Legal Aspects of Satellite Constellations

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In recent years a few entrepreneurs proposed launching into space large fleets of satellites, consisting of hundreds of satellites, often referred to as 'constellations'. Their role is to provide satellite services to the largest possible number of users on Earth. This article provides a review of key legal issues associated with satellite constellations, including responsibility and liability for potential damages caused by satellites being a part of a constellation, insurance, registration of space objects, allocation of radio frequencies and orbital slots, and space debris.

Keywords: satellite constellations, space law, space insurance, liability, space debris

1 INTRODUCTION

Billions of people around the world rely on satellite infrastructures every day. The satellite applications are used for telecommunication, transportation, agriculture, fisheries, weather forecast, research on space environment, entertainment, military objectives, and many more. Continued economic growth has increased the reliance on satellites and, therefore, the satellite infrastructures are transforming, in order to keep up with the constantly expanding demand. This may lead to the increasing creation of larger fleets, consisting of hundreds or thousands of satellites, often referred to as constellations. The role of these constellations is to provide services to as many users on Earth as possible. Constellations certainly open up many new opportunities but they also give rise to potential risks and legal problems. The latter may include issues around international liability and responsibility for potential damage in space or on Earth, insurance, licensing and registration, allocation of radio frequencies and orbital slots, and even space debris. These are the problems that are the focus of this article.

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2 TERMINOLOGY

The term 'satellite constellation' is not defined in international law. Both academics and practitioners use this term without specifying its meaning as well. According to its ordinary meaning, it refers to a group of artificial satellites cooperating together under common control. The goal of constellations is to cover the largest possible area of the globe. This could have military relevance, e.g. for espionage, in case of military satellites, but it is equally important for civil purposes, e.g. to reach largest number of users for satellite services. Satellites in a constellation are often arrayed and use inter-satellite communication. This is particularly important for satellites that are placed in Low-Earth Orbit (at an altitude of 2,000 km/1,200 mi or less) in order to provide stable and continuous services.[1]

Neither the size of the individual satellites, nor the location of the constellation in space or its purpose seem to have much significance for the definition. However, the question arises whether there should be a certain minimum number of satellites in order to call a group of satellites a 'constellation'. By 2020 one of the smallest groups of satellites was the Earth observation mission called RapidEye, which consisted of five satellites.[2] The largest group was the sixty-six satellites of the Iridium constellation.[3] More recent constellation projects include hundreds and even thousands of satellites. Although the minimum number of satellites does not seem to have any significance at the moment, the different constellations vary dramatically in size. In future this may have an impact on various practical aspects, such as insurance, the allocation of orbital slots and radio frequencies, where large fleets may be treated as a single unit.[4] Thus, practitioners may in future specify a certain minimum number of satellites required to classify the group as a 'constellation'. Interestingly, one such definition has already been implemented. In November 2019 the US Government issued new Orbital Debris Mitigation Standard Practices in which it defines a *large constellation* as 'a constellation consisting of 100 or more operational spacecraft cumulative'.[5]

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1 Inter-Agency Space Debris Co-ordination Committee (IADC), *IADC Space Debris Mitigation Guidelines*, IADC-02-01 (6 Sept. 2007), http://www.unoosa.org/documents/pdf/spacelaw/sd/IADC-2002-01-IADC-Space_Debris-Guidelines-Revision1.pdf (accessed 4 Feb. 2020).

2 N. Crisp, K. Smith & P. Hollingsworth, *Launch and Deployment of Distributed Small Satellite Systems*, 114 Acta Astronautica 66 (2015).

3 More information can be found on the official Iridium website, https://www.iridium.com/company-info/companyprofile/ (accessed 4 Feb. 2020).

4 For the potential impact *see* s. 4 of this article.

5 *See* US Government Orbital Debris Mitigation Standard Practices, Nov. 2019 Update, s. 5-1, at 7, https://orbitaldebris.jsc.nasa.gov/library/usg_orbital_debris_mitigation_standard_practices_november_2019.pdf (accessed 4 Feb. 2020).

3 EXAMPLES OF MULTI-SATELLITE SYSTEMS

The first constellations already appeared in the 1960s. One of the first was the Soviet 'Molniya' (Russian: Lightning) military constellation. The first operational satellite, Molniya 1-01, was successfully placed in orbit in April 1965. The complete Molniya-1 constellation consisting of ten satellites began operating in 1968. The satellites had a lifespan of approximately 1.5 years and so they had to be constantly replaced.[6] Currently, the constellation is used for broadcasting the national television network called Orbit, and the lifespan of the satellites increased to over five years.[7] Also in the 1960s, the United States created the first global satellite navigation system called 'Transit'. The first satellite of the Transit system was launched in 1960, and until 1968 there was a fully functional constellation of thirty-six satellites. Transit operated for twenty-eight years, until 1996, when it was replaced by the US Department of Defense with the Global Positioning System (GPS).[8] In 2020, the GPS consisted of a constellation of thirty-one satellites. Although satellite navigation, like most space technologies, was initially designed to achieve military goals, over time it has become one of the most practical space applications used for civil purposes. Therefore, other states started developing their own constellations used for satellite navigation. Currently operational systems include the Chinese 'Compass' system,[9] the European 'Galileo' system,[10] and the Russian 'GLONASS' system.[11]

The above examples represent government programmes. Over time, non-governmental entities started developing constellations for commercial purposes. One example is Orbcomm, a US based company offering telecommunications and internet services. In 2020 the company had a constellation of

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[6] The lifespan of modern satellites varies; currently it can range from six months to fifteen years. It depends on several factors, including the size of satellite, the orbit, and many more. *See* S. B. Johnson, *Space Exploration and Humanity: A Historical Encyclopaedia* vol. 1, 416 (Greenwood Publishing Group: Santa Barbara 2010); Francis Lyall & Paul Larsen, *Space Law – A Treatise* 89 (2d ed., Routledge 2018).

[7] *See* 'Molniya-1', archival article of the Astronautix portal, https://web.archive.org/web/20080516082459/http://www.astronautix.com/craft/molniya1.htm (accessed 4 Feb. 2020). *See also* Russian Space Web, *Russian Communications Satellites* (27 Feb. 2019), http://www.russianspaceweb.com/spacecraft_comsats.html (accessed 4 Feb. 2020).

[8] Defence Advanced Research Project Agency (DARPA), *Transit Satellite: Space-Based Navigation*, https://www.darpa.mil/about-us/timeline/transit-satellite, (accessed 4 Feb. 2020).

