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Legal Challenges to the Construction and Operation of Small Satellite Constellations

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The emergence of the construction and operation of a small satellite constellation in Low Earth orbit (LEO) to beam high-speed Internet to all parts of the world is a relatively new development in the use of outer space. States, international intergovernmental organizations, and private companies plan to deploy small satellites into Earth's orbit because this effort is inexpensive and expandable, especially in the area of commercial activities. This movement will provide an essential tool to achieve sustainable development goals, especially for developing countries. However, it could also bring legal challenges because there is now a lack of binding regulations regarding the increasing risks of orbital collision, the proliferation of space debris, the satellite network service, and the rational, efficient, and economical use of a radio frequency allocation and the harmful interference caused by small satellite constellations in LEO. These issues could have an impact on the long-term sustainability of space activities.

Keywords

Small Satellite Constellation, Legal Challenges, Long-Term Sustainability, Low Earth Orbit

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I. Introduction

The proliferation of small satellite constellations in Low Earth orbit (LEO) to provide high-speed Internet to all areas of the world is unprecedented. States, intergovernmental organizations, and private companies worldwide plan to deploy small satellites into Earth's orbit because this effort is inexpensive and expandable, especially in the area of commercial activities. For instance, recently, in March 2018, the US Federal Communication Commission (FCC) approved SpaceX's application to launch 4,425 LEO satellites, which are the first phase of nearly 42,000 satellites envisaged. In addition to SpaceX's application, many private companies are also planning to launch small satellites' mega-constellations soon including OneWeb with 2,720 satellites, Amazon with 3,236 satellites, and Samsung with 4,600 satellites. Furthermore, Norway has recently registered 4,257 satellites for its launching network with the International Telecommunication Union (ITU), and Canada and France have registered 794 and 4,000 satellites, respectively.[1]

In light of this advanced space technology, the difference between large and small satellites has become more difficult to identify. At present, this issue is still controversial and debatable because there are many ways to define small satellite's meaning to differentiate them from the larger, less modern satellites. The most accepted definition, given by the International Academy of Astronautics (IAA) through the IAA study of the Earth observation satellites, categorizes small satellites into four groups based on their mass to define their classification. These four groups are Mini satellites, Microsatellites, Nanosatellites, and Pico satellites. Mini satellites are limited to a weight of less than 1000 kg to 100 kg, Microsatellites less than 100 kg to 10 kg, Nanosatellites less than 10 kg to 1 kg, and Pico satellites less than 1 kg.[2] Furthermore, in terms of the radio frequency assignment, the International Telecommunication Union Radiocommunication (ITU-R) has considered any satellite that weighs less than 500 kg "minisatellite." Notably, all definitions that IAA and ITU-R provide are based on their mass alone regardless of their maneuverability, shape, or other particular features.

Technically, a satellite refers to any object that orbits another larger object in space, similar to the Earth orbiting the sun; however, artificial satellites refer to objects orbiting the Earth.[3] The first artificial satellite, which was launched into space in

1 K. Nair, Small Satellites and Sustainable Development-Solutions in International Space Law 56 (2019).

2 R. Jakhu & J. Pelton, Small satellites and their regulation 2 (2014).

3 E. Howel, What is a Satellite?, National Aeronautics and Space Administration Website (Feb. 12, 2014), https://www.

October 1957, was called Sputnik,[4] which was about the size of a beach ball. Sputnik signaled the beginning of the space race. Since then, more and more objects have been launched into orbit. Companies such as SpaceX, Amazon, Telesat, and OneWeb want to launch thousands of satellites to create what they call mega-constellations. A mega-constellation is a network with hundreds or even thousands of small satellites all orbiting and working together in a complete system.[5] International organizations and private companies all have motivations for this, based on two main reasons. First, these satellites' hardware costs have decreased dramatically,[6] and second, the demand for Internet connectivity all over the world has been increasing exponentially.[7] Therefore, it has become more valuable for these entities to provide high-speed Internet at a lower price than currently exists. Most Internet satellites operate in the Geostationary Earth orbit (GEO), which is around 35,786 kilometers above the Earth's surface.[8] They remain fixed on top of one area, but the small satellite constellation that SpaceX, OneWeb, Amazon, and Samsung are proposing will also operate in what is called "Low Earth orbit," or between 180 to 2,000 kilometers above Earth's surface.[9] In theory, this should cut down on latency issues, with speeds up to 20 times faster than current GEO satellites.[10] A small satellite constellation's construction and operation can offer the excellent opportunity to connect the world; however, it could also cause legal issues regarding potential orbital collision, space debris, satellite network services, radio spectrums, and orbital slot allocation.

