

International Responsibility to Protect Freedom of Outer Space Exploration versus Freedom of Use of Outer Space

*Merve Erdem Burger**

Abstract

This study examines how the enjoyment of freedom of use affects the enjoyment of freedom of exploration in space, using the harmful interference of the LEO mega constellations in astronomical science as an example. Furthermore, the study seeks to address this interference through the implementation of Article VI of the Outer Space Treaty. The main question of the study is therefore whether states have an international responsibility to protect freedom of exploration over freedom of use. To answer this question, I first determine whether one of the freedoms should take precedence over the other. Second, I propose balancing these freedoms against each other, a concept of constitutional law, and to give more weight to one than the other to address the problem at hand. Following the examination, I conclude that states have an international responsibility to protect astronomical activities from the effects of LEO mega constellations, and that they are therefore obligated to establish the necessary domestic legal regimes to provide this protection.

Keywords: Astronomy, LEO mega-constellations, freedom of exploration and use of outer space, balancing rights, international responsibility for outer space activities.

1. Introducing the Problem at Hand

1.1 Astronomy vs. LEO Mega-constellations

Since the foundation of early civilizations, human beings have observed the sky with the naked eye to track time, orient themselves, predict the future,

* University of Neuchâtel, Faculty of Law, Chair of International Law.

discover planetary motions and so on.¹ However, it was the invention and introduction of the telescope for astronomical observations by Galileo led the development in astronomical exploration dramatically.² Since him, the moons of other planets, the celestial bodies beyond Saturn, new stars, galaxies, black holes have been discovered, and the beginnings, present, and future of the universe have been explored using Earth-based observatories and radio dishes on various continents.³ Space technology through space telescopes, exploration missions into space, and satellite communications has also played a role in these discoveries and the exploration of our universe. Nowadays, however, New Space activities, especially satellite constellations in low-Earth orbit (LEO), have disrupted the view of the sky from Earth and created a challenge especially for astronomy.

A satellite constellation is a system of similar satellites deployed together for the same mission to provide instantaneous global coverage and avoid latency and communications disruption. Direct broadcast systems and global navigation satellite systems in geostationary orbit are the examples that have been used for years.⁴ With the advent of New Space activities satellite constellations, consisting of thousands of small satellites, have been also launched at LEO to provide reliable, high-speed Internet coverage to the entire globe, including rural or underdeveloped areas.⁵ Currently, Starlink and OneWeb are the leading companies with more than 2000 satellites on LEO.⁶ The problem at hand was first discovered after Starlink launched its first 60 small satellites in May 2019. Prior to launch, there were concerns about interference between satellites and radio dishes, and Starlink had negotiated a radio frequency spectrum coordination agreement with the US National Science Foundation and radio astronomy observatories to avoid potential interference when using radio frequency spectrum. However, the day after launch, it was discovered that the satellites were bright enough to be visible

1 Early Astronomy, available at: <https://www2.nau.edu/~gaud/bio301/content/erlast.htm#:~:text=Early%20people%20noticed%20constellations%20of,on%20the%20walls%20of%20caves>. (Accessed 15.06.2022); Astronomy, available at <https://www.britannica.com/science/astronomy/History-of-astronomy> (Accessed 15.06.2022).

2 Galileo, Italian philosopher, astronomer and mathematician, available at: <https://www.britannica.com/biography/Galileo-Galilei> (Accessed 15.06.2022).

3 <https://openstax.org/books/astronomy-2e/pages/2-4-the-birth-of-modern-astronomy> (Accessed 15.06.2022).

4 <https://www.techtarget.com/whatis/definition/satellite-constellation> (Accessed 20.06.2022).

5 J. Zhang et al. (2022), LEO Mega Constellations: Review of Development, Impact, Surveillance, and Governance, *Space: Science & Technology*, Vol 2022, p. 2. <https://doi.org/10.34133/2022/9865174>

6 Ibid.

on images taken by the optical observatories.⁷ Therefore, it turned out to be that these Starlink satellites had more impact on Earth-based optical astronomy than on radio astronomy.

