Department of **Political Science**

Chair of **International Law**

"Long Term Sustainability of Outer Space Activities, Celestial Bodies and Asteroids; a military and environmental framework for their sustainable use."

Supervisor:

Professor **Sergio Marchisio**

Candidate:

Pietro Calderini Nannerini

Matr. 090972

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ABSTRACT

Questa tesi si pone lo scopo di analizzare gli strumenti e metodi che la comunità internazionale utilizza per attuare la sostenibilità a lungo termine dell'ambiente spaziale. Approfondendo i temi dell'inquinamento dello spazio da parte dell'uomo e della militarizzazione da parte di stati.

Nel primo capitolo affronterò il tema dell'inquinamento dello spazio, da una prospettiva in cui la congestione delle orbite terrestri è al centro del problema. Tramite il concetto di "capacità dello spazio" e un paragone con politiche dell'Unione Europea di regolamentazione della pesca, proporrò un sistema che permetta di regolare il futuro affollamento dello spazio. Inoltre, analizzerò come la presenza di aziende private e i loro interessi sta cambiando il modo di pensare ed agire nel settore spaziale, concentrandomi sulla estrazione di risorse naturali.

Nel secondo capitolo andrò ad affrontare le tematiche relative alla militarizzazione dello spazio e le misure che la comunità internazionale sta usando per prevenirne una corsa alle armi. Dedicandomi agli "*Space Situational Agreements*" come forma di prevenzione e mitigazione. Un altro tema importante saranno i meccanismi di rimozione dei detriti nelle orbite terrestri come un potenziale pericolo per la stabilità nella comunità internazionale. Ulteriormente, verrà approfondita la "*Prevention of an Armed Race in Outer Space"* e verranno analizzate le conseguenze che la creazione di milizie spaziali e le "*Dual Use Technologies"* avranno sul futuro delle attività spaziali.

Nell'ultimo capitolo si traggono alcune conclusioni, con delle considerazioni relative al futuro delle attività spaziali.

1. INTRODUCTION

Outer space activities since the launch of the Sputnik I in 1957 have been increasingly steady. The first space rush can be dated during the cold war, when the two main spacefaring nations, namely the United States of America (USA) and the Union of Soviet Socialist Republics (USSR), started a race towards the hegemony of space activities. The end of this space run was signed by an outstanding event for all of humankind. The moon landing. With this event the space era that had as the main players states and governments came to an end. In the years after the moon landing, the space community expanded. In the 21st century, the space domain is facing, since the early 2000s, a rapid development of private companies. Those companies are increasingly intertwined with governments and carry out activities that before were not possible for the private sector. This time the race to the domain of outer space is not hegemonic, is economic and political. The number of actors that entered in the scene of outer space activities went from 2 governments and bodies that were under the orders of those governments to thousands of private companies and 30 states. The consequences of this new space race are posing a serious threat to the sustainability of the outer space environment. On the one side we can see the increasing congestion of the Low Earth Orbit, due to the massive number of debris that have been accumulated since the first space race. On the other, an increasing level of security by the major spacefaring nations. Furthermore, the treaties, regulations and agreements are not following the same pace as technology. The five space treaties that set the basis of space law, are indeed useful, but do not cover in a specific way many of the challenges that outer space activities and the international players are facing today. In my elaborate I will tackle the main challenges that outer space is facing and the gaps of international space law that render the future of space activities uncertain and unstable. Moreover, I will establish a framework that could guarantee both under a military and environmental perspective, the sustainability of outer space activities.

2. Safeguarding space environment, a space-oriented perspective.

The congestion of the space environment is a phenomenon that has gained relevance in the last forty years. Experts have started to warn space businesses and governments about the increased number of challenges that are present in the outer space environment. We can distinguish two types of hazardous objects that put a threat to the security of space: passive man-made hazards or natural hazards, the former are those threats that can be related to the pollution of man in space, the latter refers to asteroids, meteors, and comets.[1] Therefore, since space itself being a hazardous area, we can say that space activities have an ultra-hazardous nature for the sole reason that they are carried out in outer space, and they can be harmful, for the terrestrial environment but foremost for the space one.[2]

The space infrastructure is a dimension that can be considered as scarce[3]. This scarcity is due to the extensive exploitation of space in the last decades and the lack of regulations surrounding the deployment and the end of disposal of space objects. I also given by the quantity of debris that exists in this area, that I will later analyse in the next paragraph.

Consequently, the back-contamination of earth[4] is a challenge that the international community should be aware, but the "front-contamination" of space is key for a sustainable development of outer space activities.

2.1 From back-contamination of earth to the front-contamination of Outer Space.

Back-contamination of the earth deals with the risk of contamination of the terrestrial environment by extra-terrestrial entities. Specifically, one of the concerns are the power sources of the satellites, if not properly disposed at the end of life of the object, they can fall back to the surface causing environmental damage. Some of those are big enough to not disintegrate into the atmosphere and scatter on the surface of earth. As it was the case of Cosmos 954 in 1978. Cosmos 954 was a Russian satellite, that in December 1977, embraced an erratic orbit, falling on Canadian soil. The causes of the crash are yet conflicting, for

[1] New York Extension Disaster Education Network, *Space Weather and Astro-Hazards,* https://eden.cce.cornell.edu/natural-hazards/space-weather-and-astro-hazards/ (02/06/2022), 2017.
[2] MARCHISIO S., *The Law of Outer Space Activities,* Roma, 2022, pp 287-289.
[3] Report of the Committee on the Peaceful Uses of Outer Space, June 21st, 2019, A/74/20, New York.
[4] MARCHISIO S., *The Law of Outer Space Activities,* Roma, 2022, pp 289-290.

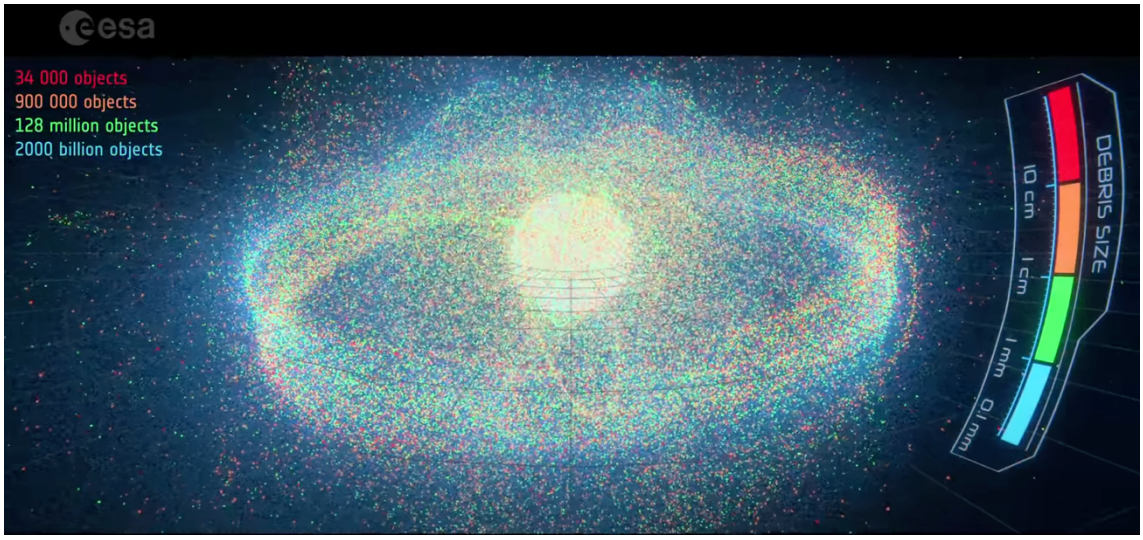
Russian officials was due to a depressurization of the satellite due to the collision with another object while outside the visibility of the Russian space object tracking facilities. Whereas for Canada the fault of the crash is to be connected with a faulty motor of the rocket launch system.[5] This shows how older satellites were not equipped with end of disposal modules. However, this case helped the international community to shed light on the practical application of space law in the case of an uncontrolled crash on a state that is not the launching state or the state or registry. After the crash, radioactive materials were found and therefore contaminated the environment. This could be considered an example of back-contamination of earth. This is only one of the cases that one can mention when it comes to crashing of inactive or active satellites with debris or of faulty re-entry of objects into earth atmosphere. My point here is that a higher degree of control of space activities will automatically lower the chances of back-contamination of earth. To have more control, the focus of the space community should aim at the uses of outer space with a "space-oriented" perspective.

The "space-oriented" perspective refers to an increased attention and awareness to the activities carried in outer space, leaving the earth contamination as an important issue, but that can be solved through a better planning of the space environment through the reinforcement of the space infrastructure security.[6] This new perspective is a direct consequence of the "front-contamination" of the Low Earth Orbit. "Front-contamination" points at the pollution of the outer space environment by man-made objects. What we are developing in today's space era is a sort of paradox. Thirty years ago, the space community was concerned with the pollution of earth by the uncontrolled re-entry of extra-terrestrial objects, now instead the main concern is the pollution of the same space environment due to the controlled entry of man-made objects.