[9] It is known in China as *Beidou*. It consists of twenty-three satellites. *See* more: L. Wang, *Directions 2017: BeiDou's Road to Global Service*, GPS World (6 Dec. 2016), http://gpsworld.com/directions-2017-beidous-road-to-global-service/ (accessed 4 Feb. 2020); G. Yuan, *Sky's the Limit for Beidou's Clients*, China Daily (16 Nov. 2015), http://www.chinadaily.com.cn/bizchina/tech/2015-11/16/content_22464083.htm, (accessed 4 Feb. 2020).

[10] In 2018, Galileo consisted of twenty-six satellites. *See* European Commission, *Space: 26 Galileo Satellites Now in Orbit for Improved EU Satellite Navigation Signal*, EC Press Release (25 July 2018), http://europa.eu/rapid/press-release_IP-18-4603_en.htm (accessed 4 Feb. 2020).

[11] In 2019, GLONASS consisted of twenty-six satellites. *See* the report of the Information and Analysis Centre for Positioning, Navigation and Timing from 21 May 2019, https://www.glonass-iac.ru/en/GLONASS/ (accessed 4 Feb. 2020).

twenty-four first-generation OG1 satellites, and a fleet of sixteen second-generation OG2 satellites.[12] Another example is the Iridium constellation, consisting of sixty-six satellites used for global voice communication and data transfer. The Iridium network is unique because it covers the entire Earth, including polar regions, oceans and airways.[13] Such large constellations are not unique to the United States, as there are examples of companies based on other continents that developed large satellite fleets. One example of a European constellations is 'O3b', operated by SES S.A. based in Luxembourg. The company has a fleet of sixteen satellites designed to transmit voice and data to mobile operators and internet service providers.[14] In Asia, the Japanese SKY Perfect JSAT Group operates a constellation of seventeen satellites for the purpose of communications and television broadcasting.[15]

By 2020, the largest group of satellites was the Iridium constellation. However, the second decade of the twenty-first century brings about much larger projects, often referred to as mega-constellations. These projects consist of hundreds and even thousands of satellites synchronized under common control. For instance, in 2016 China announced its Hongyan (Chinese: 'Wild Goose') communications constellation, consisting of over 300 small satellites to be placed in Low-Earth Orbit.[16] Another project was announced by OneWeb, a company based in the United Kingdom planning to launch over 800 satellites to provide internet services worldwide, especially in places where there is no internet at all.[17] OneWeb launched 74 satellites but it failed to secure new funding from investors and on 27 March 2020 it filed for bankruptcy protection with a pursue to sell its business.[18] However, the largest announced project is by the United States' company SpaceX. In 2016, the company's lawyers filed an application with the Federal Communications Commission[19] for permission to launch about 12,000 satellites as a part of 'Starlink' constellation.[20] In 2018, the Commission approved

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[12] *See* official Orbcomm website, https://www.orbcomm.com/en/networks/satellite/orbcomm-og2 (accessed 4 Feb. 2020).

[13] *See* official Iridium website, https://www.iridium.com/network/globalnetwork/ (accessed 4 Feb. 2020).

[14] *See* official SES website, https://www.ses.com/our-coverage/satellites (accessed 4 Feb. 2020).

[15] *See* official JSAT website, https://www.jsat.net/en/ (accessed 4 Feb. 2020).

[16] A. Jones, *Early Launch Plans for China's Hongyan LEO Communications Satellite Constellation Revealed*, GBTimes (12 Mar. 2018), https://gbtimes.com/early-launch-plans-for-chinas-hongyan-leo-communications-satellite-constellation-revealed (accessed 4 Feb. 2020).

[17] *See* official OneWeb website, http://www.oneweb.world/ (accessed 4 Feb. 2020).

[18] *See* OneWeb Press Release on 27 March 2020 available at: https://www.oneweb.world/media-center/oneweb-files-for-chapter-11-restructuring-to-execute-sale-process (accessed 4 Feb. 2020).

[19] The Federal Communications Commission is an independent agency of the United States government created by statute to regulate interstate communications by radio, television, wire, satellite, and cable; see official website, https://www.fcc.gov/ (accessed 4 Feb. 2020).

[20] S. Kettley, *SpaceX Launch: Elon Musk's 12,000 Satellite Starlink Network Will Beam Worldwide Internet,* Express Online (22 Feb. 2018), https://www.express.co.uk/news/science/919947/space-launch-starlink-satellites-internet-network-elon-musk (accessed 4 Feb. 2020).

the constellation of 4,425 satellites that are intended to provide fast and reliable internet around the world.[21] The first two test satellites called MicroSat-2a and MircoSat-2b[22] were successfully placed in orbit in February 2018.[23] A second set of sixty test satellites were successfully launched on 24 May 2019.[24] Another sixty were placed into orbit on 11 November 2019,[25] and again on 7 January 2020, bringing it to a total number of 182 satellites.[26] Initial commercial operation of the constellation is predicted for late 2020/early 2021.

4 THE LEGAL PROBLEMS

There are certain obvious benefits of having a large satellite constellation, including financial gain, competitiveness, quality of services offered, and the number of customers. In case of satellites related to defence and security, the strategic aspect should also be taken into account. It is therefore likely, for both military and commercial reasons, that the number of satellites in orbit around the Earth will increase. This may lead to certain problems of a legal nature. The most obvious is international responsibility and liability for potential damages caused by satellites. Other key issues oscillate around the insurance, the registration of space objects, the allocation of radio frequencies and orbital slots, as well as space debris. This article considers these issues on the following pages.

4.1 International responsibility and liability

The legal basis for international responsibility and liability in space can be found in the Treaty on Principles Governing the Activities of States in the Exploration and

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21 Federal Communications Commission, *Memorandum Opinion, Order and Authorization in the Matter of Application For Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System* (28 Mar. 2018), FCC 18–38, Call Sign S2983, https://transition.fcc.gov/Daily_Releases/Daily_Business/2018/db0329/FCC-18-38A1.pdf (accessed 4 Feb. 2020).

22 They are also known as *Tintin A* and *Tintin B*.

23 L. Grush, *SpaceX Just Launched Two of Its Space Internet Satellites – The First of Nearly 12,000*, The Verge (22 Feb. 2018), https://www.theverge.com/2018/2/15/17016208/spacex-falcon-9-launch-starlink-microsat-2a-2b-paz-watch-live (accessed 4 Feb. 2020).

