

A sustainable geostationary space environment requires new norms of behavior

Thomas G. Roberts^{1,2,*} and Carson Bullock²

Edited by Robert Tomos Johanson and Anthony Tabet

HIGHLIGHTS

- The absence of norms of behavior in space poses a threat to peaceful satellite operations.
- Established space actors are resisting the adoption of new norms.
- Historical satellite behavior can inform new norms such as the establishment of a minimum approach distance in the geostationary belt, which can contribute to the identification and stigmatization of highly abnormal behaviors.

Modern life is increasingly dependent on space technologies such as satellite communication, positioning, and remote sensing, but the political system that has enabled these advances remains fragile. In this essay, we highlight normative contestation—disagreements between space stakeholders in how operators should be expected to behave—in the geosynchronous orbital regime (GEO) as a threat to a secure and sustainable space domain. This conflict stems primarily from the interactions between limited resources (e.g. physical space, electromagnetic spectrum assignments) and the emphasis on maintaining total state sovereignty and independence of policy in the international arena. To preserve the peaceful use of the GEO regime, space actors must act soon to establish norms of behavior that dissuade maneuvers which place satellites close together on orbit.

Outer space is becoming crowded. Although operators have a wide field of choices for the trajectory of their Earth-orbiting satellites, not all orbits serve the same mission objectives. Space mission requirements typically determine a satellite's preferred orbital regime. For Earth-observation satellites, low altitudes are preferred to high ones. For communications missions, the geosynchronous orbital regime (GEO) is particularly useful.^[1] In GEO, satellites orbit the

Earth at the same rate that the Earth rotates around its axis, making them appear nearly stationary in the sky for observers on the ground. Because this special property exists only along one ring around the Earth—the geostationary *belt*—real estate in GEO is a finite resource. As mega constellations—networks made up of thousands of satellites—begin populating the lowest-altitude orbital regimes over the next decade, GEO, too, is expected to grow more congested.^{[2][3]}

A more congested space environment poses unique challenges in all orbital regimes. In general, more objects in orbit lead to an increased risk of collision for satellites, which in turn contributes to the growing space debris problem in the domain. In low altitude orbits, satellite collisions—including the notable 2009 collision between a U.S. commercial satellite and a retired Russian communications satellite—have already created thousands of pieces of debris that last years in orbit.^[4] Although the risk of on-orbit collision is much lower in GEO than other orbital regimes, satellites must still confront the consequences of a more congested space environment. Neighboring satellites in the geostationary belt are getting closer and closer together.

Role of Norms

To mitigate the complications of congestion both in the geostationary belt and other orbital regimes, many players in the space sector advocate for explicit norms of behavior.^[5] Norms are often defined as “standards of proper or acceptable behavior [that] establish expectations and clarify misbehavior.”^[6] Critically, norms should be distinguished from behaviors that are merely common; regular occurrence is a necessary condition, but it lacks the internalization, routinization, and expectation of adherence that true norms display. Under this definition, most space activities—including close approaches in GEO—are not bound by any universally-accepted norms. Norms should also be differentiated from laws, which are equipped with legally-binding enforcement mechanisms. This distinction is subtle, as norms and laws can be cyclically related; unspoken and internalized norms of behavior can lead to the creation of formal laws, and the existence of formal laws normatively promote certain behaviors over others. Critically, as we have defined them, norms are informal and non-binding, but can still generate consequences when broken. Clearly identifying states that fail to follow norms may discourage other operators

¹Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, MA

²Technology and Policy Program, Massachusetts Institute of Technology, Cambridge, MA

*Email: thomasgr@mit.edu

The authors declare no conflict of interest.

