University of Vienna – Faculty of Law – Department of European, International and Comparative Law

Dissertation Proposal

Working Title:

Limitation of The "Freedom Principle" in The Earth's Orbits

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I. Research Proposal Outline

1. Background and introduction – the overexploitation of the Earth's orbits

Humanity is witnessing an exponential growth of objects which set course on our finite trajectories (LEO, MEO and GEO).[1] Only in 2021, the United Nations Office for Outer Space Affairs (UNOOSA) registered a record number of launches, delivering more than 1800 objects into orbit.[2] This number of newly launched objects in 2021 almost exceeded the previous two-year figures, combined. Out of the launched objects, in the last years, there has been an enormous increase in the number of commercial satellites launched in our orbits; nevertheless, many of these satellites are being launched into large or mega-constellations especially in the LEO environment, in order to provide communication services around the globe.[3] While telecommunications satellites in mega-constellations bring great socio-economic benefits,[4] they also pose a big challenge to long-term sustainability of orbital space.[5] In LEO, Elon Musk's SpaceX has deployed nearly 3000 Starlink satellites since 2019,[6] and has requested about 30,000 more before the International Telecommunication Union (ITU).[7] Another COPUOS States Member,[8] Rwanda, and its space agency, The Rwanda Space Agency, in October 2021 registered several constellations totaling more than 300,000 satellites with international frequency regulators.[9] Concerning the launches of mega-constellations, I argue that there is a lack of mechanism, hurdle, or any kind of rejection of the initiative to launch such a quantity of objects in low-Earth orbit within and outside the global space community, which may be a cause of concern not only due to the overpopulation of a limited resource and environment that the orbits represent, but also to potentially contributing to the rapidly growing space debris concern.

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[1] LEO as low-Earth orbit, MEO as Medium Earth orbit, and GEO as geostationary or geosynchronous orbit. For more information on the various orbits, see: https://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports_RegulationBroadbandSatellite.pdf

[2] For the online UNOOSA index of objects launched into outer space, see: https://www.unoosa.org/oosa/osoindex/search-ng.jspx?lf_id=

[3] A satellite constellation is a group of artificial satellites working together as a system. Unlike a single satellite, a constellation can provide permanent global or near-global coverage, such that at any time everywhere on Earth at least one satellite is visible. Constellations with N > 50 planned satellites are considered to be 'Large' and N > 1000 as 'mega' or 'Enormous'.

[4] See for example, Lema, Maria, (2022), How telecoms can help the U.N. meet sustainable development goals, IT Proportal.

[5] „Nobody anticipated an environment where there would be so many satellites that the physical congestion of orbits would be a dominant issue." Foust, J., 2021. Satellite operators criticize "extreme" megaconstellation filings. *Space News*, https://spacenews.com/satellite-operators-criticize-extreme-megaconstellation-filings/

[6] Starlink uses a network of satellites in low-Earth orbit to beam down broadband to users' satellite dishes, called terminals. It is designed to be able to reach customers in remote areas with poor internet connectivity.

[7] Henry, Caleb. 2019. "SpaceX submits paperwork for 30,000 more Starlink satellites." SpaceNews. https://spacenews.com/spacex-submits-paperwork-for-30000-more-starlink-satellites/.

[8] The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) is the main international space policy body relevant to the peaceful uses of outer space.

[9] Selding de, Peter B. 2022. "Rwanda, home to ITU filing for 300,000+ satellite constellation, says it insists operators meet debris-mitigation guidelines." Space Intel Report. https://www.spaceintelreport.com/rwanda-home-to-itu-filing-for-300000-satellite-constellation-says-it-insists-operators-meet-debris-mitigation-guidelines/

According to the Guidelines for Long-term Sustainability of Outer Space Activities, adopted by the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), proliferation of space debris is one of the most pressing issues that humanity is facing.[10] In 2021, the United States Space Surveillance Network was tracking more than 15000 pieces of space debris larger than 10 cm across.[11] As of May 2022, the European Space Agency's statistical models estimated 36500 pieces over ten centimeters, 1,000000 from one to ten centimeters, and 130 million from one millimeter to one centimeter of space debris in orbit.[12] Even if a small piece of space debris between one millimeter to one centimeter in diameter collides with a functioning space object, the latter object is likely to be severely damaged or completely destroyed due to the high orbital velocity of the debris.[13] Another alarming report states that each month there were more than 2000 "near-misses" of two objects in LEO,[14] which numbers *tripled* by 2021, stating that nearly 6000 near-misses happened last year each month.[15]

