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Section 41
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Fig 1 – The number of debris orbiting planet earth (NASA Orbital Program Office, photo gallery.

<https://orbitaldebris.jsc.nasa.gov/photo-gallery/>)

Outline

- I. Introduction
- II. Definitions of Outer Space
 - a. Altitude-based definition: The Kármán Line
 - b. Legal definition
 - c. A universal definition
- III. Types of Space Debris
 - a. Defunct satellites
 - b. Upper rocket stages
- IV. Risks and Consequences of Space Debris
 - a. The Kessler Syndrome
 - b. Threats to human space missions and astronauts
- V. Current Legal Framework governing Outer Space
 - a. Committee on the Peaceful Uses of Outer Space (COPUOS)
 - b. Outer Space Treaty (OST)
 - c. Space Liability Convention
 - d. Registration Convention
- VI. The need for a new Legal Framework to battle Space Debris
 - a. Inadequacy of current legal framework
 - b. Lack of binding international regulations
 - c. Funding Debris Removal
 - d. International cooperation is the starting point.
- VII. Conclusion

After World War II, the Soviets and the Americans took human history in a completely new direction during the Cold War. The geopolitical competition between these two-world powers was the motive behind the first man landing on the moon. At that time, the Americans and Soviets did not consider space exploration a scientific victory for humankind but rather a matter of national security. In fact, America spent over 30 billion dollars on the space race against the Soviets between the launch of the Russian Sputnik satellite in 1957 and the moon landing in 1969(Domitrovic and Broadwater). This budget allocation America can only dedicate to serious national security concerns. While the space race was mainly motivated by geopolitical tensions at the time, it led to many of the most significant scientific breakthroughs in human history, such as satellites, the internet, and more. As the world's leading powers were obsessed with space dominance, environmental issues caused by new technologies in outer space were not among their priorities. As human activities in space are continually growing, space pollution is becoming an increasingly severe problem, and current legislation is inadequate and needs to be updated to address this issue.

Definitions of outer space vary between governments depending on their national political priorities. Reaching a global definition of outer space is particularly challenging as different world powers try to follow the definition that lies with their geopolitical interests. This paper will examine the different definitions of Outer Space referred to by different parties. In the end, we will give the approach of our research on this dilemma.

The most known scientific definition of Outer Space is the Karman Line. According to the National Oceanic and Atmospheric



Administration, "The Kármán line is a boundary 62 miles (100 kilometers) above mean sea level that borders Earth's atmosphere and the beginning of space." (May and Daisy) The Karman line is fundamentally defined based on the laws of physics. This hypothetical border defines the altitude from which airplanes cannot fly above. Only rocket-based engines can exceed this line which makes the environment above this line only accessible by rockets which operate in outer space. This line is recognized by the Fédération Aéronautique Internationale (FAI) which is the world governing body for air sports and aeronautical and astronautical world records.

Fig 2- The Karman Line(<https://www.noaa.gov/>) ("Statement about the Karman Line"). However, the Karman line is not an internationally recognized definition by all states.

It may seem counterintuitive to state that today, 62 years after the first man has been to space, no formal universal legal definition of outer space exists. The United States, as delivered by Emily Pierce, the head of the U.S. Mission To International Organizations in Vienna, "continues to hold the view that there is no need to seek a legal definition or delimitation for outer space. "(UNVIE). While the U.S. does not officially define the edge of space, it awards astronaut wings to pilots who fly above 50 miles (80 kilometers), making the American stand even more ambiguous.

Establishing a globally accepted definition of outer space is the building block in developing a comprehensive legal structure governing outer space. No political entity should dictate this definition, as it would lose its universality. For this definition to gain international acceptance, it must be based on scientific facts rather than influenced by geopolitical interests. Nations already experienced certain water territories to create international waters, an accomplishment that was described as "the greatest international legislative effort undertaken by the United Nations and probably the greatest ever undertaken in the annals of international law

as a whole" (Harrison). A similar accomplishment should be made to create an International Space Zone governed by international laws. This International Zone should be governed by an independent organization that operates under the supervision of the UN. Any object launched into space, which will eventually travel through this international zone, should be monitored by the international organization.