© 2020 The Author(s)



Figure 1: The geostationary belt. As of January 1, 2020, the U.S. Space Command's Combined Space Operations Center (CSpOC) database contains the orbital elements for nearly 800 satellites in GEO. The black points represent satellites launched within the past five years. *Data Source: U.S. Space Command Combined Space Operations Center / Space-Track.org.*

from forming cooperative partnerships with them and may also impede negotiations with their suppliers due to concerns about associating with “bad actors.” While internationally recognized space law does exist, space policy experts, including some state delegations to the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), generally agree that the existing body of law is insufficient to guide operators’ behavior, with much of it having been written forty to fifty years ago.[7] This body of international law principally includes four core agreements with widespread accession: the Outer Space Treaty (1967), the Rescue Agreement (1968), the Liability Convention (1972), and the Registration Convention (1975).[8] These laws lack enforcement power, and moreover, were written in anticipation of future conflict at a time when established norms of behavior had not yet been created, and thus they can be seen as taken less seriously than counterpart laws which are built on a pre-established shared understanding of right and wrong. Since the international legal framework for space conflicts is less evolved than those for the land, air, and sea domains, and because law progresses very slowly on the basis of consensus, any new international treaties will still necessitate the definition of norms of behavior to effectively promote responsible use of outer space.[9]

When, why, and how new norms are created has been the subject of lively academic discussion since the 1990s. According to the pioneering work by Martha Finnemore and Kathryn Sikkink, international norms undergo a three-phase lifecycle: 1) emergence, wherein the norm begins with just a few influential actors; 2) cascade, wherein the norm grows in acceptance until they reach a critical mass of proponents and become seen as typical behavior; and 3) internalization, wherein, the norm has become so routine as for its adherence to be assumed and it is no longer the subject of any significant contestation.[10] While some literature suggested a natural evolution through these phases over time, more recent works have increasingly characterized norm change as an intentional process brought about by individual stakeholders.[11] Originally developed for application in the field of sociology and behavioral economics, so-called norm entrepreneurs actively encourage the spread of certain norms. This notion of norm entrepreneurship, in turn, led to the conceptualization of norm “antipreneurs” who resist changes

to the norm status quo. The antipreneur framework has been explored to describe the failure of norms to reach cascade or internalization, in the contexts of disarmament, international trade, and democratization.[12][13] This theory has gained traction in the outer space domain because states that have enjoyed the greatest presence throughout history—the United States and Russia—have incentives to preserve the status quo because it has been historically shaped by them for their own benefit. For example, while those states with low access to space have recently acted as norm entrepreneurs in international fora by pushing for modifications to space law to promote equal access, more established space actors respond with antipreneurism by emphasizing the sufficiency of existing space law and the unwillingness to support change.[14]

A New Normal in GEO

There is no internationally agreed-upon minimum separation distance between non-cooperating satellites in GEO.[15] Most satellites maintain safe distances of over 200 kilometers from their nearest neighbors in the geostationary belt.[16] Over the past five years, however, some satellites have made a pattern of getting much closer to their neighbors—distances on the order of 10 kilometers—prompting other satellite operators to make public comments expressing concern.[17] While occasional, short-lived close approaches are often an unintended side effect of operating in a densely populated orbital regime, an intentional, long-duration close approach with a non-cooperative satellite could be interpreted as nefarious behavior. Satellites that are designed to closely approach other satellites could be used for on-orbit visual inspection, receiving another satellite’s communications, or more seriously, as part of an attack designed to disrupt, degrade, or destroy a target.[18]

To take full advantage of the geosynchronous orbital regime, satellites must use station-keeping maneuvers—periodic trajectory adjustments performed by onboard engines—to maintain their positions in the geostationary belt. When a satellite fails to station-keep—either by its operator’s choice or when it reaches the end of its operational life and has expended all of its onboard propellant—its orbital period falls out of sync with the Earth’s rotation due to a combination of external

forces from the Moon and Sun, and it appears to slowly drift in the sky for observers on the ground.[19] The same onboard propulsion system that is used to station-keep, however, can also be used to efficiently reposition a satellite from one longitude on the geostationary belt to another.