Moreover, both accidents and intentional destructive events – such as anti-satellite (ASAT) weapon tests – can produce large quantities of orbital debris that remain as threats for years or centuries on the Earth's orbit**.** The growing number of space debris are directly linked to increased risks of collision and interference with the operation of space objects, creating a snow-ball effect or cascade of collisions, known as *Kessler-syndrome.*[16] Additionally, most nuclear power sources (NPS) satellites are said to reside in the most densely populated regions of LEO, thereby enhancing the danger of collision with space debris.[17] The risks listed above not only endanger humanity's access to space, but they are also directly associated with the safety of astronauts, the dark and quiet skies problem,[18] and generally, to the sustainability of the outer space environment.

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[10] Guidelines for the Long-term Sustainability of Outer Space Affairs of the Committee on Peaceful Uses of Outer Space (LTS Guidelines), 2019.

[11] Gregerson, Erik. Space Debris. Britannica. See: https://www.britannica.com/technology/space-debris

[12] European Space Agency, *Space Debris by the Numbers* (information last updated on 10 May 2022), https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers

[13] Kurt, Joseph. (2015) *Triumph of the Space Commons: Addressing the Impeding Space Debris Crisis Without an International Treaty, 40 WM. & Mary Envitl. L. & Pol'y Rev. 305, 307.*

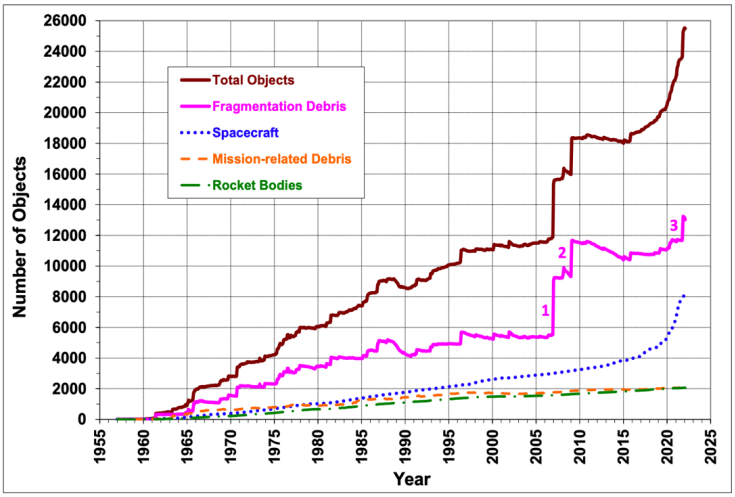
[14] A Near-miss on Earth orbit occurs when two spacecraft pass within 1 kilometer (0.6 miles) of each other.

[15] McDowell, Jonathan. "Jonathan's Space Report | Space Statistics." https://planet4589.org/space/stats/conlist.html.

[16] Kessler, Donald J. and Cour Palais, B.G. (1978) 'Collision frequency of artificial satellites: The creation of a debris belt', *Journal of Geophysical Research*. 83(A6), pp. 2637–2646.

[17] Baker, Howard. (1989) „Space Debris: Legal and Policy Implications" 23-24 and 35-37.

