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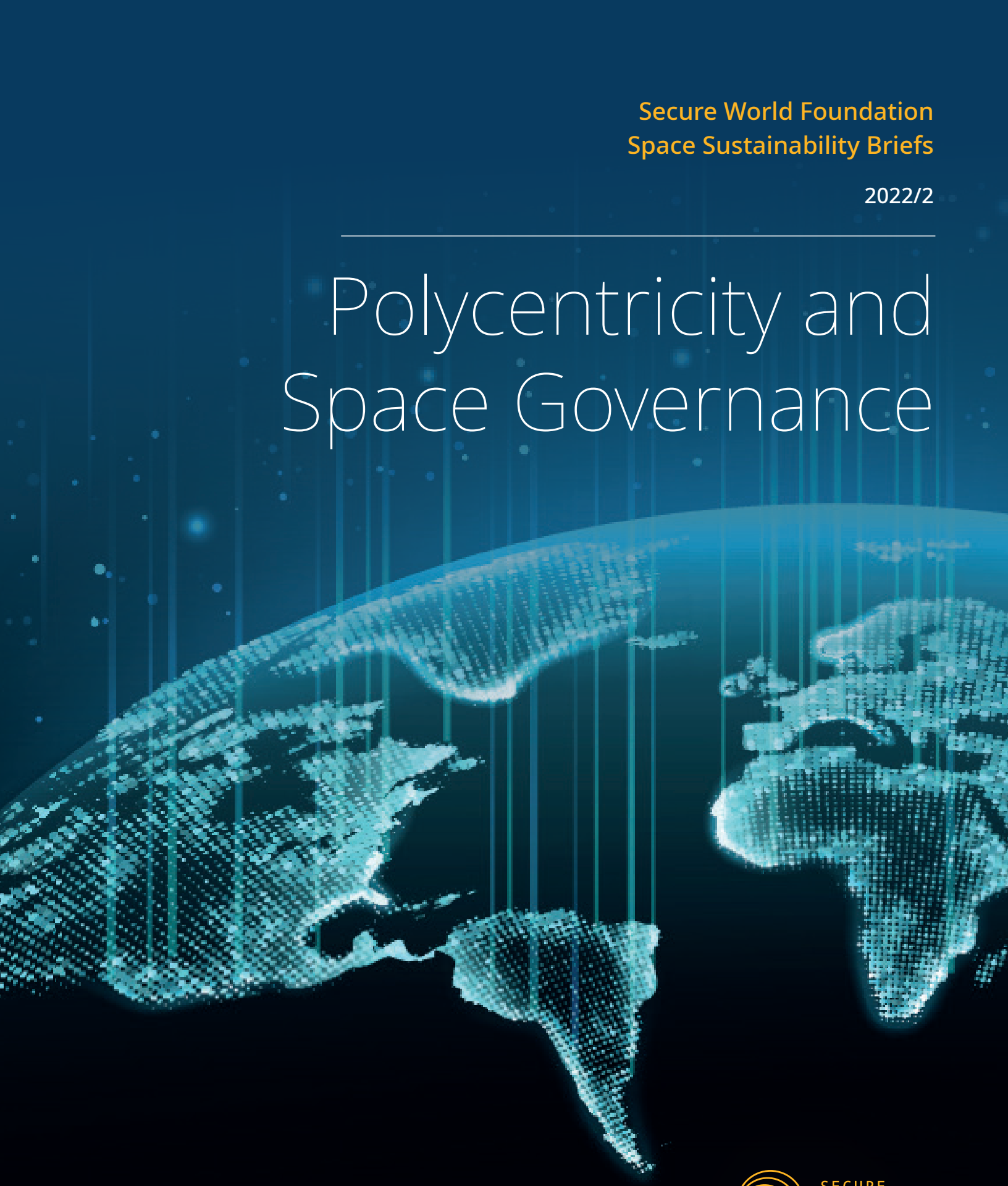
Polycentricity and Space Governance



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Polycentricity and Space Governance

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TERMS

- **Norm Entrepreneurs**

  Actors who develop and promote the adherence of new rules of behavior. [1]

- **Complex Adaptive System**

  A self-organized group that changes its rules as it gains more experience. [2] *This term is most often used in relation to environmental governance.* [3]

- **Decentralization**

  The transfer of authority and responsibility for public functions from the central government to intermediate and local governments, quasi-independent government organizations, or the private sector. [4]

- **Permissionless Innovation**

  A principle, coined by researchers at the Mercatus Center, suggesting that innovators be generally left free to experiment with new technologies and business models without oversight from a governing body. [5]

- **Polycentricity**

  A system of governance in which there are multiple decisionmaking centers that interact with each other over a common domain.

- **Precautionary Principle**

  A principle suggesting innovators be overseen by public officials, mandating approval before beginning to develop and deploy new capabilities. [6]

- **Self-governance**

  The ability of a group to self-regulate independently, without oversight from an external authority. [7] *Self-governance is sometimes treated as synonymous to polycentricity, but this is a false equivalence. Self-governance can be one component of a polycentric system, but polycentric systems are not entirely self-governed.*

- **Subsidiarity**

  Originally enshrined under the Catholic Church in 1891 as a "middle way" between laissez-faire capitalism and socialism, subsidiarity allowed more independence among the more local levels of authority. In the context of governance, subsidiarity refers to the delegation of rulemaking to a lower, usually more specific, body. It is an organizing principle that matters ought to be handled at the lowest competent authority, and that a central authority should perform only those tasks which cannot be performed at a more immediate or local level. [8]

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1 Finnemore & Sikkink 1998.
2 Ostrom 1999.
3 DeCaro et al. 2017.
4 European Parliament, Fact Sheets on the European Union – The Principle of Subsidiarity, https://www.europarl.europa.eu/factsheets/en/sheet/7/the-principle-of-subsidiarity
5 Therier 2016.
6 Therier 2016.
7 Murtazashvili 2018.
8 European Parliament, footnote #4 above.