Unlike other orbital regimes, satellite positions in GEO are regulated by the International Telecommunications Union (ITU), a specialized agency of the United Nations. Charged with preventing harmful interference in the radio-frequency spectrum, the ITU allocates satellite licenses to member states. A geostationary satellite license from the ITU grants states the right to communicate in select bands of radio frequencies from specific positions in the geostationary belt, which they can then apportion to individual operators.[20] Without the ITU's regulatory framework, GEO satellites might attempt to communicate with their ground stations over the same frequencies from similar positions in space as their neighbors, confusing receivers on the ground, and jeopardizing the satellites' missions. Due to the geometry of the geostationary belt, orbital positions can be measured in degrees corresponding to the longitude of the point directly below on the Earth's equator. The ITU licensing system also assigns satellites to orbital slots, or small sectors of the geostationary belt, generally about 0.1 or 75 km wide.[21] A GEO satellite at 78.5W, for example, appears directly overhead for observers in Quito, Ecuador. At an altitude of almost 36,000 km, satellites in GEO can observe approximately one third of the Earth's surface, so a satellite at 78.5W is also well-positioned to serve the United States and Canada. Although the ITU frequency licenses only hold for their corresponding orbital slots, satellite operators often choose to maneuver and operate in other parts of the geostationary belt not covered by their original ITU license.[16] In those cases, operators may choose to take over an existing license held by the same ITU member state, not communicate with ground stations while in the new orbital position, or disregard the standards put in place by the ITU.

Although many satellites operate at one longitude for many years, others reposition themselves as their mission requirements change over time. Operators are not required to report satellite maneuvers. So, while some satellite operators publicly declare their plans to reposition their satellites, either through press releases, public filings, or by maintaining an online maneuver schedule, others do not.[22][23][24]

In 2015, a Russian satellite known as both *Luch* and *Olymp-K* maneuvered from 96.4E to 17.9W and positioned itself between two Intelsat satellites, getting as close as 10 km to both satellites between June and September of that year.[16] Intelsat—a U.S. commercial satellite operator with more than 60 satellites in GEO—quickly expressed concern about the incident. In an interview with *SpaceNews* in October 2015, after *Luch* had maneuvered to another location, a senior Intelsat executive called *Luch*'s behavior "not normal" and "irresponsible," a rare public rebuke of a foreign satellite operator's on-orbit activities.[25] Although there are mechanisms in place for international satellite operators to

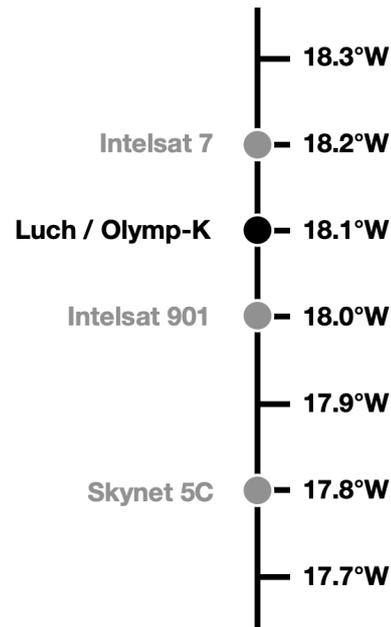


Figure 2: A portion of the geostationary belt (July 15, 2015). *Luch*, highlighted in black, was in this portion of GEO from June 22 to September 24, 2015. Data Source: U.S. Space Command Combined Space Operations Center / Space-Track.org.

communicate with one another through the U.S. Department of Defense, which manages a public database of space objects called Space-Track, the Russian Ministry of Defense did not respond to Intelsat's messages, nor are there any existing norms or international laws that might compel it to do so.

Three years later, in September 2018, France accused Russia of using *Luch* to spy on a military satellite jointly operated by France and Italy.[26] In a public address, the French Minister of the Armed Forces Florence Parly said that *Luch* "got so close that we might have imagined it was trying to intercept our communications." [27] An analysis of the public space object catalog shows that *Luch* approached the French satellite in October 2017, almost a year prior to the defense minister's remarks. Despite the concern from France, the Russian satellite was actually much closer to other neighbors at the time, including Pakistan's *Paksat 1R* and Russia's own *Raduga 4* satellite 5 km and 10 km away respectively. Pakistan has made no public statements about *Luch*'s behavior on orbit.