[18] According to the International Astronomical Union (IAU), the scientific concerns regarding satellite constellations are two-fold: a) to minimize solar heating effects, the surfaces of these satellites are often made of highly reflective metal, and reflections from the Sun in the hours after sunset and before sunrise make them appear as dots moving in the night sky. Although many of these reflections may be too faint to see with the naked eye, they can still be detrimental to the sensitive instruments of large ground-based astronomical telescopes; b) despite notable efforts to avoid interfering with radio astronomy frequencies, aggregate radio signals emitted from the satellite constellations can still threaten astronomical observations at radio wavelengths. See: https://www.iau.org/public/themes/satellite-constellations/



The Figure shows a historical increase of the cataloged objects in orbital space based on data available on 1 March 2022. The three upward jumps in fragmentation debris correspond to (1) the Anti-satellite (ASAT) test conducted by China in 2007, (2) the accidental collision between Iridium 33 and Cosmos 2251 in 2009, and (3) the ASAT test conducted by the Russian Federation in November 2021.[19]

Finally, the global space economy is rapidly booming – in 2021 its worth was estimated at 469 billion dollars.[20] Currently, the private space sector represents more than 80% of the global space economy, and 90% of today's spacecrafts are said to be commercial.[21] The New Space concept furthermore, entails the trend on the miniaturization of satellite manufacturing taking place, which brings down the price of satellite operation, largely contributing to the turbulent scenery and increasing density of the Earth's trajectories. Undoubtedly, there is a growing number of non-maneuverable nano and cube satellites on LEO, which poses new types of questions relevant to the sufficient regulation of the Earth's orbits.[22]

2. Research questions

As a reflection to the above challenges, the main questions to be answered in the framework of the dissertation can be summarized as follows:

1) *Is there a legal lacuna relevant to the limitation of the freedom principle in international space law with respect to the Earth's orbits?*
2) *If there is a legal lacuna, how can it be best addressed in accordance with international law?*

[19] Orbital Debris – Quarterly News. National Aeronautics and Space Administration (NASA). Volume 26, Issue 1. March 2022. See: https://orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv26i1.pdf
[20] Space Foundation, July 2022, Colorado Springs, https://www.spacefoundation.org/2022/07/27/the-space-report-2022-q2/
[21] Ibid.
[22] Marboe, Irmgard. (2016). Small is Beautiful? Legal Challenges of Small Satellites, in book: Private Law, Public Law, Metalaw and Public Policy in Space (pp.1-16).

Despite the intensifying threats due to the overexploitation of the Earth's orbits, the existing international legal framework for space activities generally favors the so-called *freedom principle* approach set out in Art. I, Para. 1 of the OST, which entails the freedom of exploration and use of space, while also taking into consideration the need to balance the interests of all spacefaring and non-spacefaring (as well as developed and developing) nations. The freedom principle is one of the most fundamental principles of international space law,[23] which states that 'Outer space, including the Moon and other celestial bodies, shall be free for exploration and use by all without discrimination of any kind on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies'.[24] Besides the declaration of the universal freedom of exploration and use, there are some limitations or restrictions included in the OST and in other international space law treaties developed by COPUOS and adopted by the UN General Assembly (UNGA) relevant to the Earth's orbits, such as the liability regime (Art VI OST and the Liability Convention);[25] the due regard principle and non-interference (Art IX OST); and the ban on weapons of mass destruction to place in the Earth's orbit (Art IV OST).[26] For the sake of this research, the freedom principle and the relevant sources on existing limitations applicable to the Earth's orbits will be interpreted and analyzed.[27] Examples from other fields of public international law, – e.g., in the Law of the Sea and Environmental Law – will also be used for comparison in the dissertation, especially concerning the due regard (or due diligence)[28] principle and the so-called, common but differentiated responsibilities principle (CBDRs)[29], to see how such ideas and limits are already regulated, whether and how they are enforced, and successfully implemented in those fields.[30]

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[23] Some of the principles of international space law are the non-appropriation, non-discrimination, international responsibility, and the freedom principles.

[24] Art I, Para 1 of the OST.

[25] The OST and the Liability Convention provides that a launching State shall be absolutely liable to pay compensation for damages caused by its space objects on the surface of the Earth or to aircraft, and liable for damage due to its faults in space. Furthermore, Article VI of the OST imposes international responsibility on States for 'national activities in outer space' undertaken either by 'governmental agencies or by non-governmental entities'. This provision is further specified in the same paragraph of the OST that the 'activities of non-governmental entities in outer space' require authorization and continuing supervision by the appropriate State Party.' Even though the range of space activities and the number and type of participants in these activities has grown exponentially, there is no further mechanism for such authorization and supervision, besides the obligation on the States to do so. Moreover, damage to the 'orbital environment', itself is not considered under space law, neither occurring in outer space, nor on Earth in areas outside the national sovereignty of States. Thus, a potential *polluter* may not need to worry about environmental degradation, even when they might affect the environment significantly, as long as there is no damage to foreign property or persons.