Once the brightness and visibility of the Starlink satellites were detected, experts from astronomy societies, industry, space policy institutes, and other space community stakeholders studied the impact of the LEO mega constellations on Earth-based optical astronomy and radio astronomy, identified problems, and made recommendations to mitigate the problems. The SATCON1 and SATCON2 workshops and the Dark & Quiet Skies conferences in 2020 and 2021 are important examples of this international effort on the topic.⁸ In addition to the workshops and conferences, the International Astronomical Union has established the Centre for the Protection of Dark and Quiet Sky from Satellite Constellation Interference to coordinate international multidisciplinary efforts to help mitigate the adverse effects of satellite constellations on Earth-based optical and radio astronomy.⁹ According to the scientific society, the visibility and reflection of sunlight from LEO mega constellations have implications for scanning and imaging galaxies, and detecting near-Earth objects, for deep space observations, for amateur astronomers, and for the rituals of indigenous peoples.¹⁰ Therefore, reducing visibility at the design phase of the satellite and using sun-shielding via avoiding the use of reflective materials in the design were firstly recommended as mitigation measures. In addition, it was found that the positional accuracy of satellites was important for pre-planned observations or time-critical observations. Therefore, it was recommended that the publicly available positional information or processed telemetry data be determined and disseminated. Moreover, the astronomical society was also asked to develop software to identify, model, subtract, and mask satellite trails, as well as software to predict the timing and projection of satellite transits. Overall, coordination between the astronomical community and private stakeholders was recommended to protect astronomy.¹¹

7 N. Firth (May 28, 2019). SpaceX's Starlink satellites are clearly visible in the sky-and astronomers aren't happy, *MIT Technology Review*, available at: <https://www.technologyreview.com/2019/05/28/135193/spacexs-starlink-satellites-are-clearly-visible-in-the-skyand-astronomers-arent-happy/> (Accessed 20.06.2022).

8 Satellite Constellation 2 Workshop, available at: <https://aas.org/satellite-constellations-2-workshop> (accessed 30.06.2022); Dark and Quiet Skies for Science and Society Conference II, available at: https://www.unoosa.org/unoosa/en/ourwork/psa/schedule/2021/2021_dark_skies.html (Accessed 30.06.2022).

9 About CPS, available at: <https://cps.iau.org/about/> (Accessed 30.06.2022).

10 Walker, C. & Hall, J. (ed.) (2020). Impact of Satellite Constellations on Optical Astronomy and Recommendations Toward Mitigations, Report from the SATCON1 Virtual Workshop, p. 9. Available at: <https://noirlab.edu/public/media/archives/techdocs/pdf/techdoc003.pdf> (Accessed 01.06.2022).

11 Walker & Hall, p. 16 - 22.

After studying the impacts and determining mitigation measures, a team from the Zwicky Transient Facility (ZTF) observed how often Starlink satellites appear in images taken between November 2019 and September 2021 and published its findings. The scientists found that the Starlink satellites have become five times dimmer than their predecessors, but their brightness magnitude is still close to the agreed-upon limit. They were spotted in 5,301 images. Mostly they appeared at twilight observations, and in August 2019, 18 percent of twilight images were affected by Starlink satellites. Researchers expect that every twilight image will be affected by satellites as the number of satellites reaches to 10,000 over the next decade.¹²

In summary, the LEO mega constellations since the start of their launch have affected astronomical activities in several ways. In particular, the brightness of the satellites and their light reflection affect optical astronomy on Earth. The companies have taken the remedial actions recommended by the astronomical community, but the situation is not yet fully resolved, and with the launch of more satellites on LEO (as already announced by the companies), the problem may become more severe.