The primary purpose of this research is to analyze the legal challenges posed by the proliferation of small satellite constellations in LEO, which will affect the long-term sustainability of outer space activities. This paper is divided into six parts including Introduction and Conclusion. Part two will describe the legal challenge of a potential collision with the other satellites already launched. Many small satellites in LEO could endanger other space missions' safety and could affect space activities' sustainability. Part three will discuss the legal challenge of space debris. The predicted

nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-a-satellite-58.html.

4 F. Tronchetti, Fundamentals of space law and policy 4 § 26 (2013).

5 V. Braun, *Small Satellite Constellations and End-of-Life Deorbit Considerations*, Handbook of Small Satellites: Technology, Design, Manufacture, Applications, Economics and Regulation 268 (2019).

6 M. Dornik & M. Smith, *Small Satellite Industry and Legal Perspectives in the United States*, *in* Small Satellites: Regulatory Challenges and Chances 68-9 (I. Maeboe ed., 2016).

7 V. Velivela, *Small satellite constellations: The promise of Internet for all*, ORF Issue Brief 1 (2015).

8 A. Allison, The ITU and Managing Satellite Orbital and Spectrum Resources in the 21st Century 8 (2014).

9 *Supra* note 1, at 56.

10 A. Carazo, *Mega-Constellations: Legal Aspects*, *in* Promoting Productive Cooperation Between Space Lawyers and Engineers 141 (2019).

launch of small satellite constellations into LEO would undoubtedly generate space debris, particularly for small satellites that usually have a short lifetime, carrying the risk of colliding with functional satellites. Part four will examine the legal challenge of the satellite network service. When the small satellite constellations are completed and functional, it could cause the free flow of information across borders. Part five will tackle the legal challenge of radio frequency allocation and harmful interfrence. Radio frequencies are considered limited natural resources. There is a risk of insufficient radio frequencies and increased harmful interference as more and more small satellite constellations are launched. Part six is the conclusion and final comments.

II. The Legal Challenge of the Potential Satellite Collision

When the small satellite constellations are launched, the potential collision with the other satellites in outer space will be much higher. Theoretically, there is the possibility of a massive collision in LEO, namely the Kessler Syndrome. In 1978, NASA scientist Donald J. Kessler envisaged that LEO would become overcrowded, which could cause collisions.[11] Each collision would generate more space debris that would cascade onto the Earth.[12] Recently, there was a reported accidental collision in LEO between the Iridium 33 and defunct Russian satellite Cosmos 2251, which alerted the world to the sustainability of peaceful operations in outer space.[13]

Article IX of the Outer Space Treaty 1967 (OST) deals with several obligations relating to the protection of the outer space environment. However, most are not relevant to the small satellite constellation activities, especially the potential of satellite collision. Despite of Article IX, the Treaty shall be thus guided by the principle of cooperation and mutual assistance. Because they are conducting all their activities in outer space, each party needs to make cooperation for involvement. Although the language of the OST is quite general and ambiguous, this obligation is admittedly of a general nature. The principles of cooperation and mutual assistance are not explicitly

11 L. De Gouyon Matignon, *The Kessler Syndrome*, Space Legal Issues, Mar. 27, 2019, https://www.spacelegalissues.com/space-law-the-kessler-syndrome.

12 V. Degrange, *Active Debris Removal: A Joint task and obligation to cooperate for the benefit of mankind*, *in* Space Security and Legal Aspects of Active Debris Removal 3 (A. Froehlich ed., 2019).