[26] The existing limitation of placing in orbit any objects carrying out nuclear weapons or any other kinds of mass destruction (Art. IV OST) does not include a specific strong legal obligation to avoid the over-congestion and pollution of the Earth's orbits.

[27] Textual, systematic, teleological and historical interpretations will be taken into consideration.

[28] See for example, Setsuko, Aoki. "Standard of Due Diligence in Operating a Space Object, The." *Proceedings of the International Institute of Space Law,* 55, 2012, pp. 392-405.

[29] Indeed, there are arguments among space law professionals that "a differential approach with variegated commitments could serve to increase the flexible uptake by all spacefaring actors, without the need to limit those commitments to a universally acceptable threshold that may render them ineffective from the very beginning". See: Man, Philip De and Munters, Ward. 'Reciprocal Limits to the Freedom to Use Outer Space by All States: Common but Differentiated Responsibilities?', (2018), 43, Air and Space Law, Issue 1, pp. 21-51.

[30] Some of the international law sources and instruments that are going to be scrutinized relevant to due regard and CBDRs are Principle 7 of the Rio Declaration at the Rio Summit in 1992, where the concept of CBDR was enshrined; and the (very

Besides COPUOS, the International Telecommunication Union (ITU), a specialized UN agency for telecommunications,[31] has competence to regulate the peaceful use of outer space, more specifically relevant to the efficient management of radio frequencies and associated orbits. The ITU Constitution (entered into force in 1992) declares that, like radio-frequency spectrum, the geostationary and associated orbits around the Earth are a *limited natural resource* – both need to be shared fairly and in a way that avoids harmful interference.[32] While the ITU does determine orbital slots, they are at geostationary orbit (GEO). Mega-constellations, however, are meant to be in low Earth orbit (LEO), where there is no international regulator of slots.[33] To what extent the ITU Regime restricts the OST freedom principle, and how much we can apply its mechanism for the protection of the orbital environment in non-telecommunications matters will be analyzed in the dissertation. Furthermore, the issue of the lack of definitions, and their relevance will also be elaborated throughout the research project, such as: the lack of legal definitions of the various orbits; the orbital space environment as a natural resource; responsible behavior in space; space sustainability; space debris, etc.

Apart from the United Nations and its specialized agency, the ITU, the jurisdiction remains with States to authorize and supervise their national entities for carrying out certain activities in space, and accordingly, pursuant to Article VI of the OST and the Liability Convention, internally implement relevant applicable laws and regulations. Distinguished space law professionals have argued that the ideological divide that had emerged regarding the management of the legal regime for the use of outer space, particularly following the conclusion of the Moon Agreement in 1979, meant that *hard law* instruments were not an option as the way forward to address the growing concerns in outer space.[34] As a consequence, The Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space (LTS Guidelines), a "soft law" instrument,[35] was adopted in 2019 by COPUOS, recognizing some of the most pressing issues relevant to "the long-term sustainability" of the Earth's orbits. In fact, the substantive Preamble of the LTS Guidelines separately points out that 'The Earth's orbital space environment constitutes a *finite resource* that is being used by an increasing number of States, international intergovernmental organizations and

successful) Montreal Protocol; and the Paris Agreement. Cases before the International Court of Justice (ICJ), and the International Tribunal for the Law of the Sea (ITLOS) will also be analyzed relevant to the two concepts.

[31] The International Telecommunication Union was established in 1865 under the name of International Telegraph Union. To find more on the history of ITU, see: https://www.itu.int/en/history/Pages/ITUsHistory.aspx

[32] 'In using frequency bands for radio services, Member States shall bear in mind that radio frequencies and any associated orbits, including the geostationary-satellite orbit, are limited natural resources and that they must be used rationally, efficiently and economically, in conformity with the provisions of the Radio Regulations, so that countries or groups of countries may have equitable access to those orbits and frequencies, taking into account the special needs of the developing countries and the geographical situation of particular countries.' (Art 44, Para 2, ITU Constitution).

