes. This means that a multilateral STM system will need to adopt data standards to integrate data from multiple sources and compile it into a single database. Since SSA data are currently collected by various entities using a variety of sensors, ensuring that the data are harmonized will be important. Additionally, STM will require an open data system so that data are public and verifiable. The need for openness is rooted in trust. STM will require some satellite operators to move their on-orbit assets in order to avoid conjunctions with other space objects. If the data underlying the decision-making process are unavailable to operators, then they may balk at requests to maneuver on orbit. The ability to verify data is implicit to trust in that system. Of course, this is not so easy to implement. Currently, most states collecting SSA data do so for national security reasons, and importantly the three major collectors—the United States, China, and Russia—all maintain adversarial positions in relation to the others. Additionally, the data that are publicly available are incomplete at best. An open data structure will need to find a way to balance between openness and national security concerns.

The second critical component of an effective STM system is processing the collected data so that judgements can be made. SSA presents a “big data” problem. SSA sensors do not constantly watch a given space object in orbit. Instead, they sense and measure objects as they pass. These data are then processed using algorithms that predict the orbital trajectory of an object until it passes another sensor and the data can be updated. As part of its SSA mission, CSpOC performs this analysis and shares the results with operators whose spacecraft may be in danger of a conjunction. These predictions can be inaccurate or missed if there are flaws in the underlying algorithm. For instance, in 2009, the satellites Iridium 33 and Cosmos 2251 collided in orbit in the first recorded collision of two intact satellites. Notably, neither operator was notified that there was a potential for the two crafts to collide. This was in part due to the fact that the U.S. military had not included the Iridium constellation on its list of priority satellites, which raises questions about the processing standards used to model the space environment.<sup>10</sup>

<sup>7</sup> See generally Tiffany Chow, [Space Situational Awareness Sharing Program: An SWF Issue Brief](#) (2011).

<sup>8</sup> 10 U.S.C. § 2274.

<sup>9</sup> Chow, *supra* note 7, at 4–6.

<sup>10</sup> Brian Weeden, [Billiards in Space](#), SPACE REV. (Feb. 23, 2009).

The methods used to model the space environment must be effective in accurately predicting potential on-orbit conjunctions. To a large extent, the algorithm's success rate will be based on the underlying data that are collected, but the algorithm used to process that data into a model of the space environment will need to be carefully designed as well. Missing potential collisions or providing an inordinate number of false positives could cause operators to lose faith in the STM system itself, which could lead to ineffectiveness. As a result, the modelling methods will need to be continually refined to ensure that there is integrity in the results. Those methods should also be open so that the results can be verified. Openness here, again, serves the end of creating trust in the system.

The third element of STM is legal standards. As noted above, CSpOC notifies operators when their satellites are at risk, but it has no authority to compel an operator to maneuver to avoid a collision. Interestingly, from a U.S. perspective, no federal agency currently has the authority to compel an operator to move an object in orbit. This jurisdictional hole is the result of U.S. space regulations being fragmented across multiple agencies, and the problem grows when it is transposed into the international context. While CSpOC can notify another operator or that operator's state authority, there is no guarantee that either will react and no legal requirement that either do so.

Therefore, having legal standards and rules for when a spacecraft must maneuver to avoid another object becomes critical. This is important because maneuvering on-orbit is costly in terms of fuel, meaning that the life of the spacecraft is shortened. Some operators may choose to take the risk of collision rather than expend available fuel, such as when the satellite is already close to the end of its life. In such cases, while the loss to the operator may make economic sense, the damage will increase risk for all operators in or near that orbit. As a result, legal standards are needed to ensure that all operators behave responsibly on-orbit and have a clear understanding of what constitutes responsible behavior.

