PROTECTING *the* EARTH *from* SPACE POLLUTION *and* SATELLITE CRASHES

UNOOSA COMMITTEE

UNOOSA: PROTECTING EARTH FROM SPACE POLLUTION AND SATELLITE CRASHES

Table of contents

Key Terms

- **Group of Governmental Experts (GGE) :** A UN-established group of specialists from different countries who analyse specific global issues and produce recommendations.
- **Panel of Experts (PoE) :** A smaller, more technical body that provides detailed research, monitoring, or reports.
- **Outer Space Treaty :**The foundation of space law.
- **Space Traffic Management (STM)** A system to monitor and regulate satellite movement in orbit.
- **Kessler Syndrome** A chain reaction of collisions creates more and more debris.
- **Extended Producer Responsibility (EPR) :**A policy where companies are responsible for their products after use.
- **Circular Economy :** An economic system where materials are reused and recycled.
- **Mega-Constellations :** Large networks of satellites (e.g., thousands at once).
- **Space Domain Awareness (SDA) :** The ability to **detect, track, and understand everything happening in space** (satellites, debris, threats).
- **AUKUS** A security alliance between:
  Australia
  United Kingdom
  United States
- **Inter-Agency Space Debris Coordination Committee:** A group of major space agencies working together on **space debris issues**.
- **International Civil Aviation Organisation :** A UN agency that manages **global air traffic rules**.
- **Federal Aviation Administration (FAA) :** Regulates commercial space launches in the U.S.

1. Introduction to the Committee: UNOOSA

1.1 Historical Background

The United Nations Office for Outer Space Affairs was initially created as a small expert unit within the United Nations Secretariat to service the ad hoc Committee on the Peaceful Uses of Outer Space, established by the General Assembly in its resolution 1348 (XIII) of 13 December 1958.

The unit was moved to work under the Department of Political and Security Council Affairs in 1962 and, in 1968, was transformed into the Outer Space Affairs Division of that Department. In 1992, the Division was transformed into the Office for Outer Space Affairs within the Department for Political Affairs. In 1993, the Office was relocated to the United Nations Office at Vienna. At that time, the Office also assumed responsibility for substantive secretariat services to the Legal Subcommittee, previously provided by the Office of Legal Affairs in New York.

1.2 Mandate and Functions

The United Nations Office for Outer Space Affairs (UNOOSA) is mandated to promote international cooperation in the peaceful exploration and use of outer space and to ensure that space activities are carried out in accordance with international law. Acting as the secretariat to the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), UNOOSA supports Member States in developing legal and technical frameworks that enhance the long-term sustainability of outer space activities.

One of its core functions is assisting with the implementation of the five UN space treaties, including the Outer Space Treaty. UNOOSA maintains the United Nations Register of Objects Launched into Outer Space, promoting transparency and accountability among launching states. It also facilitates dialogue on emerging challenges such as space debris, satellite congestion, and space traffic management.

In addition, UNOOSA provides technical assistance and capacity-building programs to developing countries, helping them access space science and technology to support sustainable development. Through initiatives in satellite applications, disaster risk reduction, and climate monitoring, UNOOSA ensures that outer space remains accessible and beneficial to all humankind.

1.3 Role in Global Space Governance

The United Nations Office for Outer Space Affairs (UNOOSA) plays a vital role in shaping and coordinating international space governance. As the secretariat to the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), it organises sessions, prepares reports, and facilitates negotiations among Member States on legal, scientific, and technical space-related matters. Through this function, UNOOSA ensures structured dialogue on issues such as space debris, satellite traffic, and the long-term sustainability of outer space activities.

UNOOSA also supports the implementation of international space law, particularly foundational treaties such as the Outer Space Treaty. It maintains the United Nations Register of Objects Launched into Outer Space, which promotes transparency and accountability by recording information about launched space objects. This contributes to confidence-building and responsible state behaviour in orbit.

Furthermore, UNOOSA strengthens global governance by encouraging cooperation between established and emerging space actors. Through capacity building initiatives, technical assistance programs, and information-sharing platforms, it promotes equitable access to space technology and sustainable development. In doing so, UNOOSA helps ensure that outer space remains a domain governed by international cooperation rather than unilateral control.

2. Background Information

2.1 Understanding Space Pollution

The space around Earth, once empty, is now crowded with human-made objects from decades of space activity. Satellites, spent rocket parts, and fragments from break-ups or explosions form space debris — thousands of pieces of junk orbiting the planet at high speed.

Since the start of the space age, over 6,000 launches have resulted in tens of thousands of objects in orbit, but only a fraction are functioning satellites; the rest are defunct hardware or debris tracked by surveillance networks.