[33] Samson, Victoria. Insight - Threats to space aren't just weapons. *Secure World Foundation*. March 2021. https://swfound.org/news/all-news/2021/03/insight-threats-to-space-aren-t-just-weapons

[34] Freeland, Steven. The Role of 'Soft Law' in Public International Law and its Relevance to the International Legal Regulation of Outer Space. Soft Law in Outer Space. December 2012, 9-30.

[35] I am aware that there are various alternate theories relevant to soft law. For the sake of this proposal, soft law instruments are intended to refer to written instruments that might purport to specify standards of conduct, but do not emanate from the traditional 'sources' of public international law set out in Art. 38 of the Statue of the International Court of Justice (ICJ).

non-governmental entities'.[36] Accordingly, the LTS Guidelines is considered to be a milestone document as it codifies, for the first time, an internationally accepted set of best practices for the protection of the Earth's orbits as limited resources. Furthermore the LTS Guidelines was adopted by 92 COPUOS States Members – including the largest space-faring nations – showing wide appreciation of the urgency of addressing the issue.[37] Despite the non-binding nature of the LTS Guidelines under international law, space policy and law experts assert that, 1) existing United Nations treaties and principles on outer space provide the fundamental legal framework for the soft-law instrument, and 2) it can have a legal character in the sense that States may choose to incorporate elements of the LTS Guidelines in their national legislation.[38] Whether this multilateral voluntary instrument, and its 21 guidelines are enough to successfully incentivize the global space community – including COPUOS member States, governmental and non-governmental entities, etc. alike – in a timely manner, (or whether a more "hard" approach is necessary) is going to be investigated in the dissertation.

After careful analysis of the growing concern in orbital space and existing regulations, and making relevant comparisons in the public international law field, it is my intent to add an empirical, behavioral economic touch to my research to study existing systematic behavior of States from a behavioral point of view, and to potentially propose improvements of the international legal system for the protection of the orbital space environment.

"Economics has changed the nature of legal scholarship, the common understanding of legal rules and institutions, and even the practice of law".[39] Nevertheless, economic and other (e.g., reputational) incentives have played significant roles for States in the evolution of the use and exploration of space. Economic considerations, therefore, play an influential role in the legal proposals – de lege ferenda – of this research. Within this section I plan to introduce the concept of Law and Economics (or the economic analysis of law), applicable to public international law and international space law topics. Furthermore, I make a distinction between the two leading models of law and economics, that are the (neo)classical[40] and the behavioral methods.[41] When it comes to international law, behavioral insights are said to have the potential to bridge the gap

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[36] A/74/20, para 163 and Annex II.

[37] The 92 States that adopted the LTS Guidelines, includes all spacefaring countries and the vast majority of other countries that rely heavily on space applications for their national security and prosperity. This is significant because protection of the Earth's orbits is essentially a global challenge that can only be addressed successfully if all countries act collectively.

[38] Martinez, Peter. (2021) 'The UN COPUOS Guidelines for the Long-term Sustainability of Outer Space Activities', *Secure World Foundation,* Washington DC.

[39] Cooter, Robert and Ulen, Thomas, "Law and Economics, 6th edition" (2016). Berkeley Law Books.

[40] According to the neoclassical or standard economic model of individual choice, most people seek to maximize utility subjects to various constraints (such as those imposed by income, time, cognitive resources and the like), and that decision makers have well-defined preferences and make well-informed, self-interested decisions based on those preferences, which attitude can be explained through the so-called rational choice theory.