The space environment *per se*, is not safeguarded, private companies and states, keep launching objects regardless of the amount of space that there is left in the Lower Orbit. Congestion of the Low Earth Orbit (LEO) is by now an established reality. According to the European Space Agency (ESA) Space Debris User Portal, there are 31050 debris objects regularly tracked. But the number of debris estimated is much higher, according to the

[5] ALEXANDER F. COHEN, *Cosmos 954, and the International Law of Satellites Accidents,* in Yale Journal of International Law, Vol. 10:78, 1984, pp. 78-91.
[6] European Space Policy Institute, *Security in Outer Space: Perspectives on Transatlantic Relations,* Report 66, Vienna, 2018, pp. 5-7.

forecast there are 130 million space debris objects between 1mm and 1cm.[7] The space community is developing more sophisticated and cutting-edge technologies to track the debris that are present into space. An example could be the development by the USA's Joint Space Operation Centre (JSpOC) of the U.S. Space Fence, which replaced the Air Force Surveillance System. This new system made operational in 2019 and in which the U.S. government spent $1.594 millions, has the capability to track 500.000 objects between 1 and 10 centimetres and 200.000 objects as small as 5 centimetres.[8]



Although the awareness about the current conditions of the outer space environment, the international community struggles to keep the pace with the technological developments. Indeed, International law and space law are prone to have an earth-oriented perspective.[9] The main concern of the Outer Space treaties is the back-contamination that extra-terrestrial entities could bring to the earth environment and not to the environment of outer space itself. There are two articles from the space treaties and one principle from the principles relating to the use of nuclear weapons in outer space that can be considered having a "earth-oriented" wording. Article IX of the Outer Space Treaty (OST) of 1967 states as follows « *States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extra-terrestrial matter and, where*

[7] European Space Agency, *Space Environment Statistics,* in Space Environment Report https://sdup.esoc.esa.int/discosweb/statistics/, (10/05/2022).
[8] European Space Policy Institute, *Security in Outer Space: Perspectives on Transatlantic Relations,* Report 66, Vienna, 2018, p. 22.
[9] Ibid.2

necessary, shall adopt appropriate measures for this purpose. »[10]. Article 2 of the Convention on International Liability for Damage Caused by Space Objects (LIAB) elaborates « *A launching State shall be absolutely liable to pay compensation for damage caused by its space objects on the surface of Earth or to aircraft in flight.* »[11]. Lastly, of importance is principle 5 of the principles relating to the Use of Nuclear Power Sources in Outer Space, the first section of the document goes as follows «*Any State launching a space object with nuclear power sources on board shall in a timely fashion inform States concerned in the event this space object is malfunctioning with a risk of re-entry of radioactive materials to the Earth.* »[12]. Those three documents show how international space law is more concerned with the pollution of earth by outer space activities. The space-contamination that we are facing and that we will face in the next years it directly correlated with the pollution of the earth environment itself. Therefore, an increased regularization of the legal framework concerning the capacity of the space environment and the uses of it will decrease the risks for the earth environment, due to the increased safety of the space environment *per se.*

The space-oriented articles that serve as a basis for the preservation of space in the outer space treaties are three. The first, is Article I of the OST: « *The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.* »[13]. Points at the safeguard of cosmic environment as essential for the freedom of outer space activities.[14] The second one is Art. IX of the OST; it might be considered as the basis for the environmental protection of outer space. The section of the article that has a space-oriented perspective states that States Parties to the Treaty « *shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination.* »[15]. The last space-oriented article is Art. 7 of the Agreement Governing the Activities of States on the Moon and other Celestial Bodies (MOON). The wording of the article is clear, State Parties to the agreement « *shall take measures to prevent the disruption of the existing balance of its environment, whether by introducing adverse changes in that environment, by its*

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[10] *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies,* concluded in London, Moscow and Washington D.C. on 19 December 1966 and entered into force on 10 October 1967, General Assembly resolution 2222 (XXI).
[11] *Convention on International Liability for Damage Caused by Space Objects,* concluded in New York on 29 November 1971 and entered into force on 1 September 1972, resolution 2777 (XXVI).
[12] United Nations General Assembly, Resolution 4768, 14 December 1992, A/RES/4768.
[13] Ibid. 10
[14] MARCHISIO S., *The Law of Outer Space Activities,* Roma, 2022, p. 289.
[15] Ibid. 10

harmful contamination through the introduction of extra-environmental matter or other- wise. »[16]. While this is the one agreement that reflects at best the needs of the space community, is the one that has received less signatories out of the 5 space treaties. As it can be read, the article is very strict on the introduction of matter that is not from the moon surface and that can impact in harmful way its environment.

The space community even though is developing at an impressive pace, is trying to outrun the regulations that are being developed in order to guarantee a sustainable future of space to the next generations. The international community on the other hand, is not showing a high degree of involvement in agreeing on a set of binding norms that could be useful to a sustainable development of outer space. In order to decrease the front contamination of outer space the space community needs to implement a more stringent set of norms, which include a higher degree effectiveness of international treaties, primary norms, and applicability of secondary norms.

2.1.1 The capacity of the space environment and the legal framework surrounding its use.

The concept of space capacity was created in order to have a metric approach to the problem of exploitation of the outer space environment[17]. Specifically focuses on the LEO region, due to its high density of active and inactive space objects. Before starting with this topic, I would like to bring further attention to the legal framework surrounding the space capacity environment.

The reason why the outer space treaties remain relevant in today's context is because of their nature. The nature of those provision lies in the sharing of values that signatories associate with them. They do not address a specific issue as we will see, but they help to establish a good conduct or at least a preferrable one, when carrying out outer space activities. All the treaties are voluntary, meaning that states can choose whether or not to sign the treaty and they are to be implemented correctly in national legislation by the signatories if they want to have binding effects. This shows the degree of liberty that surrounds the space regulatory framework. « *International custom is generally considered to be the product of two constitutive elements: diurnitas and opinio iuris. The first refers to general and consistent conduct by States, while the second means*

[16] *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies* concluded in New York on 5 December 1979, entered into force on 11 July 1984, (resolution 34/68, annex).
[17] European Space Policy Institute, *Space Environment Capacity,* Report 82, Vienna, 2022, p. 39.

that the practice stems from a belief of legal obligation. »[18] This is an excerpt from the book "The Law of Outer Space Activities" by Professor Sergio Marchisio. If seen in the light of space law, one could assume that is more a matter of *diurnitas* than *opinion iuris,* due to the lack of a binding legislative tool when it comes to space activities and by the wide consensus that is shared between the major spacefaring nations.

Now, I will move to the analysis of the articles and the treaties which influence the *diurnitas* of spacefaring states, but that do not lay down effective provisions for the regulation of the outer space capacity. Starting from the OST, Article I[19] as cited in the previous paragraph, provides that states carry out space activities considering the interest of all humankind. Although, in the future if the capacity of space keeps shrinking an obligation for the states to lessen the risks correlated to it must be considered. Article VIII of the OST, affirms that a State Party to the Treaty « *on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body.* »[20] The wording is clear, a state has jurisdiction over personnel and space object. Although, with the current scenario this article could interfere with the removing of debris, if a state does not give consensus to remove one of its space objects. This could seriously impede the capacity to develop an active system of orbital debris removal. The last article of the OST that I am going to analyze is Art. IX. The last part deals with a consultation mechanism, that it is used to prevent harmful interference in outer space. In the light of the capacity of the space environment this mechanism is probably the best tool that states have when it comes to the avoidance of harmful interferences. Under the consultation mechanism states that plan experiments or activities and if it considers that this activity could be harmful for others, it is under the obligation to undergo international consultations. Moreover, and this is the part of interest, states that think that the activity carried by another state might cause harm to them can send a request of consultation regarding such activity.

Those regulations are useful in today's context if we consider the safeguard and prevention of harmful uses in space. Another legal concern is whose fault is in the case of a collision in outer space. Here is useful to investigate the regime of fault-based liability provided in Articles II and III of the LIAB. In opposition to the regime of absolute liability, this regime concerns the collisions that happen in outer space. The damage in this case is

[18] MARCHISIO S., *The Law of Outer Space Activities,* Roma, 2022, p. 289.
[19] Ibid. 10
[20] Ibid. 10

caused directly in the outer space environment. An example that could be the Iridium 33-Cosmos 2251 case[21]. The former was an U.S. active commercial communication satellite whereas the latter an inactive Russian communication satellite. The Cosmos 2251 collided with Iridium 33 on February 10th, 2009. The collision produced almost 2,000 debris, which are currently orbiting around the LEO region and as forecasted by the National Aeronautics and Space Administration (NASA. In this case the LIAB has never been invoked, however the problem remains in who's responsibility is for the debris that orbit around earth as a consequence of the collision. Moreover, who is the responsible state for the control of those debris. Hence, the regime of fault-based liability, it is useful if used to determine the responsibility of the act but lacks the secondary norms to provide an obligation.

The last treaty that I will mention will be the Convention on Registration of Objects Launched into Outer Space (REG). As was the case for Cosmos 2251, there are some space objects that are not registered to the Secretary General on the UN, under article II of the REG, those are highly hazardous for the Outer Space environment. The space capacity is limited and measured based on how many objects systems can detect, the un-registration of objects could render the calculations faulty and bring to collisions as it happened between Iridium 33 and Cosmos 2251.

