

The Principle of Non-Appropriation and the Exclusive Uses of LEO by Large Satellite Constellations

*Yuri Takaya-Umehara, Quentin Verspieren, Goutham Karthikeyan**

Abstract

Newly proposed projects of large satellite constellations are challenging the established business models of the satellite industry. Targeting the Low Earth Orbit (LEO), already the most populated orbit for space applications, these constellations pose an increasing risk regarding the sustainable use of outer space. According to the Inter-Agency Space Debris Coordination Committee (IADC), presenting at the Scientific and Technical Subcommittee of the UN COPUOS in 2018, the implementation level of the IADC Space Debris Mitigation Guidelines in LEO is considered as “insufficient and no apparent trend towards a better implementation is observed”, when compared with GEO. In parallel, 11 private entities such as OneWeb, Telesat and SpaceX have applied for approval from the U.S. Federal Communications Commission (FCC) to initiate large satellite constellation projects.

Before the launch of these massive constellations, several legal issues have been identified from the perspectives of international obligations related to liability and registration. Taking them into consideration, as well as the IADC recommendations, the present article reviews one of the most fundamental principles in space law, the principle of non-appropriation, to clarify its applicability to the exclusive use of specific LEO orbits by large satellite constellations. After this clarification, the paper concludes with proposals for possible solutions.

Keywords: Non-Appropriation Principle, LEO, Exclusive Use, Large Satellite Constellation, Mega Constellation

* Yuri Takaya-Umehara, The University of Tokyo. Quentin Verspieren, The University of Tokyo. Goutham Karthikeyan, The University of Tokyo & Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency (ISAS-JAXA)

1. Introduction

New projects of Large Satellite Constellations (LSC), in other words “mega-constellations”, are challenging not only the established business models of satellite telecommunication industry but also the existing legal norms in international space law. Targeting the Low Earth Orbit (LEO) which is already the most populated orbit for space applications such as Earth observation and telecommunication, these constellations highlight the shortcomings in the present regulatory framework under the International Telecommunication Union (ITU) as well as legal norms and efforts to ensure the sustainable use of outer space by mitigating space debris. In fact, according to the IADC (Inter-Agency Space Debris Coordination Committee), presenting at the Scientific and Technical Subcommittee of the UN COPUOS in 2018, the implementation level of the IADC Space Debris Mitigation Guidelines in LEO is considered as “insufficient and no apparent trend towards a better implementation is observed”, compared with GEO.

The risks of occupying LEO by LSC were recognized when the US Federal Communication Commission (FCC) accepted applications for the approval of LSC-based frequencies from private entities such as SpaceX, OneWeb, Telesat, O3b Networks, Theia Holdings in March 2017. As of April 2018, 12 entities have applied and 4 of them obtained the approval for the use of LEO frequencies by LSC with a massive number of LSC satellites. In total, FAA approved the use of 5462 satellites for LSC to the 4 private entities. Such an accelerated use of LEO by LSC warrants legal studies to investigate whether or not it accords to the existing principles in international space law as well as the ITU regulatory framework.

Recognizing the need for legal consideration, the present article aims to clarify the legal elements on LEO usage by LSC which might constitute the violation of the principle of non-appropriation, stipulated in Article II of the Outer Space Treaty of 1967. For this purpose, the article consists of the following sections: technical aspects of LSC [2]; legal aspects of the LEO usage by LSC [3]; the applicability of non-appropriation principle to the use of LEO by LSC [4]; and possible proposals [5] and conclusion [6].

2. Technical Aspects of LSC

The Low Earth Orbit (LEO) zone is defined as the spherical region that extends from the Earth’s surface up to an altitude of 2,000 km¹. According to the UCS Satellite database², the total number of identifiable satellites in LEO is 1,186. This comprises of a sizeable 60% of the total number of satellites in any orbit around the earth. This does not include the current estimates of total

1 Inter-Agency Space Debris Coordination Committee. "IADC space debris mitigation guidelines." *IADC-02-01 Revision*, 1 2007.