Since its launch in September 2014, *Luch* has occupied a wide stretch of the geostationary belt, from 96.4E to 23.6W and seventeen more positions in between.[16] When compared with other GEO satellites in the U.S. Space Command's Combined Space Operations Center (CSpOC) space object catalog, *Luch*'s movements are unprecedented.

Although the CSpOC catalog contains more than 45,000 space objects, it does not include the orbital elements for a small number of military satellites from the U.S. and its allies. According to data from the International Scientific Optical Network, a space surveillance network

managed by the Russian Academy of Sciences, several U.S. satellites—USA 253, 254, 270, and 271—have performed close approach maneuvers with non-cooperative satellites from Russia, China, Pakistan, and Nigeria at distances near 10 km.[28] The recently declassified Geosynchronous Space Situational Awareness Program (GSSAP) likely uses pairs of satellites in near-geostationary orbits to inspect satellites from above and below as opposed to occupying a nearby slot in the geostationary belt itself.

Mechanisms for a New Norm of Behavior for GEO Operations

What has been done to promote or prevent norms of behavior in the space domain, and where do these contemporary efforts stand? The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) publishes voluntary guidelines on long-term sustainability via a working group of its Scientific and Technical Subcommittee. The process began in 2010, and the guidelines were finalized and fully adopted in June 2019.[29] Historically, these guidelines have been informed by recommendations from other international organizations, such as the ITU and the Interagency Debris Coordination Committee (IADC), a collection of national civil space agencies dedicated to mitigating the creation of space debris. Typically, COPUOS, despite it being the primary forum for international norm-setting, continues to defer to national implementation strategies, and each session gives state delegations ample time to discuss their own national contexts. While this practice allows states that routinely follow existing voluntary guidelines to lead by example, it unfortunately also leaves room for states to remain lax in their implementation.

As a salient example, we may consider the norm surrounding post-mission deorbiting for lower-altitude satellites. The 2019 update to COPUOS' recommendations includes the phrase "the post-mission lifetime of a satellite in orbit should not exceed 25 years." This 25-year rule came directly from a 2007 recommendation by the IADC, which in turn was based on a guideline from a set of internal NASA standard practices published in 2001.[30] However, the same NASA document allows for a number of possible exceptions from this rule via storage orbits, exemplifying the push and pull between international organizations that take cues, at times aggressively, from national regulations that may in practice be more lax when applied in those national contexts.

How might a voluntary guideline on the minimum close approach distance affect satellite behavior in the geostationary belt? Suppose the Committee's member states agreed on a close approach distance of 10 km in GEO—effectively forbidding the maneuvering behavior of *Luch* and the GSSAP satellites that some operators have deemed "too close" to other neighbors. An analysis of the last five years of satellite maneuvering activity in the geostationary belt suggests that the vast majority of satellites—approximately 96 percent—already adhere to this norm on a daily basis. Only a small number of satellites would need to adjust their behavior to no longer violate the new norm. However, the act of recommending a close-approach distance remains

important because it changes the norm status quo by making explicit a previously implicit assumption by the majority of space operators that they should not approach other satellites without permission. Setting a low threshold, such as 2 km (which would require fewer than 1 percent of satellites to change their regular behavior), may not encourage any operator to critically examine their behavior, while setting a high threshold, such as 25 km (which would affect more than 10 times as many satellites), may make compliance needlessly burdensome. As the geostationary belt becomes more congested, space system engineers have incentives to design satellites that can safely operate in closer proximity to one another, rendering a specific close approach threshold obsolete. A voluntary guideline is best positioned for success when it is both clearly achievable and negotiable over time, leaving enough rule-breakers to be effectively named, shamed, and catalogued by good-faith actors.