Gaining momentum in the last decades are the soft law mechanisms, which have been the center of political debate concerning outer space activities. Although voluntary and non-legally binding, they become useful for states when it comes to space national legislation. The United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) Guidelines for the Long-Term Sustainability of Outer Space Activities aim at promoting the long-term sustainability of Outer Space activities and has an agenda that is focused on large constellations of satellites. The Inter Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines are yet non-binding. They focus on limitation of debris released during normal operations, minimization of the potential for on-orbit break-ups, post mission disposal and prevention of on-orbit collisions[22]. The last soft law mechanism is the International Organization for Standardization (ISO) 24113 "Space systems – Space debris mitigation requirements". The latter can be considered « *a normative interpretation of the guidelines and best practices from the IADC, COPUOS and other bodies.* »[23]. These mechanisms that I have

[21]Weeden B., *2009 Iridium-Cosmos Collision Fact Sheet,* in Secure World Foundation, 2010.
[22] European Space Policy Institute, *Space Environment Capacity,* Report 82, Vienna, 2022, p. 9.
[23] Ibid. 21.

mentioned are of great use to national space legislations, but nonetheless the utility, they all rely of the goodwill of the state in the correct implementation into national systems.

Still, in most countries those guidelines or measures are not explicitly mentioned in the legislative systems. This could bring to a free rider problem in the space community, some states could benefit from the good behavior of others, with no regard for the international community. I am referring to the anti-satellite weapon test (ASAT) conducted by the Chinese government on January 11th, 2007.[24] This type of "destabilizing actions", lead to the formation of debris that are hazardous for the other space objects orbiting in the same region. It is exactly in this concept of exploitation and sustainability of the outer space environment that the space capacity threshold base model is found to be useful. Indeed, if focuses on the « *foundation that orbital environments are a limited natural resource.* »[25].

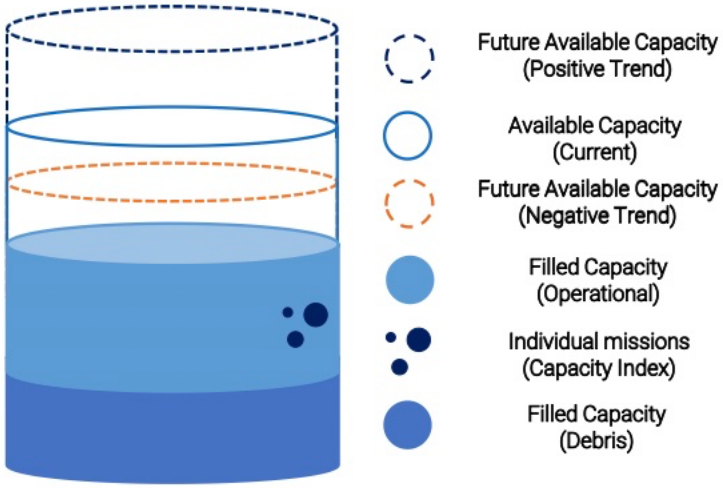

Figure 15: Simplified visual overview of the Space Environment Capacity Concept

The above figure shows how a threshold-based model could represent the actual capability of the space environment. The current available capacity is the one in the straight blue lines. The dark blue is the filled capacity, is the amount of area that is occupied by space objects that are not active and that cannot be removed. Then we have the operational filled capacity, which is the area occupied and used by space objects that are operational. An interesting topic are the Individual missions and their capacity index. Space missions occupy more capacity than their actual space once into orbit. This is the capacity index. At the current state of space missions, we could face in the future two different scenario. On the one side a positive trend, in which the available capacity increases, due to the introduction of a system of safeguard for the outer space environments. On the other, we could face a shrinking of

[24] MARCHISIO S., *The Law of Outer Space Activities,* Roma, 2022, p. 338.
[25] European Space Policy Institute, *Space Environment Capacity,* Report 82, Vienna, 2022, p. 40.

the available capacity, a negative trend that will lead to the total congestion of the lower earth regions. This model is very useful to have a forecast of the future scenario and to raise the awareness on the condition of the space environment.

The current regime is increasing the debate on the saturation of the orbital environments, but it also catalyzes states to occupy the space environment rather than prioritize the long-term sustainability of outer space activities.[26] Stakeholder, mainly private ones, have called for an increased regularization in the regulations regarding the saturation of the outer space environment. The problem lies in the political fora, which is unable to come down to an agreement at the international level due to the inability of states to institute an agenda of enforceable actions that will increase the future available capacity if the outer space environment.

2.2 How the system of fishing quotas in the European Union is relevant for a future regulation of the Earth Orbital Environment.

The EU Common Fisheries Policy (CFP) is a framework that regularizes the fishing market to safeguard the marine environment. The philosophy that lies behind the CFP is very similar to the one that is shared by the international space community on the sustainability of outer space activities. The European Commission justifies the introduction of the new fisheries policy rules because *« fishing is an activity that exploits common natural resources, it needs to be regulated to safeguard fair access, sustainability and profitability for all.* »[27]. Similarly, the first set of guidelines developed by the UNCOPUOS defines the sustainability of outer space activities *« as the conduct of space activities in a manner that balances the objectives of access to the exploration and use of outer space by all States and governmental and non-governmental entities only for peaceful purposes with the need to preserve the outer space environment in such a manner that takes into account the needs of current and future generations.* »[28]. The outer space environment more specifically orbits placed in the LEO region and the activities that are carried in those orbits can be considered, like fishing, activities that exploit common natural resources. This resource is the available capacity of the orbits that surround earth. While is true that the

[26] European Space Policy Institute, *Space Environment Capacity,* Report 82, Vienna, 2022, p. 12.
[27] European Commission, *The new Common Fisheries Policy: sustainability in depth,* https://ec.europa.eu/oceans-and-fisheries/policy/common-fisheries-policy-cfp_en, 2015.
[28]European Space Agency, *clean space, the UN, and the sustainability of space resources*, https://blogs.esa.int/cleanspace/2017/03/10/clean-space-the-un-and-the-sustainability-of-space-activities/,2017.

potential and the exploitation of outer space itself is endless, the orbits that are used by governmental and non-governmental bodies are not. Orbits can be compared to the number of fishes that we have in the seas, with the sole difference that while the fishing population can reproduce, new orbits cannot be created. They can be cleaned, and debris can be dragged in the earth's atmosphere or be pushed further in a "graveyard orbit". Although as we have seen, the international community, still lacks a mechanism of enforcement that will contribute significantly to the actual safeguard of the orbits around earth. Therefore, as it has been done with the fisheries, a similar system could be implemented also in outer space. There are some clear differences that I think cannot be reflected in the outer space environment, but the general framework could be a good base for the implementation of a common long term sustainability policy for outer space activities.

In particular, the mechanism of finishing quotas in the European Union (EU). Before moving to the actual mechanism, I would like to take a step back and look at the bigger picture. In the CFP, the first step of the procedure is to ask research institutes for scientific and technical advice. Which analyzes the data and the research results regarding the fishing industry and the condition of the exploitation of the different species of fish. Then they give their advice to the European Commission (EC), that after a round of review either goes through a process of co-decision with the EU Parliament and the EU Council or asks back for scientific advice to the committees. If the co-decision goes through in the Council and the Parliament, fishing quotas are released to the Member States (MS). What makes the CFP interesting is the fact that it stems from the EU Treaties, making the EU the main legislator over this policy. It finds it legal basis in Articles 38-43 of the Treaty on the Functioning of the European Union (TFEU).[29] The rules regarding the fisheries are regulations which means that they are binding legislative acts that must be enforced throughout the whole European Union. This is the first key point that should be taken in consideration when trying to adopt this framework to outer space activities. What the international space community lacks is a higher body that through a system consultations and technical scientific advice, prior to the release of the binding act, can establish a mechanism of allocation of quotas or payloads to each spacefaring state. The second key point is the system of allocation of those quotas in the context of earths orbits. In the EU's CFP the quotas are set through a system of Total

[29] Marcus Ernst Gerhard Breuer, *the common fisheries policy: origins and development,* in fact sheets on the European Union, https://www.europarl.europa.eu/factsheets/en/sheet/114/the-common-fisheries-policy-origins-and-development, 2022.

Allowable Catches (TCAs), which are a catch limit that fisheries have usually during the year. Then TCAs are translated into Individual Quotas that are given to the MS. The MS then decide how to distribute those quotas to their fisheries. Like the launching state is liable under Art. II of the LIAB convention, MS are responsible for their fisheries not to exceed the limit of quotas that have been allocated in that given year. Moreover, those quotas can be traded, exchanged, or transferred to another MS.

This system as it is functioning with the fisheries, it could work also with the activities carried in outer space. This could work through a threshold-based model, using the space capacity mechanism as the equivalent of TCAs and to allocate orbit quotas to spacefaring nations. The allocation of the quotas could be under the scientific and technical advice of committees, such as the IADC and the UNCOPUOS, to have the biggest possible fora of nations participating in the decision-making mechanism. Quotas should be translated into the amount of payload that a state can launch in orbit each year. In the quotas that allocated to each state it should be taken into consideration the previous amount of operational fille capacity that they have exploited in the past. The only way in which in the future there could be a decrease in the filled capacity occupied by debris is through active orbital debris removal. Therefore, in the allocation of orbital quotas to states, there could be a bonus in the yearly allocated quotas if the state has carried operations of active debris removal on its own space objects.

Spacefaring nations under this mechanism will be responsible for the exceeding of launched payload by their private companies to which they will allocate the quotas. Since the outer space environment should be accessible to all and the activities of current spacefaring nations should not impede the future of nations developing the capacity to launch objects into space, the quotas shall be shared equally within all the nations that take part to the initiative. This could lead to a decrease in the number of launches of space objects by major spacefaring nations, that could although buy more orbital quotas or payloads from nations that not yet have developed the capacity to launch objects into space, in exchange of the use of their launching systems. However, we can already see prospects of the Kessler syndrome[30] in certain earth orbital areas, and one cannot underestimate the fact that *« at high enough levels*

[30] Alver J., Garza A., May C., An Analysis of the Potential Misuse of Active Debris Removal, On-Orbit Servicing, and Rendezvous & Proximity Operations Technologies, https://swfound.org/media/206800/misuse_commercial_adr_oos_jul2019.pdf, The George Washington University, 2019.

of economic activity, the resource is destroyed with certainty ».[31]This system of orbital quotas could bring to the reduction of the short-term economic exploitation of the earth's orbital environment but will increase the chances for a sustainable conservation of orbital resources.