The need for legal standards exists at both the domestic level and the international level. On the one hand, a domestic authority is the most likely actor to be able to compel an operator to behave a certain way on orbit, and STM rules should be made a clear part of the licensing procedure. On the other hand, international cooperation and coordination is needed so that national authorities know when they are required to act in this capacity. Legal standards are not just important to compelling an operator, but they also serve a critical role in dispute resolution both pre- and postconjunction.

### *Moving Forward*

The biggest obstacle to STM is not data, or algorithms, or even law. The main obstacle is trust. Creating a multilateral system requires design that instills trust in the users of that system. A notable problem is, of course, the presence of adversarial relationships among the United States, China, and Russia, who would likely need to be both the biggest contributors of data and the biggest consumers of benefits from STM. This section will attempt to define how an international system for STM might emerge.

First, any STM system, whether national or international, must be built upon strong, open data and modelling. Without this foundation, the legal system will suffer from an inability to properly identify situations in which action should be required. Integrity of the technical system is paramount to the legal system, in whatever form it emerges. While states may be wary of full openness for national security reasons, there is no need to compel states to share sensitive data or algorithms. A multinational data pool could help to fill gaps, and algorithms could be developed outside the national security context.

Second, political limitations must be taken into account. While the most effective way to establish uniform STM rules with global coverage would be through a treaty that establishes an intergovernmental organization for such purposes, such a solution is very unlikely to materialize, as currently states seem to be unwilling to move forward on a variety of proposals for increasing collective security in space. This means that an international framework for STM will likely emerge bottom up, that is, its source will not be the result of direct negotiations among states.

Instead, it will bubble up from the domestic level through state legislation, judicially made liability rules, and best practices among operators.<sup>11</sup>

A likely path begins with the U.S. SSN system.<sup>12</sup> There have been efforts in the United States to move the function of working with operators from the military to a civilian agency. The most recent action has been the issuance of Space Policy Directive-3 on STM, which calls for the function to be moved to the Department of Commerce. While the establishment of such a system requires Congressional action, it would open the door for U.S. leadership in STM, especially if the United States ensures that the system is based on clear, open data and modeling. The U.S. could domestically promulgate STM regulations that would clearly indicate responsible behavior for spacecraft within its jurisdiction. Obviously, these regulations would only apply to operators within U.S. jurisdiction, but the provision of an open, clear data source as a global public good could have a huge influence on the rules that operators from different states establish. For instance, courts in other states might look to U.S. practice to determine liability issues since U.S. practice would be one of the few places that a court could look to make a determination as to the negligence of a spacecraft operator.

As the rules that emerge solidify into best practices, it will become easier for states to come to consensus on the norms, rules, and protocols that will govern STM at the international level. A gradual emergence of the law, especially in a highly technical and militarily strategic domain, will be more palatable to states. It will, of course, require leadership from one of the larger space actors—such as the United States—that is willing to maintain an open model of the space environment.

Such a system will help commercial entities understand the risks they face so that they are better able to court investors, but it could also have major benefits for military actors. The establishment of legal rules of behavior will make all satellites, including military satellites, safer. Such rules of the road also give military actors a metric with which to measure whether an act might be hostile or not.<sup>13</sup>

As space technology continues to push new frontiers in applications from Earth orbit, congestion of the space environment will only increase. This means that an STM system will be necessary to coordinate the numerous spacecraft operators. These standards in turn need to be based on a strong technical foundation to ensure that those regulated by the system also trust it.

<sup>11</sup> Israel, *supra* note 5, at 118–119.

<sup>12</sup> For a fuller assessment of this idea, see [Space Traffic Management: How to Prevent a Real Life “Gravity”](#); Hearing Before the Subcomm. on Space of the H. Comm. on Science, Space, and Technology, 113 Cong. 113–74 (2014) (written testimony of P.J. Blount, Adjunct Prof., Air & Space Law, Univ. of Miss. Sch. of L.).

<sup>13</sup> Matthew T. King & Laurie R. Blank, [International Law and Security in Outer Space: Now and Tomorrow](#), 113 AJIL UNBOUND 125 (2019).