To tackle the issue of the sustainability of outer space environment we need to define Space Debris. "Space debris is regarded as all man-made objects, fragmented or not, which are no longer functional. This includes defunct satellites, spent launch vehicles, parts of launch vehicles and satellites, as well as particles exhausted by spacecraft engines." (Stubbe 16) The service life of these objects is expired, and no recycling measures could be taken to integrate them back to service. The categories include defunct satellites that have completed their missions, spent rocket stages discarded after launch, fragments from disintegrations, collisions or explosions of satellites or stages, and even tiny flecks of paint stripped off these objects due to friction.

Defunct satellites constitute a significant portion of space debris. The European Space Agency (ESA) reported that out of 1600 satellites in orbit are not functioning. Defunct satellites, no longer controlled or maneuverable, can collide with operational satellites, space stations, or crewed spacecraft. Having high velocities in orbit, these objects can cause significant damage. Many incidents that proved the danger of these satellites including "the operational US communication satellite Iridium 33 collided with the abandoned Russian spacecraft t Cosmos 2251. The event occurred at an altitude of 790 km and resulted in the creation of two debris clouds." (Stubbe 18). Moreover, while much of the smaller debris will burn up in the Earth's

atmosphere upon re-entry, larger objects such as defunct satellites could stay intact in part and reach the Earth's surface, posing a potential risk to people's lives and properties on Earth.

Another type of space debris includes upper rocket stages. An upper rocket stage contains its own engine and fuel supply. Once the lower stage has consumed its fuel and separated, the upper stage's engines ignite to propel the payload (such as a satellite or a spacecraft) to its desired orbit or trajectory. Upper rocket stages also pose significant risks as they present from the total debris "around 11% rocket bodies" (Stubbe 24). Upper rocket stages often have leftover fuel, which can explode if not correctly passivated after their operational life. Such explosions can create large debris clouds, significantly increasing the risk of further collisions. Given these risks, there is a growing emphasis on best practices for the design and operation of launch vehicles, including strategies for the passivation and disposal of upper stages. These strategies include de-orbiting upper stages to burn up in the Earth's atmosphere, placing them in a designated disposal orbit. Reusable rockets that SpaceX is working on could also decrease the risk of upper stages.

To bring international attention to the dilemma of outer space pollution we first need to highlight the risks and danger consequences of space debris. First suggested by NASA scientist Donald J. Kessler in 1978, the Kessler Syndrome hypothesizes that the density of objects in low Earth orbit could become keep increasing so that "collisions between objects will cause an infinite chain of collisions, each collision generating space debris that increases the likelihood of further collisions" (Kessler and Cour-Palais). The Kessler Syndrome presents a real challenge to the long-term sustainability of outer space. These hypothetical inevitable collisions chain will jeopardize all human activities in outer space, such as weather forecasting, global

communications, navigation, and future scientific exploration (“Space Debris and Human Spacecraft”). With average speeds of 10 km/s in low Earth orbit, debris can cause considerable damage upon impact, endangering spacecraft, and the crew onboard (“Space Debris and Human Spacecraft”). The International Space Station was forced to perform numerous "debris avoidance maneuvers" to mitigate this risk. According to the European Space Agency report, the ISS executed 25 such maneuvers between 1999 and 2018 (“ESA Commissions World’s First Space Debris Removal”). A significant incident illustrating the threat of space debris to human space missions was the collision between the Iridium 33 and Cosmos 2251 satellites in 2009. This event, the first-ever unintentional hypervelocity collision between two intact artificial satellites, created thousands of pieces of debris, further increasing the risk to human space missions (Kelso). Space debris also poses a risk to astronauts during spacewalks outside the spacecraft. Astronauts on these walks are outside the most protective structure of their spacecraft and thus are more vulnerable to potential impacts. For instance, in 2015, a small piece of debris created a 7mm chip in one of the ISS's Cupola windows, highlighting the threat even tiny debris poses to astronauts (“ESA Commissions World’s First Space Debris Removal”).