This debris comes from past launches, explosions in orbit (often due to leftover fuel), collisions and other release events. Even small fragments larger than 1 cm can damage satellites or spacecraft because of their high speeds.

As debris continues to accumulate, the risk of future collisions increases, potentially creating even more debris and endangering satellites, space missions, and the long-term use of certain orbits — a phenomenon known as Kessler syndrome.

2.2 Satellite Crashes and Re-entry Risks

ESA works to protect spacecraft from space debris by predicting and avoiding possible collisions in orbit. Using data from the US Joint Space Operations Centre, along with its own tracking systems, ESA's Space Debris Office regularly analyses close approaches between satellites and known debris, estimates collision risk, and advises satellite operators on avoidance manoeuvres. On average, ESA conducts about a dozen collision-avoidance manoeuvres each year.

ESA also monitors objects that re-enter Earth's atmosphere. Most debris burns up before reaching the ground, and the risk to people or property is extremely low. In rare cases, parts of large or dense spacecraft can survive reentry, but no injuries from debris have ever been confirmed. ESA can model and predict reentry behaviour to help manage casualty risk, and controlled reentries are planned to minimise danger.

2.3 Growth of Commercial Space Activities

Space economy refers to the set of activities, industries, technologies, services, and resources that generate economic value through the space exploration, understanding, management, and exploitation of outer space.

Commercial satellite use began in 1962 with Telstar 1, transmitting TV signals across the Atlantic Ocean. Syncom 3 expanded the possibilities in 1964 by broadcasting the Olympics. NASA's TIROS satellites advanced meteorological research, while Intelsat I, launched in 1965, demonstrated commercial viability. Later, France's Arianespace and the USA's Iridium Communications furthered satellite services. By 2004, global investment across all space sectors was estimated at US$50.8 billion. As of 2010, 31% of all space launches were commercial. By 2035, the space economy is projected to reach $1.8 trillion.

The commercial spaceflight sector primarily generates revenue by launching satellites into Earth's orbit, facilitated by providers deploying satellites into Low Earth Orbit and Geostationary Earth Orbit. The Federal Aviation Administration (FAA) licenses six U.S. spaceports and oversees commercial rocket launches, with global capacity expanding from sites in Russia, France, and China. Investment in reusable launch vehicles by companies like SpaceX and Blue Origin is driving innovation in this sector. In 2022, 74 FAA-licensed commercial space operations were conducted, and this number is expected to double in the near future.

Commercial satellite manufacturing encompasses non-military, civilian, governmental, and non-profit satellite production, as well as ground equipment manufacturing, support for satellite operations, and transponder leasing to provide satellite access. Satellite subscription services offer access to a variety of television channels (such as DirecTV and Dish Network), radio stations (such as SiriusXM), and other media content via satellite transmission. Satellite imagery provides detailed views of Earth and is sold by imaging companies to governments and businesses, including Apple Maps. Satellite telecommunications enable Internet services globally. Satellite navigation systems use signals from satellites for precise positioning and timing. Space tourism ventures (led by SpaceX, Virgin Galactic and Blue Origin) envision recreational human space travel. Commercial space resource recovery involves extracting materials from asteroids and other celestial bodies for use in space or on Earth.

Space commerce regulation has historically faced challenges regarding property rights in space. Still, legislation like the U.S. Commercial Space Launch Competitiveness Act aims to clarify ownership and encourage commercial space exploration.

3. Legal and Institutional Framework

3.1 Outer Space Treaty (1967)

The **Outer Space Treaty (OST)**, formally called the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, is the foundational legal framework of international space law. It was negotiated under the auspices of the United Nations and opened for signature on 27 January 1967 by the United States, the United Kingdom, and the Soviet Union, and entered into force on 10 October 1967. As of October 2025, 118 countries are parties to the treaty, with an additional 20 signatories. The treaty was developed in response to the space race, the launch of Sputnik in 1957, and the development of intercontinental ballistic missiles, aiming to prevent the militarisation of space and ensure its peaceful use for all humanity.

The OST establishes several core principles. First, space must be used for **peaceful purposes**: nuclear weapons and other weapons of mass destruction are prohibited in orbit, on celestial bodies, or elsewhere in space, and the Moon and other celestial bodies cannot be used for testing weapons, military manoeuvres, or establishing military bases, installations, or fortifications. Conventional weapons and the use of military personnel for peaceful missions are permitted. Second, space shall be **freely explored and used by all nations**, with activities benefiting all countries and humanity. Third, **no country may claim sovereignty** over outer space, the Moon, or any other celestial body. Fourth, **states are responsible for all national space activities**, whether conducted by governmental or private entities, and remain liable for any damage caused by their space objects. Fifth, **astronauts are considered envoys of humanity** and must be humankindsted if in distress. Finally, the treaty obliges states to **avoid harmful contamination** of space and celestial bodies. It includes a **consultation clause** allowing states to request discussions if an activity may interfere with peaceful space operations.