2 Union of Concerned Scientists. "UCS Satellite Database." 2018.

debris in LEO, which range from 14,000 [> 10 cm] - 400,000 [1 cm-10 cm] objects³. Within this context of an already crowded environment, recent plans for large constellation of satellites raise the important question of the future sustainability of LEO space environment. The trend in the growing business models for large satellite constellations are driven by their disruptive potential and the enabling trends of lowered launch, manufacturing costs combined with a peaking optimism in the industry, all resulting in a reduced barrier to entry. The three main areas these business models target are: 1. Satellite Internet, 2. Earth Observation and 3. IoT. Rather than driven primarily by demand, most of these businesses aim to sustain themselves by higher revenue through higher market share and favourable economies of scale. Higher market share can be correlated to the need of a higher coverage, higher total throughput and lower latency, all of which results in the increase in the required number of working satellites. This gives birth to 'large/mega' satellite constellation business models. In the case of the United States, the regulatory authority, FCC has to date authorized 5 NGSO (Non-Geostationary Orbit) large LEO constellations out of the total 9 applications. The following are the applications that have been approved so far: (1) OneWeb - June 2017 - 720 satellites, (2) Telesat - November 2017 - 117 satellites, (3) SpaceX - March 2018 - 4435 satellites, (4) O3b - May 2018 - additional 26 satellites, and (5) Karousel LLC - August 2018 - 12 satellites. The other companies that have applied for the FCC approval include: (6) Kepler - 2-140 satellites, (7) LeoSat - 78 satellites, (8) Boeing - 1396-2956 satellites, and (9) Theia - 112 satellites.

With this rising demand for approvals for satellite constellations, the FCC has further relaxed its rules⁴ for application to NGSO constellations - one of which is that the companies must honour the FCC approval by adhering to the requirement that launch and operation of 50% of the authorized satellite must occur within 6 years of grant. Operators that successfully complete this milestone will have an additional three years to deploy the rest of their constellations. This is in contrast with the former rule that 100% of the satellites needed to be launched within the 6 years of authorization. After this relaxation, OneWeb has filed for the authorization of an additional 1260 satellites.

Even under the assumption that only 50% of the proposed satellites make it to orbit, that still results in roughly 5000+ satellites in orbit within the next 9 years, which can have massive ramifications with respect to space sustainability. In addition, the IADC Statement on Large Constellations of

3 Wright, David. The Current Space Debris Situation. Union of Concerned Scientists (UCS), Beijing Orbital Debris Mitigation Workshop. 2010.

4 FCC FACT SHEET* Updating Rules for Non-Geostationary-Satellite Orbit Fixed-Satellite Service Constellations Report and Order and Further Notice of Proposed Rulemaking, IB Docket No. 16-408, 20, 2017.

Satellites in Low Earth Orbit⁵ reports that most of the proposed satellite constellations concepts plan to operate at altitudes above 1000 km where their life time is almost eternal due to the lack of any natural atmospheric drag. Therefore, these satellites would continue to be in orbit perhaps even beyond their operational lifetime unless stringent measures are taken for post mission disposal.

Technical studies have been conducted in the past on the effect of these constellations on space debris^{6 7} and satellite interference⁸ and a rigorous discussion of the same is beyond the scope of the paper. However, the general conclusion drawn from the studies is that, provided the satellite operators adhere to the various established recommendations (for e.g. recommendations for post-mission disposal by the IADC or the Equivalent Power Flux Density recommendations by the ITU), it is possible to promote a peaceful and sustainable use of the LEO region.

However, more important and pertinent questions are related to the 1. Legal framework of the utilization of LEO - for example with respect to principle of non-appropriation of Outer Space (which can be extended to LEO orbits as the authors validate below) and 2. Regulatory framework - for example which authoritative body would ensure (and by what mechanism) that the satellite operators adhere to the various established regulatory guidelines.