The main dilemma that makes battling space pollution more challenging is the current legal framework. We will first analyze the current legal system governing outer space pollution and then move to the criticism of this system and providing potential alternatives.

COPUOS is a United Nations entity that drives international cooperation for the peaceful use of outer space. Established in 1959, COPUOS is a global forum for developing laws and principles governing space activities, fostering dialogue, and understanding among member states. COPUOS consists of 95 member states, representing a broad spectrum of the international community. The leading states benefiting from outer space, including the United States, Russia,

and China, are key contributors to the Committee. Unlike other UN voting that uses the veto, COPUOS operates on the principle of equality, giving each member state one vote regardless of its space capabilities. COPUOS has made significant contributions to the current international space law. It was central in formulating the main UN treaties on outer space, such as the Outer Space Treaty, the Liability Convention, and the Registration Convention. These treaties are considered the current legal framework governing outer space.

Besides COPUOS the OST is another important treaty trying to legalize access to outer space. The OST is “the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies” (Outer Space Treaty, 1967). Signed in 1967, this treaty established the foundational principles for the “peaceful exploration and use of outer space”. The OST was signed after several years of negotiations led by the United States, the Soviet Union, and the United Kingdom. These three nations first proposed a draft treaty in 1966, which was then opened for signature after a year of intense negotiations. The OST states that space exploration should be carried out for the benefit of all countries. It also states that "outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means". It also prohibits placing "nuclear weapons or any other weapons of mass destruction in orbit or on celestial bodies". The treaty states that "the Moon and other celestial bodies shall be used exclusively for peaceful purposes" (Outer Space Treaty, 1967). While the treaty only requires states to avoid harmful contamination of space and celestial bodies and to adopt appropriate measures for this purpose, it does not explicitly approach the space pollution challenge.

The third important part of the current legal framework governing outer space is the Space Liability Convention which was formulated under the supervision of COPUOS and adopted in 1972. The SLC is mainly concerned with establishing legal mechanisms for damage caused by space objects. It defines the concepts of "launching state" and "space object" and sets forth the principles for determining liability in the event of damage caused by space objects. The SLC holds the launching state liable for damage caused to other aircraft in flight, space objects such as satellites, people, or property. One of the most notable applications of the SLC was the Cosmos 954 incident in 1978. Cosmos 954, a nuclear-powered Soviet satellite, crashed in Canada, causing radioactive contamination. Canada made a claim under the SLC, and the Soviet Union eventually agreed to pay compensation, marking the first and only settlement under the SLC (Kopal). While this convention aims to force international laws in outer space, it does not hold states accountable for using technologies that can impact the environment of outer space in the long term.

Finally, another yet important outer space convention is the Convention on Registration of Objects Launched into Outer Space, known as the Registration Convention, was adopted by the United Nations General Assembly in 1974. It builds upon the basic principles established by the Outer Space Treaty (OST) and the Space Liability Convention. The Registration Convention binds member states to establish a national registry for objects they launch into outer space and report specific details about each object launched to the United Nations. However, not all states operating in outer space are parties to the convention. Even states under this convention do not fully follow what it states. The convention also does not cover space objects launched by non-state entities, such as private space companies, that are not authorized and supervised by a state, which is an increasing issue given the growth of commercial space activities.

The current legal framework governing outer space discussed previously needs to focus on the sustainability of the outer space environment. The treaties of this framework developed during the cold war focused only on preventing any military use of outer space by the world's powers. With the rise of nuclear weapons and weapons of mass destruction, the outer space legal framework was trying to prevent military regimes from using Earth's orbit as a launching platform to target on-the-ground locations. If the next global war occurs in space, science fiction apocalypse movies are likely to become a reality. However, the different parties using outer space were heavily involved in developing the most efficient and advanced space technologies that deliver the required results while ignoring these technologies' long-term impact. The orbit was considered an experimental field or junkyard for testing emerging technologies. When launching space objects into orbit, there were no procedures implemented to handle the debris of these objects after the end of their lifetime.