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Polycentricity and Space Governance

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1. INTRODUCTION

In the 65 years since Sputnik left Earth, conditions in space have grown increasingly complicated. With a wide variety of stakeholders investing in space activities,[9] the burgeoning commercial sector changing old dynamics,[10] and new constellations of private satellites influencing terrestrial operations,[11] useful orbits are both more in demand and more threatened than ever. While interest in space has grown exponentially, understanding of space governance has lagged behind. Discussions of norms for space are promising, but relying on governance at only one level is inefficient and ultimately may do more harm than good. [12]

Today, space, like most other shared domains, is inherently polycentric—with both resources and consequences spanning jurisdictions.[13] Embracing the fragmented nature of space and governing at multiple levels will help develop a resilient space governance regime.

But how to best leverage a fragmented system? First, we must examine the current state of space governance to develop an understanding of the actors, their interactions, and the extent of their authorities. This report seeks to lay the foundation for future efforts to exploit the polycentric nature of space and establish an effective governance framework. First, I review the literature and define polycentricity. Where did the concept come from, and in what domains is it typically noted today? I then use the social science literature to contextualize a discussion of the space governance system today, with a description of the basic levels of governance and descriptions of the entities that belong to each group. With that background in polycentricity and space governance, I then propose a preliminary framework for analyzing the appropriate levels at which to govern different situations in space.

[9] UCS Satellite Database.
[10] Chelsea Gohd. "SpaceX hints at replacing Russian space station services." Space.com. 28 February 2022.
[11] Christopher Miller, Mark Scott, Bryan Bender. "UkraineX: How Elon Musk's space satellites changed the war on the ground." POLITICO. 8 June 2022.
[12] Elinor Ostrom. "Polycentricity, Complexity, and the Commons." The Good Society, Penn State University Press: Vol. 9, No. 2 (1999), pp. 37-41.
[13] Vincent Ostrom, Charles M. Tiebout, Robert Warren. "The Organization of Government in Metropolitan Areas: A Theoretical Inquiry." American Political Science Review: Vol. 55, No. 4 (Dec. 1961), pp. 831-842.

2. WHAT IS POLYCENTRICITY?

Polycentricity is a system of governance in which there are multiple decisionmaking centers presiding over the same domain. The term was originally coined by chemist and social scientist Michael Polanyi as he described cooperation among scientists and how intellectual freedom sustains science.[14] Vincent Ostrom, Charles M. Tiebout, and Robert Warren applied this concept to governance, describing a system in which multiple "decision centers" take each other into account in order to govern and provide public goods and services. Ideally, polycentric governance systems employ a "combination of autonomy and overlap" to innovate and adapt.[15] Several comprehensive histories and descriptions of the evolution of polycentricity have been written in the recent past. [16]

While definitions of polycentricity differ slightly from one author to another, it can most generally be described as:

> **A system of governance in which multiple authorities oversee the same area, albeit with different but overlapping interests and scopes of responsibility.**

Polycentric governance has historically most often been examined in the context of municipal governments and environmental management, including water governance and climate change mitigation.[17] More recently, polycentricity has been applied in the context of transnational financial institutions [18] and is beginning to be considered in the context of internet governance[19] and space.[20]

Polycentricity is not a novel concept. In fact, it is an inherent attribute of most governance systems, particularly global systems. Fundamentally, a polycentric governance system has three defining attributes:

1. Multiple levels at which decisions are made,
2. Levels that coexist and cooperate, functioning in the context of each other, and
3. An "exchange between coexisting and competing ideas, practices, and methods.[21]

Because of the sheer number of actors and interests, global governance in particular is "inevitably" decentralized and polycentric. [22] Space governance, as a subset of global governance systems, has become increasingly fragmented as utility of the domain has grown and barriers to entry have fallen. Of course, the barrier to entry in space is still quite high, with launch costs, the cost of infrastructure, and the level of technical understanding required; nevertheless, the number of states that have at least one satellite in space increased by 43 percent (33 more states) in the decade from 2012 to 2022.[23] This is to say nothing of the wide and ever-increasing variety in types of individual actors launching satellites, with militaries and civil agencies now joined by academics, private industries, and even hobbyists.[24]

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[14] Polanyi, Michael. 1951. The Logic of Liberty. Chicago, IL: University of Chicago Press.
[15] Ostrom, Tiebout, Warren 1961.
[16] See Aglicia & Tarko 2012, Stephan, Marshall, & McGinnis 2019, Tepper 2019, Kuhn & Schingler 2021, and Kuhn 2021.
[17] See, among many others, Dietz, Ostrom, Stern 2003; Andersson & Ostrom 2008; Ostrom 2012.
[18] Backer 2011.
[19] Shackelford 2013; Oberlack et al. 2018; Newig et al. 2019.
[20] Tepper 2019.
[21] Kuhn 2021.
[22] Tepper 2019.
[23] McDowell.
[24] AMSAT – Amateur Radio in Space, https://www.amsat.org/

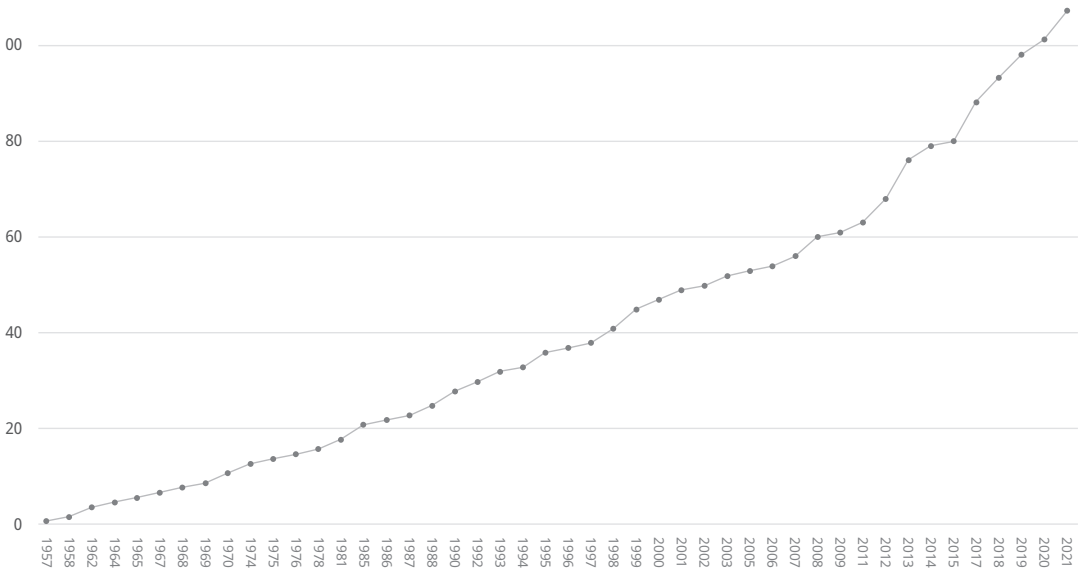

Figure 1. Number of new states in space by year from the beginning of the Space Age in 1957 until the end of 2021.[25]