While the OST prohibits certain military activities, it does not fully regulate conventional weapons in orbit or emerging commercial and resource-extraction activities in space, such as lunar or asteroid mining. Jurisdiction and control over space objects remain with the launching state, which also bears liability for any damage. Subsequent treaties and agreements, including the 1968 Rescue Agreement, the 1972 Liability Convention, the 1976 Registration Convention, and the 1979 Moon Treaty, further developed space law, though the Moon Treaty has been adopted by few states. Modern initiatives, such as the U.S. 2015 Commercial Space Launch Competitiveness Act and the Artemis Accords, clarify legal issues surrounding space resources.

Overall, the OST remains the **cornerstone of space law**, promoting the peaceful and civilian use of space, encouraging international cooperation, and ensuring that outer space remains a **global commons for all humanity**, underpinning projects like the International Space Station and the Artemis Program. Its principles of peaceful use, freedom of exploration, non-appropriation, responsibility, and liability continue to guide multilateral space governance and policy today.

3.2 Liability Convention (1972)

The **Convention on International Liability for Damage Caused by Space Objects**, commonly known as the **Liability Convention**, was adopted in **1972** and entered into force that same year, as a follow-up to the Outer Space Treaty. Its purpose is to establish clear rules on **state liability** for damage caused by space objects, providing a legal framework for handling accidents in space and on Earth. It applies to all space-faring nations and their activities, including those carried out by government agencies or private entities under national authorisation. The convention distinguishes between two types of liability. **Absolute liability** applies when a space object from one state causes damage on the **surface of the Earth or to aircraft in flight**, meaning the launching state is fully responsible regardless of fault.

Fault-based liability applies to damage caused **in outer space** to other space objects or activities, meaning liability depends on proving negligence or wrongful action. This distinction encourages safety and accountability while recognising the unique risks of space operations.

Under the convention, a **"space object"** includes satellites, rockets, and any component launched into outer space. The launching state retains jurisdiction and control over its object and must compensate the damaged state for proven losses, including physical damage and, in some cases, economic losses. States are also required to **notify and consult** one another in the event of accidents or potential harm, thereby promoting transparency and cooperation.

The Liability Convention complements the Outer Space Treaty by **clarifying responsibility for damages**, ensuring that states are accountable for both national and private space activities. It has been applied to incidents such as satellite collisions and re-entering spacecraft that cause damage on Earth. By providing clear legal recourse, the convention reduces disputes between countries, strengthens international cooperation, and supports the safe and responsible use of outer space. It remains a **key pillar of international space law**, alongside the OST and subsequent treaties such as the Registration Convention and the Moon Treaty.

3.3 Registration Convention (1976)

The **Convention on Registration of Objects Launched into Outer Space**, commonly known as the **Registration Convention**, was adopted by the United Nations in **1976** and entered into force later that same year. It was developed as a follow-up to the **Outer Space Treaty** to establish a more structured framework for **accountability, transparency, and international cooperation** in space activities. The convention requires that all space-faring nations, whether conducting government or private launches under their authorisation, maintain records of the space objects they launch and provide this information to the United Nations. This registry allows other states and the international community to identify, track, and attribute responsibility for objects in space.

Under the Registration Convention, each state party must submit to the UN key information about every space object it launches, including: the **name of the launching state**, the **name of the space object**, its **orbital parameters**, the **date and location of launch**, and the **general function or purpose** of the object. This information is maintained by the **United Nations Office for Outer Space Affairs (UNOOSA)**, creating a publicly accessible registry that supports **safety, transparency, and conflict prevention**. By linking each object to a specific

In the launching state, the convention establishes responsibility and liability for space objects, particularly in the event of accidents, collisions, or interference with other space activities.

The Registration Convention complements other key space treaties, particularly the **Outer Space Treaty** and the **Liability Convention**. While the Outer Space Treaty outlines general principles such as non-appropriation, peaceful use, and state responsibility, and the Liability Convention defines liability for damages caused by space objects, the Registration Convention provides a **practical mechanism for identifying which state is responsible for each object in orbit or beyond**. It enhances accountability by allowing states to monitor each other's space activities. It supports international efforts to prevent misunderstandings or jurisdictional disputes, especially as the number of satellites and other space objects continues to grow.

