Space Governance Analysis as a Product of Multi-Actors Communication and Through the Lens of Systems Feedback Loops[1]

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This article explores the evolving architecture of space governance, highlighting a shift from rigid, abstract legal frameworks to more dynamic, context-sensitive mechanisms. Drawing on recent research, it identifies five key features of contemporary space governance: reduced abstraction, flexibility, multilogue application, dynamism, and a subjective scope of law enforcement. These elements reflect a movement toward governance practices that are grounded in real-world space activities, responsive to rapid technological change, and inclusive of diverse actors and perspectives. The transition from linear, top-down regulation to a more interactive, adaptive approach addresses the growing complexity and fragmentation in the global space arena. The study also examines common misconceptions that act as feedback loops or system traps, impeding sustainable governance. It argues that overcoming these traps requires greater system awareness and a shift in mindset—from promoting isolated interests to engaging in coordinated efforts based on mutual understanding and differentiated solidarity. In doing so, the paper advocates for a governance model that can ensure the sustainable and responsible use of outer space for both present and future generations.

Keywords: space governance, evolving architecture, legal frameworks, flexibility, subjective law enforcement

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[1] A feedback loop is a cause-and-effect system in which the outputs of system feedback in as inputs and prompt new cycles (Feedback Loops; 2022).

Introduction

The development of prospective space governance can metaphorically be depicted as a vast construction site with the goal of building "sustainable space activity." In this process, each participant has the right to vote on the type of construction, but all are subject to two opposing principles: particularization, to reflect each interest (commercial, national, subjective, etc.), and unification, for a common understanding of the foundation for interaction. Viewing this metaphor through the lens of systems theory (Meadows, 2023), we can clearly identify the elements (actors with their interests: states, private entities, international organisations, academia, etc.), interactions (guided by opposing principles), and the aim (a sustainable space environment with numerous sub-goals according to the interests of each actor). Recent initiatives addressing various urgent issues in space activities focus on analysing the behaviour of space actors, emphasizing recommendations and guidance rather than obligations. This paradigm is characterized by its flexibility, co-constructive approach, reliance on the willingness of actors, and the pursuit of common understanding in dangerous situations.

If we descend from metaphor to facts, the characteristics of future space governance are described in the UN Secretary-General report "Our Common Agenda," namely international cooperation through effective multilateralism (High-Level Advisory Board, 2023) and multi-stakeholder dialogues on outer space with stronger involvement of all relevant stakeholders, combination of binding and non-binding norms on the peaceful, secure and sustainable use of outer space to coordinate space traffic and the elaboration of new instruments to prevent weaponization of outer space (Our Common Agenda Report of the UN Secretary-General, 2021). The Open-ended Working Group on Reducing Space Threats Through Norms, Rules, and Principles of Responsible Behavior (OEWG) stated that it is important to emphasize identifying positive behaviors that make operators in outer space feel safe, secure, and confident in the intentions of others. Non-binding norms, rules, and principles are rooted in values and depend on practice; they are subject to reinterpretation. As a result, this type of norm often guides and reflects how law is interpreted and applied in practice and can help resolve conflicting legal rules. General commitments leave room for interpretive differences and loopholes, such as the meaning of "long-lived" debris or of "due regard" (UNIDIR, 2023). This recalls with positions of researchers that argued that the UN space treaties are highly significant for space activity, but the momentum in adopting of hard law has waned and soft law in foreseeable future continue to shape, guide and influence the behaviour of space actors (Jakhu et al., 2021). Noticeable in this context is the position of Jessica West and Jordan Miller, who argue that to mitigate the negative effects of the grey zone (unclear or contested rules), space governance should be broad and layered. Broad engagement is necessary to avoid fragmented governance and to address gaps in the rules, actors, and domains. This approach is essential for determining the outcomes we need to achieve (West & Miller, 2023).