> Despite the common framing of some articles on decentralization in governance, polycentricity is not a decision to be made and implemented. It is an inherent property or characteristic of the way space governance has evolved over time. The "good" or "bad" comes not from the type of system itself, but from a misunderstanding about the appropriate levels of government at which actions should be taken, and frustration at stagnation within the current system.

Rather than advocating for a particular system of governance itself, this paper considers the attributes of a polycentric system, examines other domains governed by polycentric systems, draws analogies from those domains to space, considers the best way to leverage a polycentric system in space, and begins to develop a framework to work within the polycentric nature of space governance to address space sustainability challenges.

It is easy to pick a system or a level of governance and declare it superior, but every system and level of governance is best suited for different situations. Conflict and other high salience situations tend to "centralize decision-making and control" in the name of efficiency and the greater good.[26]

In polycentric systems, there are many different levels, some more "general purpose governments" and some more "highly specialized" units.[27] Combinations of these varying levels can mitigate the disadvantages of completely centralized or completely self-governing systems. Decentralizing regulation has advantages: specialized entities can tap into local knowledge, smaller organizations generally require more member participation and can more readily validate credibility of participants, the connectivity of smaller networks provides many sensors for knowledge and changes, and smaller systems tend to be more agile with adaptable rules, lower enforcement costs, and redundancy built into the system. Centralization, however, can address some of the failures of these systems, including leveling the varying degrees of buy-in from organizers, widely organizing groups with broad goals and principles, and providing the ability to scale up to handle larger common pool resources.[28]

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[25] McDowell.
[26] Ostrom, Tiebout, Warren 1961.
[27] Ostrom 1999.
[28] Ostrom 1999.

Centralization in this context may be efficient, but in the long term, centralization can hinder innovation and neglect the varying interests of the public. Thus, the advantage of a polycentric system is that there are levels of both centralization and decentralization in place to varying degrees, providing safeguards at high and low levels of the governance hierarchy. Having a state or international system of governance provides legitimacy, giving individuals and smaller organizations the confidence to participate in the domain. At the same time, smaller, more decentralized units are able to focus more on the essential local or otherwise niche issues that are altogether necessary for the health of the entire operating environment.[29] Local organizations have more technical and localized knowledge, more buy-in by participants, more adaptable rules, and easier enforcement mechanisms.[30]

3. THE GLOBAL SPACE ARENA AS A POLYCENTRIC SYSTEM

In the early days of spaceflight, outer space was a relatively monocentric domain, with two major powers and limited utility. Sixty-five years later, this is no longer the case. With a myriad of different actors and interests, there are many different levels and centers at which governance in space is "done," and many facets even among those levels and centers.

Today, space supports everything from military sensing networks to agricultural patterns and weather predictions to internet access and streaming services. This ambitious growth in utilities has brought with it lagging, but still ambitious, growth in its corresponding governance apparatus. There are three broad categories into which governing bodies in space fit: international, national, and subnational. Figure 2 depicts these three levels and provides illustrative examples of entities in each level. Within these levels, there are a number of different types of individual entities, from international organizations such as the United Nations and the International Telecommunication Union (ITU), international standards bodies such as the International Organization for Standardization (ISO), to national regulators, to private companies, city governments, and trade associations.

Each level of government broadly has different aptitudes and faces different challenges. Subnational governing bodies, for example, are often more agile than their national and international counterparts because of their comparatively small interest groups and may therefore be best suited to oversee circumstances with innovation, or those that require the ability to answer to shifting conditions.

[29] Ostrom 1999.
[30] Ostrom 1999.