24 S. Hall, *After SpaceX Starlink Launch, a Fear of Satellites That Outnumber All Visible Stars*, The New York Times (01 June 2019), https://www.nytimes.com/2019/06/01/science/starlink-spacex-astronomers.html (accessed 4 Feb. 2020); M. Wall, *SpaceX's 60-Satellite Launch Is Just the Beginning for Starlink Megaconstellation Project*, Space.com (24 May 2019), https://www.space.com/spacex-starlink-satellites-launch-just-beginning.html (accessed 4 Feb. 2020).

25 A. Thompson, *SpaceX Just Launched 60 Starlink Satellites (And Nailed a Milestone Rocket Landing)*, Space.com (12 Nov. 2019), https://www.space.com/spacex-starlink-launch-fourth-rocket-landing-success.html, (accessed 4 Feb. 2020); S. Clark, *Successful Launch Continues Deployment of SpaceX's Starlink Network*, Spaceflight Now (11 Nov. 2019), https://spaceflightnow.com/2019/11/11/successful-launch-continues-deployment-of-spacexs-starlink-network/ (accessed 4 Feb. 2020).

26 *See* Official Starlink website, https://www.spacex.com/news/2020/01/07/starlink-mission (accessed 4 Feb. 2020).

Use of Outer Space, including the Moon and Other Celestial Bodies of 1967, also known as the 'Outer Space Treaty' (OST).[27] According to Article VI of the OST:

> States Parties to the Treaty shall bear international responsibility for national activities in outer space (…) whether such activities are carried on by governmental agencies or by non-governmental entities (…). The activities of non-governmental entities in outer space (…) shall require authorisation and continuing supervision by the appropriate State Party to the Treaty.[28]

The matter of liability is regulated in detail in the Convention on International Liability for Damage Caused by Space Objects, also known as the Liability Convention (LC)[29]:

> a launching state shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the Earth or to aircraft in flight.[30]

However, in the event of damage being caused anywhere else, the launching state will be liable only 'if the damage is due to its fault or the fault of persons for whom it is responsible'.[31] The term '*launching state*' means '(i) A state which launches or procures the launching of a space object; (ii) A state from whose territory or facility a space object is launched'.[32]

A key distinction has to be made between the OST and the LC provisions. Under Article VI OST, each state is *responsible* for 'national activities in outer space'. However, under Article VII OST and Article II LC it is the 'launching state' that is *liable* for damages caused by the space object.[33] International responsibility for space activities rests solely on states; and it has to be interpreted in the light of general international law, as a breach of an international obligation arising out of an act or omission and attributable to a state.[34] The main criterion for liability, unlike in case of responsibility, is damage (and its attributability), and its only consequence is the duty to pay for the damage. No fault, either subjective (culpa, intent, negligence), or objective (breach of law) is necessary for liability

27 Adopted by the UN General Assembly in its resolution 2222 (XXI), opened for signature on 27 Jan. 1967, entered into force on 10 Oct. 1967, 634 UNTS 205. By 1 Jan. 2019 it was ratified by 109 States and signed by another 23 States. More on the development of the Space Treaties *see* D. M. Bielicki, *Air Law & Space Law – Historical Aspects and Perspectives for Future*, 63 J. Brit. Interplanetary Soc'y 262ff (2010).

28 Article VI OST.

29 Adopted by the UN General Assembly in its resolution 2777 (XXVI), opened for signature on 29 Mar. 1972, entered into force on 1 Sept. 1972, 961 UNTS 187. By 1 Jan. 2019 it was ratified by ninety-six States and signed by another nineteen States. Moreover, ESA, EUMETSAT, EUTELSAT and INTERSPUTNIK signed a declaration of acceptance of rights and obligations of the Convention.

30 Article II LC.

31 Article III LC.

32 Article I(c) LC.

33 *Handbook of Space Law*, Research Handbooks in International Law, 52 (F. G. von der Dunk & F. Tronchetti eds, Edward Elgar: Cheltenham 2015).

34 *See* Arts 1–3 of the ILC Articles on State Responsibility. *See also* F. G. von der Dunk, *Liability Versus Responsibility in Space Law: Misconception or Misconstruction?*, Proc. Thirty-fourth Colloquium L. Outer Space 366–367 (1992); P. S. Dempsey, *Liability for Damage Caused by Space Objects Under International and National Law*, XXXVII Annals of Air & Space L. 333 (2012).

to occur.[35] Responsibility is borne for 'activities', whereas liability is given for 'damages' caused by space objects.[36] In the context of large constellations of satellites, different states might thus be held responsible from that to be held liable.

Pursuant to Article II LC, a launching state is to be 'absolutely liable', without proof of fault, to pay compensation for damage inflicted on the surface of the Earth, or to aircraft in flight. This is a distinct concept of liability that recognizes situations approved by states (e.g. through licensing process), which may nevertheless present acute and catastrophic danger. Absolute liability is therefore automatic and unlimited, in order to enable full compensation to be made available in ultra-hazardous situations.[37] It seems that only in some exceptional situations the absolute character of the provision can be disregarded, in particular when the victim had a certain impact on their own damage by, for instance, ignoring warnings about an imminent danger.[38] This is contrasted with Article III LC which refers to 'fault liability' in case of damages in outer space. In this case, the launching state is only liable if the damage is due to its fault or the fault of persons for whom it is responsible. The damage caused may apply to a person or an object in space, and may be caused by a functional space object, as well as a non-functional debris.[39] However, in all cases, the causal link between the damage and the space object, and the identification of the launching state(s) of the latter, must be established. Proof of causation may be difficult in some cases of damage in space, especially when the damage was caused by space debris. This also means that incidents caused by debris may not always be dealt with in a satisfactory manner.[40]

By 2020, Article II of the LC, concerning absolute liability, had practical application to two events only. The first took place in January 1978, when Kosmos 954, a Soviet nuclear reconnaissance satellite caused the spread of radioactive debris over a significant, uninhabited area of North-West Canada. Canada demanded compensation from the Soviet Union of more than 6 million Canadian dollars for undertaking operations directed at locating, recovering, removing and testing the debris and cleaning up the affected

35 von der Dunk, *supra* n. 34.
36 S. Hobe, B. Schmidt-Tedd, K-U. Schrogl & G. M. Goh, *Cologne Commentary on Space Law* vol. 1, 104 (Carl Heymamms Verlag: Cologne 2009).
37 *Ibid*, vol. 2, at 121–125.
38 F. G. von der Dunk, *Passing the Buck to Rogers: International Liability Issues in Private Spaceflight*, 86 Neb. L. Rev. 412 (2007).
39 Hobe, Schmidt-Tedd, Schrogl & Goh, *supra* n. 35, vol. 2, at 132–133.
40 Lyall & Larsen, *supra* n. 6, at 100.