Finding nemo[2]

Since such an outcome could serve as the foundational concept of space governance, namely space sustainability, it has been extensively promoted in the field of environmental protection and is well known among the general public. However, sustainability remains an elusive and challenging goal for the space industry, partly because the meaning of the term 'sustainability'

[2] In this article, this word is used in the original Latin sense that could be translated in English as nothing or all. https://www.latin-dictionary.net/search/latin/nemo

varies depending on the context – whether in space or on Earth (Jones & Jain, 2023). According to its original sense, as reflected in the "Our Common Future Report," sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It encompasses two key concepts: "needs," which include the essential needs of the world's poor and should be given overriding priority; and "limitations," which are imposed by the state of technology and social organization on the environment's capacity to meet both current and future needs (Brundtland Report, 1987). Few decades passed and sustainability was recognised as no longer an attainable goal, thus, humanity should now focus on the concept of resilience because the global system was about to embark on a period of uncontrolled decline, which would lead to a new type of equilibrium, the functioning of which we are currently unable to perceive (Gambino, 2012). Taking this into account, the concept of sustainability develops with additional senses, reflected by the principle of solidarity, based on responsibility, the renewal of the relationship between human and nature, taking account of the dynamics of the environment, citizen participation, a bottom-up approach to standard-setting, etc (Lucas, 2020). Thus, in Art. 1 of the Draft of the International Covenant on the Human Right to the Environment stated that the realization and enjoyment of the right to a clean, healthy and sustainable environment shall be fostered through a symbiotic connection between human beings and natural ecosystems, in a mutually beneficial relationship based on the recognition and enforcement of the rights of nature (Draft, 2025). The similar approach is possible to find on the national level, for instance, The US Environmental Protection Agency (EPA) defines environmental sustainability as the ability to "create and maintain conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations." (Learn, 2025) This shade of sustainability is especially crucial in the context of proclaimed in the Zero Draft of the Declaration on Future Generations intergenerational solidarity and responsibility (Zero, 2024), critical both from the perspective of space activity input for application of Sustainable Development Goals and for widen of human industry through deep space exploration.

The United Nations (UN) defines space sustainability as the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations. According to NASA, space sustainability is characterized as a safe, peaceful, and responsible activity with additional aim, namely, the limiting harm to terrestrial life (NASA's, 2024). From this point of view, the initial key concepts of sustainability, i. e. "needs" and "limitations" still be actual to space sustainability, but as we go into the details and their interpretation by different actors, questions may arise about their scope.

For developing new governance frameworks, UN Secretary General outlined such areas of space sustainability: space traffic management, space debris removal and space resource activities (Pact, 2024). This suggestion to comprise separate, mutually reinforcing instruments, is an alternative to the develop a unified regime for space sustainability for fostering transparency, confidence-building and the interoperability of space operations in Earth orbit and beyond, including on the Moon and other celestial bodies (Strengthening, 2021).

One example could be the initiative of Space Sustainability Rating, which not only validates commitment to responsible and sustainable space practices but also enhances the company's reputation as a trustworthy and environmentally conscious player in the satellite industry, improving reputation, competitiveness, attracting investors, regulatory compliance, long-term

viability, and risk mitigation (David et al., 2023a). Nevertheless that it focuses only on the space debris, but in the broad context of more responsible space activity for preserving outer space their framework consist of six modules: 1) mission index which measures the impact of the mission on the space environment; 2) the ability of the mission to perform collision avoidance manoeuvre and the associated processes; 2) data sharing; 4) detection, identification and tracking; 5) application of design and operation standards; 6) external services, which assess the capability of the mission to be compatible with future on-orbit servicing missions (David et al., 2023b). This example shows that the issue of space debris is closely related to situational awareness as a means of avoiding collisions, as well as to secondary production, which is closely tied to the extraction of space resources. Therefore, narrowing the regulation to only one issue, without considering the interactions among various factors, will inevitably lead to gaps and misunderstandings.

The dilemma of whether to adopt a unified regime for space sustainability or to develop new governance frameworks for different areas of space sustainability could be detrimental to the effectiveness of achieving space sustainability. This is due to a lack of a systems thinking approach and the risk of being guided by misconceptions, which will be discussed below.

