Crowded Orbits: What's at Stake with Space Sustainability

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Highlights

- **The sustainability of outer space is increasingly at risk due to the accumulation of space debris and rising levels of orbital congestion.**
- **If left unaddressed, these trends could render parts of Earth orbit inaccessible: a scenario that would severely impact communication, navigation, weather forecasting, and all other activities that rely on space-based infrastructure and data.**
- **Existing international guidelines mark important milestones toward sustainability, but their voluntary nature and limited enforcement significantly reduce their overall effectiveness.**

Introduction

Outer space plays a vital role in modern life. Societies and economies around the world depend on space-based infrastructure for essential functions — including communication, health, education, navigation, security, and broader socio-economic development. However, this interconnection extends far beyond the realm of technology: space matters increasingly shape politics, geopolitics, and policymaking at both national and international levels. Given this deep and growing reliance, ensuring continued access to outer space is no longer just a concern for space agencies or private companies — it is a matter of public interest and global equity. Yet, this access is increasingly under threat.

One of the most urgent and visible threats is the accumulation of orbital debris. Commonly known as "space junk," this includes, for example, defunct satellites, abandoned rocket stages, and fragments from past collisions, explosions, or malfunctions. These objects pose significant risks to active satellites and space missions, with the potential to trigger chain-reaction collisions, disrupt critical services on Earth, and limit the future use of orbital space. The issue of space debris is part of a much broader challenge: space sustainability. This concept refers to "the use of outer space in a manner that maintains its potential to meet the needs and aspirations of present and future generations." [1] It underscores the importance of preserving outer space for peaceful purposes, scientific progress, and socio-economic benefit.

Understanding space sustainability — and why it matters — is essential for anyone involved in shaping policy today, and increasingly, for society at large. For this reason, this brief outlines the key risks to sustainable space activity and explains why they deserve attention beyond the space sector alone.

[1] Sergio Marchisio, Security in Space: Issues at Stake, in Space Policy, 2015

Context

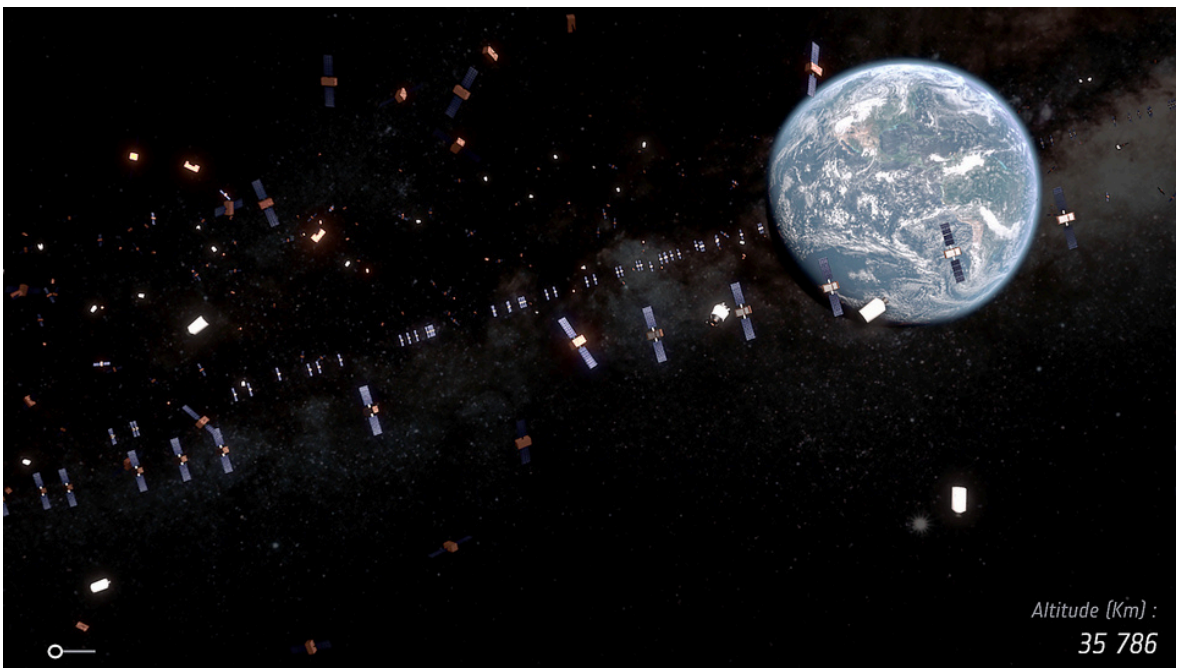
Earth's orbital environment is a finite and fragile resource. While space may seem vast and limitless, the regions most commonly used for satellite operations — particularly low Earth orbit (LEO) — are becoming increasingly congested and contested. In fact, in 2024 approximately 35,000 objects were tracked by space surveillance networks: about 9,100 of these were active payloads, while the remaining 26,000 were pieces of debris larger than 10 cm. However, the estimated number of debris objects larger than 1 cm — large enough to cause catastrophic damage — exceeds one million.