areas. The case was resolved by diplomatic means, and the Soviet Union agreed to pay the amount of approximately 3 million.[41] The second event took place a year later. On 11 July 1979, the remains of the American Skylab space station were scattered over Western Australia and the southern part of the Indian Ocean without causing any damage to a person or a property and, consequently, no claims have been made.[42] In case of modern constellations, most satellites are designed to completely burn up as they descend through the atmosphere at the end of their life cycle. However, there is always a risk that a satellite could break up over a populated area. Therefore, it should not be assumed that potential absolute liability is not applicable at all. Article III of the 1972 LC, concerning damage caused 'anywhere else', other than on the surface of the Earth or to aircraft in flight, have not had any practical application yet. However, it is worth mentioning that collisions in space took place but the State Parties to the LC decided not to use the provisions of the Convention. For instance, the biggest collision of two objects in space took place on 10 February 2009. Deactivated Russian military telecommunications satellite Kosmos 2251 and operating American telecommunications satellite Iridium 33 collided 789 km above North Siberia. Both satellites, flying about 11.7 km/s, were destroyed.[43] More recently, on 2 September 2019, European Space Agency (ESA) performed a collision avoidance manoeuvre to protect its Aeolus Earth observation satellite from colliding with a SpaceX satellite in the Starlink constellation.[44] Following this event, ESA announced that it is developing a collision avoidance system that will 'automatically assess the risk and likelihood of in-space collisions, improve the decision making process on whether or not a manoeuvre is needed, and may even send the orders to at-risk satellites to get out of the way'.[45] In case of a damage caused, it is important to identify the state internationally liable for activities carried on by non-governmental entities. International law provides that space activities require 'authorisation and

[41] The claim was based on Art. II of the LC and on General Principles of International Law. *See* more: *Settlement of Claim Between Canada and the Union of Soviet Socialist Republics for Damage Caused by 'Cosmos 954'* (Released on 2 Apr. 1981), http://www.jaxa.jp/library/space_law/chapter_3/3-2-2-1_e.html (accessed 4 Feb. 2020).

[42] Lyall & Larsen, *supra* n. 6, at 106–107. For more space-related cases *see* Damian M. Bielicki, *Evidence from Space in Cases Before International Courts and Tribunals*, in *Outer Space Law: Legal Policy and Practice* 335 ff (Yanal Abul Failat & Anél Ferreira-Snyman eds, Globe Law and Business 2017).

[43] B. Iannotta, *U.S. Satellite Destroyed in Space Collision*, Space.com (11 Feb. 2009), https://www.space.com/5542-satellite-destroyed-space-collision.html (accessed 4 Feb. 2020).

[44] European Space Agency, *ESA Spacecraft Dodges Large Constellation*, ESA Safety & Security (3 Sept. 2019), ttps://www.esa.int/Safety_Security/ESA_spacecraft_dodges_large_constellation (accessed 4 Feb. 2020).

[45] European Space Agency, *Automatic Collision Avoidance*, ESA Safety & Security (22 Oct. 2019), https://www.esa.int/Safety_Security/Space_Debris/Automating_collision_avoidance (accessed 4 Feb. 2020).

continuing supervision' by the appropriate state.[46] Therefore, states require private entities to obtain a license from relevant authorities, prior to their engagement in space activities. They are also required to obtain appropriate insurance cover. These aspects are discussed in the following sections.

4.2 Registration, radio frequencies and orbital slots

The OST requires that space activities carried on by non-governmental entities be 'authorized and continually supervised' by the appropriate State Party to the Treaty.[47] The primary purpose of registration is to assist in the identification of an object, e.g. in case of a collision. It is also helpful for traffic management. Therefore, each object released into space should be registered in at least two of the three available registers. First, each state can have a national registry and, if that is the case, each launching state shall inform the Secretary-General of the UN of the establishment of such a registry.[48] Where there are two or more launching states, they shall jointly determine which one of them shall register the space object.[49] However, states do not always agree on which one should register the object.[50] Moreover, there are many states that do not maintain their own national register.[51] The state on whose registry an object launched into space is carried shall 'retain jurisdiction and control' over such object.[52] Second, space objects can also be registered in one of the two registers maintained by the United Nations. The first one is maintained by the UN Office for Outer Space Affairs (OOSA). It has its legal basis in the UN General Assembly Resolution 1721 (XVI) of 1961 and it contains a list of the objects launched into space.[53] The second is a register of space objects launched into Earth orbit or beyond and it is maintained by the UN Secretary-General in accordance with the Registration Convention of 1975.[54]

46 Article VI OST.
47 *Ibid*.
48 Article II of the Convention on Registration of Objects Launched into Outer Space, adopted by the UN General Assembly in its resolution 3235 (XXIX), opened for signature on 14 Jan. 1975, entered into force on 15 Sept. 1975, 1023 UNTS 15. By 1 Jan. 2019 it was ratified by sixty-nine States and signed by three other States.
49 Article II(1) and (2) *ibid*.
50 Lyall & Larsen, *supra* n. 6, at 79.
51 According to UN OOSA, in 2019 there were only forty States and organizations maintaining their own register. *See* http://www.unoosa.org/oosa/en/spaceobjectregister/national-registries/index.html (accessed 4 Feb. 2020).
52 Article VIII OST.
53 UNGA Res. 1721 (XVI) 1961: *International Co-operation in the Peaceful Uses of Outer Space*, http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/resolutions/res_16_1721.html (accessed 4 Feb. 2020).
54 *See* Arts III and IV of the Registration Convention.

The register enables identification of the 'owner' of a given satellite, which is important in the case of potential liability.