[41] The behavioral economics (or economic psychology) model seeks to understand deviations from behavior predicted by rational choice models (using the so-called bounded rational method), and to understand how and why people actually behave the way they do in the real world.[#] In other words, behavioral economics examines the differences between what people "should" do, and what they actually do, and the consequences of those actions. See: University of Chicago, Behavioral Economics explained. See: https://news.uchicago.edu/explainer/what-is-behavioral-economics

between rationalist and constructivist theories of international law.[42] Across game theories and individual studies for example, subjects – e.g., individuals or States – consistently behave in a manner not predicted by rationalist assumptions of narrow self-interest.[43] Taking into consideration such elements is especially relevant concerning the protection of the orbital environment. Hence, through behavioral analysis, I hope to identify the systematic structure of the overexploitation of the orbital space environment dilemma.[44] Some of the relevant behavioral economics and game theories applicable to the Earth orbits are, the first-come-first-served structure of orbital use; the Earth's orbits as a limited resource; the tragedy of the commons; and the collective action (free-rider) problem. After a short analysis of these problems, I hope to gain new ideas on different layers of appropriate behavioral incentives, and to incorporate them in my legal proposals to support State's compliance.[45]

3. Current state of research

The subject of the overexploitation of the Earth's orbit (mostly relevant to space debris) and the urgency of the topic have gained significant attention in recent years, usually under the phrases, "space sustainability" or "the long-term sustainability of outer space activities".[46] Many well-known space law and policy professionals have raised awareness and discussed the space debris issue by publishing articles, book chapters, which include most notably works of, Ram S. Jakhu[47], Jenni Tapio[48], Orsola Greco[49], Ward Munters[50], Olga Volynskaya[51], Michael R.

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[42] Hafner-Burton M., Emmilie & Haggard, Stephan, and Lake A. David & Victor G. David, *The Behavioral Revolution and International Relations,* 71 INT'L ORG. SUPP. Si (2017).

[43] Experiments suggest for example that rationalist theories may be faulted for neglecting: (1) reciprocity*;* (2) the distinction between (perceived) fair and unfair sanctions; (3) altruism, spitefulness, and preferences for equality; (4) the role of trust and communication; *(5)* the intentions of the other players; and (6) the "type" of actor. Aaken, van Anne, (2018) 'Behavioral Aspects of the International Law of Global Public Goods and Common Pool Resources,' *American Journal of International Law,* 112, no. 1, pp. 67-79.

[44] It is important to keep in mind an important challenge with respect to combining behavioral insights with public international law research, which is the direct attribution of individual decision making to States as an entity (the billiard ball).

[45] As presented in the introduction of this proposal, by now, private space companies are responsible for more than 80% of all global space activities. Hence, another question arises when dealing with international space law and the behavioral method, which is, to what extent – despite Art VI OST – it is worth looking "inside the billiard ball", to analyze the behavior of various entities within a State, such as analyzing private companies as a separate unit (macro level), either influencing decision-making of the State, or by directly following or disregarding international regulations (especially in the absence of a national space law) relevant to a bottom-up approach?

[46] World Space Week Association for example dedicated the 2022 World Space Week theme to Space and Sustainability; or see for example two most recents publications of the United Nations Office for Outer Space Affairs (UNOOSA) on space sustainability: https://t.ly/BrQ- or https://t.ly/r2U5.

[47] Ram S. Jakhu, 'McGill Declaration on Active Space Debris Removal and On-Orbit Satellite Servicing, 12 November 2011', (2012), 37, Air and Space Law, Issue 3, pp. 277-280.

[48] Palmroth M, Tapio J, Soucek Alexander, Perrels A, Jah Moriba, M. Lönnqvist, M. Nikulainen, V. Piaulokaite, T. Seppälä, J. Virtanen, Toward Sustainable Use of Space: Economic, Technological, and Legal Perspectives, Space Policy, Volume 57, 2021.

[49] Greco, Orsola. 'Small Satellites: A Threat for the Future Sustainability of Outer Space Exploration?', (2019), 44, Air and Space Law, Issue 1, pp. 91-110.

[50] Munters, Ward. (2019). Space Debris: Between Unity and Fragmentation - Risk as a Static Principle with Dynamic Outcomes. Conference: 70th International Astronautical Congress (2019) - Joint Session International Institute of Space Law and International Astronautical Federation, Washington D.C., USA.