The rapid growth in space activities over the past decade has placed mounting pressure on these orbital zones, raising serious concerns about their long-term sustainability. For example, in 2023, more satellites were launched than in any previous year, setting a new record for global space activity.

Definition of the problem

The threats to the long-term sustainability of outer space are diverse. Some, like the accumulation of orbital debris and orbital congestion, have been concerns for decades; others are more recent, such as the brightening of the night sky caused by satellite reflections. For the purpose of this brief, the primary focus is on the issue commonly referred to as space junk, or space debris.

Space debris can consist of a variety of different objects, but the Inter-Agency Space Debris Coordination Committee defines orbital debris as "all man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are nonfunctional" [2]. It may result from natural decay, collisions with other objects (man-made or natural objects in orbit), damage sustained by exposure to radiation and space weather, and even intentional destruction. A critical concern is the inadequate deorbiting of satellites at the end of their operational life: many remain in orbit, inactive and unmanaged, further contributing to the debris population.



[2] Migaud M. R., Protecting Earth's Orbital Environment: Policy Tools for Combating Space Debris, in Space Policy, 2020

The main **consequences** and risks posed by space debris and orbital congestion include, but are not limited to:

- **increased collision risk**: collisions between such objects can generate thousands of additional fragments, each capable of causing further collisions. As a result, operational satellites face higher chances of damage or destruction, threatening all the essential services linked to space activities (e.g. communication, Earth observation, etc.).
- **rising economic costs**: the growing need for collision avoidance manoeuvres places a financial burden on satellite operators
- **a limited access**: since certain orbital regions become increasingly congested, they may become unusable for future missions. This could limit access to orbital zones, hindering future space missions and technological advancements.

Ongoing Efforts & Challenges

As a response to the growing threats to the sustainability of space activities, several international initiatives have been introduced.

Notably, the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) adopted the Guidelines for the Long-term Sustainability (LTS) of Outer Space Activities in 2019: these voluntary guidelines offer a comprehensive framework focused on policy, safety, and international cooperation to promote sustainable space operations. Complementing these efforts, the European Space Agency (ESA) introduced the Space Debris Mitigation Requirements in 2023, establishing stricter technical standards for disposal and collision avoidance in ESA missions.

While many other examples could be cited, the core challenge remains. In fact, the voluntary nature of these initiatives results in uneven implementation across countries and private actors; also, the absence of binding international regulations and enforcement mechanisms continues to limit their overall effectiveness, underscoring the urgent need for stronger global coordination and long-term commitment to sustainable space practices.

Policy recommendations

1. **Promote international coordination:** encourage broader participation in global sustainability frameworks, such as the UNCOPUOS Guidelines on the Long-Term Sustainability of Outer Space Activities.
2. **Support transparency and data-sharing:** this could be helpful in space traffic management and to prevent eventual collisions (which would lead to more debris).
3. **Encourage sustainable design and end-of-life planning:** promote the development and deployment of satellites designed with responsible disposal plans or reusability features.
4. **Raise cross-sectoral awareness:** integrate space sustainability into broader policy dialogues on digital infrastructure, climate action, and global security. This is essential to a sense of shared responsibility.

Implications

Failure to address the growing challenges to space sustainability carries significant risks: the most serious long-term threat is that outer space could become inaccessible. The unchecked accumulation of space debris may trigger a self-perpetuating cycle of collisions, rendering key orbital regions unusable. This would jeopardize satellites that provide essential services such as communication, navigation, and Earth observation. Clearly, ensuring the sustainability of space activities is not just a technical concern, but a pressing global priority. In fact, the continued benefits of space-based infrastructure are deeply intertwined with our daily lives, global development, and environmental monitoring.

Losing access to outer space would mean losing access to many of the systems we now depend on — often without even realizing it.

Conclusion

Space sustainability is no longer a niche issue whose consequences are limited to the space sector: it is a global concern that intersects with public policy, economic development, and international cooperation. For this reason, as space becomes more accessible and commercialized, coordinated efforts to preserve its long-term usability must be both promoted and implemented.

The challenges are varied and complex, but viable solutions exist. Greater awareness, stronger cooperation, and responsible behaviour today can ensure that outer space remains a safe and accessible environment for future generations.

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