Satellite constellations may lead to more challenges to the registration system, in particular to the way in which satellites are registered. Should each satellite be registered separately? Should a constellation be registered as a single complex space object, or perhaps as a group of interrelated space objects? The current practice is inconsistent. There are examples of satellites belonging to a constellation but registered separately, like in the case of the Navstar satellites that jointly create the GPS system, and the Kosmos satellites that are a part of the Russian GLONASS system. There are also examples of registrations of multiple satellites in one application in the same administrative process, like in the case of Cluster II mission of the ESA, consisting of four satellites (named Rumba, Tango, Salsa and Samba) flying in a close configuration ('cluster') and registered jointly.[55] The UN General Assembly in its resolution 62/101 of 10 January 2008 recommended that:

> in cases of joint launches of space objects, each space object should be registered separately and, without prejudice to the rights and obligations of States, space objects should be included, in accordance with international law, including the relevant United Nations treaties on outer space, in the appropriate registry of the State responsible for the operation of the space object under article VI of the OST.[56]

Additionally, relevant state institutions are responsible for frequency assignment, and for allocating a position in the Earth's orbit.[57] These activities are coordinated by the International Telecommunication Union (ITU), and more specifically by the ITU Radiocommunication Sector, commonly known as the ITU-R. In particular, the ITU allocates orbital positions and coordinates efforts to eliminate harmful interference between stations of different states and private users.[58] Moreover, the ITU-R improves the use made of the radio-frequency spectrum by ensuring their rational, equitable, efficient and economical use.[59]

The ITU registers all frequency assignments in a database called the Master International Frequency Register (MIFR).[60] The MIFR is the final step in the

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55 *See* Letter dated 27 Sept. 2000 from the Legal Adviser of the European Space Agency to the Secretary-General, UN Secretariat Document ST/SG/SER.E/375 of 12 Oct. 2000, https://www.unoosa.org/documents/pdf/ser375E.pdf (accessed 4 Feb. 2020).

56 Paragraph 3(c) of resolution 62/101 of the UNGA: '*Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects*', adopted during 62nd Session of the UNGA, 10 Jan. 2008, A/RES/62/101.

57 Lyall & Larsen, *supra* n. 6, at 241.

58 Articles 1(2) (a) and (b) of the Constitution of the International Telecommunication Union adopted by the 2018 Plenipotentiary Conference, https://www.itu.int/en/history/Pages/ConstitutionAndConvention.aspx (accessed 4 Feb. 2020).

59 Article 12 *ibid*.

60 *See* ITU MIFR, https://www.itu.int/en/ITU-R/terrestrial/broadcast/Pages/MIFR.aspx (accessed 4 Feb.. 2020). *See also* ITU FAQ, https://www.itu.int/net/ITU-R/index.asp?category=information&rlink=faq&lang=en&faq=notification (accessed 4 Feb. 2020).

frequency coordination process and provides legal protection against harmful interference for assigned frequencies.[61] As noted by the ITU, radio frequencies and associated orbits are 'limited natural resources and [they] must be used rationally, efficiently and economically'.[62] Thus their allocation may be problematic in future due to an increasing number of satellites, including large constellations.[63]

In 2019, at the World Radiocommunication Conference (WRC-19) in Sharm El-Sheikh, Egypt, Member States of the ITU established regulatory procedures for the deployment of non-geostationary satellite systems (i.e. below the distance of 35,786 km/22,236 mi) in specific radio-frequency bands and services.[64] Under this agreement, 10% of satellite constellation must be deployed within two years after the end of the current regulatory period for bringing into use, 50% within five years and complete the deployment within seven years.[65] If constellation ventures fail to launch enough satellites by the milestones, or within the total fourteen years allotted, their spectrum rights will be limited proportionally to the number launched before time ran out. According to the ITU, this mechanism will allow the MIFR to reasonably reflect the actual deployment of satellite constellations, and it will improve the functioning of coordination mechanisms. It will help determine which spectrum applicants are truly building and launching satellites, and which are not.[66]

4.3 Space insurance

Space insurance is designed to protect against the financial consequences of losses occurring before, during, and after the launch of satellites. There are two main types of insurance: (1) first-party property insurance, and (2) third-party liability insurance.[67]

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[61] *Ibid.*

[62] Article 44(2) of the ITU Constitution. *See also* the Preamble to the Radio Regulations 2016, http://search.itu.int/history/HistoryDigitalCollectionDocLibrary/1.43.48.en.101.pdf (accessed 4 Feb. 2020).

[63] M. J. Peterson, *International Regimes for the Final Frontier* 194 (State University of New York Press 2005); M. J. Kleiman, J. K. Lamie & M-V. Carminati, *The Laws of Spaceflight – A Guidebook for New Space Lawyers* 118–119 (American Bar Association, Chicago, IL 2012).

[64] *See* ITU Radiocommunication Sector, *Provisional Final Acts of the World Radiocommunication Conference 2019*, Sharm El-Sheikh, Egypt (28 Oct.-22 Nov. 2019), 425–426 (Geneva: ITU 2019), https://www.itu.int/en/ITU-R/conferences/wrc/2019/Documents/PFA-WRC19-E.pdf (accessed 4 Feb. 2020).

[65] Sections 10–11 of the ITU Resolution COM5/7 (WRC-19), *A Milestone-Based Approach for the Implementation of Frequency Assignments to Space Stations in a Non-geostationary-Orbit Satellite System in Specific Frequency Bands and Services*, The World Radiocommunication Conference (Sharm el-Sheikh 2019), CMR19/2000-E.

[66] ITU Press Release, *ITU World Radiocommunication Conference Adopts New Regulatory Procedures for Non-geostationary Satellites: Multiple Satellite Mega-Constellations in Low-Earth Orbit to Provide Extensive Global Telecommunications Coverage* (ITU: Sharm El-Sheikh 20 Nov. 2019), https://www.itu.int/en/mediacentre/Pages/2019-PR23.aspx (accessed 4 Feb. 2020). *See also* C. Henry, *ITU Sets Milestones for Megaconstellations*, Space News (21 Nov. 2019), https://spacenews.com/itu-sets-milestones-for-megaconstellations/ (accessed 4 Feb. 2020).

[67] Miguel Calvete, *Insuring Outer Space Activities*, in *Outer Space Law: Legal Policy and Practice* 143 (Yanal Abul Failat & Anél Ferreira-Snyman eds, Globe Law and Business 2017).