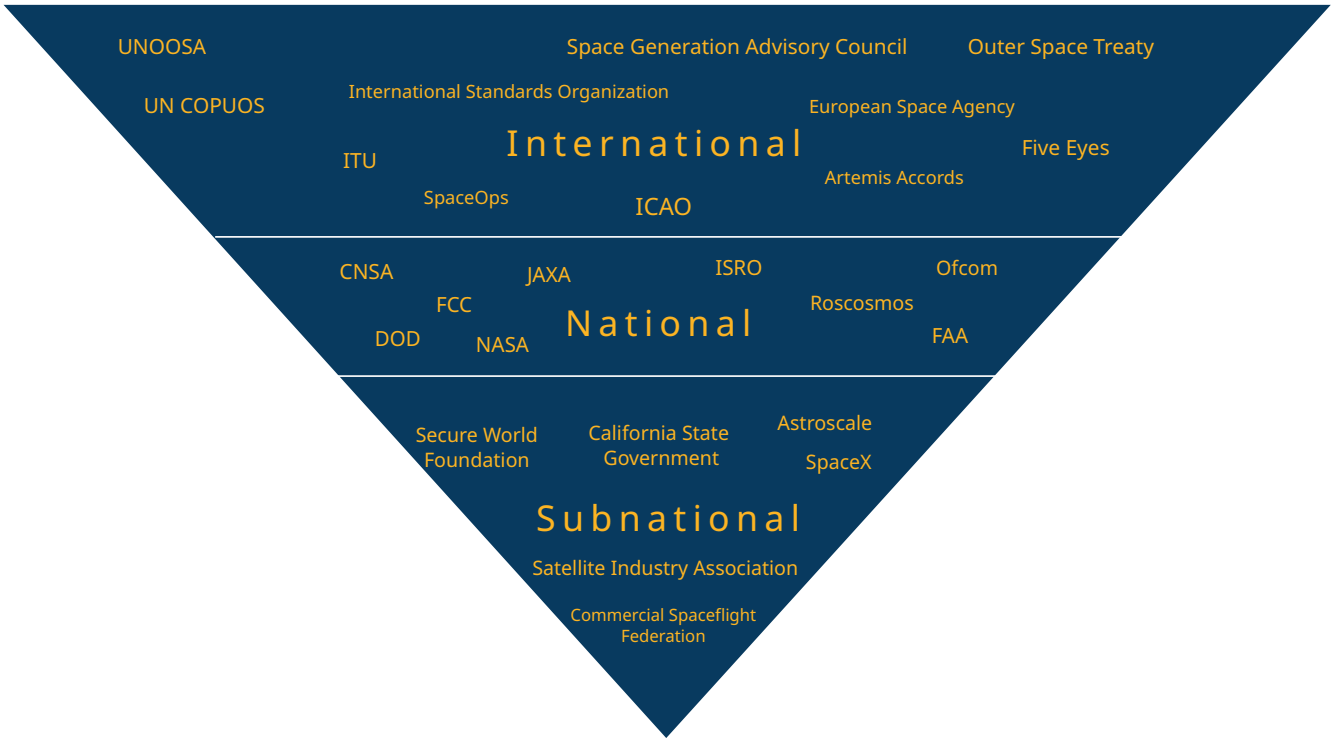

Figure 2. Levels of space governance with examples of entities at each level. These are not exhaustive lists of each level, but rather illustrative examples of the types of *entities* found at each level.

3.1 International

The international level of space governance is often the first that comes to mind. International governing bodies and agreements get a lot of attention and have had a long history, relatively speaking. The most well-known of these bodies include the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) and the ITU.[31] These bodies are the principal international fora for the progressive development of cooperative space governance instruments that include binding treaties, such as the 1967 Outer Space Treaty, and non-binding instruments, such as the UNCOPUOS Guidelines for the Long-Term Sustainability of Outer Space Activities.[32]

In addition to the UN, there are also voluntary international standards organizations that—either in part or in whole—address space, including the ITU and the ISO.

International organizations are most useful for determining high-level goals, publicizing pertinent issues, and gaining interest in and rallying support for a cause. They rarely, however, have effective mechanisms for enforcement and cannot mandate any meaningful direct action to be taken, simply because of the variety of actors involved.

3.2 National

National governance centers in the polycentric space system are the bodies that coordinate and represent countries on space issues. There can be several within a nation, each with

[31] Tepper 2019.

[32] United Nations Office for Outer Space Affairs, Working Groups of the Committee and its Subcommittees, https://www.unoosa.org/oosa/en/ourwork/copuos/working-groups.html

different agendas, but all informed by the broader national strategy. In the United States, for example, there is the National Aeronautics and Space Administration, which has oversight of civil governmental and scientific space activity. The US Department of Defense, however, has oversight of military space activity, and the Office of the Director of National Intelligence has oversight of intelligence community space activity. US commercial space activity is overseen by another set of entities, namely the Federal Communications Commission, the Federal Aviation Administration, and the National Oceanographic and Atmospheric Administration, depending on the specific type of space activity. Additionally, the State Department and Department of Commerce also play a role in regulating space export controls.

Other nations have different arrangements, and many have centralized multiple functions into a fewer number of agencies. In the United Kingdom, nearly all regulatory and oversight of space activities is done by the UK Space Agency, which also conducts its own civil governmental space program, while spectrum regulation is handled by Ofcom.[33]

National bodies are, by design, slow to make decisions. This ensures the longevity of rules, once passed, to generally be able to withstand changes in leadership over the short term. This does, however, mean that national governments find it difficult to measure up against the rapid pace of technological and social change occurring in space.

3.3 Subnational

Subnational entities make up a growing proportion of the space industry. Subnational refers to a "second" or "third" level of government that could, but does not necessarily have to "encompass characteristics that are political or financial." [34] Subnational governmental entities are generally understood to play an important role in "service delivery" and goods provision.[35] Subnational governance bodies in space include things like state governments, private companies, and other organizing bodies and associations.

The subnational level is most traditionally understood to encompass local and regional governments. At first glance, space and local government do not seem to have much overlap, but space development does not exist in a vacuum. Launch sites must be located somewhere, and communities must have regulations around how launch affects the nearby environment. Space infrastructure must be manufactured somewhere on Earth, the operation of the infrastructure occurs at bases on Earth, and all of these issues intersect with local governments. This intersection is becoming more and more reflected in actions taken between regional governments, space agencies, and industry and academia, including in California a recent memorandum of understanding with the city of Santa Barbara and a regional development plan between San Luis Obispo, Cal Poly, and the US Space Force.[36]

There is a large industry stake in space. Many global powers, including the US rely on space for their security—missile warning systems, positioning, navigation, and intelligence. But space-based capabilities also fuel modern economies with GPS, streaming services, and weather predictions. Globally, the space economy was estimated to be worth $469 billion in 2021.[37] The share of space launches has officially surpassed strictly government-use infrastructure by

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[33] "Spectrum management." Ofcom.

[34] Gutierrez 2015.

[35] Observatory on Subnational Government Finance and Investment".

[36] Building a Thriving Space Enterprise on the Central Coast of California: Commercial Space Master Plan, Vandenberg Space Force Base.

[37] Space Foundation, Space Foundation Releases the Space Report 2022 Q2 Showing Growth of the Global Space Economy, https://www.spacefoundation.org/2022/07/27/the-space-report-2022-q2/.

leaps and bounds.[38] While not as developed as in the case of cyber, the private space sector nonetheless has considerable power today when it comes to passively or actively setting behaviors.[39]

As with the international level, there are also associations bringing together all of these players—though often they are dominated by representatives from industry—in order to gather consensus and act collectively, with more power. There are also non-governmental organizations that work both in this role and in a more advisory capacity.[40]

4. A FRAMEWORK FOR THE POLYCENTRIC SPACE GOVERNANCE SYSTEM

Fragmentation in space governance is not the problem. The challenge facing space actors is, rather, finding the right level of governance for different situations. International standards rarely have teeth, national governments move slowly, and subnational components can be niche and focused on the short term. In order to govern effectively, decisions should be passed on to the level most suited to each challenge.