Factors contributing to the breakdown of general consensus

Pluralism of interpretations

The comprehensive scope of governance involves considering the entire system, including the similar, opposite, or different interests of each actor that impact one another at different levels. It starts at the level of the individual, moves to the level of other actors and the relationships between them, extends to the system as a whole, the subsystems and aspect systems, and finally to the environment, or vice versa. Besides the possibility of switching vertically between levels, another strategy is to switch horizontally. This approach successively covers perspectives from various roles, helping participants see the big picture (Vincent & Westelaken, 2023). It is a system thinking description of the current situation, where national and regional entities coordinate space traffic with different sets of standards, best practices, definitions, languages, and modes of interoperability. This relative lack of coordination widens the gap for countries with less space capacity, making it harder for them to operate their limited space assets in an increasingly complex environment. There is also a lack of consensus on how risks should be communicated and addressed. For example, if two outer space actors become aware of a potential collision between their space assets, they are often unaware of the maneuvering capabilities or intentions of the objects at risk. This is especially true for private actors or countries with limited space capabilities (Strengthening, 2021).

The same tendency could be noted in law-making process on the example of drafting EU Space Law, which has shaken up experts on both sides of Atlantic. From European site, Dr. Stefoudi outlined as weak aspect of this initiative lack EU competence in space, lack of timelines and legal certainty concerning national legislations, but as a strengths were highlighted EU strategic autonomy in space, establishing a minimum level of regulation and uniform approach in space (Stefoudi, 2024). At the same time, American expert Dr. Rozpedowski stated that the EU's push for a unified Space Law grounded in its EU Space Strategy, which reflected efforts to minimize regulatory redundancies and avoid legal fragmentation at the EU-level, while acknowledging the "need to be prepared for a more competitive and contested space environment." This expert highlight as a disadvantage the same issue pointed

above as advantage, namely the EU's strategic autonomy and technological sovereignty in space interpreted as areas of competition and divergence with the risk of diverging standards, disparate regulations and procurement practices that could directly and significantly impact US interests and also legally fragmented global space policy can result in the heightening of tensions, escalation of conflicts, and duplication of efforts leading to inefficiencies and increased costs of compliance. Furthermore, differences in strategic outlooks and threat perceptions between the EU and the US could complicate efforts of forging a unified approach to space security and defence at a time of global power redistribution and rebalancing, which pose a risk in the situation, when China and Russia enhance their comprehensive strategic military, economic, and technological partnership and develop increasingly sophisticated space capabilities (Rozpedowski, 2024). Here is an example of international academic communication, but diversion is also notable within the same actor's role. For instance, the "UK Space Regulatory Review" highlighted, on one hand, close collaboration with the US and other partners to reduce bureaucracy and duplication in licensing space launch systems, to promote best practices in space, and to open markets for emerging technologies. On the other hand, it emphasized delivering the Plan for Space Sustainability announced in June 2022, which includes developing sustainability standards and aligning with the Astra Carta initiative to position the UK as a global leader in setting industry standards supported by other space nations (Space, 2024). This document also reflects the need for clear legislation for private entities: "The challenge for industry is to understand the term "acceptable" in s.9(4)(b) of Space Industry Act as this was considered unclear and subjective. This uncertainty adds costs, time, and delays for applicants negotiating the licensing process. We will explore ways to address this issue and provide clarity" (Space, 2024). These few examples illustrate some aspects of the complexity of multidimensional communication within the space governance process, which is much more complicated in reality.

Communication through the threat of the "fog of war"

To efficiently resolve problems with myriad interconnections and details, individuals often shift from a time-consuming, sophisticated, and fully informed style of decision-making to a more automatic, primitive, single-feature type of response (Cialdini, 2009). There are a lot of psychological research explaining the limitations of our ability to comprehend reality arguing that the purpose of human's mindset in the creation such map of reality guaranteeing to take decisions for survival (van der Kolk, 2015). It creates a context for defining and solving complex problems.

Given these emerging risks, several national security strategies, doctrines, concepts and policies describe outer space as a warfighting or operational domain. These are not just theoretical concepts, they are being backed by the development of military capabilities to deny, disrupt, degrade, or destroy the space systems of adversaries. This can include direct-ascent missiles, manoeuvrable satellites, Earth or space-based laser systems, electromagnetic and cyber capabilities or even the use of nuclear weapons. A major challenge in space security is the dual use nature of many capabilities. Any satellite capable of manoeuvring to change its orbit or to avoid a collision is also capable of manoeuvring purposefully to collide. Any satellite designed to service, repair or refuel another satellite could be instructed to cause damage instead (Strengthening, 2021).