First-party property insurance, also known as material damage insurance, covers physical damage to, or loss of, a space object during its manufacture, pre-launch, launch and whilst it is in orbit. It may involve different parties, including a satellite manufacturer, satellite operator, or a provider of launch services.[68] Third-party liability insurance covers the legal liabilities to third parties for bodily injury or property damage. It is applicable to the situations when the space object is on the ground, during launch or in orbit.[69] There are other variants of these two types of space insurance as well; these may include the service interruption, loss of profit, loss of revenue, and other aspects related to space activities.[70]

If a space activity is carried on by a non-governmental entity, most national laws require from such entities to take out insurance for potential damages caused by their space activities. The main focus of this article is on the relevant legal provisions in the United States[71] and the United Kingdom.[72]

In the United States, the matter is regulated in the US Code: Title 51 – '*National and Commercial Space Programs*'.[73] The entity whose space activities were approved by the Secretary of Transportation (licensee)[74] shall obtain liability insurance or demonstrate financial responsibility 'in amounts to compensate for the maximum probable loss'.[75] In the event of third-party claims for death, bodily injury, or property damage or loss resulting from a space-related activity, a licensee shall obtain insurance or demonstrate financial responsibly of no more than USD 500,000,000.[76] However, the statutory law allows for the government to support space companies and insure through the Federal Aviation Administration up to USD 3.2 billion (as of 2020) – to be adjusted for inflation at time of claim. Additionally, a licensee shall obtain insurance of no more than USD 100,000,000, against 'a person for damage or loss to Government property resulting from an activity carried out under the license'.[77] These amounts are for the total claims related to one launch or re-entry. However, the required amounts can be changed by the Secretary of Transport, after proper consultations with NASA,

68 Lloyd's, *Space Insurance*, available at Lloyd's official website: https://www.lloyds.com/tools-and-systems/risk-locator/class-of-business-guidance/space (accessed 4 Feb. 2020); Marsh, *Space and Satellite Insurance*, available at Marsh's official website: https://www.marsh.com/uk/industries/aviation-aerospace/space-and-satellite-insurance.html (accessed 4 Feb. 2020).

69 *Ibid*.

70 *Ibid*.

71 US Code: Title 51 – *National and Commercial Space Programs*, Subtitle V Pub. L. 111–314— (18 Dec. 2010).

72 Section 4, Outer Space Act 1998 c. 38.

73 51 U.S.C. §70112 (currently §50914), https://www.law.cornell.edu/uscode/text/51/50914 (accessed 4 Feb. 2020).

74 For license application and requirements *see* 51 US Code §50905.

75 US Code, Title 51, Subtitle V, Ch. 509, §50914(a)(1).

76 US Code, Title 51, Subtitle V, Ch. 509, §50914(a)(3)(A)(i).

77 US Code, Title 51, Subtitle V, Ch. 509, §50914(a)(1)(B) and §50914(a)(3)(A)(ii).

the United States Air Force and other relevant agencies.[78] Since the abovementioned amounts are per satellite, potential lower insurance requirements are certainly an important factor for insuring a satellite constellation.

In the United Kingdom the matter is regulated by the Outer Space Act 1986 (OSA),[79] the Space Industry Act 2018 (SIA) and other statutory instruments.[80] The OSA applies to activities carried out by UK nationals and companies outside the UK, while the SIA is the main regulatory framework for all space-related activities carried out in the UK.[81] Both regimes require the licensees to indemnify the UK government against any claims brought in respect of damage or loss arising out of space-related activities.[82] Insurance cover is one of the conditions to obtain a licence. A risk assessment is carried out for each new licence application for a given mission and an appropriate liability limit is determined, which must be specified in the licence.[83] This limit, in most cases, is capped at EUR 60,000,000, along with a third-party liability insurance requirement.[84] However, the UK Space Agency (UKSA) indicates that for low-risk small satellites, it may lower or waive the third-party liability insurance requirement.[85] Therefore, the regulations allow for flexibility in this matter, so insurance can be set at a different level, which can be attractive for the operators of multiple-satellites or small satellite operators.[86] In other words, the UK government can assist the licensee by lowering financial responsibility, and the UK Government would take part of the risk by meeting the remaining liability. Moreover, from 1 October 2018, the UKSA introduced a new approach to the in-orbit third-party liability insurance requirement by changing the 'per-satellite' requirement to a 'per-occurrence' requirement, also known as 'any one occurrence'.[87] For example, when there are multiple satellites of the same standard-mission, the UKSA may allow all of

78 §50914(a)(2) *ibid*. *See also* M. Schaefer, *The Need for Federal Preemption and International Negotiations Regarding Liability Caps and Waivers of Liability in the US Commercial Space Industry*, 33 Berkeley J. Int'l L. 223–273 (2015); M. Tse, *'One Giant Leap [Backwards] for Mankind': Limited Liability in Private Commercial Spaceflight*, 79 Brook. L. Rev. 291–320 (2013).

79 Outer Space Act 1986 c. 38.

80 Section 38 of the Space Industry Act 2018 c. 5.

81 *See* s. 1 *ibid*.

82 Section 10 Outer Space Act.

83 Section 12 Deregulation Act 2015 c. 20.

84 G. Danby, *Outer Space*, Briefing Paper no. CBP 7464 of 10 Mar. 2017, House of Commons Library, at 4.

85 UKSA indicates that a 'low-risk satellite' would be at a 'very low, sparsely-populated altitude, with an orbital lifetime of less than a year and with few high-value assets nearby'. It would, 'in most cases, carry a negligible risk of third-party damage' and, therefore, the UKSA may lower or waive the third-party liability in such cases. *See* UKSA, *Fact Sheet: The UK Space Agency's New Requirements for In-orbit Third-Party Liability Insurance*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/744408/TPL_Insurance_Fact_Sheetsw2.pdf (accessed 4 Feb. 2020).

86 L. J. Smith & R. J. M. Leishman, *Up, Up and Away: An Update on the UK's Latest Plans for Space Activities*, 44 Air & Space L. 18 (2019).

87 *See* UKSA Guidance on Licence to operate a space object, https://www.gov.uk/guidance/apply-for-a-license-under-the-outer-space-act-1986#space-liability-and-insurance-requirements (accessed 4 Feb. 2020). *See also* House of Commons Science and Technology Committee, *Satellites and Space*,

the satellites to be covered under a single EUR 60,000,000 per-occurrence insurance policy. If a certain number of satellites have been launched by that operator, the UKSA may ask to add an aggregate (a limit) to the insurance policy, that is the maximum that an insurer will pay out in total within the policy period.[88] For example, an operator of a satellite constellation may have an insurance policy of EUR 60,000,000 per-occurrence with EUR 200,000,000 in the aggregate, where the latter is the total amount that the insurance company will pay for the policy period.[89] This approach seems to recognize the changes in the space sector and to address industry's concerns, in particular the possibility of launching large constellations of satellites. This can also have a great effect with regard to investment and development of the UK space sector.