13 P. Larsen, *Small satellite legal issues*, 82 J. Air L. & Com. 300 (2017).

defined in the Treaty, and no real examples are given.[14] Accordingly, there is a lack of specific details to cope with orbital collision avoidance. Moreover, the due regard obligation in Article IX is ambiguous because it is difficult to determine what kind of space activity corresponds to the potential interests of over 100 State parties.[15]

Notably, all rights and obligations for large satellites are practically applicable to small satellites as well because there is no distinction between small and large satellites in the current space law regime.[16] It is evident that when the OST was signed, no legal challenges were ever anticipated in the construction and operation of small satellite constellations in LEO. Therefore, all types of satellites are recognized as space objects regulated by the two major international space law treaties relevant to the damage caused by space activities, such as the OST and the 1972 Liability Convention. A State party has the option to bring a claim for compensation under any of these treaties if other State party causes damage. It is thus necessary to take into consideration that all damage liability is recoverable. To this point, Article VII of the OST stipulates that the launching State shall be held internationally liable for damage caused by their space objects on Earth, in the airspace, or outer space. Nonetheless, the 1972 Liability Convention sets two different liability regimes for damage caused by space objects of the launching States. Article II prescribes 'absolute' liability for damage caused on Earth and in the airspace, while Article III prescribes 'fault' liability for damage which was caused in outer space. Article III is clear on the need to establish fault in order to successfully claim compensation for damage in outer space. However, it does not give any legal indication on what may constitute 'fault.'[17] Article I further clarifies that a "launching State" is "a state which launches or procures the launching of a space object or a state from whose territory or facility a space object is launched."[18]

Furthermore, in light of State responsibility regime for space activities, Article VI of the OST stipulates that States party to the Treaty shall have international responsibility for national outer space operations whether government agencies or non-governmental bodies carry out the activities. The operations of non-governmental entities in outer space shall entail the authorization and continued

14 C. Johnson, *The legal status of megaleo constellations and concerns about appropriation of large swaths of earth orbit*, *in* Handbook of Small Satellites: Technology, Design, Manufacture, Applications, Economics and Regulation 1345 (2020).

15 N. Palkovitz, Regulating a Revolution: Small Satellites and the Law of Outer Space 41-2 (2019).

16 S. Mosteshar & I. Marboe, *Authorisation of Small Satellites under National Space Legislation*, *in* Small Satellites: Regulatory Challenges and Chances 134 (I. Marboe ed., 2016).

17 *Supra* note 15, at 106.

18 1972 Liability Convention art. 1.

supervision of the relevant State party. The construction and operation of small satellite constellations are considered as "space activity," so that they should comply with Article VI. A State is also responsible for such activities if carried out by an international organization in which that State participates.[19]

In addition to the two treaties related to the specifics of damage liability and the authorization and supervision of space activity, there are two international guidelines for the operation of small satellite constellations in outer space. They are as follows:

A. Guideline for the Long-term Sustainability of Outer Space Activities

The concern regarding the long-term sustainability of outer space activity was examined from many different angles by the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPOUS) for several years. Eventually, the UNCOPOUS's working group on the long-term sustainability of the Scientific and Technical Subcommittee, created a set of voluntary comprehensive guidelines to enhance the long-term sustainability of space activity, specifically in the security of space operation. The primary purpose of these guidelines, officially adopted in June 2019, is to address and to mitigate the problems of space activities affecting the long-term sustainability of outer space, such as the proliferation of space debris, the complication of space operations, the emergence of small satellite constellations, and the increasing risk of collisions.[20] Therefore, implementing the guidelines should also foster international collaboration in peaceful use and outer space exploration.

These guidelines describe the long-term sustainability of outer space activities as preserving the ability to indefinitely conduct future space activities to realize the objectives of equitable access to the benefits of outer space exploration and to conduct the activities for peaceful purposes while meeting the needs of current and future generations. Thus, when planning and carrying out their national operations in outer space, the states should draw on those principles, which would apply to both government and non-governmental organizations. They also refer to all space operations, whether scheduled or continuing, and to all phases of the space mission, including launch, service, and disposal. To preserve the use of outer space for current and future generations and to uphold the long-standing principle laid down in Article I of the OST, all states and intergovernmental organizations should

19 *Supra* note 2, at 63.