In order to begin to determine where the right level for an activity is, we first must determine the criteria to judge. In reviewing the literature on polycentricity both theoretically and applied in several domains, I have found that two broad criteria combined help to determine the most effective levels of governance for different scenarios:

Criteria 1: Barrier to Entry

- How widely accessible is a technology or domain? If a technology or domain is not widely accessible, it can be easier and more efficient for a smaller group to gain consensus, and have decisions made and actions moved forward. If a technology is widely proliferated, collective action is more difficult.[41] Low entry costs into a domain tend to encourage more innovation and an increase in decisionmaking centers.[42] Barrier to entry is in part dictated by the pace of technological change. Where technology evolves more rapidly, barriers to entry generally decline. With some reservations, lower levels of governance will be more equipped to oversee domains with low barriers to entry, as they are more agile.

Criteria 2: Risk to Operations

- How great a danger does a technology or action pose to normal operations in a domain? The less danger associated with a technology or action, the more likely it is that a lower level of governance can be an appropriate level to oversee it. According to the principles of subsidiarity, when issues can be localized, they should be, in order to streamline governance. When actions pose a high risk to normal operations or when the risk posed affects large swaths of the operators, decisionmaking should be moved up the chain to a higher level of governance. Like barriers to entry, this criteria is mutable over time. What once posed a danger could become normalized over time, or as technology changes.

[38] UCS Database.
[39] Dickey 2022.
[40] See Oltrogge & Christensen 2020; Johnson 2020 for more comprehensive surveys of the system.
[41] McGuire, The Collective Action Problem.
[42] Ostrom, Tiebout, Warren 1961.

	LOW RISK TO OPERATIONS	HIGH RISK TO OPERATIONS
HIGH BARRIER TO ENTRY	**Subnational** Launch provision	**International** Nuclear nonproliferation measures, ASAT bans
LOW BARRIER TO ENTRY	**Subnational** Data storage and sharing, smallsats	**National** Jamming, cyber threats

Figure 3. Framework for polycentric space governance in the context of barriers to entry and risk to operations. Representative governance issues are included in each of the four quadrants.

While not exhaustive, these two criteria together encompass a wide range of situations and provide a good starting point for determining appropriate levels of governance.

In situations with a high barrier to entry, whether that be through expensive technology, nuclear weapons, or niche interests, the "coherence and effectiveness of small groups" will tend to allow interested entities to organize more easily than in situations with very low barriers to entry.[43]

The easier entry is into a given domain, the more likely it is that technological and social change will outpace the ability of higher levels of government to respond. In situations with lower risk to the environment, these low barrier domains or technologies may be most effectively governed at a subnational level, allowing localized groups to form and self-govern. This will allow groups to take advantage of the benefits of decentralization, allowing rules to change as "experience accumulates" and, with relatively separate governance systems, allow for more experimentation in order to "drastically reduce the probability of immense failures for an entire region." [44]

While it can be preferable to move governance down to the lowest level to allow for flexibility and responsiveness when possible, situations with security and sustainability challenges will require higher levels of governance. The international and national levels are more positioned to consider long-term sustainment of the space environment, rather than be swayed by short-term gain. As stated above, the higher the risk to the operational environment, the higher the level of government that that situation should be handled at. This is exemplified by international efforts like the Partial Test Ban Treaty and current attempts to ban the use of kinetic anti-satellite weapons. These goals come from the highest level, in reaction to situations that have the potential to render orbits completely unusable.

Issues that are very likely to lead to catastrophic risk, and that deal with technology or domains that have a higher barrier to entry are generally best handled at the international level. For situations with high barriers to entry, international bodies are able to set standards before mass proliferation of a risky technology, for example, and are more likely to have success in shaping norms around potential risks from the outset. In riskier scenarios, it is more important to have one standard well communicated and enacted broadly.

These categories are mutable, designations of situations are flexible and will change over time. However, broadly, this matrix can be a helpful tool for conceptualizing the levels of government that could be most effective at dealing with different situations in space.

[43] Olson 1971.
[44] Ostrom 1999.

A framework, however conceptually helpful, means little if it is not applicable and understandable. This matrix, while new, can be used to evaluate situations in space and in a number of different domains beyond. In an increasingly globalized world, barriers to entry and risk to operations will continue to be salient characteristics of new situations. To test the applicability of this framework, I will briefly consider three of today's space governance challenges through these characteristics.

4.1 Artemis Moon Landing Sites

The US-led Artemis missions come at a time of sustained international cooperation among allies and increased polarization between adversaries, both terrestrially and in space. These missions bring together US space capabilities with that of an international coalition for the purpose of returning to the Moon. At the same time, China's taikonauts are beginning to inhabit their own space station, Tiangong, and Beijing has announced plans for a base on the Moon with Russia.[45] In addition to scientific discovery, the Artemis missions are also explicitly driven by "economic opportunity," bringing a new layer into the global competition.[46]

These missions, in keeping with activities with a high barrier to entry and with potentially great international implications, are currently being led at the highest levels, through international coalitions. The Artemis Accords, currently signed by 21 state signatories, dictate "lunar safety zones" to guide actors in these endeavors.[47] The Artemis partners have made strides to expand their governance system beyond international fora, at least nominally, stating that partnerships not only between spacefaring nations, but also between governments, industry, and academia will be prioritized. As it currently stands, these partnerships will likely reinforce current capabilities and expand expertise, providing, as Ostrom, Tiebout, and Warren once noted, "useful duplication" into the governance system and building the foundation for interdependent decisionmaking centers.[48]

The Artemis missions, and civil space science, are often still governed at the highest level. But as lunar bases—both the US-led plans and those from Beijing—are established, a presence on the Moon and beyond may be regularized, and barriers to entry will fall. If, as is an expressed hope, these missions bring back more information about lunar mining, barriers to entry may fall further and Moon-basing may become the purview of even subnational governance structures, beholden to industry interests.

4.2 Space Traffic Management

Another area in which the current governance regime is evolving is in space traffic management. Space traffic management data occupies a unique spot in space architecture, where barriers to entry are lowering and the market is flooding with private actors, but holdovers from long-time national security concerns remain.

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[45] Tepper & Shackelford 2022.
[46] NASA, Artemis, https://www.nasa.gov/specials/artemis
[47] Gilbert 2022.
[48] Ostrom, Tiebout, Warren 1961.