Even though the peaceful use of outer space is a cornerstone principle of space law, the root of space program to the protection of national security and prism always works during the communication on the subject of space governance. For example, the lack of clarity surrounding the definition and identification of "space weapons" is a long-standing obstacle to agreement on arms control measures in space (The role of norms, 2023). Disagreement regarding whether certain types of space activities, such as active debris removal, should be classified as military (as advocated by BRICS) or civilian (as supported by other states), has resulted in the failure to adopt an "International Code of Conduct" (Marta, 2015). The states provide the communication exceptionally through the context of their traditional positions. As was noted in the research "Clearing the Fog. The Grey Zones of Space Governance" Russia and China objected to efforts to develop norms of responsible behaviour, relying only on narrowly interpreted laws to preserve order while maintaining strategic freedom, at the same time United States are unwilling to agree to new legal restrictions or obligations. Diplomats persist in separating discussions on limiting weapons in space from discussions that limit weapons on Earth that are aimed at space; as well, Open-ended working group on reducing space threats through norms, rules and principles of responsible behaviours discussions display efforts to disregard cyber or other terrestrial activities that affect space (West and Miller, 2023).

This fog of mistrust is rising according to recent diplomatic tension, connected with the situation when Russia offered the resolution about banning the placement of weapons of any kind in outer space at the same time of vetting a resolution offered by Japan and the United States and in the days following the launch of "Cosmos 2576" in an orbit with some of the same parameters as USA 314 (Foust, 2024).

Misconceptions as a factor in altering feedback loops for prospective space governance.

These examples illustrate an approach to creating new space governance that prioritizes not the strict application of detailed legal procedures, but rather allows significant room for interpreting norms, rules of behaviour, communication mechanisms, and standardization.

To maintain coherence, it is necessary to consider aspects beyond strict legal and regulatory frameworks, particularly the nature of information transmission. Dr. R. Duke describes this complexity as follows: "The transmission of an idea from speaker to listener involves translating it into a sequential string of component descriptions that the listener uses as building blocks to reconstruct into their own proper image" (Duke, 1974). Thus, the complexity of issues and their transmission, coupled with the different contexts of participants, can lead to unintentional misunderstandings and cognitive biases.

This is why nontraditional channels of communication have become increasingly preferred in multilateral forums. For instance, the High-level Advisory Board on Effective Multilateralism recommended the "Arria formula" (Strengthening, 2021) to the Committee on the Peaceful Uses of Outer Space and other governance bodies. This approach suggests increasing the use of procedures that effectively include external technical experts in Member State discussions and accommodate the growing involvement of private sector actors in outer space. This also pertains to nonlinear approaches (Erwin, 2024) for understanding interactions and developing possible reaction scenarios that place the observer within the complex system, conveying the system's logic without relying on the cumbersome sequential detailing of simple parts. From this perspective, observation becomes possible through system thinking – a method that focuses on the collection of elements and their interconnections (Meadows, et al., 2016).

According to Argyris and Schön's action theory, the complexity of problem (for example, *the ensuring space sustainability*) confounds our mental map, in other words, comprehension of issue, and encourages us to search another strategy that will address and work within the governing variables (for example, *change of national legislations, adoption of recommendations on the base of Outer Space Treaty*), but we will have the chance to obtain radical changes by subjecting the governing variables to critical scrutiny (for example, *to change space governance mechanisms from recognition the space as an operational environment to the renewal of the relationship between humanity and space, taking account of the dynamics of the environment, citizen participation, a bottom-up approach to standard-setting*). Where something goes wrong, it is suggested, an initial port of call for many people is to look for another strategy that will address and work within the governing variables, adapting to environmental changes through actions (*space debris mitigation, sustainability rating, etc*.) (single-loop learning) (Barbat, et al., 2011). An alternative response is to question to governing variables themselves, to subject them to critical scrutiny that led to an alteration in the governing variables and, thus, a shift in the way in which strategies and consequences are framed (*circular space economy or something more innovative*) (double-loop learning) (Smith, 2013).