20 Report of the Committee on the Peaceful Uses of Outer Space, U.N. Doc. A/74/20 (June 12-21, 2019), ¶ 163 & annex II, https://www.unoosa.org/res/oosadoc/data/documents/2019/a/a7420_0_html/V1906077.pdf. *See also* P. Martinez, *The UN COPUOS Guidelines for the Long-Term Sustainability of Outer Space Activities*, 8 J. Space Safety Engineering 98-9 (2021).

voluntarily take action through any national or other relevant processes to ensure that these guidelines are applied wherever possible and practicable with respect to their interests, requirements, and capacities and complying with any applicable international law. These guidelines are divided into the following four sections: (1) policy and regulatory framework for space activities; (2) safety of space operations; (3) international cooperation, capacity-building, and awareness; and (4) scientific and technical research and development.[21]

B. Draft International Code of Conduct for Outer Space Activities.

The Draft International Code of Conduct for Outer Space Activities (ICoC) was initially proposed by the European Union (EU) to ensure the sustainable use of the common outer space activities.[22] Specifically, it aims to ensure the continued peaceful use of outer space for current and future generations by recognizing that increasing space debris would directly affect space operations' safety. For instance, the risk of accidents, possible collisions between space objects, and all types of harmful interference may occur between the other member states' functional satellites.

The ICoC's fundamental purposes are to build accountability and confidence-building measures,[23] a series of instruments intended to demonstrate, forecast and monitor the states' activities regarding space operations' maintenance and security. The ICoC's secondary goals are to improve the stability, protection, and sustainability of all outer space operations by both drawing up proposals to resolve space debris mitigation and proposing a reporting mechanism for the member states. Non-governmental entities under their jurisdiction also carry out various operations in space. The ICoC requires that states continue to respect the existing international space law instruments as follows:

- The 1963 Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water and the 1996 Comprehensive Nuclear Test Ban Treaty;
- Constitution and Convention of the International Telecommunication Union and its Radio Regulation, as amended;
- The 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the moon and other celestial bodies;

21 *Id*. at 102-3.

22 A. Froehlich, *The Right to (Anticipatory) Self-Defence in Outer Space to Reduce Space Debris*, *in* Space Security and Legal Aspects of Active Debris Removal 78 (A. Froehlich ed., 2019).

23 *Id*.

- The 1972 Convention on International Liability for Damage Caused by Space Objects;
- The 1975 Convention on Registration of Objects Launched into Outer Space; and
- The 1968 Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space.[24]

Notably, the Guideline for the Long-Term Sustainability of Outer Space Activities and the Draft International Code of Conduct for Outer Space Activities are explicitly able to deal with the construction and operation of small satellite constellations. However, both are non-legally binding and stands voluntarily, which demand the cooperation of all states and their non-government entities to be responsible for transparency and confidence-building under international laws and obligations. Consequently, this is a core legal challenge dealing with potential satellite collisions.

III. Space Debris

Since the advent of the space age, more than 10,596 satellites have been launched into Earth's orbit,[25] of which about 3,372 are still operational.[26] In a few years, however, the number of satellites would be rising dramatically according to SpaceX's proposal to launch 42,000 satellites as part of its Starlink Internet initiative.[27] If this continues, SpaceX alone will be responsible for a fivefold rise in the number of spacecraft deployed by all humans. Among them, the primary concern is debris. As summarized by a theory of the Kessler Syndrome, when two objects collide in space, they generate more debris that collides with other space objects, creating even more shrapnel and litter until the entirety of the LEO is impassible.

Space debris proliferation is a significant concern due to the increasing outer space use by spacefaring nations and their non-organization entities. According to the NASA database, more than 500,000 pieces of debris are being tracked when they

24 C. Johnson, Draft International Code of Conduct for Outer Space Activities Fact Sheet (Feb. 2014), https://swfound.org/media/166384/swf_draft_international_code_of_conduct_for_outer_space_activities_fact_sheet_february_2014.pdf.

25 UNOOSA, Online Index of Objects Launched into Outer Space, The United Nations Office for Outer Space Affairs Website (Apr. 30, 2021), https://www.unoosa.org/oosa/osoindex/search-ng.jspx?lf_id=.