3. Legal Aspects of the LEO Usage by LSC

3.1 Legal Status of LEO

LEO are “limited natural resources”. The concept of natural resources in outer space covers tangible and intangible resources as well as exhaustible and inexhaustible resources. In terms of radio frequencies and any associated orbits including Geostationary Orbit (GEO), they are defined as “limited natural resources”⁹ by Article 44 paragraph 2 of the Constitution of

5 Inter-Agency Space Debris Coordination Committee. "IADC Statement of Large Constellation of Satellites in Low Earth Orbit" *IADC-15-03 Revision 4*, 2017.

6 Virgili, B.B., Dolado, J.C., Lewis, H.G., Radtke, J., Krag, H., Revelin, B., Cazaux, C., Colombo, C., Crowther, R. and Metz, M., 2016. Risk to space sustainability from large constellations of satellites. *Acta Astronautica*, 126, pp.154-162.

7 Foreman, V.L., Siddiqi, A. and De Weck, O., 2017. Large Satellite Constellation Orbital Debris Impacts: Case Studies of OneWeb and SpaceX Proposals. In *AIAA SPACE and Astronautics Forum and Exposition* (p. 5200).

8 Lal, B., de la Rosa Blanco, E., Behrens, J.R., Corbin, B.A., Green, E.K., Picard, A.J. and Balakrishnan, A., 2017. Global trends in small satellites. *Institute for Defense Analysis, Tech. Rep. P-8638*, 7.

9 Article 44 paragraph 2 stipulates that “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

International Telecommunication Union (ITU)¹⁰ due to its “limit” for the use. The provision stipulates that “[i]n 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”. In practice, satellites are to be operational through radio signal and use the radio frequency spectrum to provide their services, requiring orbital locations and allocated frequencies for space communications service.¹¹

3.2 Legal Basis for the LEO Usage by LSC

Although the deployment and operation of LSC in LEO is provocative from the perspective of sustainability in outer space, those activities are categorized into the use of outer space which are legal under Article I of the Outer Space Treaty of 1967 (OST)¹². As the provision is regarded as customary international law which stipulates that the exploration and use of outer space “shall be the province of all mankind”, any state including non-state party to the treaty has the right to deploy and operate LSC into LEO. As to private entities, states parties bear state responsibility for their national activities with the obligation to authorize and continuously supervise them under VI of the OST; therefore, the LSC activities by private entities are legal with meeting those conditions.

Taking it into consideration, the following section introduces the non-harmful interference principle as one of major concerns raised by the LSC in LEO is causing interference in satellite telecommunication.

3.3 Non-Harmful Interference under ITU Law

Any kind of telecommunication activity is subjected to ITU law, requiring states and agencies not to cause harmful interference. The deployment and operation of LSC in LEO raising concerns in this respect, the present section introduces ITU’s principle of non-harmful interference.

Article 45 imposes on ITU member states the following 3 obligations which are: not to cause any harmful interference to the radio services or communications of other member states or of operating agencies when they establish and operate any radio services or communications;¹³ to ensure all

access to those orbits and frequencies, taking into account the special needs of the developing countries and the geographical situation of particular countries.”

10 The Constitution of International Telecommunication Union, 22 December 1992; 1825 UNTS 1; UKTS 1996 No. 24; Cm. 2539; ATS 1994 Nov. 28.

11 F. Tronchetti, "Legal Aspects of Space Resource Utilization." In Dunk, F. (eds.) *Handbook of Space Law*, Edward Elgar Publishing, 2015, p. 798.

12 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 27 January 1967, 610 UNTS 205.