Today in space traffic management systems, agility is necessary and innovation is encouraged. The ability to track smaller and smaller pieces of debris, for example, or to rapidly share pertinent information, would be a boon to the space traffic management industry. While delegating this task down into the subnational level could pose a potential security risk—if not for the data, then for the hindrance to communicating potentially threatening situations—these tasks have been delegated to the national level, and even within some governments there is restructuring, as decisionmakers reevaluate policies that govern these systems. The US military currently operates the country's space traffic management system. This is in flux, however, as a Space Policy Directive from the Trump administration mandated moving these capabilities from the Department of Defense to the Department of Commerce.

Polycentric governance systems allow for agencies to specialize more, allowing the agencies most suited to the challenge at hand the ability to take over.[49]

4.3 Space Security: Anti-Satellite Test Ban

In April 2022, the United States declared that it would no longer conduct destructive direct-ascent anti-satellite missile tests in space, and it introduced a draft UN General Assembly resolution to that effect in September 2022 that was adopted by a large majority of 155 states who voted in favor.[50] In keeping with the matrix in Figure 3, this action was immediately escalated to the highest levels of governance, suggested as a matter of implementing top-down norms on the global stage, rather than originating as a grassroots movement.

When there is a high barrier to entry, as in this case involving relatively sophisticated missile technology, and a high level of risk to operations in the domain, decisions should be made at the highest level, socialized internationally, and then, eventually, accepted as a norm.

5. Polycentricity in Other Domains

Space is not the only polycentric domain. While space governance is still a nascent field, analogies from other domains that have seen similar governance challenges can help inform the trajectory of the polycentric space system.

This report does not seek to provide an exhaustive list of all analogous domains. There exists a significant body of work on the parallels between space power and sea and air powers, for example. Rather than repeat this work, I examine specific cases with relevance to space that have not before been closely and extensively paralleled.

5.1 Maritime

By far, the most commonly drawn parallel is between space and the sea.[51] Both have economic, scientific, and security applications and are both commons that, initially, had higher barriers to entry that became less expensive over time. Compelling comparisons have more recently been drawn to "blue water" maritime more specifically.[52]

While these parallels are all fascinating and useful, I choose to consider two slightly lesser drawn-upon examples when it comes to polycentric maritime systems: commercial whaling and lobster fisheries. Both of these industries experienced changes in technological or social conditions that necessitated novel governance solutions to these challenges.

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[49] Ostrom 2002.

[50] Foust 2022.

[51] Among many others, see Gray 1999; France 2000; Fox 2001; Pfaltzgraff, Jr 2011; Bowen 2017; Townsend 2019.

[52] Bowen 2020. According to Burgess 2017, "'Blue water' areas [are areas] outside the 12-nautical mile mark and often further than the 200-mile EEZ of any country."

Regulations have thus far not been able to keep pace with the social and technological revolutions that have made space more accessible and more crowded. Lagging regulations are also a problem in commercial exploitation of the sea.

Commercial Whaling

With the development of the harpoon gun in 1886 as well as the earlier advances in industrial fishery vessels and long-range fishing boats, whale populations in northern oceans—where British and American whalers had hunted before—had been nearly depleted, leading them to exploit the southern oceans around Antarctica. New vessels allowed for longer range trips and allowed whalers to process catches quicker and in larger quantities. The Antarctic blue whale population began to decline rapidly in the 1930s and, as the practice continued relatively unfettered, was decimated by 1965.[53] Following this, the southern seas whaling industry collapsed in the 1960s, taking both the blue whale population and the economy surrounding it with it.

The technology evolved—changing an industry that had been around in the southern oceans since the late 1700s—and governance lagged behind, leading to the devastation of whale populations and fundamental changes in the Antarctic ecosystem. This lesson eventually prompted an understanding that oversight and collective action were necessary to maintain the Antarctic environment and any economic benefit that could still be derived from the southern oceans. By 1972, more than 20 international fishery commissions existed with goals to promote sustainable fishing and prevent the extinction of more oceanic species, including by restricting yearly yields.[54] The concerns of the past are also now informing other industries in the region, including tourism. Mindful of the fragile ecosystem, organizations like the International Association of Antarctica Tour Operators are now working to establish norms of behavior and other rules to govern the industry and the environment, restricting all actors to maintain the utility of the environment for all.[55]

Much like the southern seas in the early 20th century, many more companies are seeing potential economic benefits in space now that were not accessible just a few decades ago and much like the southern seas whaling industry, there is very little oversight that is up to date with the commercial space sector. We have seen in Antarctica and in other commons that too much individual free reign threatens to extinguish the benefit of the environment for all, whether it be through the near extinction of species of whales or through the pollution of highly used orbits.

With the development of the harpoon gun, the whale populations around the Antarctic and beyond changed dramatically, and regulations were not able to keep pace. This caused a fundamental shift in the goods provision from that environment. After many years of ineffective goods management, a polycentric solution was established, as the problem clearly showed that the system of self-governance that preceded it was ineffective. In the 1970s, interest groups and industry associations banded together to establish standards of behavior and best practices for operations in the region, which individual operators comply with, along with their own individual operating standards. In addition to this, internationally and nationally actors established regulations and standards around whaling and protected species.

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[53] Soroos 1988.
[54] Soroos 1988.
[55] About IAATO.

Lobster Fisheries

Another small subset of economic maritime interests, fisheries face both short-term economic pressure, the fear of scarcity, and long-term concerns for the sustainability of the environment.[56] Maine's lobster fisheries are small, locally and independently run, rather than run by corporations, and while not as intensely "clannish"[57] as they have been in history, they tend to be a close-knit community, with boats and licenses still often passing down from generation to generation and with local communities aware of the industry and its players. Boats are allowed a specific number of pots, or traps, and fishermen may only catch lobsters of a certain size and in certain conditions.

These regulations were enacted in conjunction between regulatory bodies and scientists, with local input, in order to allow for maximum yields while maintaining a thriving lobster population so that the fishing industry, ideally to strike a balance between short-term profits and profits over time.[58] State and local governments issue fishing licenses and set specific guidelines on the size of lobsters available for harvest, but they cannot patrol every lobster trap and every boat on the coast all the time.