[51] Volynskaya, Olga, and Gennady Zhukov. "Long-Term Sustainability of Space Activities versus Imminent Danger from Space: Is Space Law Ready to Meet the Challenge." *Proceedings of the International Institute of Space Law,* 56, 2013, pp. 359-366.

Migaud[52], Peter Martinez[53], Rutwik Navalgund[54], Christopher J. Newman[55], and Fabio Tronchetti[56]. The change in focus between analyzing the regulation of GEO and LEO within the past half of the century has also caught my attention. It was notable that starting from the 1970s research papers had dealt more with the regulation of GEO,[57] however, in the last decade – as a response to the new type of challenges in LEO – the concentration has shifted towards the protection of the LEO environment. In fact, growing concerns due to the increasing number of megaconstellations and the lack of an existing international regulator at LEO – such as the ITU in GEO – has been expressed by distinguished scholars, and civil societies, such as, Victoria Samson[58] and Christopher D. Johnson[59] from Secure World Foundation; or by Steven Freeland[60], Kai-Uwe Schrogl[61], and Annette Froehlich[62]. Many space law and policy experts see the solution for the growing challenges in LEO in the establishment of a space traffic management (STM) or coordination system, (see for example, articles by Johnson, Nathan A[63], Frans von der Dunk[64], or Frandsen, Hjalte Osborn[65]). Other space professionals, e.g., Jean-Francois Mayence[66], Lotta Viikari[67], or Moriba Jah[68] rather approach the protection of the Earth's orbits from a more environmental point of view. Although it can be argued that international space law already has much stronger mechanisms (e.g., liability regime) than international environmental law (IEL), I

[52] Migaud, R Michael, Protecting Earth's Orbital Environment: Policy Tools for Combating Space Debris, Space Policy, Volume 52, 2020.
[53] Martinez, Peter. 'The UN COPUOS Guidelines for the Long-term Sustainability of Outer Space Activities', *Secure World Foundation,* (2021)Washington DC.
[54] Navalgund, Rutwik, 'Reduce, Reuse and Recycle: An Environmental Law Approach to Long-term Sustainability of Outer Space', (2020), 45, Air and Space Law, Issue 3, pp. 285-308.
[55] Newman, Christopher J. & Williamson, Mark. Space Sustainability: Reframing the Debate, Space Policy, Volume 46, 2018, pp 30-37, ISSN 0265-9646.
[56] Tronchetti, Fabio. "The Problem of Space Debris: What Can Lawyers Do About It." *Zeitschrift fur Luft- und Weltraumrecht - German Journal of Air and Space Law,* vol. 64, no. 2, 2015, pp. 332-352.
[57] See for example, Ram S. Jakhu. "The Legal Status of the Geostationary Orbit." *Annals of Air and Space Law,* 7, 1982, pp. 333-352.
[58] Samson, Victoria. Insight - Threats to space aren't just weapons. *Secure World Foundation*. March 2021. https://swfound.org/news/all-news/2021/03/insight-threats-to-space-aren-t-just-weapons
[59] Johnson, Christopher. "The Legal Status of MegaLEO Constellations and Concerns About Appropriation of Large Swaths of Earth Orbit," *In: Pelton J. (eds) Handbook of Small Satellites. Springer, Cham*, Mar 5, 2020.
[60] Martin, Anne-Sophie, and Steven Freeland. "From One to Many: "Mega" (Constellation) Challenges to the Legal Framework for Outer Space." *Annals of Air and Space Law,* 46, 2021, p. 131-176.
[61] Schrogl, Kai-Uwe. "Structural Reform of ITU: Consequences for the Development of the Use of Outer Space and Space Law, The / Die Strukturreform der ITU: Auswirkungen auf die Entwicklung der Weltraumnutzung und des Weltraumrechts. *Zeitschrift für Luft- und Weltraumrecht - German Journal of Air and Space Law,* vol. 42, No. 2, 1993, pp. 182-193.
[62] Froehlich, Annette. (2019). Legal Aspects Around Satellite Constellations. 10.1007/978-3-030-06028-2.
[63] Johnson, Nathan A. "Right of Way for on-Orbit Space Traffic Management." *Proceedings of the International Institute of Space Law,* 58, 2015, pp. 497-520.
[64] von der Dunk, Frans G. "Space Traffic Management: A Challenge of Cosmic Proportions." *Proceedings of the International Institute of Space Law,* 58, 2015, pp. 385-396.
[65] Frandsen, Hjalte Osborn. From Lone Travelers to Traffic Participants – An Argument for Basic Rules of the Road for the Emergent Traffic System in Low Earth Orbit. 2021.
[66] Mayence, Jean-Francois, The 5th Eilene M. Galloway Symposium on Critical Issues in Space Law Art IX of the Outer Space Treaty and Peaceful Purposes: Issues and Implementation, December 2, 2010 – Cosmos Club, Washington D.C.
[67] Viikari, Lotta. (2008) The Environmental Element in Space Law. Leiden, Boston, Martinus Nijhoff Publishers.
[68] Jah, Moriba. "Opinion: Why I'm a space environmentalist -- and why you should be, too." *CNN*, 7 September 2022, https://edition.cnn.com/2022/09/07/opinions/moriba-jah-space-junk-scn-opinion-hnk-spc-intl/index.html