13 Art. 45(1) of the ITU Constitution.

agencies to follow the provision;¹⁴ and to recognize the necessity of taking all practical steps to prevent the operation of electrical apparatus and installations from causing harmful interference.¹⁵ Not only to states but also private entities engaged in international operation are also subjects to this provision¹⁶. On the other hand, the exception to the provision remains for military radio-communication activities. Article 48 ensures member states “entire freedom” in military radio installations,¹⁷ though requiring them to observe statutory provisions to prevent harmful interference as well as to follow the Administrative Regulations concerning the types of emission and the frequencies to be used.¹⁸ In particular, if their military installations are to be used for public correspondence or other services in the scope of the Administrative Regulations, member states are also obliged to comply, in general, with the regulatory provisions for the conduct.¹⁹ As two provisions, Article 45 and Article 48, require states to control all telecommunication offices and stations which are engaged in international services and capable for causing harmful interference,²⁰ member states are responsible for their civil, commercial and military activities. Even if states lack their domestic law to authorize commercial activities, such as a licensing system, operating agencies enter in the scope of state control in accordance with Article 45 covering “recognized” as well as “duly authorized” operating agencies²¹. Therefore, for example, the US FCC that has authorized private entities to deploy LSC into LEO, needs to ensure whether an authorized LSC could or not cause any harmful interference with radio services or communications of other states.

4. Applicability of the Non-Appropriation Principle to the LEO Usage by LSC

4.1 What is the Non-Appropriation Principle?

LSC raise concerns in the international community such as the IADC and the International Academy of Astronautics (IAA) whether or not it would result

14 Art. 45(2) of the ITU Constitution.

15 Art. 45(3) of the ITU Constitution.

16 The ITU Constitution also applies to private entities that operate all stations engaged for international operation. Article 6.1 of the Constitution first stipulates that all telecommunication offices and stations established or operated by member states “which engage in international services or which are capable of causing harmful interference to radio services of other countries” must observe the provisions in the ITU law. Article 6.2 extends the same obligation to private operate agencies/entities authorized by member states. Thus, Article 6 covers civil and commercial activities, while it excludes military activities from obligation in accordance with Article 48.

17 Art. 48(1) of the ITU Constitution.

18 Art. 48(2) of the ITU Constitution.

19 Art. 48(3) of the ITU Constitution.

20 Art. 6(1)(2) of the ITU Constitution.

21 Art. 45(1)(2) of the ITU Constitution.

in the almost-exclusive use of selected orbits, the so-called “curtains of satellites”.²² The non-appropriation principle defined in Article II of the OST states that, Outer space, including the Moon and other celestial bodies, “is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means”. The principle, that serves to regulate the exploration and use of outer space, is a fundamental rule and recognized as customary international law. The principle applies to LEO as the scope of its application and includes any orbits around the Earth and other celestial bodies, inter-planetary transfer orbits and Lagrangian point(s). In short, the use of LEO by LSC falls into the scope of the principle.

The principle prohibits any states from claiming sovereignty in outer space (including celestial bodies) which makes a difference between the legal status of air space and outer space. According to the Chicago Convention of 1944²³, every state has complete and exclusive sovereignty over the airspace above its territory, while the legal status of outer space is *res communis omnium* where it is free for exploration and use but “no portion of outer space may be appropriated to the sovereignty of individual states”²⁴. By prohibiting states to claim any sovereignty in outer space, Article II transformed the legal status of outer space from *res nullius* to *res communis omnium* and the ultimate goal of the principle is to prohibit any taking of land by claims of sovereignty²⁵ to prevent space colonization and an extension of the arms race in outer space. Thus, the principle is known for denying any claim of state sovereignty in outer space; however, an emphasis needs to be put on the provision that it also prohibits national appropriation, as well as private appropriation,²⁶ by means of “use, or occupation, or by any other means”.

4.2 Exclusive Use of LEO by LSC

As noted above, no state could subject (any part of) outer space to its sovereign control, or regard it as part of its territory²⁷. By prohibiting the claim of sovereignty, the principle prevented outer space from being colonized by states.²⁸ The principle also prohibits national appropriation of outer space “by means of use or occupation”. This paper claims that the

22 K-U. Schrogl, C. Jorgenson, J. Robinson, A. Soucek, *Space Traffic Management - Towards a Roadmap for Implementation*, IAA, June 2018, p. 13. Texts are available at: <https://shop.iaaweb.org/?q=node/9994> [last accessed on 10 September 2018].