2.3 The Artemis Accords, a non-binding guide for the sustainable use of Outer Space Activities.

The Artemis Accords have been adopted on October 13th ,2020. Although, the accords have gained the signature of 13 countries, including Italy, nonetheless the opposition by China and Russia. They are, like the other soft-law mechanisms, non-binding, but the peculiarity of those accords is that they aim at the creation of a practical set of principles, that also take into consideration private bodies in the space community.

They want to increase safety and sustainability of outer space activities through practical guidelines. Those guidelines are written in 13 sections and were elaborated with respect to the OST and the other relevant space treaties. Although, some provisions of the treaty raised the question of whether they were violating some clauses of the OST. The Artemis Accords are a high-level political commitment of states; therefore, states do not share an obligation to follow those principles, but the principles that stem from the accords are related to a series of practical applications in the field of outer space. Some Criticism has been raised on the Artemis Accords due to them not being discussed in the United Nation's Committee on Peaceful Uses of Outer Space, which has been the main arena for confrontation and development of the agreements in the international practice. This although can be seen as a change in the international practice of states when it comes to the new regulations of space activities.

The Artemis Accord fall into the category of treaties that are carried out by a limited but open-ended group of countries. The ten sections of the accords refer to three main objects: the first is to reinforce the tenets of international law, emphasizing the peaceful use of space, the compliance with international law and the 1967 OST. The second, is the promotion of transparency and interoperability, in the light of the current international standards and the development of new standards when necessary. The third objective instead aims at diminishing the uncertainty surrounding the space resource recovery and utilization.[32] Under the second objective is interesting to point out what is written in section two regarding

[31] Walker J. & Gardner R., *Probabilistic Destruction of Common-pool Resources,* Indiana University, USA, 1991.
[32] MARCHISIO S., *The Law of Outer Space Activities,* Roma, 2022, pp. 313-316.

private bodies. The Artemis Accords, acknowledge the importance of private actors in the exploration and exploitation of outer space specifying that *« In the instruments described in this Section, the Signatories or their subordinate agencies should describe the nature, scope, and objectives of the civil cooperative activity;* ».[33] This provision alone increases the commitment of states, but more importantly of private bodies to an increased transparency when is comes to communication, scope and objective of their space activities.

While is true that the accords are a step towards an increased transparency for outer space activities, there are some provisions that create grey areas when it comes to the operations carried on the Moon.

2.3.1 Safety zones around lunar installations, the thin line between scientific research and national appropriation.

Safety zones in the have been established under section 11 part 7 of the Artemis Accords, under the deconfliction of outer space activities. It is the one that raised the most concerns in the space community, it has raised questions of compliance with the OST treaty, more specifically with Article II from which stems the principle of non-appropriation.[34] The subsection of part 7 describes the four principles of the safety zones, which I will analyse.[35] The first one states that *« the size and scope of the safety zone, as well as the notice and coordination, should reflect the nature of the operations being conducted and the environment that such operations are conducted in; ».* Here the wording is clear, that the operations that will be taken in the safety zone should reflect the size of the safety zone itself. This although could bring to the formation of spheres of interest.[36] Which could lead to an increase security level between safety zones depending on their size and on the scientific activity carried within. Additionally, the establishment of a safety zone is inherently creating obligations for other states. While is true that is no were mentioned a violation to the right to access to another's state safety zone, is true that there will be some sort of limitation of another state to act in that specific area, creating a conflicting interest.

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[33] The Artemis Accords, adopted on October 13th,2020.
[34] Ibid.10
[35] Ibid.32
[36] Guoyu Wang, *NASA's Artemis Accords: the path to a united space law or a divided one?*, in The Space Review, https://www.thespacereview.com/article/4009/1, 2020.

The second principle refers to the size of the safety zones, which should be determined following scientific and engineering principles. Interesting instead is the third principle which explains the nature of the safety zones as follows *« The nature and existence of safety zones is expected to change over time reflecting the status of the relevant operation. If the nature of an operation changes, the operating Signatory should alter the size and scope of the corresponding safety zone as appropriate. Safety zones will ultimately be temporary, ending when the relevant operation ceases; »*. The true nature of the safety zones is given not by the Artemis Accords, but by the state that enforces the safety zone. Is the state that decides how relevant is the operation carried on the Moon and what length of time will be needed in order to carry out that operation to completion. Moreover, there is no given expiration for the disassembly of the safety zone, giving to the operating signatory a potentially unlimited amount of time to carry out the operation if deemed necessary. There is a lack of clarity of who decides how to regulate these safety zones. It could lead to a "first come first served" race to whom establishes the most safety zones at once, establishing again a free rider problem that we are facing in outer space activities.

The fourth principle of the safety zones is linked only with Article XI of the OST, it is a mechanism of notification of changes in the nature of the established safety zone to the Secretary General of the United Nations (UN). However, if seen in this context, sub-paragraph d, part 7 of section 11, does not sufficiently enhance the climate of transparency and clear communication needed for safety zones. There is no obligation to for the operating signatory to constantly and continuously inform the international community of the activities carried in the safety zone. Following this rationale, the Hague International Space Resources Working Group said that the Article II of the OST offers too little explanation on how safety zones do not amount to the *de facto* appropriation of lunar surface[37]. Moreover, the commitment of state signatories to respect the non-appropriation principle is stated in section 10 regarding the space resources, not in section 11. This could bring to a different interpretation of the safety zones if the legal basis for non-appropriation is placed in another section of the accords. Lastly, but of crucial important, is the silence on the operationalization of Article I of the OST, which it stress the development of Outer Space activities for the benefit of all countries and all humankind. This reinforces my previous argument of the free

[37]Vazhapully K., *Space Law at the Crossroads: Contextualizing the Artemis Accords and the Space Resources Executive,* in OpinioJuris, http://opiniojuris.org/2020/07/22/space-law-at-the-crossroads-contextualizing-the-artemis-accords-and-the-space-resources-executive-order/, 2020.

rider problem in the context of exploitation of moon resources and the risk of running into a "first come first served" development of moon's safety zones.

The safety zones promoted by the USA in the Artemis Accords could be interpreted as the development of the previously proposed "Self-Defence Zones", proposed in the early 1980s by the US Department of Defence, the initiative was part of the "Commission on Integrated Long Term Defence Strategy"[38]. In those zones it was implied that the state who had authority over such areas had the right to inspect, expel or make harmless the invading satellite. The safety zones provided in the Artemis Accords are a good initiative to provide a regulatory framework for activities on the moon and on celestial bodies, but their nature could turn out to increase the in-security surrounding the activities carried on the moon's surface, instead of promoting a peaceful and scientific environment.

2.4. Private actors and the appropriation of resources on Celestial Bodies and Asteroids.

Private actors went from being simply contractors of governments since the early 1960s, with model of traditional procurement, to establishing real Private Public Partnerships (PPP).[39] In the traditional model of procurement, companies are the ones that simply deliver a finished product with the costs of production and risk included in the cost of that good. The evolution of private companies in the space sector arrived in the 21st century when in Europe space agencies shifted their approach giving the opportunity to private companies to establish PPPs. If compared to the traditional model of procurement, they are a greater involvement of the private sector in all the phases that relate to the space activity. This could go from the design of the spacecraft to the operations of launching and monitoring. It is a long-lasting relationship between public and private.[40] They provide benefits for the agencies that use this tool when carrying out space activities. For the government or space agency that establishes the partnership there is a flexibility and efficiency of programme development, a transfer of risks to the private sector and a reduction of the upfront costs. Whereas, for the private company we find more autonomy and action for technical management, a return of the investment and an increased competitive advantage. However, this increase in the PPPs

[38] Newsome T.A., *the legality of safety and security zones in outer space: a look to other domains and past proposals,* Montreal, 2016.
[39] European Space Policy Institute, *Space Environment Capacity,* Report 70, Vienna, 2022, p. 63.
[40] European Space Policy Institute, *Space Environment Capacity,* Report 70, Vienna, 2022, p. 23.

meant also that the private companies have more freedom of exploration and exploitation than they had 50 years ago. Moreover, the regulations surrounding the actions of private bodies in outer space are scarce and most importantly they lack specificity and enforcement powers. This poses a big threat to the non-regulated extraction of resources from celestial bodies.

2.4.1 The freedom of exploitation of Moon's resources under current international space law.

The treaty that we should keep in mind when it comes to matters related with the moon is the "Agreement Governing the Activities of States on the Moon and other Celestial Bodies" (MOON). This agreement indeed has the aim to safeguard the moon's environment in order to prevent wrongful uses of it. It is clearly explicated in Article 7 of the agreement that states should take all the preventive measures in order to prevent an alteration of the existing environment of the moon. The wording is pretty clear[41], the moon should not be a place in which an exploitation of resources shall be done in a way that alters permanently its environment. Only 7 states ratified the treaty, and 18 states took part to it. More importantly, none of the major spacefaring nations is within them. This can be interpreted as a clear sign from the nations that have more influence in the space sector, to not wanting to have limitations in a future in which space mining is a profitable venture.