26 UCS, UCS Satellite Database, Union of Concerned Scientists Website (Jan. 1, 2021), https://www.ucsusa.org/resources/satellite-database.

27 L. Dormehl, SpaceX plan to put 42,000 satellites in orbit could face a big legal roadblock, Digitaltrends Website (Feb. 7, 2020), https://www.digitaltrends.com/cool-tech/possible-legal-case-astronomy-satellite-constellation.

orbit the Earth.[28] NASA also warns that many millions of pieces of debris cannot be tracked because they are not large enough to be tracked by conventional methods.[29] Consequently, this debris could pose a collision risk for other operational satellites.

The increase of space debris in LEO by the launch of small satellite constellations has been envisaged due to the satellites having a short average lifespan of three to five years. They will become debris in space. Presently, there is no international formal definition of "space debris." Nonetheless, this term has exponentially increased in use, especially in a Technical Report on Space Debris (1999) by the Scientific and Technical Subcommittee of the UNCOPUOS, which defines space debris as "all man-made objects, including their fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional."[30]

If the law remains unchanged, small satellite constellations would cause a dramatic increase in space debris in the future. Currently, however, there is no hard law either in the form of an international treaty or any other global framework that aims to deal with this anticipated problem. In terms of space debris, the existing international law regimes, specifically the Outer Space Treaty and the 1972 Liability Convention, only deal with the consequences when debris causes any damage. They do not consider the generation of defunct space debris. Following are three sets of voluntary space debris reduction principles, and their recommendations to resolve space debris question.

A. The European Space Debris Safety and Mitigation Standard

The European Space Debris Safety and Mitigation Standard, issued by the European Space Agency (ESA), was developed from an existing document called the National Center for Space Studies (CNES) to outline safety, mitigation, and space debris guidelines. These guidelines set out the measures to build and operate a space vehicle to prevent or eliminate space debris' potential production.[31] These guidelines also prescribe action to shield a spacecraft from the risk of space debris collisions. It defines protocols for implementing the specific specifications for compliance with the general safety standards specified for a project or a space-related process.

These guidelines are to be followed by all ESA programs, national space agencies,

28 M. Garcia, Space Debris and Human Spacecraft, National Aeronautics and Space Administration Website (Aug. 7, 2017), https://www.nasa.gov/mission_pages/station/news/orbital_debris.html.

29 *Id*.

30 Technical report of the Scientific and Technical Subcommittee on Space Debris, U.N. Doc. A/AC.105/720 (1999), https://www.unoosa.org/pdf/reports/ac105/AC105_720E.pdf.

31 F. Alby et al., *The European Space Debris Safety and Mitigation Standard*, 34 Advances in Space Res. 1260-63 (2004).

European industries, and all entities involved in the management, research, planning, manufacturing, launch, and advancement of space missions in Europe or any European agency working outside of Europe. It specifies the criteria that must be applied to all spacecraft orbiting or intended to orbit the Earth, including launch vehicles and their components. These directives should be checked after reading the European Space Debris Mitigation Handbook.[32]

B. The Inter-Agency Space Debris Coordination Committee's Space Debris Mitigation Guideline

To address the increased population of space debris, particularly in LEO, the Inter-Agency Space Debris Coordination Committee (IADC), an international forum of space agencies engaged in the worldwide coordination of their activities to coordinate actions related to human-made and natural debris problems in space, has established non-binding guidance, the so-called IADC Space Debris Mitigation Guidelines.[33] These guidelines set out four primary practices for the limitation of space debris: (a) Limit debris released during normal operation; (b) Minimize the potential for on-orbit break-ups; (c) Post mission disposal in the geosynchronous region, LEO region, and other regions; and (d) Prevention of on-orbit collisions.[34]

These guidelines' primary purpose is to share space debris analysis information between member space agencies, promote opportunities for collaboration in space debris research, ascertain the success of existing cooperative activities, and review debris reduction strategies.[35] They have served as an incentive for the UNCOPUOS to follow its guidelines directly under the IADC recommendations. There are, however, no guidelines yet related to Active Debris Removal for the international community.