The use of outer space also has limits, especially in the context of overusing most operational orbits. The hyper-traffic in low Earth orbit, driven by their technical and financial accessibility, also prompts public discussion about the importance of measuring the consequences of exploiting this finite resource (Waserman et al., 2023). The Zero Debris approach aims to prevent its generation by 2030 through anticipation and mitigation of adverse effects; it encourages the exchange of perspectives and contributions toward achieving the target, development of relevant technologies, and national legislation relevant to the peaceful exploration and use of outer space that enhance the long-term sustainability of outer space activities. These efforts correspond to the requirement to enact effective environmental legislation, ensuring that environmental standards, management objectives, and priorities reflect the environmental and developmental context. Whereas the climate change and space sustainability have the common roots of overuse and characteristic of complicity of economic, political, secure, environmental, and other interactions, we assume that would be useful for deeper understanding the problem of ensuring of space sustainability by the nonlinear form. The author of "Limits of Growth" Dr. Meadows pointed out a set of obstacles or misconceptions of humans' comprehension of climate change (Meadows et al., 2016) that will be analysed through the lens of space sustainability.

Inappropriate frames mislead us, draw attention to enlarging the perceptions of time, place, sense of responsibility and other implicit regulating factors. For example, seems that we have a lot of time to deal with the space debris issue. Changing the frames in the context of space governance was demonstrated in the Interconnected Disaster Risk Tipping Point, where it was argued that if we look at the problem of space debris as solely an issue of increasing pollution in orbit, then our solutions will focus on practical means to clean it up. The presence of debris is a fact of the world, and we will need to keep up with the rate of change, until our capacity to clean up the debris becomes overwhelmed, and the risk tipping point is reached anyway. However, if we can look deeper at the root causes of why the debris is there in the first place, for example, global demand pressures or insufficient risk management, then we can see how the contamination of our orbit is part of wider societal processes. As such, the solutions to address the problem are more fundamental. We need to reimagine our socio-ecological systems to create truly sustainable, resilient, and equitable systems that work for

people and the planet in the long term (Risk, 2023). From this perspective, in order to change the values and frameworks of space governance (e.g., addressing root causes rather than consequences), communication efforts should focus more on engaging decision-makers who may have entrenched patterns of behaviour and rigid limitations, with the aim of broadening their understanding of this complex issue.

Uncertainty in the complex system arises from a set of interactions that are not entirely understood and accurately measured, operating under implicit rules and often producing results different from expectations and collective efforts. This issue relates to technology/culture ratio, suggesting that sustainable development is primarily achieved through technology, but rather through the values and norms of society that promote sustainable space activity. This idea is exemplified by the rapid advancements in active debris removal technologies, which, despite their potential benefits, are restricted in their use by some states due to their recognition as potential weapons (Frigoli, 2019).

Autonomous behaviour of the environment (climate and outer space) should be part of the humans' actions of their saving. Noticeably, Mr. Meadows emphasizes that errors in understanding exponential growth and the system's capacity to cope persist even among highly educated adults because they were not explicitly taught skills related to recognizing systems of multiple causes, effects, and unintended impacts (Meadows, et al., 2016). An example of the autonomous behavior of one system affecting another is the rising risk of collisions with space debris in low Earth orbit, which is making insurance for satellites increasingly unattainable as insurers no longer offer coverage or limit coverage for collision hazards.

Magnification – since seemingly small changes can cause major problems, efforts to reduce system problems must consider signals that do not initially seem important or significant. The limited action can be that participants persist in using approach without stopping to reflect their assumptions, listen to other ideas or consider their options. Nevertheless, that the space activity grew exponentially, for example Space X alone possesses thousands of operational satellites, there are some structural changes in the approaches to using the space services. For example, Erwan Le Ho, Head of Sustainable Development at Thales Alenia Space stated: "The only effective way to preserve this universal heritage would be to moderate our use of it. Do we really need mega constellations which, by definition, are useless at least three quarters of the time since they fly over the oceans?" (Lucchese, 2023).