While the current legal framework governing outer space tries to hold states accountable for their nonpeaceful actions happening in outer space, it does not clearly state the consequences for states who do not obey the treaties they signed. Besides, the current legal framework is not completely followed by the leading countries. "It should, however, also be taken into consideration that the conclusion of the treaty occurred under rather unfavorable political conditions." (Stubble 89). While the issue of binding international regulations is a significant problem in all UN treaties, the issue is much more highlighted in outer space geopolitics. When international criminal activities happen on earth, other rivals point out how such actions disregard international regulations. This geopolitical mechanism helps the people to witness the

crimes of their regimes through the eyes of their rivals. Even though rivals' claims are usually exaggerated, they push for further investigation from other neutral parties. However, all global powers in outer space agreed that their hypothetical national security concerns take higher priority than space sustainability because "Outer space may be used for civil, scientific or military purposes." (Stubble 34). As a result, outer space rivals will not point fingers at each other when polluting space, which hides dangerous space activities from public criticism. As a result, international regulations are responsible for pointing fingers at polluting states even though rival states do not necessarily argue about space pollution. International treaties should also force polluting states to get involved with space debris removal.

Space debris removal refers to actively removing space junk from orbit around Earth. As the issue of space debris continues to exacerbate, proactive efforts by the world's powers are crucial to fund and support debris removal operations. This requires a global commitment, as the space environment is a shared resource, and the consequences of inaction could harm all space-faring nations and future generations. It is the responsibility of countries like the United States, Russia, and China to lead the way in funding debris removal initiatives. This includes direct funding for research and development of debris removal technologies and deploying these technologies. For example, the European Space Agency's ClearSpace-1 mission, scheduled for 2025, is a pioneer in active debris removal missions, intending to capture and deorbit a specific piece of space debris (ESA). However, funding initiatives like these should become more common from all states launching objects into outer space.

Moreover, the private sector should be encouraged to participate in debris removal efforts. Governments should provide funding for private companies to engage in debris removal activities. A good example is the Japanese company Astroscale, which develops technologies for satellite end-of-life and active debris removal services. Furthermore, legal and policy frameworks should be adapted to facilitate debris removal. This could include clarifying issues related to liability and ownership of debris and providing regulatory certainty for debris removal activities. The current legal framework, primarily based on the Outer Space Treaty and the Space Liability Convention, needs to address space debris removal adequately. Revising these or creating new comprehensive regulations could provide a solid legal foundation for these operations.

International cooperation is the starting point to create a comprehensive legal framework for outer space that addresses all aspects of space exploration and prioritizing the environmental sustainability of outer space. Space is a global property of all mankind. Actions in space by one country can have implications for all other countries. If space pollution is not approached now, further space activities by all states will be hindered due to the high volume of debris in orbit. The role of this legal framework is to ensure that all nations, regardless of their level of space capabilities, participate in shaping the rules and conventions that govern current and future space activities. Besides creating this legal framework, “the rule of law must be reflected in the form and content of the treaties, as well as in their ability to be respected and enforced.” (Steer and Hersch). It is crucial to exclude any political bias in this framework, “one cannot ignore the fact that most of the attempts to come to agreements so far have stalled or fallen apart, often due, as illustrated previously, to political hurdles and the impasse in the meetings of these bodies.” (Steer

and Hersch). This inclusive legal movement will foster a sense of shared responsibility and common good for the sustainable use of space.

The environmental sustainability of outer space is a critical issue that requires immediate attention and collective contributions from the international community. The rise of space debris caused by increasing human activities in space presents a significant threat to space and Earth's environments. While the existing space law treaties provide a foundational framework for governing space activities, they do not entirely address the challenges posed by space debris and environmental sustainability in outer space. All stakeholders in outer space, including the world's powers and the private sector, should collaborate to update and strengthen the legal framework for outer space to tackle the environmental urging problems in outer space.

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