Additionally, the USA's presidency in 2015 enacted the U.S. Commercial Space Launch Competitiveness Act, establishing a national framework for private companies on the extraction of space resources. This was a sign from the USA to establish themselves as the first country with tangible interests in the future of space mining. Paragraph 3, section 51302 titled "Commercial Exploration and Commercial Recovery" of chapter 513 is clear on the right of an US citizen regarding the exploitation of space and shall *« promote the right of United States citizens to engage in commercial exploration for and commercial recovery of space resources free from harmful interference, in accordance with the international obligations of the United States and subject to authorization and continuing supervision by the Federal Government ».*[42]When it comes to space exploration, a state that gives the authority to a private body to pursue the exploitation of space resources can be, without an established system of safeguards, disrupting for the outer space environment. Moreover, in section 51303 named "asteroid resource and space resource

[41] Ibid. 13

[42] U.S. Commercial Space Launch Competitiveness Act, concluded in Washington on November 16th, 2015, and entered into force November 25th, 2015, H.R. 2262.

rights", a United States citizen *« engaged in commercial recovery of an asteroid resource or a space resource under this chapter shall be entitled to any asteroid resource or space resource obtained, including to possess, own, transport, use, and sell the asteroid resource or space resource obtained in accordance with applicable law, including the international obligations of the United States ».*[43] This part could be interpreted as a clear violation of the principle of non-appropriation listed in the OST and the MOON agreement. Although cannot be considered in violation of international law, due to the fact that international space law does not deal with private bodies, but only with the actions of states and are states that are responsible for the behaviour of private companies.

Under the MOON agreement it cannot be considered a violation due to the fact that the USA is not a member. Moreover, the articles that are at the basis of the protection of the environment of asteroids and celestial bodies, namely I and II of the OST, are flawed in the sense that, the interpretation given of non-appropriation refers to the territory and cannot explicitly be applied to the natural resources present in the territory. Under the current scheme, there is a lack of an international framework that plainly sets out a threshold in order to prevent a point of non-return in the exploitation of the resources on the moon. Following the USA's initiative, in Luxembourg, on August 1st, 2017, entered into force the "Luxembourg Law on the exploration and use of space resources". This law, as in the one in the USA, gives the right of ownership to the citizens of Luxembourg over extracted space resources. Luxembourg is trying to establish itself in Europe as a hub for the space utilization in the future, being the forerunner of many space projects.

Clarification at the international level is needed in order to give a sustainable future to the extraction of space resources. The tendency of the international community seems going in the opposite direction. The Artemis Accords are a multilateral agreement in which is explicated again that the extraction of space resources is not considered a mean of appropriation and therefore does not constitute a violation of article II of the OST. The international community is not ready to establish an international framework, specially when it comes to the resources present on the moon and on asteroids, due to the increasingly high economic interests at stake.

Space resources extraction on the moon and on asteroids is scarce of an international mechanism that will prevent their future excessive exploitation. While is true that the practical and tangible use of these resources is not to be massively exploited in the near

[43] Ibid. 42

future, the legal basis with which those activities will be started is extremely important. At this current pace, there is a high risk of falling into a model of extraction that is completely de-regularized and that aims only at maximizing the profit that could come from the mass mining of surfaces such as the one of the moon.

3. Militarization of space objects and celestial bodies.

Security in Outer Space has many faces, it's not only about orbital debris or rogue satellites. There are other threats that are increasingly relevant and have a role in the stake of the outer space future. It has become a new domain full of unlimited possibilities and in the future who will control the most of it will very likely be a hegemon in the international arena, whether we are talking about a government or a private company. For this reason, the research for new space technologies has not only focused and developed on the space research and resources, but also to the militarization of the space objects or of technologies against space objects. Under the current legislative regime for outer space activities, space is a domain that is supposed to be used only for peaceful purposes with respect for all humankind. In the past years there have been many instruments that have been developed and proposed to the international space community by states, international organizations, and committees. Although all of those instruments have contributed to create a climate of peace in the outer space arena, there are still a lot of tensions that could cause to an open warfare due to the increased economic and political interest that sparked in the last 20 years. In this chapter I will analyse the instruments that are used to prevent and armed race into space, how debris mitigation plays a crucial role in security, the current state of proliferation of armaments in space and the unclear introduction of space forces by spacefaring nations.

3.1. The use of legally binding instruments in opposition to non-legally binding instruments for the Prevention of an Armed Race in Outer Space.

Instruments for the Prevention of an Armed Race in Outer Space (PAROS) have been developed in order to decrease the security tensions between states in outer space, since an open warfare in the space domain would inevitably lead to the disruption of most of the technologies we use and services we utilize. There are debates whether or not, when it comes to the militarization of outer space a binding agreement should be drafted or if the current norms of international space law should be kept as a guide for the non-proliferation of weapons in outer space. In this paragraph I will confront the problems and the threats of not having a binding regime that prohibits states to deploy weapons in outer space.

States take advantage of the fact that international law does not regulate certain aspects related to the proliferation of armaments in outer space.[44] The only weapons that are

[44] MARCHISIO S., *The Law of Outer Space Activities,* Roma, 2022, p. 352.

explicitly prohibited in a treaty are weapons of mass destruction, under Art. IV of the OST. Their placement is prohibited in outer space or on celestial bodies under any circumstance. This although leaves a vast array of other technologies that have been developed, such as dual use satellites, ASAT missiles and cyber-attacks. States, even though we are living in a moment of peace, are taking the momentum, and starting to test those technologies. Therefore, instruments have been developed and proposed by experts and governments in order to mitigate this trend of increased militarization of outer space. Throughout the development of regulations that will prevent the use of weapons in outer space, there has always been a division between those that prefer a norm-based approach and those that instead advocate for a law-based approach.[45]The former refers to the mitigation of PAROS through means that are non-binding for the states and increased transparency and confidence building measures. The latter instead encourages the prevention of PAROS through a means that are binding, such as a treaty. On the one side, there is the belief that a norm-based approach will foster the customary nature of international law in the common practices that states have when carrying out military operations related to space. On the other side, those for a law-based approach are sceptical of the nature of a norm-based approach since *«Legally binding measures have traditionally been viewed as the gold standard for arms control and disarmament mechanisms, particularly in the nuclear, biological and chemical regimes. ».*[46]Therefore, the question is why a regime of binding norms should not be used for Outer Space Activities? The answer is not straightforward, the international community cannot reach an agreement that is suitable for all the needs of the states. The problem is the fragile trust that states share with each other. Under a realist perspective, once a state raises its security or increases its military capabilities in a certain sector, in this case outer space, the other states perceive it as a threat and therefore increase their security as well. This is not due to an imminent attack from one state to another, but because there is a lack of trust in the goodwill between states. This can be well applied when talking about militarization of space activities. In the case of a binding agreement in which a state is a signatory and another one is not, the former loses its ability to increase its security, while the latter can increase it without having to worry about the former state since it is signatory of an agreement, that for example restricts the use of dual

[45] María Garzón Maceda, Eleanor Krabill, Almudena Azcárate Ortega, *2021 Outer Space Security Conference Report,* Geneva, 2021, p. 12.
[46] Ibid. 45, p. 15.

use satellites in outer space. Due to this climate of increased security, the way that has been paved as the most suitable for the moment is the norm-based approach.

The Group of Governmental Experts on Transparency and Confidence Building Measures (GGE on TCMBs) was created following a Russian initiative. It was composed by 15 governmental members, with the members of the security council of the UN as permanent members of the group, and the other 10 chosen by the Secretary General based on equal geographical representation. The group is important because reflects in its members' the multinational character of outer space activities and because does not undermine the ambitious nature of states but combines them with the realist needs for the future of outer space.[47] The report proposed to the UN, was clear, practical, and implementable guide for a norm-based approach in outer space. It was endorsed by the General Assembly by consensus in 2013[48], and encouraged states to implement in their national legislations the proposed TCMBs. While is true that those measure could be the first ones to have a wide acceptance by the international community and that they could function as the basis of a future binding agreement, they are not to be confused as a replacement for one. They can help to reduce the climate of mistrust that is shared among nations in order to decrease the threats related to the security of states, but they cannot substitute the nature of a binding agreement and the mechanisms that stem from it.[49] Although, the report of the GGE on TCMBs was a big step towards raising the awareness when it comes to the increasing relevance of transparency and confidence building measures and it can lowers the security threads that surround the space environment. In the current state of events, while technologies are still being developed and tested, the report and the workings of the GGE might be enough to mitigate the risks of a conflict in outer space until the basis for a binding treaty are reached. Another draft has been proposed by Russia and China, and it was the first attempt to bring a law-based approach to the prevention of an armed race in outer space.

The Treaty on the Prevention on the Placement of Weapons in Outer Space, the Threat or Use of Force Against Outer Space Objects (PPWT), was first proposed by China and Russia, in a first version in 2004 at the Conference on Disarmament (CD), which is the only forum for multilateral negotiation when it comes to disarmament, then reformulated in 2014 considering the proposals of other states. The treaty's main obligations are not to place

[47] MARCHISIO S., *The Law of Outer Space Activities,* Roma, 2022, p. 355.
[48] United Nations General Assembly, Resolution 6850, 10 December 2013, A/RES/68/50.
[49] Ibid. 45.

any weapons in outer space; not to resort to the threat or use of force against outer space objects of States parties to the treaty; not to assist states or promote activities that are inconsistent with the object of the treaty.[50] The draft treaty to enter into force needs the ratification of 20 states, included the permanent members of the security council. Even though the treaty has not been adopted, this statement contained in Article XIII of the draft treaty has a high political value. It will not only prevent the placement and use of weapons in outer space, but more importantly will also prevent that all the decisions of the security council to pose a threat to the security of outer space. And since, the main security concerns when it comes to outer space are between three of the members of the security council the entering into force of the treaty will drastically reduce the risk of an escalation. While is true that the draft treaty prohibits the placement and use of weapons in outer space, it is silent of the production and research and storage of weapons on earth.[51] This is a normative feature that is recurrent in disarmament treaties. And the omittance by China and Russia when proposing this draft raised some questions.