These misconceptions alter the cause-and-effect relationships (feedback loops) within the complex system of space governance by amplifying their contested, congested, and competitive characteristics (reinforcing type of feedback loop). Therefore, they must be considered to prevent or address system traps (archetypes) (Medovz, 2023).

The "tragedy of the commons" trap, where multiple actors independently act in their self-interest and deplete a shared resource to the detriment of all, can be mitigated by rebuilding feedback between consequences and causes for each actor. This can be achieved by privatizing resources (e.g., private entities avoiding the creation of space debris to preserve their investments) and regulating access to resources (e.g., distribution of slots in geostationary orbit, safety zones, etc.).

The "resistance to external influence" trap occurs when different actors move the stock (technical and economic potential or global security), leading to resistance. The solution could be to concentrate all resources spent on resistance towards achieving common goals. Redefining broader goals, such as survival in deep space, may be preferable than winning a conflict. This opens the door for strategic parity, similar to that which allowed the adoption

of space treaties decades ago, and advances interoperability. Therefore, the idea of a unified regime for space sustainability is preferable than developing governance frameworks for different areas of space sustainability.

The "pursuit of false goals" trap occurs because the system is sensitive to its goals. If solutions aim to achieve goals different from those declared, the results will align with the original, not the declared goals. For example, when a Russia proposed a resolution to ban the placement of weapons in outer space while simultaneously vetting a resolution with similar aims and placing weapons in outer space, its initial aim is to ensure its own military advantage, not to promote the peaceful use of outer space. The global governance system will respond to this initial aim, not the proclaimed one, because actors will focus on countering the initial aims. Magnifying such situations across numerous actors with their interactions, switching vertically between levels or horizontally, demands careful attention to the goals to ensure the space governance system remains on its intended course.

Conclusions

Based on this research, the following key points of the space governance design can be outlined:

1. Reduced Abstraction: space governance has moved towards a more practical (concrete) approach where the enforcement of laws is influenced by current practices. This means that legal frameworks are less theoretical and more grounded in the realities of space activities, ensuring that regulations are relevant and applicable to contemporary issues.
2. Flexibility: the same set of abstractive norms can be adapted to different situational contexts. This flexibility allows the modifications in the application of laws to accommodate the unique characteristics of various space-related activities. Such adaptability is crucial for addressing the diverse and evolving challenges in space governance.
3. Multilogue Application: the application of legally binding norms has transitioned from a one-way directive approach to a more interactive and dialogue-based process. This multilogue application involves multiple stakeholders, including international organizations, private entities, and national governments, in the interpretation and enforcement of space laws. Such an approach promotes inclusivity and ensures that diverse perspectives are considered in the governance process.
4. Dynamism: the interpretation of norms is not static, but changes over time and space. This dynamism ensures that legal frameworks remain relevant as new technologies emerge and as our understanding of space evolves. It also means that legal interpretations can vary based on different contexts, reflecting a more nuanced application of laws.
5. Subjective Scope of Law Enforcement: there has been a significant shift in how laws are enforced, moving away from a linear, rigid comprehension of binding norms to a more subjective and non-linear interpretation. This change emphasizes the importance of context and activity in the application of laws, allowing for a more dynamic and responsive legal framework. The focus is on understanding the broader implications of activities and ensuring that law enforcement is adaptable to various scenarios.

These features underscore the complexity and evolving nature of space governance nowadays when the general consensus is almost lost. By embracing reduced abstraction, flexibility, dynamism, multilogue application, and a subjective scope of law enforcement, space governance can effectively address the unique challenges posed by space activities and ensure sustainable through responsible use of outer space.

A brief overview of common obstacles (misconceptions) and their impact as feedback loops, system traps, on the space governance system highlights the complexity of governance procedures and the traps, we must avoid achieving sustainability that meets the needs of present and future generations based on different dimensions of solidarity. This is possible only with system awareness and the intention of actors not just to promote their own mental maps, but also to understand and coordinate with the mental maps of others for common, yet distinct, aims.

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