4.4 Space debris

Space debris have not been defined in the Space Treaties created under the auspices of the United Nations. The term was defined by ESA as 'non-functional, human-made objects, including fragments and elements thereof, in Earth orbit or re-entering into Earth's atmosphere'.[90] One of the most important institutions coordinating activities related to space debris is the Inter-Agency Space Debris Coordination Committee (IADC). It is an international forum of governmental bodies which in 2020 associated thirteen space agencies.[91] IADC created a similar definition of *space debris*, as follows: 'Space debris are all man made objects including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non functional'.[92] Space debris can be created as a result of a satellite explosions, military tests, collisions with other objects in space, and other events. According to ESA, in 2019 there were over 34,000 objects greater than 10 cm, and

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Third Report of Session 2016–17, 25–26, https://publications.parliament.uk/pa/cm201617/cmselect/cmsctech/160/160.pdf (accessed 4 Feb. 2020).

88 *See* the UKSA New Requirements for In-orbit Third-Party Liability Insurance, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/744408/TPL_Insurance_Fact_Sheetsw2.pdf (accessed 4 Feb. 2020).

89 *Ibid*.

90 Definition provided by the European Space Agency, https://www.esa.int/Our_Activities/Space_Safety/Space_Debris/FAQ_Frequently_asked_questions (accessed 4 Feb. 2020).

91 American NASA (National Aeronautics and Space Administration), British UKSA (UK Space Agency), Canadian CSA (Canadian Space Agency), Chinese CNSA (China National Space Administration), European Space Agency, French CNES (Centre National d'Etudes Spatiales), German DLR (Deutsches Zentrum für Luft- und Raumfahrt), Indian ISRO (Indian Space Research Organisation), Italian ASI (Agenzia Spaziale Italiana), Japanese JAXA (Japan Aerospace Exploration Agency), Russian ROSCOSMOS (Russian Federal Space Agency), South Korean KARI (Korea Aerospace Research Institute) and Ukrainian NSAU (National Space Agency of Ukraine).

92 IADC, *supra* n. 1, para. 3.1.

millions smaller than 10 cm, classified as space debris and circling planet Earth.[93] In the future, satellite constellations may significantly increase the number of objects classified as space debris which can affect the sustainability of space activities. The historical example of the above mentioned[94] collision of deactivated Russian satellite Kosmos 2251 and operating American satellite Iridium shows that the danger is real. Moreover, in this example, both satellites belonged to constellations.

At present, the mitigation of space debris is a matter for voluntary compliance by states with non-legally binding space debris mitigation guidelines.[95] The Space Debris Mitigation Guidelines were adopted by the Scientific and Technical Subcommittee of the UN Committee on the Peaceful Uses of Outer Space (COPUOS) in 2007.[96] They were also endorsed by the UN General Assembly in its resolution 62/217 of 22 December 2007.[97] In 2008 ESA developed its own Requirements on Space Debris Mitigation for Agency Projects. They have since been superseded by the standards developed by the International Organization for Standarization (ISO), specifically the ISO24113 standard on debris mitigation requirements.[98] However, these Guidelines do not explicitly mention the issue of large satellite constellations. In order to fill in the gap, in June 2019 the UN COPUOS adopted 'Guidelines for the Long-term Sustainability of Outer Space Activities'.[99] The term *long-term sustainability* in the context of space activities is defined as:

> the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations.[100]

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93 European Space Agency, *Space Debris by the Numbers*, ESA Safety & Security (Jan. 2019), https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers (accessed 4 Feb. 2020). *See also* ESA's Annual Space Environment Report issued on 17 July 2019, https://www.sdo.esoc.esa.int/environment_report/Space_Environment_Report_latest.pdf (accessed 4 Feb. 2020).

94 *See supra* 4.1.

95 Anél Ferreira-Snyman, *Environmental Responsibility for Space Debris*, in *Outer Space Law: Legal Policy and Practice* 264 (Yanal Abul Failat & Anél Ferreira-Snyman eds, Globe Law and Business 2017).

96 UN Office for Outer Space Affairs, *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space* (UN, Vienna 2002), https://www.unoosa.org/pdf/publications/st_space_49E.pdf (accessed 4 Feb. 2020).

97 Resolution 62/217 of the UNGA: *International Cooperation in the Peaceful Uses of Outer Space*, adopted during 62nd Session of the UNGA (22 Dec. 2007), A/RES/62/217.

98 The standards are available on the official ISO website: https://www.iso.org/standard/72383.html (accessed 4 Feb. 2020). *See also* ESA Safety & Security, *Mitigating Space Debris Generation*, https://www.esa.int/Safety_Security/Space_Debris/Mitigating_space_debris_generation (accessed 4 Feb. 2020).

99 UN COPUOS, *Guidelines for the Long-Term Sustainability of Outer Space Activities*, Annex II of the COPUOS Report of the 62nd Session (12–21 June 2019), https://www.unoosa.org/res/oosadoc/data/documents/2019/a/a7420_0_html/V1906077.pdf (accessed 4 Feb. 2020).

100 Section 5 *ibid*.

The Guidelines specify that the emergence of large constellations may, among other things, affect the long-term sustainability of space activities.[101] They are grouped into four categories: (1) policy and regulatory framework for space activities; (2) safety of space operations; (3) international cooperation, capacity-building, and awareness; (4) scientific and technical research and development. The Guidelines are not legally binding and they provide a recommendation for states and international intergovernmental organizations to take measures voluntarily, through their own national, or other applicable, mechanisms, 'to ensure that the guidelines are implemented to the greatest extent feasible and practicable'.[102]

In 2007 IADC also published a set of Space Debris Mitigation Guidelines but without addressing the issue of large satellite constellations, as this was not yet relevant at the time.[103] In September 2017, the IADC issued an official statement concerning large satellite constellations in Low-Earth Orbit.[104] The Committee drew attention to a number of issues that should be taken into account by both satellite manufacturers and satellite operators. Firstly, in order to minimize the potential risk of collision, the Committee recommends considering an appropriate distance between the various satellites of the same constellation, as well as between different constellations. Additionally, their design should take into account the possibility of manoeuvring.[105] The Committee only mentioned the need of 'sufficient altitude separation' without specifying any buffer zone. Presumably, imposition of a zone would require a technical justification and other considerations. Therefore, these concerns could perhaps be addressed through inter-operator coordination, or through inter-agency cooperation of the states concerned. Secondly, the Committee recommends that the period of use for each satellite should not exceed twenty-five years, after which they should be removed from the orbit around the Earth.[106] Moreover, satellites should be designed in such a way as to increase the probability of their removal from the orbit in case of a failure or termination of the mission.[107] Third, satellites should be designed in such a way as

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101 Section 1 *ibid*.