The situation at hand poses a technical problem, but there is also legal side of it that is needed to be addressed, and that is what this paper intends to do. Therefore, in the study I will re-read and redefine the problem from a legal point of view. Then, for the resolution, I ask if article VI of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space (Outer Space Treaty) regarding *the international responsibility of states for outer space activities* is applicable to the situation. And ultimately, the study tries to answer if states have an international responsibility to protect Earth-based optical astronomy from the LEO mega constellations.

1.2 Identification of the Legal Problem: Conflict Between the Freedoms of Outer Space

1.2.1 The Definition of Freedoms of Outer Space

After the announcement of the successful launch of Sputnik I, no state protested and argued about the legality of the operation. Therefore, everyone accepted that outer space was a new realm of human activity and was open for use.¹³ Following the launch, this status was first formally recognized in the 1962 (XVIII) "Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space," adopted by the General

12 Mroz et. al. (2022). Impact of the SpaceX Starlink Satellites on the Zwicky Transient Facility Survey Observations, *The Astrophysical Journal Letters*, Vol. 924: L30.

13 Lai, A. K. (2021). *The Cold War, the Space Race, and the Law of Outer Space Space for Peace*, UK: Routledge, p. 22- 23.

Assembly on December 13, 1963.¹⁴ Later, Article I and Article II of the Outer Space Treaty (OST) reaffirmed the freedoms and legal status of outer space.¹⁵ Under Article I of the OST, States are guaranteed the use and exploration of outer space, free access to outer space, and freedom of scientific research in outer space. All the freedoms mentioned in the text are legally equivalent, without favoring one activity over another. Only scientific exploration in outer space is given special attention before the other freedoms, since the article requires states to facilitate and encourage the international cooperation in such investigations.

States, regardless of their economic development, are intended to be the recipients of these freedoms. However, this does not mean that private actors are not allowed to conduct space activities. According to Article VI of the OST, actors other than States may use the freedoms of outer space in the same way as states since state parties of the Treaty have international responsibility for national activities of public and private sector, and for assuring that national activities are carried out in conformity with the Treaty. Private actors, furthermore, can perform their outer space activities under the authorization and the continuous supervision of the relevant state.¹⁶

1.2.2 Which Activity Is Carried Out Under Which Freedom in the Present Problem

The OST does not further define the terms *exploration*, *use* and *scientific investigation*. Therefore, we use the dictionary meaning to define what space exploration and use are about, and to determine under what freedom Earth-based optical observations are made and LEO mega constellations are launched.

According to the dictionary definition, *exploration* is the discovery of something new for scientific and non-scientific purposes; *use* is the ability for any entity to utilize outer space and its resources for commercial and non-commercial purposes. Therefore, the launch of LEO mega constellations is obviously a "use of outer space" for commercial purposes, since the satellites launched occupy an orbital position, use a radio spectrum for operations, and charge a monetary amount for the Internet service they provide.

In the case of Earth-based optical astronomy, we should first discuss whether it is an "outer space activity" since all the facilities of the observatories remain on Earth. There is no clear indication in the OST text that any space activity must be conducted only "in" outer space. It mentions location when referring to scientific investigations "in" outer space, and it specifically requires states to

14 UNGA Res. 1962 (XVIII) (13 December 1963). Available at: https://www.unoosa.org/pdf/gares/ARES_18_19_62E.pdf (Accessed 30.06.2022).

15 UNGA Res. 2222 (XXI). (19 December 1966). Available at: <http://www.un-documents.net/a21r2222.htm> (Accessed 30.06.2022).

16 Hobe S., Schmidt-Tedd, B. & Schrogl K.-U. (ed.) (2017), *Cologne Commentary on Space Law Outer Space Treaty*, Berlin: Berliner Wissenschafts Verlag, p. 191-192.

facilitate and encourage international cooperation with respect to this freedom. Moreover, historically Earth-based optical astronomy was considered to be an outer space activity, like in the case of the West Ford Experiment.¹⁷ Therefore, it is not incorrect to conclude that Earth-based optical astronomy is an outer space activity and enjoys the protection of the OST.¹⁸

Consequently, the launch of LEO mega constellations is a form of utilization of the freedom of use of outer space, and the Earth-based optical astronomy is a form of utilization of the freedom of exploration. Both freedoms are protected by the OST at the same level; there is no hierarchy between them.