C. The UNCOPUOS Space Debris Mitigation Guideline

The deployment and operation of small satellite constellations will be subject to the UNCOPUOS Space Debris Guidelines adopted by United Nations General Assembly in 2007.[36] These guidelines have become mandatory laws for some states because they

32 *Id*.

33 IADC Space Debris Mitigation Guidelines, IADC-02-01 Revision 1 (Sept. 2007), https://www.unoosa.org/documents/pdf/spacelaw/sd/IADC-2002-01-IADC-Space_Debris-Guidelines-Revision1.pdf.

34 M. Yakovlev, The IADC Space Debris Mitigation Guidelines and Supporting Documents § 587 (2005), https://conference.sdo.esoc.esa.int/proceedings/sdc4/paper/35.

35 J. Pelton & W. Ailor, Space Debris and Other Threats from Outer Space 31-2 (2013).

36 Space Debris Mitigation Guidelines of the United Nations Committee on the Peaceful Uses of Outer Space, G.A. Res. 62/217, U.N. Doc. A/62/217 (Dec. 22, 2007), https://www.unoosa.org/documents/pdf/spacelaw/sd/COPUOS_space_

have been absorbed into national regulations.[37] Therefore, the launch licenses issued by those states for small satellites have the following guidelines for government authorizations to launch:

(a) Limit debris released during normal operations;
(b) Minimize the potential for break-ups during operational phases;
(c) Limit the probability of accidental collision in orbit;
(d) Avoid intentional destruction and other harmful activities;
(e) Minimize the potential for post-mission break-ups resulting from stored energy;
(f) Limit the long-term presence of spacecraft and launched vehicle orbital stages in the LEO regions after the end of their missions; and
(g) Limit the long-term interference of spacecraft and launched vehicle orbital stages with the GEO region after the end of their missions.[38]

Notably, both the IADC and the UNCOPUOS guidelines suggest that debris mitigation steps should be applied by all states voluntarily. In this case, such "voluntary guidelines" are not binding under international law which does not impose any sanctions for enforcement. Consequently, without any legal consequences, states are not obliged to follow the guidelines. The guidelines do not address the remediation of current space debris, which has an enormous capacity to produce additional debris due to fragmentation.

IV. The Satellite Network Service

When small satellite constellations are completed and functional, the traditional firewall systems are ineffectual because most Internet connections exist in a submarine fiber-optic cable network. This network connects the servers and Internet providers of different countries and regions across stretches of oceans and seas. Unlike the cable network, small satellite constellations operate in LEO, facilitating an almost lightspeed data transfer in a space vacuum. Therefore, technically, small satellite constellations will become the direct Internet service provider and bypass

debris_mitigation_guidelines.pdf.

37 *Supra* note 13, at 296.

38 A. de Waal Alberts, *The Degree of the Lack of Regulation of Space Debris Within the Current Space Law Regime and Suggestions for a Prospective Legal Framework and Technological Interventions*, *in* Space Security and Legal Aspects of Active Debris Removal 101 (A. Froehlich ed., 2019).

the firewall. Furthermore, the satellite network could cover anywhere globally, and foreign network providers can provide international network services freely. Countries have typically regulated the flow of information across borders by restricting Internet access, censoring publications, restricting access to airwaves, and controlling domestic printing and broadcasting.[39]

This legal issue is similar to direct television via satellite. Before 1982, direct television via satellite, the so-called Direct Broadcast Satellite (DBS) was emerging, which could reach home television audiences without the cooperation of ground stations under the receiving country's control. At that time, there was a fear that DBS would be abused to export Western culture, ideology, and commercialism to less developed countries.[40] It was perceived that broadcasts from outer space would impact heavily on the economic, social, political, military and cultural outlooks of the residents of Earth.[41]

The issue of the free flow of information was thus raised in the UN General Assembly and has been discussed frequently. The Group of 77, composed mostly of less developed countries of the General Assembly, called for a New World Information Order (NWIO) to redirect the flow of news and information between developed and developing countries. The NWIO is generally linked to three principles:

(a) Developed countries should provide resources to improve their national news media infrastructure so that less developed countries can compete with news media from developed countries;
(b) An international code of professional responsibility should apply to the activities of foreign journalists; and
(c) International news and information should be subject to some form of censorship in order to protect countries from defamatory statements that interfere with domestic or foreign policy and from reporting that is culturally or ideologically biased.[42]

The DBS discussion came to an end in 1982 when the United Nations General Assembly adopted a resolution on direct television broadcasting, namely "Principles

39 J. Paul, *Images from Abroad: Making Direct Broadcasting by Satellites Safe for Sovereignty*, 9 Hastings Int'l & Comp. L. Rev. 329 (1985).