The convention applies to a broad range of space objects, including **satellites, rockets, space stations, and any other launched objects**, whether placed in **Earth orbit, deep space, or on other celestial bodies**. By providing precise information about orbital parameters and launch details, it also contributes to the **safety of space operations**, helping to avoid collisions and other hazards. The Registration Convention encourages **international cooperation**, as states can coordinate their activities more effectively when the location, purpose, and ownership of objects are known.

In addition, the Registration Convention has long-term significance for **emerging space activities**, including commercial satellite constellations, space resource utilisation, and large-scale orbital projects. Maintaining a registry of objects and linking them to a responsible state provides a legal and administrative framework for managing **space traffic and accountability**, which is increasingly important as space becomes more congested. The treaty also reinforces the concept that outer space is a **shared global domain**, where transparency and cooperation are essential for ensuring that space remains safe, peaceful, and accessible for all humanity.

Overall, the Registration Convention is a **cornerstone of international space governance**, providing essential mechanisms for **tracking, accountability, and cooperation**. Alongside the Outer Space Treaty, the Liability Convention, and the Moon Treaty, it forms a core part of the **international legal framework governing space activities, ensuring that space exploration and utilisation can proceed safely and responsibly** for the benefit of all nations.

4. Current Situation

4.1 Increasing Satellite Launches

Global satellite launch activity hit record levels in 2024, driven by national space programs and commercial mega-constellations. There were 259 orbital launches, an 18 % increase from the previous year, mostly focused on low Earth orbit (LEO) due to its strategic and commercial value.

The United States led worldwide with around 154 launches, over half of the total, including many for SpaceX's Starlink constellation. Commercial efforts like Starlink's nearly 9,800 satellites and Amazon's Project Kuiper are expanding orbital infrastructure.

China remains a major competitor, launching more than 120 remote sensing satellites in 2025 and planning large constellation projects supported by new launch facilities.

Europe is investing in next-generation launchers like Ariane 6 to remain competitive, while emerging spacefaring nations are increasing their activity. Türkiye's Plan-S initiative now has 16 IoT satellites in orbit, and Iran and others are pursuing partnerships and new launch programs.

The global space economy reached about $415 billion in 2024, with satellites as a central driver of technological competition and commercial growth.

4.2 Orbital Congestion and Collision Risks

The rapid growth of satellite deployments—especially in low Earth orbit (LEO)—is intensifying competition for orbital slots and radio frequency spectrum, both of which are finite and vital for satellite services such as navigation, remote sensing, and broadband. This has led to increased orbital congestion, interference risks, and disputes over access and priority.

Key Issues:

- Orbital and Spectrum Scarcity: LEO's limited space and high demand for key frequency bands create choke points where satellites risk collision and signal interference without effective coordination.
- Regulatory Limitations: The International Telecommunication Union (ITU) manages global access to orbits and spectrum, but its processes are slow, and its enforcement powers are weak, relying on voluntary national compliance.
- State vs Private Claims: Governments and commercial firms increasingly clash over rights to orbital positions and frequencies, often securing filings well before actual launches. This undermines equitable access and fuels diplomatic tensions.
- Mega Constellations: Large satellite networks intensify competition, raise debris and interference risks, and can dominate resources, potentially limiting opportunities for smaller actors or developing space programs.
- Governance Challenges: Without stronger international laws, binding arbitration, and enforceable coordination mechanisms, disputes over orbital congestion and spectrum allocation threaten sustainable and fair use of near-Earth space.

4.3 Expanding Commercial and Military Use

Space surveillance, traditionally managed by government agencies, is increasingly commercialised, with private firms providing data, sensors, and analytical services to complement national capabilities. This transformation enhances technological innovation, expands coverage of objects in orbit, and supports strategic space domain awareness (SDA).

Key Points:

1. *Shift to Public–Private Collaboration:*
   - Private companies now play a central role in tracking satellites, debris, and other orbital objects.
   - Commercial data supports government monitoring, reducing costs and improving responsiveness
2. *Strategic and Security Considerations:*
   - Reliance on private actors introduces governance and security challenges.
   - Clear policies are needed to ensure data reliability, protect sensitive information, and maintain national security.
3. *Alliances and Cooperation*:
   - Initiatives such as AUKUS demonstrate the integration of military and commercial capacities.
   - Collaboration among allied nations improves shared awareness of orbital activities and strengthens resilience against potential threats.
4. *Implications*
   - Commercialisation promotes efficiency and innovation in space surveillance.
   - Balancing private-sector involvement with national security responsibilities is critical for sustainable space governance.