1.2.3 The Conflict Between the Freedoms of Outer Space and the Problem at Hand

The enjoyment of freedoms of outer space is not limitless, there are restrictions to these freedoms defined in article I of the OST itself and also in other articles of the Treaty that all space actors must comply with before and during the performance of their activities. According to the OST:

- (1) The exploration and use of outer space, shall be carried *for the benefit and interest of all countries* irrespective of their degree of economic or scientific development;
- (2) The exploration and use of outer space shall *be the province of mankind*;
- (3) The outer space shall be free for exploration and use by all States *without discrimination*;
- (4) The outer space, including the Moon and other Celestial bodies is *not subject to national appropriation*;
- (5) Outer space activities shall be carried out *in accordance with international law*, including *the Charter of the United Nations* in the interest of maintaining *international peace and security*;
- (6) The Moon and other celestial bodies shall be used exclusively for *peaceful purposes*;
- (7) Outer space activities shall be conducted with *due regard*, States should *avoid harmful contamination of outer space* and celestial bodies, as well as *adverse changes to the Earth environment* resulting from the introduction of extraterrestrial matter. If there is a *potential harmful interference* with other activities, *international consultations* shall be taken before or during the activity.¹⁹

17 Walker, C. & Benvenuti, P. (2021). Dark and Quiet Skies for Science and Society II Working Group Reports, p. 116. Available at: https://www.iau.org/static/science/scientific_bodies/working_groups/286/dark-quiet-skies-2-working-groups-reports.pdf (Accessed 30.06.2022).

18 Hobe, Schmidt-Tedd & Schrogl, p. 196.

19 Hobe, Schmidt-Tedd & Schrogl, p. 200-209.

As seen above freedom of use and freedom of exploration are equally protected as long as they are conducted in accordance with these restrictions. To identify the legal conflict in the study, we first consider whether the activities in the case violate the restrictions established by the OST.

Earth-based optical astronomy has been conducted for years under freedom of exploration and the legality of the activity has never been an issue. Whereas LEO mega constellations have generated technical and legal discussions in relation to its impact on astronomy, especially on the Earth-based optical astronomy, since the first launch of the satellites.

In general, we can say that the operations of the companies that have LEO mega constellations, are conducted in accordance with freedom of use and do not breach common benefits clause, the province of humankind principle and peaceful uses of outer space principle. Since they were licensed by the US Federal Communications Commission prior to launch, it is reasonable to assume that they are acting in accordance with the U.S. Space Law, therefore their activities are legal.²⁰ However, there are some arguments that LEO mega constellations violate the principle of non-appropriation (Article II) and the principle of due regard, prohibition of harmful contamination, and harmful interference with other outer space activities (Article IX). Currently, there is no limit on the number of satellites that can be launched and a limited mission duration for small satellites, so it is legally controversial whether LEO mega constellations constitute appropriation of outer space and harmful contamination of outer space. As for harmful interference, the solution, as pointed out by OST, is international consultations to address the interference.

In the case of harmful interference, we can say that all parties have begun to work together to resolve the issues from the beginning and take action to end the interference.²¹ As mentioned earlier, the brightness of Starlink satellites have already weakened, and only 18% of the imaging from ZTF has been affected by the Starlink project.²² So legally, it appears that everyone involved is doing what they have to do according to the law, however the impact still remains to be a concern for astronomical societies.

At this point, I believe that two freedoms, are not breaching the restrictions of freedoms of outer space, however, they are conflicting with each other, and complete enjoyment of both freedoms seems impossible. This is because the claiming of one freedom interferes with the claiming of the other

20 Sheetz, M. (5 November 2021). In Race to Provide Internet from Space, Companies ask FCC for about 38,000 new broadband satellites, *CNBC*, available at: <https://www.cnbc.com/2021/11/05/space-companies-ask-fcc-to-approve-38000-broadband-satellites.html> (Accessed 01.07.2022).