Although is clear that the latter countries have been forerunners in the proposals for a binding treaty for PAROS. China that in the CD of 2000 stated that *« Conference must first re-establish the Ad Hoc Committee under agenda item 3 to negotiate and conclude an international legal instrument prohibiting the testing, deployment and use of weapons, weapon systems and components in outer space so as to prevent the weaponization of, and an arms race in, outer space. ».*[52] Moreover, both the countries in 2019 during the CD explicitly supported the *« negotiation by the international community of a legally binding multilateral document that would provide reliable guarantees for the prevention of an arms race in outer space and the placement of weapons…»*[53] following the PPTW draft proposed in 2014. However, the scepticism surrounding the PPTW has been growing stronger since there are some missing provisions that are of utmost importance when it comes to outer space, such as the prohibition of the use of ASAT missiles and a procedure of verification of the articles contained in the draft, and the modification brought by Russia and China in 2014 did not seem to clear the wording of comma e of Article I of the PPWT, which still alludes that an action of use of force will be interpreted as a breach of the treaty only if intended.[54]

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[50] MARCHISIO S., *The Law of Outer Space Activities,* Roma, 2022, p. 358.
[51] MARCHISIO S., *The Law of Outer Space Activities,* Roma, 2022, p. 359.
[52] Conference on Disarmament, CD 1606, 9 February 2000, CD/1606.
[53] Conference on Disarmament, CD 2161, 27 June 2019, CD/2161.
[54] Ibid. 51

The measures of soft law that have been developed by the GGE to promote transparency and confidence building will be fundamental for a peaceful use of outer space, but not sufficient. During the CD in 2021 the Group 21 on PAROS, explicitly reaffirmed its recognition that *« the legal regime applicable to outer space does not in and of itself guarantee the prevention of an arms race in outer space. For that purpose, the Group stresses the need to consolidate and reinforce that regime and enhance its effectiveness. ».*[55] The enhancement of the effectiveness of the regime surrounding PAROS, could be achieved if the international community will manage to establish a framework in which, transparency and sharing information are strictly intertwined with a proposal that will be discussed in the CD and be enforced as legally binding for the signatories. Confidence building and trust between states are the foundations for a successful establishment of a treaty for a secure future of outer space and it could be achieved only if states lower their security thresholds and set aside the urge to be hegemons in the new space domain.

3.1.1. The use of Space Situational Awareness agreements (SSA) as a deterrent for the use of force in Outer Space.

Space Situational Awareness (SSA) agreements have been developed in the context of security in outer space. *« Space Situational Awareness refers to the knowledge of the space environment, including location and function of space objects and space weather phenomena. »* [56] This concept if used in the frame of PAROS, could come to use for an increased trust and confidence between states carrying outer space activities. SSA agreements have as the main goal the sharing of information in order to decrease the resilience that there is around the space infrastructure system. The number of agreements that has been developed since 2010 has raised by eight times. Yet alone the USSTRATCOM went from 19 purely commercial in 2010 to 81 in 2017, comprising of commercial, governmental, and classified agreements.[57] The stakeholders in the space infrastructure are highly reliant on SSA systems and accords, they help to coordinate and harmonize the security challenges that the space infrastructure is facing. They are proving to be fundamental in the current transatlantic relations between Europe and the USA. The countries in Europe are establishing bilateral agreements in which the US is benefitting of the SSA technologies to acquire data that the European nations are

[55] Conference on Disarmament, CD 2215, 27 August 2021, CD/2215.
[56] European Union Satellite Centre, https://www.satcen.europa.eu/page/ssa, Madrid, 2022.
[57] European Space Policy Institute, *Security in Outer Space,* Report 66, Vienna, 2022, pp.42-43.

developing. On the one side we have the USA that is carrying this bilateral agenda in order to increase transparency and to maintain its superiority in the field of space data. On the other side instead the European countries and ESA are becoming increasingly reliant on the SSA capacity of the USA, which is mostly in the hands of the USA's military.

	(Transatlantic) Diplomacy and cooperation frameworks *Harmonise and coordinate space security efforts among stakeholders*
Space Situational Awareness (SSA) *Monitor space environment threats*	Examples: • SSA Data Sharing Agreements of a bilateral nature • Compatible academic environment with favourable schemes for SSA related research

The reason why I think that SSA data sharing agreements are relevant as a deterrent for the use of force in outer space, is their nature of transparency. Threats that bring to the use of force are due to the climate of mistrust and lack of transparency when it comes to the sharing of information between states. SSA, is a branch of security in outer space that cannot be achieved by only one country to the fullest, even the USA, which has one the most advanced and sophisticated structures for the tracking of objects, sometimes needs to rely on agreements in order to be more aware of the situation of their space infrastructure. But in order to have genuine relation, cooperation is needed and the degree of collaboration when it comes to the sharing of data must be the highest possible, with the highest degree of transparency. This means co-dependency between states that want to have an efficient space infrastructure that is able to predict threats and as a consequence prevent them. The establishment of SSA agreements it is itself a lowering of the threats between states. When it comes to prevention of a conflict in space, since the amount of data needed to carry out military operations in space is considerably high, states that are part to those agreements would not be likely to cause harm to each other.[58] The segment that is particularly important in my opinion for confidence building in SSA agreements, lays in the European Union's Space Surveillance and Tracking (SST) which is an area of SSA.[59] While this area is mostly used to avoid collision between space objects, I believe it has a strong security implication when it comes to the detection of harmful objects and the manoeuvring of dual-use satellites. In the scenario in which a dual-use object is noticed as a threat to another one, the SST systems could be used to track the object and then either neutralizing it under the right of

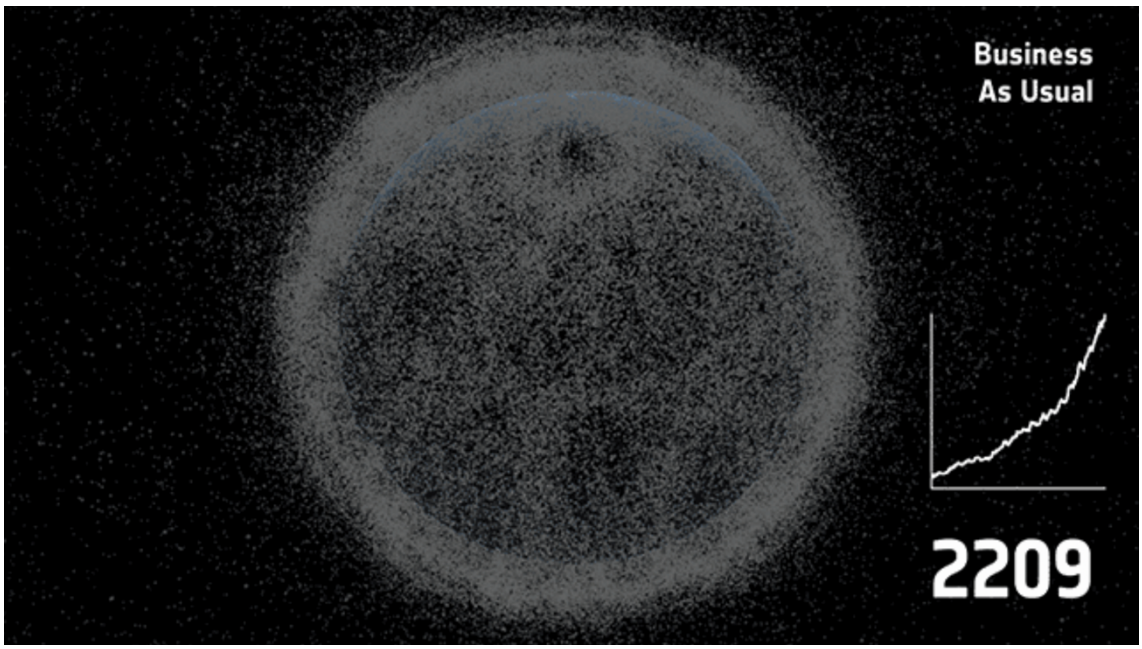
[58] Boyce B., *21st Century Deterrence in the Space War-Fighting Domain: Not Your Father's Century, Deterrence, or Domain,* 2019, Colorado Springs.
[59] European Space Policy Institute, *Security in Outer Space,* Report 66, Vienna, 2022, p. 31.

self-defence contained in Art.51 of the UN Charter or to ask for consultations to the nation to which the object belongs, preventing an escalation.

This framework, since the majority of SSA operators in Europe is military, could already well be seen as a deterrent for the uses of force and mitigate the way towards a broader use of data sharing for transparency and confidence building that ultimately, I believe will be fundamental for the prevention of an armed race to space.

3.2. How debris mitigation and active removal is a key security issue for spacefaring nations in today's outer space activities.