5. Key Challenges

5.1 Weak Enforcement of Debris Mitigation

Debris mitigation involves systematic actions to reduce or eliminate the generation, accumulation, and negative impacts of unwanted material fragments within environmental systems. This concept is central to maintaining ecological integrity and resource efficiency. Its application aims to prevent pollution, safeguard biodiversity, and protect human infrastructure from physical damage or functional disruption caused by discarded elements. Effective strategies contribute directly to cleaner ecosystems and a more stable planet.

Planetary protection is designed to **prevent harmful contamination of other celestial bodies** by Earth organisms and vice versa. Its legal basis is **Article IX of the Outer Space Treaty (1967)**, which requires states to avoid harmful contamination of outer space and celestial bodies.

The practical implementation is guided by the **COSPAR Planetary Protection Policy**, a set of **non-binding scientific guidelines** used by space agencies worldwide. These protocols classify missions by **target (e.g., Mars, Europa) and mission type** (orbiter, lander, sample return), and specify measures such as **spacecraft sterilisation** or avoidance of sensitive regions. For example, missions to Mars that might encounter environments capable of supporting life must follow **strict decontamination protocols** because some extremophiles (such as *Deinococcus radiodurans*) can survive Mars-like conditions, potentially for millions of years underground.

While COSPAR guidelines are **not legally binding**, most space agencies follow them, incorporating planetary protection into **mission planning and national regulations**. This **soft-law approach** has generally worked well since the 1960s, demonstrating that consensus and scientific authority can shape behaviour even without formal treaties.

However, **new challenges** are emerging, with **private companies and non-traditional actors** planning Mars missions or asteroid mining. These developments put voluntary compliance to the test and have sparked discussions about **strengthening planetary protection** through national laws or future international agreements. The situation mirrors other space governance issues, such as **space debris mitigation**, where voluntary guidelines also face compliance challenges.

In Low Earth Orbit (LEO), debris proliferation has reached a critical point, necessitating proactive governance (European Space Agency 7; NASA, Orbital Debris FAQ; United States, Executive Office of the President, §3(c)). Recognising this, the international community developed consensus-based Space Debris Mitigation Guidelines in the 2000s (United Nations Office for Outer Space Affairs, Compendium CRP.9). The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) published a set of voluntary guidelines in 2007 (endorsed by the UN General Assembly) outlining best practices to curb orbital debris generation. These include measures such as designing satellites to minimise debris release during normal operations, avoiding in-orbit explosions (through fuel depletion and battery-saving at the end of life) (NASA, Battery Safing Limits), and disposing of defunct objects (via controlled re-entry or by moving them to graveyard orbits). While not legally enforceable, the UN's guidelines have become an essential reference for national space agencies and operators, establishing an international norm that the creation of long-lived debris is irresponsible.

Individual agencies and multinational forums have developed their standards alongside the UN-endorsed guidelines. Notably, NASA established its first Orbital Debris Mitigation Standard Practices in 1995 and has since updated them (NASA, Guidelines and Assessment Procedures for Limiting Orbital Debris). These U.S. Government Standard Practices (recently revised in 2019) set important limits on permissible debris release and orbital lifetime for satellites and upper stages. For example, satellites in LEO should deorbit within 25 years of mission end, and the probability of accidental explosion must be below certain thresholds. The European Space Agency (ESA) likewise adopted an official Space Debris Mitigation Policy for Agency Projects in 2014, requiring all ESA missions to incorporate debris-reduction measures from design through end-of-life (ESA, Space Debris Environment Report 2025 7). ESA's policy aligns with the broader guidelines but makes them a mandatory project requirement within the Agency.

Other national agencies (Russia, China, Japan, etc.) and international organisations such as the Inter-Agency Space Debris Coordination Committee (IADC) have issued similar codes of conduct (UNOOSA, Space Debris Mitigation Guidelines 1). The IADC's guidelines informed the UN COPUOS guidelines, illustrating a progression from expert technical recommendations to widely recognised international standards. Despite this framework of debris mitigation guidelines, compliance remains uneven. The guidelines are voluntary globally; not all satellite operators adhere to them (ESA, Space Debris Environment Report 2025 7). Many older satellites and rocket bodies were launched before such guidelines existed, and even today, some launches occur without robust end-of-life plans (NASA Office of Inspector General 4, 33). There's no global enforcement to ensure compliance or penalise violations (UNOOSA, Space Debris Mitigation Guidelines 3). But unlike past biological risks, space debris poses immediate threats to operations (ESA, Space Debris Environment Report 2025 7).