23 Convention on International Civil Aviation, 7 December 1944, 14 UNTS 295.

24 N.S. Malcolm, *International Law*, Edited by 7th edition: Cambridge University Press, 2014, p. 393.

25 S. Hobe (eds.), *Cologne Commentary on Space Law: In Three Volumes. Vol. 1*, Heymann, 2015, p. 53.

26 S. Hobe (eds.), *ibid.*, p. 50.

27 S. Hobe (eds.), *ibid.*, p. 53

28 S. Hobe (eds.), *ibid.*

exclusive use of LEO by LSC contravenes both the latter means of national appropriation.

Firstly, it is important to specify that, as the scope of the non-appropriation principle includes outer space and celestial bodies, it applies to orbits around the Earth and other celestial bodies as well as inter-planetary transferring orbits.²⁹ The terms “use or occupation” need to be read in the context of Article I that ensures free exploration and use of outer space to “any state”. Any orbit, be it in LEO or anywhere else, is a precisely defined area of outer space that can be physically occupied by spacecraft, substantially resulting into national appropriation; therefore, the exclusive use of a specific orbit by any public or private would fall under the “means of occupation” as stated in the OST, being in direct violation of the non-appropriation principle.

Secondly, in light with ITU’s conception of orbits are “limited natural resources,”³⁰ the debate over the violation of the non-appropriation principle by “means of [exclusive] use” of LEO can be equated to the debate over the legality of the exploitation of natural resources in space. As argued by Philip De Man, the specific use made of an orbit conditions its classification as a natural resource or not.

“In the case of point-to-point traversal of a medium, its use is incidental to the main goal of transportation, and is a means of overcoming the obstacle of distance, while the placement of a satellite in a particular orbital position is a necessary precondition for actualizing the economic value of the medium itself”³¹

Therefore, the exclusive use of an orbit by an LSC for obvious economic benefits would justify its classification as natural resource and, due to the exclusive nature of the use, trigger a violation of the non-appropriation principle, as argued in the following section.

Finally, an important aspect of the exclusive use of LEO by LSC is the growing contradiction between the “first come, first served” principle under ITU regulation³² and the non-appropriation principle. While the organized allocation of GEO slots has been motivated by the high interests and expected use of a relatively limited orbital region, LEO have been considered until now exempt from the risk of over-crowdedness. However, now that the advances of space engineering allow the deployment of constellations large enough to constitute an exclusive use of specific orbits in the LEO region or as some scholar said, to “exclude new competitive systems”,³³ the limit of the

29 The scope of Article II’s application

30 *Supra*, footnote 7.

31 P. De Man, *Exclusive Use in an Inclusive Environment*, Springer, 2016, p. 199.

32 Mark Griffin, *Orbit/Spectrum Allocation Procedures*, Training Workshop on Satellite, Bangkok, Thailand. 28-30 September 2010

33 R.S. Jakhu, J.N. Pelton (eds.), *Global Space Governance: An International Study*, Springer, 2010, p. 374.

“first come, first served” principle is reached as it directly contradicts, not to say violates, the non-appropriation principle. It would therefore be beneficial for both the respect of international space law and the sustainability of the LEO environment to call ITU’s “first come, first served” principle’s fairness into question.³⁴ A notable inspiration is the IADC’s classification of protected regions of outer space, with LEO being the “protected region A” while GSO is labelled “protected region B.”³⁵

4.3 “Appropriation by Use” of LEO

In line with the “exclusiveness” argument above, the difference between the use of outer space and the appropriation of outer space by use needs to be addressed. While the former is legal under Article I of the OST, the latter is prohibited under Article II. Although the line between them needs to be clear, as LEO is intangible, it is difficult to draw as the use of outer space is not explicitly limited and no state claims the ownership of LEO. In principle, any act of appropriation has the effect of excluding others from enjoying free access to outer space³⁶ and a similar discussion has been taken in the context of exploiting natural resources in outer space.