To complement the formal process at COPUOS, Transparency and Confidence-Building Measures (TCBMs) represent a strong platform for promoting both terrestrial and space cooperation by facilitating predictable processes. The Secure World Foundation and Open Lunar Foundation have held workshops, most recently in December 2019, on "rationales behind norms and norm creation and adherence, avenues for norm development, and the life cycle of norms." [7] Participants were encouraged to propose their own space sustainability recommendations. Workshops like these can be part of a wider lineage of diplomacy that lies between formal channels and grassroots norm change approaches, which have a history of success in measures of confidence-building.[31]

Regardless of the forum in which satellites operators develop norms of behavior in the geostationary belt—either in response to continued close approach behavior by a small handful of actors or in an attempt to anticipate and prevent it—the changing space environment demands that space actors act soon to preserve the peaceful, sustainable use of the regime for decades to come.

Acknowledgements

The authors would like to thank Kaitlyn Johnson from the Center for Strategic and International Studies for her support and feedback on this work and the *Review's* editorial team for the opportunity to contribute to the journal's inaugural issue.

Citation

Roberts, T. G. & Bullock, C. A sustainable geostationary space environment requires new norms of behavior. *MIT Science Policy Review* 1, 34-38 (2020).

Open Access



This *MIT Science Policy Review* article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to