21 Satellite Constellation 2 Workshop *op.cit*; Dark and Quiet Skies for Science and Society Conference II *op.cit*.

22 Mroz et. al. *op.cit*.

freedom. Therefore, I believe that the freedom of exploration conflicts with the freedom of use in the case of astronomy vs. LEO mega constellations. To resolve this conflict, I suggest to protect Earth-based astronomy against LEO mega constellations via the application of international responsibility article of the Outer Space Treaty. To do that, the freedom of use should be balanced by the freedom of exploration, namely freedom of use in this case should be restricted in favor of the full realization of freedom of exploration.

2. Balancing the Two Freedoms of Outer Space

2.1 Why Balancing?

Balancing is a method of interpretation used in various national legal systems to resolve conflicts of values and interests in the absence of meta-rules for conflict resolution. Balancing is often applied in constitutional interpretation, as constitutions contain more abstract provisions such as principles.²³ It has also become a concept for qualifying human rights in European Court of Human Rights judgements.²⁴

In balancing, the weights of competing principles or rights are compared in concrete cases and the limits of what is legally possible are determined.²⁵ For this purpose, values and protected interests are defined and compared, and then it is decided which right/principle should take precedence over the other in order to resolve the respective conflict without necessarily invalidating the latter.²⁶

This case involves a conflict between principles that have the same legal value, and there is no secondary rule to resolve this conflict. Therefore, I will attempt to apply a balancing approach to determine the limit one of the freedoms over the other, and then the obligations of the states.

2.2 How to Balance Freedoms of Outer Space?

To apply the balancing approach to freedom of exploration and freedom of use, I must first identify the values with which freedoms are associated. Therefore, I examine the relationship between freedoms of outer space and human rights since human rights are the most value-based rules in international law.

Firstly, I defined that the protection of Earth-based optical astronomy is linked to the protection of the right to science. The right to science is first

23 Novak, M. (2010). Three Models of Balancing (in Constitutional Review), *Ratio Juris*, Vol. 23, No.1, p. 101.

24 Cali, B. (2007). Balancing Human Rights? Methodological Problems with Weights, Scales and Proportions, *Human Rights Quarterly*, Vol. 29, No.1, p. 252.

25 Möller, K. (2007). Balancing and the Structure of Constitutional Rights, *ICON*, Vol. 5, Number 3, p. 456.

26 Aleinikoff, A. (1987). Constitutional Law in the Age of Balancing, *The Yale Law Journal*, Vol. 96, No. 5, p. 945.

enshrined in article 27 of the Universal Declaration of Human Rights. According to article 27:

“(1) Everyone has the right to freely participate in the cultural life of the community to enjoy the arts, and to share in scientific advancement and its benefits.

(2) Everyone has the right to the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author.”

The Declaration briefly establishes the right, but it is later detailed by the International Covenant on Economic, Social and Cultural Rights. Article 15 of the Covenant states that:

“(1) The States Parties to the present Covenant recognize the right of everyone;

a. The right to participate in cultural life;

b. to enjoy the benefits of scientific progress and its applications;

c. to enjoy the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author.

(2) The steps to be taken by the States Parties to the present Covenant to achieve the full realization of this right shall include those necessary for the conservation, the development and the diffusion of science and culture...”

Except for these articles mentioned above, the right to science has received very little attention from the Human Rights Committee or academia, therefore our understanding of the legal scope of the right is limited. Thanks to the work of the UNESCO Venice Statement on the Right to Enjoy the Benefits of Scientific Progress and its Application²⁷ and the 2012 report of the Special Rapporteur in the field of cultural rights on the right to enjoy the benefits of scientific progress and its applications, we can understand more of its content.²⁸

27 UNESCO Venice Statement on the Right to Enjoy the Benefits of Scientific Progress and its Application, available at: https://www.aaas.org/sites/default/files/VeniceStatement_July2009.pdf (Accessed 01.07.2022).