Although exploiting natural resources “out of existence” still remains debatable whether or not it falls into the scope of “use” under Article I of the OST or constitutes the national appropriation, “occupation” in any other form of outer space constitutes national appropriation.³⁷ Furthermore, mining activities to exploit space resources is associated with the installation of stations on celestial bodies. If such an installation is permanent and for exclusive use by one state, it would result into “the appropriation of the land on which it is built.”³⁸ In order to avoid violation of the principle of non-appropriation, the exclusiveness³⁹ in occupying and using the mining zone needs to be avoided. In sum, ensuring the equitable access of other countries is a key to comply with the principle.

5. From a legal to a regulatory issue

By investigating expected large satellite constellation projects and by reviewing existing interpretations of international space law, this paper argues that the exclusive use of specific LEO orbits by a large constellation of satellite could constitute a violation of the non-appropriation principle by

34 *Ibid.*

35 *Supra*, footnote 1.

36 S. Hobe (eds.), *supra* note 25, p. 58.

37 S. Hobe (eds.), *supra* note 25, p. 54.

38 R.H. Mankiewics, “Interventions with respect to permanent stations on the Moon”, 11 Proc. Coll. L. Outer Space 1968, p. 163. Cited in: P. De Man, *ibid.*, p. 381.

39 For a comprehensive study over the non-appropriative use of space resources, *see*, P. De Man, *ibid.*

means of occupation and by means of use, drawing a parallel between orbits as resources and the exploitation of tangible mineral resources in space. Based on this, the important question to be raised is what constitutes an exclusive use of a specific orbit. In other words, an important hurdle in the concrete evaluation of whether a planned or established constellation potentially violates the non-appropriation principle through an exclusive use of LEO resides in the lack of clear definition on what can be considered an exclusive use. While the authors claim that legal issue can be clearly solved *in abstracto*, it naturally shifts towards a regulatory challenge.

This regulatory challenge consists in first defining qualitatively what is the exclusive use of an orbit before translating this definition into measurable, technical rules. In this paper, the authors define an exclusive use of an orbit by a state⁴⁰ as *any use that would prevent/hinder the usage of the same orbit by any other state*. Translating this definition into an applicable regulation could consist in defining a threshold of orbital collision risk or a threshold of density of satellites along an orbit based on its altitude, shape, relative velocity of neighbouring objects, etc. It is however not the purpose of this space law paper. What is more appropriate here is to think about which organization or forum would be in charge of elaborating this technical definition. Serious candidates could be the ITU, with excellent track-record in dealing with the use of the GEO region but which would have to review its “first come, first served” principle, or the UNCOPUOS, aiming for the widespread adoption of a new piece of international law. Moreover, even if its rules suffer from a low implementation rates, the IADC would be an appropriate discussion platform thanks to its very deep technical focus.

6. Conclusion

The various announced projects of LSC, also called mega-constellations, push existing regulations and practices to their limit, forcing researchers and practitioners around the world to rethink the applicability of existing space law principles to this new trend. In this paper, the authors, after providing background information on current LSC plans as well as recalling the legal status of the LEO region, investigate whether the deployment of an LSC having an exclusive use of an orbit constitutes a violation of the non-appropriation principle as stated in OST Article II. This paper concludes that:

- The exclusive use of an orbit by an LSC constitutes a violation of the non-appropriation principle by means of occupation due to the innate nature of orbit being a specific location in space that can be occupied,

40 In this definition, the authors chose to use the term “state” in reference to the applicability of OST to only states. It should however be understood in the broader sense of “satellite operator.”

but most notably by means of use, considering orbits as “limited natural resources” and invoking parallels with the exploitation of natural resources in outer space;

- ITU’s “first come, first served” principle is reaching its limits with current LSC projects and should be re-evaluated;
- The main challenge ahead is not legal but technical and regulatory and consists in defining precisely what can constitute an exclusive use of an orbit and in translating such definition into a clear regulation or code of conduct.