This urgency has led experts to call for stronger measures, such as binding rules or economic incentives, inspired by the relative success of planetary protection frameworks (National Academies of Sciences, Engineering, and Medicine 15–16).

5.2 Regulation of Private Space Actors

The global space economy is rapidly shifting from government-dominated exploration to one increasingly driven by private actors. Companies such as SpaceX, Blue Origin, Rocket Lab, and startups across Asia, Africa, and the Middle East are reshaping the space landscape, raising new questions about whether the United Nations Office for Outer Space Affairs (UNOOSA) is equipped to regulate these actors and whether existing legal frameworks align with commercial interests.

UNOOSA's Role in Space Governance: Headquartered in Vienna, UNOOSA serves as the Secretariat for the Committee on the Peaceful Uses of Outer Space (COPUOS). It helped develop the five foundational space treaties, including the 1967 Outer Space Treaty (OST), which establishes principles such as the non-appropriation of celestial bodies, peaceful use of space, and state responsibility for national activities, including those by private entities. These treaties were robust during the Cold War's state-led era of exploration. Still, they were not designed for private mega-constellations, lunar mining, or space tourism, creating tension between traditional frameworks and modern commercial realities.

Rise of Commercial Space: Private actors now operate on a global scale: SpaceX runs Starlink, with thousands of satellites; Blue Origin develops reusable rockets and lunar systems; OneWeb and competitors pursue global broadband; and startups from countries like Pakistan, Nigeria, Brazil, and the UAE work in Earth observation, small satellites, and launch services. These activities raise complex legal questions, including the regulation of debris mitigation, liability for accidents, and rights to extract resources from celestial bodies.

Alignment and Shared Interests: Despite the gap between 1960s treaties and today's space economy, there are areas of alignment. Peaceful use norms benefit companies by ensuring stable conditions for investment. Space debris mitigation guidelines help protect orbital assets, and UNOOSA's capacity-building initiatives enable emerging states to create regulatory environments conducive to private space actors, opening new markets.

Tensions and Legal Friction: Conflicts exist between UNOOSA's state-centred frameworks and private commercial interests:

State Responsibility vs Corporate Autonomy: Under the OST, states oversee all national space activities and indirectly regulate private companies, which startups may see as bureaucratic.

Resource Utilisation and Ownership: The OST prohibits sovereignty claims, creating uncertainty for commercial lunar or asteroid mining. The Artemis Accords grant private-use rights, while UNOOSA and many states remain cautious.

Mega-Constellations and Spectrum: Companies race to secure orbital slots and radio frequencies, potentially clashing with UNOOSA's principle of equitable access.

Soft Law vs Binding Rules: Voluntary guidelines, such as the Long-Term Sustainability Guidelines, are not enforceable, prompting private actors to seek clarity or flexibility.

Case Studies:

SpaceX: Starlink has sparked debates at COPUOS on orbital congestion and light pollution; UNOOSA guidelines encourage debris mitigation, but enforcement relies on national licensing.

Blue Origin: Collaborates with NASA's Artemis program, which can conflict with UNOOSA's cautious stance on lunar resource extraction.

Emerging startups: UNOOSA capacity-building helps create legal legitimacy but can slow operations compared to companies in more flexible jurisdictions.

UNOOSA's Readiness: Institutionally, UNOOSA is adapting through initiatives like Space Law for New Space Actors and Access to Space for All. Legally, frameworks remain state-centric, requiring private actors to comply via national governments. Politically, UNOOSA balances states that advocate strict governance against those that favour commercial flexibility.

Private Sector vs UNOOSA: Private actors seek clear property rights, predictable licensing, and streamlined regulations, while UNOOSA provides consensus-building platforms, soft-law guidelines, and advocacy for sustainability and equity. The gap highlights the challenge of maintaining long-term order while accommodating commercial innovation.
UNOOSA has been the guardian of outer space law for over six decades, but private actors are now central to space activity. Its challenge is to adapt **without compromising legitimacy**, balancing equitable access, sustainability, and commercial certainty. While UNOOSA is not yet fully ready for this new era, it is actively evolving, and the next decade will test whether it remains the cornerstone of global space governance or is partially superseded by parallel frameworks such as the Artemis Accords. *SpaceX*
Founded in 2002 by Elon Musk, Space Exploration Technologies Corp. (SpaceX) is a private aerospace manufacturer and space transport company headquartered in Hawthorne, California. Its mission is to reduce space transportation costs and enable the colonisation of Mars, positioning the company as a central driver of the shift from government-led space exploration to a commercial, private-sector-dominated space economy.