Outer space debris are not an issue that has been developed only in recent years, but it has been a concern for the space actors since the 1970s, even more after the publication in 1978 of the paper "*Collision Frequencies of Artificial Satellites: The Creatin of a Debris Belt"* by Donald J. Kessler and Burton Cour-Palais.[60] Space debris are a negative externality of space operations and a side effect of the operations carried out by space actors. If we carry operations as usual in the next 200 years it will lead to a scenario of orbital decay in which collisions between space objects, passive or active, will be the primary source of space debris. A forecast has been made by the ESA which I will show with the following illustration.[61]



[60] May C.R., *Triggers and Effects of an Active Debris Removal Market,* Centre for Space Policy and Strategy, January 2021, p.2.
[61] European Space Agency, *Active Debris Removal,* https://www.esa.int/Safety_Security/Space_Debris/Active_debris_removal, 31/05/2022.

As it can be noted, this will be the situation of the earth's orbit in 2209 if operations are carried as the same rate as we do now and we don't neither respect the mitigation measures like those proposed by the IADC nor we implement systems of Active Debris Removal (ADR). Although there are different views over the debris mitigation and removal, this area of interest is gaining momentum in the space community. Experts developed a series of solutions regarding the problem of space debris, on the one side there is mitigation and on the other ADR. On the mitigation side there are guidelines developed by the IADC, which I have mentioned in earlier paragraphs, but they are not binding and only 13 space agencies have adhered to them. Mitigation can be carried out by space actors following what is called the "25 years rule". Outer space actors are invited to not station in orbit objects with a lifespan superior to 25 years.[62] In the LEO as of today we have already reached the threshold of 2500 intact objects, with 3200 orbiting objects.[63] A report of COPUOS in 2012 claimed that if the number of launches per year is set at 36, with states respecting the 25 years rule and with a compliance to the rule of 90% it will still take 200 years to reach the threshold of stability.[64] Although, the number of launches carried our per annum only in the period between 2013 and 2016 reached 125.[65] Notwithstanding, the development by private actors in the Newspace economy of mega constellations: those objects are non-navigable and could increase the population density of the LEO region by two or three times.[66] Therefore, is straightforward that mitigation is not the only tool that can be used to prevent overpopulation in outer space, ADR is needed.

The latter has a variety of uses that make those mechanisms key for the security and stability of outer space. A NASA predicted in 2012 that in order to have a stable LEO region, the number of debris that should be removed should be 5 every year[67], however a recent study carried out by the European Space agency estimates that this number now fluctuates

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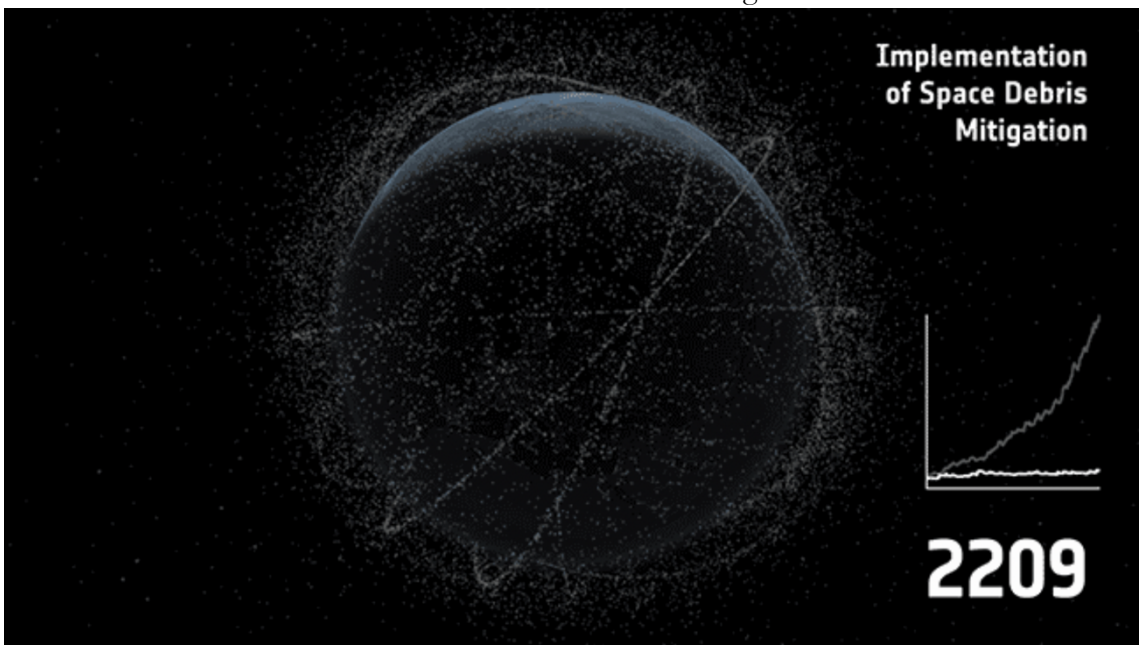
[62] European Space Policy Institute, *Security in Outer Space,* Report 66, Vienna, 2022, p. 25.
[63] Ibid 61.
[64] Committee on the Peaceful Uses of Outer Space, *Active Debris Removal — An Essential Mechanism for Ensuring the Safety and Sustainability of Outer Space*, in Long-term sustainability of outer space activities, Vienna, 2012, A/AC.105/C.1/2012/CRP.16, p.21.
[65] Ibid. 60.
[66] Dobos B., Prazak J., To Clear or to Eliminate? Active Debris Removal Systems as Antisatellite Weapons, in Space Policy, Vol. 47, Prague, 2019, p. 218.
[67] Committee on the Peaceful Uses of Outer Space, *Active Debris Removal — An Essential Mechanism for Ensuring the Safety and Sustainability of Outer Space*, in Long-term sustainability of outer space activities, Vienna, 2012, A/AC.105/C.1/2012/CRP.16, p.22.

between 5 and 10 per year.[68] Granting that ADR is carried out in compliance and at the needed rate the orbital situation in 2209 will be the following.



However, ADR is not as easy as it might seem, there are technical and legal obstacles that make those actions not only dangerous, but also unsettling for the current balance of power. Further, the technologies that allow ADR are still being developed and far away from carrying post mission disposal actions. Technical obstacles are related to the operational side of ADR technologies. Important is the status of the orbiting object: it can be cooperative or uncooperative, is the capacity of the object to be disposed of to help or not the ADR system in carrying out its mission.[69] Another obstacle is the ownership of the object. In the case of smaller objects this is controversial since the establishment of the ownership is basically impossible. Whereas, when it comes to larger objects an ADR operator will have to ask the permission to the state liable for the space object. In international space law there are no provisions that take care of this situation, but the state will still have to respect the provisions that are contained in the OST. A solution could be the establishment between the parties of a legally binding contract that incorporates both the domestic law of the state involved and the international law norms.[70] It could be seen also as solution to the problem of security between states.

[68] Ibid 62.
[69] May C.R., *Triggers and Effects of an Active Debris Removal Market,* Centre for Space Policy and Strategy, January 2021, p.5.
[70] Way T.A and Koller J.S.., *Active Debris Removal: Policy and Legal Feasibility,* Centre for Space Policy and Strategy, April 2021, pp.3-6.

When it comes to ADR many states perceive them as a threat because of the possibility to use them as weapons, the inclusion of a third party, in this case an ADR operator will decrease the security threshold between states. The operator would have no reason to cause harm to an object that has not been contracted to, that being the object that is owned by that state that commissioned the mission. The binding contract between the parties makes sure that also the liability in the case of an accident falls either on the operator or on the state, depending on the agreement between the parties.

ADR is key for the future and current security of space activities and its operational implications could cause a high degree of tensions between states if the intention of ADR is harmful towards an object of ownership of another state. However, in the current scenario, technologies are still being developed and only a few concrete possibilities of ADR are being concretively developed by private operators or space agencies, like those co-funded by the European Commission and carried by the Surrey Space Centre.[71]

3.2.1. Dual use systems, how the development of technology is creating grey areas in international space law.

Dual use generally means that *« the device or the system has been designed for or used by more than two actors. »*[72] and *« they perform both military and civilian functions ».*[73] Dual use systems in outer space are devices or systems that are designed for commercial, military, and national intelligence activities, but operated for civilian or commercial purposes, with the potential to be used for military and national intelligence activities. Usually the competence is shared, through a Public Private Partnership (PPP), on the one side we have the operator that is a private company and on the other the state. This partnership allows a degree on involvement of the state in the operationality of the space object, in this lies the concern when it comes to dual-use objects. Until the object is operated by a private firm or a contractor, the latter acts as a sort of cushion for the security thread that the object could represent, due to the neutrality of the operator itself. But, if the operator has some degree of interoperability with the state of launch of the dual-use objects, and the state retains some intelligence or military

[71] Dobos B., Prazak J., *To Clear or to Eliminate? Active Debris Removal Systems as Antisatellite Weapons*, in Space Policy, Vol. 47, Prague, 2019, p. 221.
[72] Otani Y., Ohkami Y., Kohtake N., Sakurai T., *Dual Use Concept on Civil and Defence Uses in Outer Space,* in Trans JSASS Aerospace Tech, 2012, Tokyo, Vol. 10, ists28, p.2.
[73] International Committee of the Red Cross, *The Potential Human Cost of the Use of Weapons in Outer Space and the Protection Afforded by International Humanitarian Law,* Position Paper submitted in the General Assembly Resolution 75/36, 2021.

functions of the object in question, this could rise tensions at the international level. This is a trend that is very popular between nations that are developing this type of capacity.