102 Section 16 *ibid*.

103 IADC, *supra* n. 1.

104 IADC Statement on Large Constellations of Satellites in Low Earth Orbit, ADC-15-03 (Sept. 2017), https://www.iadc-online.org/Documents/IADC%20Statement%20on%20Large%20Constellations%20rev%203.pdf (accessed 4 Feb. 2020).

105 Section 4.2.1 *ibid*.

106 Section 4.4.3 *ibid*. It is worth noting that the UN COPUOS submitted an annual report during 55th Session in which it is stated that this recommendation has not been followed at a satisfactory level and that there is no visible tendency for its implementation. *See* IADC, *An Overview of IADC's Annual Activities*, 55th Session of the Scientific and Technical Subcommittee of the UN COPUOS, 13 (29 Jan.–9 Feb. 2018), https://www.iadc-online.org/Documents/IADC-18-02%20IADC%20Presentation%20to%20the%2055th%20UN%20COPUOS%20STSC%20(2018).pdf (accessed 4 Feb. 2020).

107 Sections 4.2.2, 4.3.1 and 4.3.3 *ibid*.

to minimize the likelihood of an explosion.[108] According to ESA, break-ups, accidental explosions, and other anomalous events are responsible for a significant number of debris in Low-Earth Orbit.[109] In particular, the IADC recommends sound implementation of passivation measures,[110] that is the elimination of all stored energy on a spacecraft or orbital stages to reduce the chance of break-up.[111] Fourth, the Committee recommends increasing the capacity to track and monitor objects in space. Finally, operators should also make any information about trajectory changes publicly available.[112] These are the most important issues that should help avoiding creation of space debris, but the list is not exhaustive.[113] Several states have created internal regulations on space debris, based on the IADC and the UN COPUOS Guidelines.[114]

It is worth noting that new space entrepreneurs seem to take into account space sustainability. For example, OneWeb which was planning to launch a constellation of over 800 satellites, prepared an official statement in which it addressed the issues raised by IADC and pledged to work towards sustainable space exploitation.[115] OneWeb agreed on a number of points raised by the Committee. In particular, it agreed that: large constellations should not overlap in altitude; operators should be able to control the flight paths of their assets; and spacecraft should be disposed of promptly and reliably at the end of their missions.[116] Moreover, OneWeb advocated for implementation of new systems for the sustainability of industry-wide space activities. In particular, the company supported initiatives such as (1) commercial tracking available to all operators; (2) sharing information about owner/operator, satellite status, its manoeuvrability, capability etc.; (3) development and incorporation of anomaly resolution aides; and (4) active debris removal.[117]

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108 Sections 4.3.2, 4.3.4 and 4.4.2 *ibid.*

109 As of Jan. 2019, ESA estimated over 500 of such events; *see* ESA Safety & Security, *Space Debris by the Numbers*, https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers (accessed 4 Feb. 2020).

110 Section 4.3.4 *ibid.*

111 Typical passivation measures include venting or burning excess propellant, discharging batteries and relieving pressure vessels. *See* more: s. 3.4.1. of the IADC Space Debris Mitigation Guidelines.

112 Section 4.3.5 *ibid.*

113 *Ibid.*, at 5.

114 F. Tronchetti, *Fundamentals of Space Law and Policy* 81–82 (Springer 2013).

115 *See* OneWeb, *Thought Leadership in Space Sustainability*, https://www.oneweb.world/assets/news/media/OneWeb_Sustainable_Space.pdf (accessed 4 Feb. 2020).

116 *Ibid.*, at 2.

117 *Ibid.*

5 CONCLUSIONS

The great advantage of using large satellite constellations is their ability to provide services, such as voice communication, data transmission, satellite television and many others, to a great number of potential users. This is especially important in remote or difficult to reach areas. Moreover, such constellations bring other benefits to different actors, including financial benefits manifested in the form of fees and taxes to government agencies and economic development to communities that are able to access the internet and other services.

When considering registration of satellite constellations in a particular state, licensees take into account a number of different factors, including the ease and speed of obtaining permits, the relevant laws and procedures, fees, and location. One of the largest costs that has to be considered is the required insurance cover. In case of large constellations, insurance requirements may fluctuate around an amount that is unprofitable. The UK seems to recognize this problem by introducing per-occurrence insurance with the option to add an aggregate to the third-party liability insurance policy. The UK Government enables and encourages commercial spaceflight activities within a comprehensive, yet flexible, regulatory framework. Such flexibility in the imposition of insurance conditions is to be welcomed for the UK space sector to thrive and expand.

It is worth noting that not all states register their space objects. Some states that actively participate in space exploitation are not parties to the Registration Convention. Moreover, there are many states that do not maintain their own national register.[118] In cases when two or more states are involved in a given mission, they do not always agree on which one should register the object.[119] Registration is of great importance in case of large constellations. Some even suggest that satellites that are launched together and have the same technical characteristics and owner, should be registered together, in one application, in the same administrative process, and not separately.[120] A similar solution could be taken into account in the administrative process related to the issuance of radio frequencies and orbital slots. The processes and regulations shall keep pace with innovations in the space sector.

At present, there are no legally binding provisions that would adequately regulate the matter of space debris. There is no obligation to remove an object from Earth orbit and, therefore, space objects often remain in orbit for many years

118 According to UN OOSA, in 2019 there were only forty states and organizations maintaining their own register. *See* http://www.unoosa.org/oosa/en/spaceobjectregister/national-registries/index.html (accessed 4 Feb. 2020).

119 Lyall & Larsen, *supra* n. 6, at 79.

120 *Ibid.*, at 242.

after they stopped being operations. An implementation of a legally binding provision on international level may turn out to be very difficult, as it requires a compromise and political will of states. Several states have created internal regulations on space debris, based on the IADC and the UN COPUOS Guidelines.[121] Currently, such implementation seems to be the most achievable solution. However, states could perhaps go a step further by requiring, from the applicants during the licensing process, to provide relevant procedures and technical measures preventing harmful interference and congestion in space. This could be one of the necessary conditions to obtain a licence, just like with the current UK requirement for space insurance. Any mandatory measures to mitigate space debris are likely to lead to an increase in the cost of space activities, especially in the context of large constellations. However, the problem of space debris is closely linked to the issue of liability and responsibility and, therefore, an adequate legal protection is in states' direct interest.

[121] Tronchetti, *supra* n. 113, at 81–82.