28 2012 Report in the Field of Cultural Rights on the Right to Enjoy the Benefits of Scientific Progress and Its Applications, available at: <https://www.ohchr.org/en/documents/thematic-reports/ahrc2026-report-right-enjoy-benefits-scientific-progress-and-its> (Accessed 01.07.2022).

According to the Venice statement; the normative content of the right includes

“the creation of an enabling and participatory environment for the conservation, development and diffusion of science and technology, which includes, inter alia, academic and scientific freedom, ..., freedom to seek, receive and impart information, association and movement; equal access and participation of all public and private actors, and capacity building and education.”

And States have a duty to *respect the freedoms essential to scientific research and creative activity* and a duty to take measures to encourage and strengthen international cooperation and assistance in science and technology for the benefit of all people.

In the 2012 Report of the Special Rapporteur, science is defined as knowledge that is verifiable and refutable, in all fields of research, including the social sciences. The terms benefits of science and scientific progress convey the notion of a positive impact on the well-being of people and the realization of their human rights. The benefits of science include not only scientific results and outcomes, but also the scientific process, its methods and tools.

Considering our comprehension due to the Venice Statement and the 2012 Report on the right to science, the protection of Earth-based astronomy as a freedom of exploration would constitute the protection of right to science, particularly the freedom of research, which ensures the conservation, development, and dissemination of the activity. So that it can be continued and humanity can continue to enjoy the benefits of astronomy.

Secondly, the launch of satellites of the LEO mega constellations falls under the freedom of use, and the protection of this freedom could be ensured under the right to Internet access. Regarding the right to Internet access, the very first debate is about its existence, whether today we can confidently talk about if there is right to Internet access in international law.

At the international level, the report of the Special Rapporteur on the promotion and protection of the right to freedom of opinion and expression by the United Nations Human Rights Council, has triggered a debate on whether the UN declares Internet access as a human right. In the report, Rapporteur Frank La Rue made a link between the right to freedom of expression and the flow of information via Internet, and emphasized that the protection of information flow should be granted as in case of right to freedom of expression. Regarding connectivity, he called states to accept policies to make Internet widely available, accessible and affordable. Therefore, he does not mention right of Internet access in terms of granting

accessibility.²⁹ In addition, in its 2016 resolution, the UN Human Rights Council also linked Internet access to the exercise of the right to freedom of expression, the right to freedom of assembly and the right to education.³⁰

The right to Internet access is also found in the case law of the European Court of Human Rights and the Court of Justice of the European Union. The courts base the right to Internet access on the right to freedom of expression and information under article 10 of the European Convention on Human Rights and article 11 of the Charter of Fundamental Rights of the European Union.³¹ As can be seen from the examples, the right to Internet access is not yet linked to connectivity, although there are programs to spread information and communication technologies in developing countries, such as 'one laptop per child', there is still no normative development in this area.³²

At the national level the answer to the existence of the right is clearer, since there are some states that grant their citizens the right to Internet access as a fundamental right. For example, the Greek Constitution states that "*All persons have the right to participate in the Information Society. Facilitation of access to electronically transmitted information, as well as of the production, exchange and diffusion thereof, constitutes an obligation of the State, [...]*" and in Portugal, Article 35(6) of the Portuguese Constitution states that "*Everyone shall be guaranteed free access to public-use computer networks.*"³³ However, these are two rare examples in the world, and to be able to argue the introduction of a new human right, we need to see more examples.

As a result, the right to Internet access has not yet been recognized as a human right in its own right, it is more under the protection of right to freedom of expression. Therefore, it is difficult to say that states today have a positive obligation to provide the necessary infrastructure to enable their citizens to access to information.