In order to enforce these regulations, which are for the long-term propagation of the environment and the industry, Maine's lobster fisheries have a history of localist policies and a "detente" between the state regulators and local fishermen.[59] Regulations are enforced on a sort of "co-management" system between the government—who sets regulations and seeks to deter lawbreaking with the threat of fines and loss of license, but who cannot police every infringement—and users who agree on laws and operate under a sort of community policing.

Because the lobster industry in Maine is relatively insular, "social and at times violent enforcement mechanisms," ranging from warnings communicated in "jokes, comments, notes, radio transmissions, knots tied in buoy lines," to social ostracism in the wider community, to more destructive and violent threats like "opening others' traps, cutting trap lines, physical threats, or, rarely, gunfire or arson"[60] are employed to maintain order and the prosperity of the environment for all. Community members act as observers and a mechanism to deter rule breaking.

This shared system of responsibilities demonstrates effectively leveraging a polycentric system. Higher levels can more effectively set mandates, but smaller institutions generally have more feasibility in enforcement. A similar co-management system may answer some of the challenges around enforcement of laws and norms in space. While states may work within multilateral bodies like the UN to create treaties and other binding laws, spacefaring nations and individual companies may hold each other accountable by their own deterrence mechanisms, which may include "softer" consequences like sanctions or the threat of "harder" retaliation.

5.2 Environmental Management

One of the largest bodies of scholarship in polycentric governance theory is around environmental management. Elinor Ostrom did much of her later work on polycentricity considering its effects on water and forest management. Environmental management presents governance challenges for some similar reasons to maritime, with the competition between

[56] McGinnis 2011.
[57] Brewer 2012.
[58] Acheson 1997
[59] Brewer 2012
[60] Brewer 2012

short-term profitability and long-term sustainability. In environmental systems, the difficulty of borders and fluidity of negative externalities also adds another complicating dimension.

Because this environment cannot be contained, and therefore preserved, by individuals, collective groups, mainly governments, have banded together to implement rules of behavior, restricting individuals for the collective good. A recent example of this was the 1987 Montreal Protocol, an international agreement regulating the release of specific particulates, aimed at reducing depletion of the ozone layer, and "widely considered an example of a successful effort to protect the global commons."[61]

A common issue with public goods and the global commons is the so-called "free rider problem," which occurs when an individual's payment for the upkeep of a private good benefits all others, and that the others do not have to pay for the benefit. In space, this means that if the United States were to dedicate significant financial resources to keeping space clear from debris—an enterprise that would benefit the US greatly, as we are very reliant on space and face an oversized threat from threats in the environment—other countries would benefit without having to contribute. It is often the case that the entity that cares most about the upkeep of a public good takes on more of the costs associated with that good.[62]

These situations benefit from the flexibility of all levels of a polycentric system. Because things like water pollution and deteriorating ozone layers affect all surrounding areas, rather than just those of the nations contributing to their destruction, international institutions are effective for spurring collective action at a national level and for raising awareness. Mechanisms like the Kyoto Protocol, while not easily enforceable at the international level, get states to commit to change and increase public pressure on governments to remain accountable to both the international system and their citizens.

These are only part of a larger solution, however. Both global and local action are necessary for effective systems. Taking the Kyoto Protocol as an example, the Kyoto Protocol Clean Development Mechanism laid out mandates that eventually became in part the US's Clean Air Act. This nation-level mandate, while not directly responsible for going into the homes of citizens to make them more energy efficient, enabled local programs and regulations, including the city of Berkeley, CA's Financing Initiative for Renewable and Solar Technology program.[63]

This mingling of the systems allows programs that best fit the community to be implemented at the local level, while still carrying out directives that are for the good of the larger community. The "shared knowledge of the costs and benefits of actions and shifts in preference functions to take into account previously unrecognized benefits for self as well as others" motivates the actionable change that collectively works to improve the environment. [64]

Space faces a similar pollution problem to the terrestrial environment. Increased debris caused by satellite collisions and ASAT tests could lead to the Kessler effect, in which debris-on-debris collisions generate new debris faster than it is cleaned out through natural means. Pollution on orbit, much like pollution in a river, affects everyone who is using or hopes to use an orbital path in the future, not only the polluter.

These concerns mirror some that stem from the Industrial Revolution, when the environment came under contestation with the growth of factories and other changes to technology

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[61] Dietz, Ostrom, and Stern 2003.
[62] Jonathan Gruber, Public Finance and Public Policy, 6th ed. (New York: Worth Publishers, 2019).
[63] Ostrom 2012.
[64] Ostrom 2012.

and the way of life. This evolution in the environment then caused a dramatic increase in pollution, negatively affecting access to the rivers and even the air itself that had formerly been an uncontested global commons.[65] During this time, there was little oversight of actors. Each individual found it was cheaper to continue to pollute than to change their practices or clean their runoff. As the number of factories and other industries grew, pollution overwhelmed the environment, making air toxic and rivers unusable. The actions of a few influenced the environment for all, because flowing rivers and the air cannot be fenced in like Hardin's pastures.[66]

5.3 Internet Governance

Though initially developed by the government and managed by a few researchers, today the internet touches everything, from the world's militaries to your refrigerator. While not quite as ubiquitous, space has also had a similar evolution, from being primarily the domain of two countries' militaries to now enabling everything from commercial farming to nuclear warning systems.

Much like space, cyber also confounds traditional understandings of sovereignty and warfighting domains, acting as an intangible extension of the terrestrial world, but also "touching the ground somewhere."[67] It is a tool of war, but also a tool underpinning the fabric of society as a whole.

The rate of technological advancement in cyber is also unparalleled. While in other domains, including space, technological development has outpaced governance, internet development has far surpassed national-level governance.

Currently, cyberspace is governed by "a mixture of soft law, national regulations, regional accords, customary international law, and multilateral treaties."[68] No one of these has the ultimate authority, however, and there are also gaps and overlaps.

Internet governance presents a challenge because of the low barrier to entry—and therefore, large number of users—the wide variety of applications, and the potential salience to security. These barriers are addressed through governance primarily at the international and subnational levels. The national level is not as well suited for much of this regulation because of the pace of change and the challenges in tracing attribution and setting borders.