40 N. Lesko, *Legal Implications of Direct Satellite Broadcasting-The UN Working Group*, 6 Ga. J. Int'l & Comp. L. 566-7 (1976).

41 C. Christol, *Prospects for an International Legal Regime for Direct Television Broadcasting*, 34 Int'l & Comp. L. Q. 142 (1985).

42 *Supra* note 39, at 335-6.

for the Use of States of Artificial Earth Satellites for International Direct Television Broadcasting."[43] The 1982 Resolution contains ten principles which are entitled: "Purposes and Objectives,"[44] "Applicability of International Law,"[45] "Rights and Benefits,"[46] International Co-operation,"[47] "Peaceful Settlement of Disputes,"[48] "State Responsibility,"[49] "Duty and Right to Consult,"[50] "Copyright and Neighbouring Rights,"[51] "Notification to the United Nations"[52] and "Consultations and Agreements between States."[53]

There is a similar concern about DBS. Nevertheless, the international community has not yet considered global regime that governs small satellite constellations for providing the Internet access to all areas of the world when the traditional firewall can no longer filter the free flow of content from the Internet. It could raise concerns about sensitive information and national security contents of the receiving countries, such as pornography, racism, and incitement to war. It is also considered that the transmission of Internet signals to a foreign country without its permission constitutes a harmful interference with the telecommunications of the receiving country and is therefore prohibited by the International Communication Union laws and regulations.[54]

V. Radio Frequency Allocation and Harmful Interference

All satellites in outer space need to use orbital slots and radio frequencies to communicate with the Earth station. They are indispensable tools for satellite

43 Principles for the Use of States of Artificial Earth Satellites for International Direct Television Broadcasting, G.A. Res. 37/92, U.N. Doc. A/37/92 (Dec. 10, 1982), https://undocs.org/A/RES/37/92.

44 *Id*. annex A.

45 *Id*. annex B.

46 *Id*. annex C.

47 *Id*. annex D.

48 *Id*. annex E.

49 *Id*. annex F.

50 *Id*. annex G.

51 *Id*. annex H.

52 *Id*. annex I.

53 *Id*. annex J.

54 *Supra* note 38, at 362.

communications and its proper function.[55] Apart from the environmental considerations, these increasing numbers of satellites could lead to congestion in useful orbits and an increased potential for conflict over frequency bands. Because radio frequency is recognized as a limited resource, there is a risk of frequency shortages when more and more satellites are launched.[56] However, the challenges are becoming more evident with the launch of small satellite constellations because the existing resources of the ITU are under-equipped to address these issues. The two primary topics are as follows.

A. Radio Frequency Allocation

The ITU has adopted the concept of equitable access, which is the presumption that each country should have the right to have access to space at all times.[57] This concept is part of Article 44(2) of the ITU Convention. It refers explicitly to the GEO, a circular orbit positioned about 35,786 kilometers above the equator. Since the ITU started to allocate orbital slots and radio frequencies, problems emerged with the first-come, first-served approach. By the time developing countries are able to build the advanced technologies necessary to construct and launch satellites, the GEO would have been overcrowded at the ITU and in space.[58] The special status of the GEO is embedded in Article 44(2) of the ITU Constitution, which provides that all member states should understand that the spectrum of radio frequencies and satellite orbits, including GEOs, are limited natural resources that must be used nationally, efficiently, and economically according to the ITU Constitution. Additionally, the Preamble to the Radio Regulations identifies the same principles. Curiously, Article 44(2) has been interpreted as saying that: "the efficient and economical use of orbits is a prerequisite for achieving the ultimate aim of equitable access."[59]

However, non-geostationary Earth orbit (NGSO) satellites, particularly LEO satellites, are not governed by the idea of an equitable access principle. Rather, these orbits and related radio frequencies and orbital slots are being allocated on a first-

55 R. Jakhu, *Regulatory Process for Communications Satellite Frequency Allocations*, Handbook of Satellite Applications 359 (J. Pelton et al. eds., 2017).