SpaceX has achieved several groundbreaking milestones. It pioneered reusable rocket technology, particularly the Falcon 9 first-stage booster, significantly lowering launch costs and demonstrating the feasibility of sustainable space operations. The company became the first private firm to transport astronauts to the International Space Station (ISS) under NASA's Commercial Crew Program using the

Crew Dragon spacecraft, starting in 2020. SpaceX is also developing Starship, a fully reusable spacecraft designed for deep-space missions, including to Mars, capable of carrying large payloads and passengers beyond low Earth orbit.

Another major achievement is the Starlink mega-constellation, which has already launched over 6,000 satellites and plans to launch up to 12,000 to provide global broadband internet coverage. This initiative highlights the commercial potential of space infrastructure but also raises concerns about orbital congestion, debris, and light pollution, prompting discussions in UNOOSA, COPUOS, and national regulatory agencies.

SpaceX has had a transformative impact on the space industry. Lowering launch costs has made satellite deployment more accessible to private companies, universities, and emerging spacefaring nations, fostering a surge in private space activity worldwide. Through partnerships with NASA, the U.S. Department of Defence, and other agencies, SpaceX demonstrates how collaboration between governments and private industry can accelerate innovation and efficiency. At the same time, its rapid expansion has influenced regulatory debates on space debris mitigation, orbital slot allocation, and commercial rights to celestial resources.

Despite these successes, SpaceX faces challenges. The rapid deployment of Starlink satellites increases the risk of the Kessler Syndrome in low Earth orbit, and the environmental impacts of rocket launches, including atmospheric emissions and light pollution, are under scrutiny. Additionally, SpaceX operates in a competitive market with companies such as Blue Origin, Rocket Lab, and OneWeb, as well as startups in Asia, Africa, and Latin America, requiring continuous innovation and scaling to maintain leadership. Looking ahead, SpaceX aims to advance Mars colonisation, expand Starlink to provide high-speed internet to underserved regions, and participate in NASA's Artemis program for lunar exploration. These initiatives will test international regulatory frameworks, including UNOOSA's voluntary guidelines, while shaping the future of space governance, sustainability, and commercial space activity.

In conclusion, SpaceX has fundamentally transformed the global space landscape by demonstrating that private companies can lead in technological, operational, and commercial innovation. Its reusable rockets, crewed missions, and satellite networks have lowered barriers for private actors while raising new regulatory and environmental challenges. The company's trajectory illustrates both the potential and the complexity of a private-sector-driven space era, highlighting the need for coordination among governments, international organisations, and commercial enterprises to ensure the safe, sustainable, and equitable use of outer space.

5.3 Lack of Global Space Traffic Management

In February 2024, **a 35-year-old Russian spy satellite** and **a 25-year-old NASA scientific satellite** narrowly avoided collision, missing each other by only **33 feet**. Such an incident could have generated **thousands of debris fragments**, endangering satellites across multiple orbits.
This event underscores the urgent need for effective **Space Traffic Management (STM)** — the coordinated monitoring, regulation, and management of all space assets orbiting Earth.
Although it is in the **United States' national interest** to lead the development of global STM tools and operational protocols, its domestic system remains **fragmented**, with **ambiguous authority structures** and incomplete integration. Since 1957, over **25,100 satellites** have been launched into orbit. As of January 2026:

- More than **16,900 satellites** remain in space
- Approximately **14,200 are operational**

Additionally:

- **46,600 tracked objects** are currently catalogued
- Over **10,500 are active satellites**
- Around **80% operate in Low Earth Orbit (LEO)** (100–1,200 miles above Earth)

The rapid increase in satellite constellations means orbital space is becoming increasingly congested. Five years ago, the number of space assets was less than one-third of today's total. Commercial constellations are projected to at least **double within the next decade**.
Despite technological progress that has made launches cheaper, **space is not unlimited**, and operational risks have increased **exponentially**.

The impact of congestion is already visible:

- SpaceX's Starlink constellation performed approximately 50,000 collision avoidance manoeuvres in six months (early 2024), averaging 14 manoeuvres per satellite.
- Astronauts aboard the International Space Station (ISS) have had to shelter in place, postpone spacewalks, and reposition the station due to debris risks.
- Diplomatic tensions have emerged between OneWeb and Starlink, and China filed a note verbale to the United Nations regarding Starlink satellites approaching its space station.

There are currently no internationally agreed "rules of the road" for STM, despite the growing complexity of the space domain.