The international level of governance came first for the internet, where the original researchers who managed the internet transitioned into management roles and established independent oversight bodies, including the Internet Engineering Task Force (IETF) and the Internet Architecture Board (IAB).[69] These bodies were eventually consolidated into the Internet Corporation for Assigned Names and Numbers (ICANN) in the 90s. Today, the cyberspace regulatory "regime complex" is made up of thousands of entities, including NGOs and oversight boards, private companies, and government organizations.[70]

These institutions can be summed up into two broad categories: top-down organizations and bottom-up organizations. As an example of the top-down organizations, the UN sponsored an internet governance forum in the 2000s to comprehensively govern cyberspace. This body was wide ranging, but "toothless," as global fora often are.[71] On the other side of the coin was the

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[65] Dietz, Ostrom, Stern 2003.
[66] Hardin 1968.
[67] Shackelford 2013.
[68] Shackelford 2013.
[69] Shackelford 2013.
[70] Shackelford 2013.
[71] Shackelford 2013.

IETF, which "evolved organically" to set standards. The IETF also has little authority to resolve disputes, but it has a more limited mandate, setting standards for communications systems.

Subnationally, the private sector in particular has a large amount of influence on norms and standards, in large part due to the pace of technological change. While the government is still a client and sometimes proprietor of cyber systems, industry has largely moved to being the primary source of technological innovation for information technology and has diversified the customer base beyond just governments. While national governments, especially recently, are moving toward regulating some internet activities—GDPR in Europe, and the talks about regulating cryptocurrencies in the United States, for example—this is preceded by years of work by the private sector to lay the foundations.[72]

The cyber industry has seen a "groundswell of private leadership" over the past several years.[73] Microsoft is working on both industry and government sides to set cybersecurity standards and to advocate for norms against attack, culminating in the "Digital Geneva Convention," engaging at all levels diplomatically as well as investing in research and development.[74] The company is taking a role that borders the traditional mandate of states, making diplomatic moves and policy recommendations to set rules of the road for cyberattacks and working to establish red lines.[75]

The "cultural norms" propagated by the private sector and other non-state actors engaged in cybersecurity work to socialize standards and norms through naming and shaming, also through "capacity building," "teaching and empowering," and creating widespread "shared expectations."[76] In this way, the private sector companies doing this work are acting as "norm entrepreneurs." Of course, they do need the support of states and international bodies to legitimize their norms for the long term, but there may be limited options for the government to reject any norms once the private sector has settled into them. This may be a different kind of peer pressure than Finnemore and Sikkink may have imagined, but it is peer pressure nonetheless from ubiquitous commercial actors.[77]

The internet, and therefore internet governance, is similar to space in that the rate of technological development has far outpaced the ability of national laws and policy, and that though beginning as a primarily governmental/military application, the private sector has since become a large stakeholder. The extent of both of these is more extreme in the case of the internet, due both to the relative maturity of the domain and to the much lower barriers to entry.

Artificial Intelligence

A more niche offshoot of the problem of internet governance is the question of artificial intelligence governance. Parallels to space can be drawn as AI too is a burgeoning field, not yet developed to its full potential, but with the promise of technological revolution. The field of AI governance today is largely dominated by the ideas of self-governance and the free market, that AI developers should not be constrained by levels of regulation because the technology is developing so quickly.[78]

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[72] Sanger 2021.
[73] Matsakis 2018.
[74] Smith 2017.
[75] "Creating a Digital Geneva Convention".
[76] Finnemore & Hollis 2016.
[77] Finnemore & Sikkink 1998.
[78] Therier 2022.

In these circles, self-governance and polycentricity have come to be seen as synonymous, but this is a false parallel. Self-governing bodies can be a part of a polycentric system, but there must be levels of guidance and oversight. Industry associations are currently spearheading this oversight, establishing voluntary standards frameworks based mostly around the ethical use of AI. Associations and corporate leaders are therefore so far leading industry from within[79]. However, these efforts still lack coordination and a long-term vision to mitigate profit-oriented short-termism.

In AI, as in space, there needs to be a middle-ground way to marry the ideas of "permissionless innovation" and the precautionary principle so that innovators cannot run unchecked. Polycentric governance structures marry the best of these worlds, creating standards and monitoring bodies—even if technically "soft"/"on the ground"—that are more adaptable than other options, such as rigid, top-down or centralized authorities.

6. CONCLUSION

With the varied and growing number of interests and actors in space, outer space is a polycentric system. Polycentric governance systems are those in which there are multiple authorities that oversee the same area, albeit with different but overlapping interests and scopes of responsibility. This multilevel system is a benefit to the evolving domain, allowing for the agility to react to changing situations and address them with the appropriate flexibility.

The challenge then, regarding polycentricity, is not that the system is fragmented. Rather, the challenge lies in embracing the "messy" system and working the issues in space governance at the appropriate levels. In this paper, I laid the foundations for determining appropriate levels of governance, scrutinizing situations by the level of risk posed to operations and by the barriers to entry in each system.

This project is only the beginning of this effort. There are still many unanswered questions regarding space governance, a major one being the topic of attribution. With the influx of new actors, the question of attribution in space is only going to grow more complicated. The simplified governance structure described in Figure 2, for example, seems relatively straightforward. Organizations fit into one of three levels, and each entity within the level has a distinct description and identifiable owner. But how will multinational corporations, for example, be viewed in space? Which country will be held responsible and/or liable if Active Debris Removal effort headquartered in State x, developed in conjunction with a team from State y, is used to interfere with a satellite operated from State z?

We are already seeing questions of attribution and acceptability bleed over in the gap between security and industry. In retaliation for commercial satellites being used to support Ukrainian efforts in the 2022 conflict with Russia, a Russian representative addressed the UN, suggesting that commercial space architecture could become a legitimate target for retaliation.[80]

Attribution problems may also plague civil space missions, even the Artemis Moon missions. Differences in understanding between the definitions of state and private actors may lead to misinterpretation of actions—willful or genuine—that may spark tensions in an already tense environment.[81]

Claire Oto
December 2022

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[79] Therier 2022.
[80] Erwin 2022.
[81] Zhen 2020.

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