the Creative Commons license, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- [1] Roberts, T. G. Popular orbits 101. *CSIS Aerospace Security* (2017). <https://aerospace.csis.org/aerospacel01/popular-orbits-101/>.
- [2] NASA. NASA ODPO's large constellation study. *Orbital Debris Quarterly News* **22** (2018). <https://www.orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv22i3.pdf>.
- [3] Flewelling, B., Ingram, C. & Cunio, P. M. Formation flying as formalism for space traffic management. *AIAA SciTech Forum* (2020). <https://doi.org/10.2514/6.2020-0236>.
- [4] Weeden, B. Iridium-Cosmos collision factsheet. *Secure World Foundation* (2010). https://swfound.org/media/6575/swf_iridium_cosmos_collision_fact_sheet_updated_2012.pdf.
- [5] Schaffer, A. The role of space norms in protection and defense. *Joint Forces Quarterly* **87** (2017). https://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-87/jfq-87_88-92_Schaffer.pdf?ver=2017-09-28-092555-747.
- [6] Krepon, M. Commentary: Norm setting for outer space. *SpaceNews* (2014). <https://spacenews.com/41789norm-setting-for-outer-space/>.
- [7] Johnson, C. Insight – developing norms of behavior for space. *Secure World Foundation* (2020). <https://swfound.org/news/all-news/2020/02/insight-developing-norms-of-behavior-for-space/>.
- [8] Nations, U. Space law treaties and principles. *International Space Law: United Nations Instruments* (2017). <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties.html>.
- [9] Johnson, C. *Handbook for New Actors in Space* (Secure World Foundation, Broomfield, CO, 2017). p. 9.
- [10] Finnemore, M. & Sikkink, K. International norm dynamics and political change. *International Organization* **52** (1998). <https://doi.org/10.1162/002081898550789>.
- [11] Lantis, J. S. *Arms and Influence: U.S. Technology Innovation and the Evolution of International Security Norms* (Stanford University Press, Stanford, CA, 2016).
- [12] Lantis, J. S. Theories of international norm contestation: Structure and outcomes. *Oxford Research Encyclopedia of Politics* (2017). <https://doi.org/10.1093/acrefore/9780190228637.013.590>.
- [13] Bloomfield, A. & Scott, S. V. (eds.) *Norm Antipreneurs and the Politics of Resistance to Global Normative Change* (Routledge, Abingdon, Oxon, UK, 2018). <https://doi.org/10.4324/9781315707341>.
- [14] Lantis, J. S. To boldly go where no country has gone before: U.S. norm antipreneurism and the weaponization of outer space. In Bloomfield, A. & Scott, S. V. (eds.) *Norm Antipreneurs and the Politics of Resistance to Global Normative Change*, 197–214 (Routledge, Abingdon, Oxon, UK, 2018). <https://doi.org/10.4324/9781315707341>.
- [15] Weeden, B. Norms of behavior in space. In *19th Annual Small Payload Rideshare Symposium* (2017). https://swfound.org/media/205892/bw_space_norms_sprsa_jun2017.pdf.
- [16] Roberts, T. G. Unusual behavior in GEO: Luch (Olymp-K). *CSIS Aerospace Security* (2020). Accessed: March 30, 2020, <https://aerospace.csis.org/luch>.
- [17] Harrison, T., Johnson, K. & Roberts, T. G. Space threat assessment 2019. *CSIS Aerospace Security* (2019). <https://www.csis.org/analysis/space-threat-assessment-2019>.
- [18] Harrison, T., Johnson, K., Roberts, T. G., Way, T. & Young, M. Space threat assessment 2020. *CSIS Aerospace Security* (2020). <https://www.csis.org/analysis/space-threat-assessment-2020>.
- [19] Soop, E. M. *Handbook of Geostationary Orbits* (Springer, Dordrecht, 2011). <https://doi.org/10.1007/978-94-015-8352-7>.
- [20] Pinnagoda, S. ITU regional radiocommunication seminar 2015. In *ITU Regional Radiocommunication Seminar* (2015). <https://www.itu.int/en/ITU-R/terrestrial/workshops/RRS-15-Asia/Documents/Harmful%20Interference.pdf>.
- [21] Space network list (SNL). *International Telecommunications Union* (2020). Accessed: February 18, 2020, <https://www.itu.int/en/ITU-R/space/snl/Pages/default.aspx>.
- [22] Gutro, R. GOES-14 (O) moving into on-orbit storage around the earth. *NASA* (2009). https://www.nasa.gov/mision_pages/GOES-O/news/orbit_storage.html.
- [23] SAT-STA-20200119-00011: special temporal authority on a satellite space stations. *U.S. Federal Communications Commission* (2020). <https://fcc.report/IBFS/SAT-STA-20200119-00011/2171055>.
- [24] Ephemeris data. *Intelsat* (2020). Accessed: February 18, 2020, <https://my.intelsat.com/ephemeris/public#/>.
- [25] Gruss, M. Russian satellite maneuvers, silence worry Intelsat. *SpaceNews* (2015). <https://spacenews.com/russian-satellite-maneuvers-silence-worry-intelsat/>.
- [26] Chrisafis, A. 'act of espionage': France accuses Russia of trying to spy on satellite data. *The Guardian* (2018). <https://www.theguardian.com/world/2018/sep/07/france-accuses-russia-spying-satellite-communications-espionage>.
- [27] Leicester, J., Corbet, S. & Mehta, A. 'espionage:' French defense head charges Russia of dangerous games in space. *Defense News* (2018). <https://www.defensenews.com/space/2018/09/07/espionage-french-defense-head-charges-russia-of-dangerous-games-in-space/>.
- [28] Weeden, B. & Samson, V. (eds.) *Global Counterspace Capabilities: An Open Source Assessment* (Secure World Foundation, Broomfield, Colorado, 2019). 3-5, https://swfound.org/media/206408/swf_global_counterspace_april2019_web.pdf.
- [29] Working group of the committee and its subcommittees. *Committee on the Peaceful Uses of Outer Space* (2019). <https://www.unoosa.org/oosa/en/ourwork/copuos/working-groups.html#STSCWGLTS>.
- [30] Orbital debris mitigation standard practices. *NASA* (2001). https://www.orbitaldebris.jsc.nasa.gov/library/usg_od_standard_practices.pdf.
- [31] Dassa Kaye, D. Track two diplomacy and regional security in the Middle East. *International Negotiation* **6**, 49–77 (2001). <https://doi.org/10.1163/15718060120848955>.