29 2011 Report of the Special Rapporteur on the Promotion and Protection of the Right to Freedom of Opinion and Expression, available at: <https://digital.library.un.org/record/706200> (Accessed 01.07.2022).

30 32/13 The Promotion, Protection and Enjoyment of Human Rights on the Internet, resolution adopted by the Human Rights Council on 1 July 2016, available at: <https://documents-dds-ny.un.org/doc/UNDOC/GEN/G16/156/90/PDF/G1615690.pdf?OpenElement> (Accessed 15.07.2022).

31 Mildebrath, H. (2021). Internet Access as a Fundamental Human Right Exploring Aspects of Connectivity, *European Parliamentary Research Service*, p. 7, available at: [https://www.europarl.europa.eu/thinktank/en/document/EPRS_STU\(2021\)696170](https://www.europarl.europa.eu/thinktank/en/document/EPRS_STU(2021)696170) (Accessed 15.07.2022).

32 About OLPC, available at: <https://laptop.org/aboutolpc/> (Accessed 15.07.2022).

33 Mildebrath, p. 28.

2.3 Result of Balancing: Protection of Freedom of Exploration

Considering the values of freedom of exploration and freedom of use, the protection of the right to science outweighs the protection of the right to Internet access, therefore freedom of use should be balanced considering the freedom of exploration.

First of all, the right to science is an established cultural right that has been protected since the declaration of the UDHR, while the right to Internet access has only been discussed for the last decade and is not yet an established right. Moreover, its content currently relates to the protection of freedom of speech rather than providing internet services to those who do not have the necessary infrastructure to access the Internet.

Even if we assume that the right to Internet access guarantees access to internet connection, LEO mega constellations are not the only way to have internet in today's world. It is one of the business models for Internet services, but there are other services for which governments would develop national strategies to provide the Internet for their citizens. Yet limiting it does not violate the right to Internet access. In contrast, we cannot restrict the right to science; since we cannot simply conduct Earth-based optical observation by other means. We cannot simply close or limit the use of Earth-based optical facilities because there is no substitute facility to replace them, and limiting the use of observatories would also be a waste of public funds.

Consequently, in this situation freedom of use should be balanced by freedom of exploration; therefore, freedom of exploration should be fully enjoyed, while freedom of use should be allowed in a manner that fully satisfies freedom of exploration. In this sense, the business of LEO mega constellations must be curtailed in favor of the unrestricted continuation of Earth-based optical astronomy. Since this statement is an obligation as a result of the balancing process, we can reach to the conclusion that States have a responsibility to protect astronomy from impact of LEO mega constellations.

3. Conclusion: International Responsibility to Protect the Freedom of Exploration

The idea behind the international responsibility of states for outer space activities is to ensure that every actor is enjoying the freedoms of outer space, as well as not breaching any restrictions set by the Treaty itself. And the method to protect the Treaty according to article VI of the OST is to establish a mechanism that governs the activities of private space sector. This mechanism is established most of the time via adopting national laws and regulations.³⁴

³⁴ Tronchetti, F. (2013). *Fundamentals of Space Law and Policy*, Heidelberg: Springer, p. 27.

In our case, considering the content of international responsibility, it is clear that states should respect to the freedom of use and freedom of exploration equally. However, protection of the OST as obligated by article VI necessitates the recognition of the conflict between the freedoms and resolve it. My suggestion in this case, is first recognizing that freedom of use and freedom of exploration are conflicting with each other, therefore the enjoyment of the freedom of use should be balanced. Then, as part of their obligation rising from international responsibility article, namely to protect freedom of exploration over the freedom of use, states need to adopt necessary measures in their domestic legal system.

In conclusion, it is for sure that the Earth-based astronomy is impacted by the LEO mega constellations. To resolve the issue from legal stand of view, states have international responsibility to protect freedom of exploration over the freedom of use, and furthermore have responsibility to adopt necessary legislation balancing these freedoms in conflict.