Several major challenges pose risks not only to space infrastructure but also to life on Earth:

1. Collision Avoidance

- · Over **1 million debris fragments larger than 1 cm** threaten operational satellites.
- · Risk of cascading collisions, known as the **Kessler Syndrome**, could render certain orbits unusable.
- · The rapid growth of satellite constellations increases collision probability.

2. Debris Mitigation

- · Missions must minimise debris generation.
- · End-of-life procedures (deorbiting, passivation) are essential to prevent long-term hazards.

3. Regulatory Frameworks

- · No unified **international STM agreement** exists at the UN level.
- · Lack of cohesive regional frameworks (e.g., within the EU) complicates coordination and enforcement.

4. Technological Gaps

- · More advanced tracking systems are required.
- · Active debris removal technologies remain underdeveloped.
- Greater precision in orbital data-sharing is necessary.

5. Private Sector Involvement

- · Commercial operators now dominate satellite launches.
- · Increased private participation demands **shared norms, transparency, and accountability**.

Comparable governance models exist:

- The **UN Law of the Sea Convention** established rules for ocean navigation and resource management.
- The **International Civil Aviation Organisation (ICAO)** created a shared airspace management system, including:
  - o Air traffic control
  - o Flight planning
  - o Data exchange protocols

An analogous framework for space could standardise:

· **Collision avoidance procedures**

· **Data-sharing mechanisms**

· **Operational coordination between states and private actors**

Historically, the **Department of Defence (DOD)** maintained the space object catalogue and provided **Space Situational Awareness (SSA)** data. In 2018, **Space Policy Directive-3** transferred responsibility to the **Department of Commerce**. After six years, the **Office of Space Commerce (OSC)** launched the **Traffic Coordination System for Space (TraCSS)**.

TraCSS aims to:

· Provide SSA data across all Earth orbits
· Partner with commercial SSA companies
· Improve collision risk monitoring

However:

· Implementation delays have been significant
· A 2024 audit cited unrealistic timelines
· Long-term behavioural norms for operators remain undefined

Without a fully operational domestic STM system, U.S. leadership in international negotiations remains weakened. Out of the 25 100+ satellites have been launched into orbit since 1957; there are more than 16,900 satellites in space, of which 14,200 are operational (as of January 2026). Several challenges in space traffic management can significantly impact life on Earth. The most significant ones are:

collision avoidance: over 1 million pieces of debris larger than 1 cm threaten satellites, risking a cascade of collisions known as the Kessler syndrome; the rapid growth of satellite constellations increases the chances of crashes

debris mitigation: space missions should limit the generation of space debris by reducing the risk of break-ups and by developing efficient end-of-life procedures

regulatory frameworks: the lack of a unified EU framework and/or the absence of an international agreement at the UN level complicates effective coordination and enforcement

technological gaps: more advanced solutions are needed to coordinate debris removal and precise tracking

private sector involvement: the increasing role of private operators highlights the need for shared practices and accountability in space traffic management

6. Questions to Ponder

- · What is UNOOSA, and what role does it play in space safety?
- What is space debris, and why can it be dangerous?
- How can satellites crash or cause problems on Earth?
- Why is it important for countries to work together to prevent space accidents?
- What can be done to reduce space pollution and make space safer?
- How do rules like the Outer Space Treaty help protect Earth and space?
- Why should we care about keeping space clean for future generations?
- How might growing numbers of satellites make space riskier?
- How do space debris and satellite crashes relate to the idea of space as a "global commons"?
- What technologies exist to clean up or avoid space debris?
- Why might increasing numbers of satellites, like Starlink, create more risks?
- How can countries determine responsibility if a satellite causes damage?
- What technologies exist to clean up or avoid space debris?
- Why is international cooperation important for space safety?

7. Bibliography

https://www.unoosa.org/
https://lifestyle.sustainability-directory.com/
https://wp.nyu.edu/
https://www.theregreview.org/
https://www.esa.int/
https://www.unoosa.org/
https://en.wikipedia.org/
https://www.csis.org/
https://www.consilium.europa.eu/
https://www.whitehouse.gov/presidential-actions/space-policy-directive-3 - national-space-traffic-management-policy
https://www.space.commerce.gov/
https://www.spacex.com/
https://www.esa.int/Safety_Security/Space_Debris
https://www.unoosa.org/oosa/en/ourwork/topics/long-term-sustainability.html https://www.icao.int/
https://www.un.org/depts/los/convention_agreements/convention_overview_con vention.htm
https://en.wikipedia.org/
https://esa.int/
https://nasa.gov/
https://ilkha.com/
https://innovationnewsnetwork.com/
https://nato.int/
https://lowyinstitute.org/
https://sciencedirect.com/
https://reports.weforum.org/
https://satexpome.com/