An example is the Italian COSMO-SkyMed satellite system, which is a dual system where the Italian Ministry of Defence and the Italian Space Agency retain 100% of the stakes, meaning that the Italian government can use the system and has access also to all the systems that are meant for commercial uses.[74] Whereas an example of a dual use object under a PPP agreement is the German observation satellite TerraSAR-X, in this case the stakeholders decide the treatment of data policy. [75]

The space treaties under Art. III of the OST say that international law must be applicable to all the space activities, therefore international law applicable to weapons can be applied both in the development and in the use of weapon systems in outer space. Under international law however there is no prohibition to place conventional weapons in outer space, making the design and use of dual-use objects lawful, in so far as an act of aggression is not committed.[76] Indeed if an act of aggression is committed this would trigger the right of self-defence contained in Art.51 of the UN Charter.

Then, when it comes to the operation of dual-use system the key is intent. This is particularly true when it comes to the use of ADR systems that interact with cooperating or uncooperating satellites, because of their capability to cause harm. Although the capacity to cause harm is not embedded in the design of the system, but in the intent of the operator that is managing the system.[77] Therefore, the introduction of a commercial third party that would operate the system with a clear contract that is released by an organization that is independent from the influence of any state could be the solution to the problem of intent when carrying out ADR.[78]

International space law, especially when it comes to dual use objects, cannot rely on the current norms of international law related to weapons. They system is leaving some areas that are unregulated and has no preventive mechanism that could regulate the production and the operability of dual use objects in outer space. This leaves "papiers blanc" to commercial actors and states, possibly increasing the security thresholds.

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[74] Otani Y., Ohkami Y., Kohtake N., Sakurai T., *Dual Use Concept on Civil and Defence Uses in Outer Space*, in Trans JSASS Aerospace Tech, 2012, Tokyo, Vol. 10, ists28, p.3.
[75] Ibid. 71.
[76] Boothby B., *Space Weapons and the Law,* in International Law Studies, Vol. 93, 2017, pp.201-213.
[77] Ibid 70.
[78] Dobos B., Prazak J., *To Clear or to Eliminate? Active Debris Removal Systems as Antisatellite Weapons*, in Space Policy, Vol. 47, Prague, 2019, p. 222.

3.2.2. Case studies: Chinese Fengyun 1 Satellite, USA-193 satellite.

The following will be two case studies of ASAT missile weapon test that occurred in the previous years. The destruction of weather satellite Fengyun 1 and National Reconnaissance Satellite USA-193. However, in the case of the latter government officials always held that the struck down of the satellite was due to the protection of civilian environment and of the population, since the USA declared that they stopped their ASAT testing over 20 years ago.[79]

The satellite was owned by the National Reconnaissance Office, but on the day of the launch contact was lost with the satellite. Usually, they would have let the satellite re-enter in the atmosphere and fall onto ground. But in this specific case, the landing point was a populated area, secondly the fuel tank was full. Tank of satellites are made of pure titanium which resist at high temperatures, therefore it would not have been a problem, as it had happened in the past just to let it re-entry in the atmosphere. The difference with USA-193 was that the tank was full of 1000 pounds of hydrazine, the fuel of the satellite. The fuel in the tank and the risk for the civilian lives that made the government decided to strike down the missile.[80] The interceptor was an SM-3 missile launched by a Navy Cruiser on February 20th, 2008, successfully hitting the target.

Instead in the case of China, the test was aimed precisely at testing the capacity of an ASAT missile developed by their program. The payload that hit the non-operational satellite was a Kinetic Kill Vehicle (KKV) at an altitude of 863km, much higher than the one carried by the USA.[81] Since the development of the missile itself was kept secret by the Chinese government there are only assumptions on what was the precise technical aspects of the KKV.

More importantly, the debris caused by Fengyun-1C, endangered the life of the other satellites. It increased the collision probability of other objects in the same orbiting region. As of 2007 the collision probability of two Italian objects increased considerably: by 12% for AGILE, an astronomical in equatorial orbit, and by 38% for COSMOS-SkyMed 1 in the sun-synchronous orbit.[82]

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[79] Wolf J., *U.S. shot raises tensions and worries over satellites*, https://www.reuters.com/article/us-satellite-intercept-vulnerability-idUSN2144210520080222, 2008.
[80] Day D.A., *Burning Frost, the view from the ground: shooting down a spy satellite in 2008,* in The Space Review, 2021.
[81] Weeden B., *2007 anti-satellite test fact sheet,* in Secure World Foundation, 2010.
[82] Pardini C., Anselmo L., *Evolution of the Debris Cloud Generated by the Fengyun-1C Fragmentation Event,* Pisa, 2007.

Those two cases are relevant because they are the first two demonstration of ASAT missile capacity by two of the main spacefaring nations. Even though from the USA's side there was no intention to demonstrate its capacity to carry an ASAT operation, both launches showed an unprecedented event in the history of military application of space. Justifying the action of other nations in the case they would want to carry other ASAT tests, creating uncertainty for future security of outer space activities.

3.3. The consequences of the creation of space forces for the peaceful environment of outer space.

The space domain is as fragile as it is important for the future development for the major economies. It is rich in natural resources, most of our daily life tasks depend on systems like GPS and telecommunications, all connected through satellites in orbit. Therefore, it has become imperative for nations with advanced space capabilities to make sure that their superiority in this domain is unmatched. This could bring a serious threat to the doctrine of the peaceful uses of outer space developed since the OST in 1967. Since to disrupt most of the space related functions that we use on earth a conflict between two states with medium or large space capabilities would suffice.[83]

In the current international arena, the three players that are developing capabilities or are planning to develop them to maintain superiority in the space domain are: the USA, Russia, and China. The USA since the establishment on December 19th, 2019, of the U.S. Space Force (USSF) with the National Defense Authorization Act, created a new branch of the armed services in 73 years.[84] Their mission is to *« The USSF is responsible for organizing, training, and equipping Guardians to conduct global space operations that enhance the way our joint and coalition forces fight, while also offering decision makers military options to achieve national objectives. »*[85] However, the problem of the USSF and their future lies in their doctrine, which is a multi-domain one[86], as of today the USSF shares a lot of missions with the U.S. Airforce, using the same equipment. It lacks a culture, there is doubt whether USSF will be able to differentiate from the U.S. Air Force due to the high number of personnel that came from it.[87] More

[83] Farley R., *Space Force: Ahead of Its time, or Dreadfully Premature*?, https://www.cato.org/policy-analysis/space-force-ahead-its-time-or-dreadfully-premature#space-force-multilateral-space-governance (02/06/2022), 2020.
[84] United States Space Force, https://www.spaceforce.mil/About-Us/About-Space-Force/History/ (02/06/2022).
[85] Ibid. 81.
[86] Major Clayton W. Couch, Why United States Space Force Doctrine Development Is Critical To Its Success, https://www.alsa.mil/News/Article/2488073/why-united-states-space-force-doctrine-development-is-critical-to-its-success/(02/06/2022), in Air Land Sea Bullet-in, 2020.
[87] Ibid. 81.

interesting, is the lack of operational military means by the USSF, which contributes to the struggle to develop a culture. The ASAT systems are in fact managed still by the U.S. Navy and the U.S. Airforce. [88]

On the other side, we have Russia and China, respectively with People's Liberation Army Strategic Support Force which centralizes a variety of capabilities including the space one[89] and the Russian Aerospace Forces. The only difference between those and the USSF is that Russia and China have still the capability to send astronauts in outer space, which could become considerably useful, whereas the US needs to rely on Russian systems in order to send astronauts in outer space or in the ISS.[90]

The space domain is not exclusive for research anymore, increasing military and commercial interests are at stake. The tendency of governments to tight the knot around the supremacy of this domain through military or technological hegemony, will lead to a series of security tensions that will not benefit the future security of the space environment, but will only render it more uncertain.

[88] Ibid 81.
[89] Costello J., McReynolds J., *China's Strategic Support Force: A Force for a New Era*, in Center for the study of Chinese military affairs Institute for National Strategic Studies China Strategic Perspectives, Vol. 13, 2018, pp.1-5.
[90] Cheng D., *Does the United States need a Space Force?, https://www.heritage.org/space-policy/heritage-explains/does-the-united-states-need-space-force, 2022.*

4. CONCLUSION.

The long-term sustainability of outer space has the potential to be achieved. The challenges to tackle are many. Of utmost important is the congestion of the outer space environment, the increase commercialization and the significant amounts of debris left by the previous generations. The international community needs to look at space through a space-oriented perspective. Its capacity is limited and if filled would mean the disruption of outer space activities as we know them now. The system of regulations and treaties are useful, and new instruments for the regulation of outer space have been proposes by both states and international organizations. Due to different security concerns and views on how to carry out operations no binding agreement is yet into sight. There is not a lack of proposals, but a lack of willingness by states to adhere. Another challenge is the militarization of outer space. It is a race in which states are trying to achieve superiority in the space domain. This tendency however, besides raising the security concerns, could raise the possibility of an escalation in outer space, which will be damaging for the whole international community. However, nations in the case of tensions will not escalate in a conflict in outer space due to it disruptive consequences. The operationality of the space domain that has become vital for our life as human beings and will be even more for the generations to come. After all, I believe that the space community is well aware of the current state of outer space and is working to develop a sustainable future. Although, this process is being slowed by the increasing economic and political interests at stake, that will prove detrimental if a proper framework for the uses of outer space is not established.

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