still believe, there are elements within IEL – such as CBDRs[69] – that are worthy of further analysis parallel to the topic of the proposed research.

When it comes to the analysis of Art I OST on the freedom of exploration and use (freedom principle), and its potential limitations in addressing the orbital space environment, I found few current comprehensive essays besides articles from Stephen Gorove[70], or Philip De Man[71] at the time of writing this exposé. I hope to fill this gap with my research and dissertation project, especially in terms of my legal proposals, taking into consideration some economic insights. Concerning the implications of behavioral economics, most Law and Economics literatures (e.g., Robert Cooter, and Thomas Ulen[72]) deal with the behavior of individual subjects in a domestic environment, and so, there are very few scholars, such as Aaken, van Anne[73] or Tomer Broude[74], who seek for the connection between the behavioral approach and public international law. There is an increasing interest in the topic of the overexploitation of orbital space analyzed through game theories, e.g., the Earth's orbits as global commons or common pool resources relevant to the free-rider dilemma, which are investigated by Brian C. Weeden[75]; Nodir Adilov, Peter Alexander and Brendan Cunningham[76] , Henri Yvon[77], Philip A. Meek[78], Ghelani Jahnavi[79], or Mai'a K. Davis Cross[80], etc, from a more economic perspective; at the same time, application of a more law and economics' perspective on the topic is rare. I hope to also touch upon these notions in my research, however, to then focus on applicable incentivization practices provided by behavioral studies that may involve better compliance.

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4. Methodology

This PhD project relies on qualitative research methods. Accordingly, a deep legal analysis is going to be carried out based on primary and subsidiary sources of public international law relevant to the freedom principle and its limitations. Furthermore, various interpretation techniques will be applied, and comparisons among some of the relevant fields of public international law will be made throughout the research. Additional literature – book chapters, articles, journals, etc. – offering numerous perspectives on the topic will also be closely examined. Practical scientific data and contemporary policy papers will also be reviewed to understand the scope, uncertainty and current mechanisms in place to tackle the space debris dilemma. Consequently, space agency and intergovernmental organizations' reports, publications by think tanks and civil societies; reports from the private sector and the industry, and case studies will be scrutinized.

The past decade has seen a surge in enthusiasm for *law and economics*, potential to inform policy innovations and ameliorate persistent societal problems. While the rational choice approach to international law has been widely accepted in legal scholarship, challenges to the rational choice paradigm in economic analysis – such as through the application of behavioral economics and law – have not been widely explored.[81] Therefore, after the thorough legal analysis of the freedom principle and its potential legal hiatus in space law, methods of law and economics will be applied, especially regarding various incentivization mechanisms applicable to the Earth's orbits, to draw space law closer to practice in the protection of the Earth's limited orbital environment.

[81] Aaken, van Anne (2014) 'Behavioral international law and economics', *Harvard international law journal*, 55(2), pp. 421.

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6. De lege ferenda – legal nature and characteristics of a 'lex specialis', normative framework on the limitation of the freedom principle in the Earth's orbits.

7. Conclusion

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