56 M. Morssink, *An Equitable and Efficient Use of Outer Space and Its Resources and the Role of the UN, the ITU and States Parties*, *in* Legal Aspects around Satellite Constellations 7 (A. Froehlich ed., 2019).

57 *Supra* note 8, at 21.

58 M. Cappella, *The principle of equitable access in the age of mega-constellations*, *in* Legal Aspects around Satellite Constellations 18-20 (A. Froehlich ed., 2019).

59 Constitution of the International Telecommunication Union 1992, art. 44(2).

come, first-served basis.[60] The emergence of a small satellite constellation in the LEO would also give rise to similar concerns.

B. Harmful Interference

The ITU is responsible for allocating radio frequency bands and monitoring radio frequency allocations with these objectives in mind. In this case, its purpose is to prevent harmful interference between radio stations in different countries. The avoidance of harmful interference is achieved through processes of allocation and registration of radio frequencies and orbital slots with the ITU. Therefore, the main goals of the ITU's international regulatory regime governing all satellite communications are to avoid harmful interference and to ensure equitable access to radio frequencies and satellite orbital slots.[61]

The ultimate purpose of the ITU Radio Regulations (RR) is to maintain a non-interference environment for the service of satellite network while ensuring rational, equitable, efficient, and economical use of the radio frequency spectrum and satellite orbit resources.[62] The procedure for organizing the use of frequencies is laid down in the ITU RR and consists, in short, of the following steps:[63] (a) Advance Publication Information (API);[64] (b) Coordination with other states;[65] and (c) Notification and recording of the specific frequencies in the Master International Frequency Register (MIFR).[66] This is in accordance with the ITU goals to ensure optimal use and equitable access.

However, the number of satellites in NGSOs is growing dramatically.[67] Because there is an ongoing demand for broadband services, many satellite operators are currently planning to deploy small satellite constellations for broadband communication service in the Ku-, Ka-, and V-band, some of which have already started launching. Consequently, new challenges are expected for increasing potential harmful interference with the existing satellites in Earth's orbit.[68]

60 *Supra* note 58, at 12.

61 *Supra* note 55, at 369.

62 A. Matas et al., ITU Radio Regulations related to Small Satellites 240 (2013).

63 ITU UNOOSA, Guidance on Space Object Registration and Frequency Management for Small and Very Small Satellites 14 (2015).

64 ITU RR regulations (sec. I) art. 9, file:///C:/Users/user/Downloads/ITU%20Radio%20Regulation.pdf.

65 *Id*. (sec. II) art. 9.

66 *Id*. art. 11.

67 S. Tonkin & J. de Vries, *NewSpace Spectrum Sharing: Assessing Interference Risk and Mitigations for New Satellite Constellations* 1 (TPRC 2018), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3140670.

68 C. Braun et al., Should we worry about interference in emerging dense NGSO satellite constellations? 1 (2019 IEEE

VI. Conclusion

To address the legal challenges of the construction and the operation of the small satellite constellations and the sustainability of the peaceful use of outer space as the province of all mankind, the current international space law regime should face challenges in dealing with such a new space activity like small satellite constellations. The possibility of using small satellite constellations to deliver high-speed broadband worldwide creates an opportunity to establish an appropriate legal mechanism to comply with these activities. The existing outer space legal regimes governing space activities are not well-suited to this unprecedented commercial space activity because the drafters created them without knowledge of small satellite constellation systems. The lack of legal clarification is a significant concern and must be resolved as soon as possible. Therefore, through the UNCOPUOS, international cooperation is a critical component to ensuring the long-term sustainability of outer space activities. Action must be taken to regulate the proliferation of small satellite constellations' construction and operation under international legal regimes. The new legal framework will promote the long-term sustainability of space activities for all sectors engaged in the small satellite constellation industry in the future, including States, non-State entities, and private companies.

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