



The Legal Status of MegaLEO Constellations and Concerns About Appropriation of Large Swaths of Earth Orbit

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Abstract

The emergence and near-term bringing into use of constellations of very numerous satellite constellations raises issues of unwanted and possibly impermissible appropriation of Low Earth Orbit (LEO) or portions thereof. Currently, coordination of orbital “slots” occurs only in the Geostationary Orbit (GSO), and there

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are no restrictive rules preventing individual actors, including both States and private entities, from deploying very numerous spacecraft into LEO. MegaLEO constellations may utilize LEO orbits to such an extent that other actors might be excluded from using these orbits. This chapter will explore explicit rights and obligations, principles of general nature, and economic and political aspects of addressing this emerging issue.

Keywords

Constellations · Global constellations · Kepler Communications · Low Earth Orbit · Megaconstellations · National appropriation · OneWeb · Outer Space Treaty · Small satellites · SpaceX · Space law · Space situational awareness · Space traffic management · Starlink · Telecommunications law

Introduction

The launching of very numerous constellations of small satellites into Low Earth Orbit (LEO) seems promising, but this activity should also give us pause. While spacecraft in LEO may only be operating in space for limited amounts of time, what does it mean to occupy LEO with such overwhelming presence – where spacecraft occupy multiple orbital planes with numerous satellites, and where other potential users of those orbits might not risk trying to share those orbits? International law currently prohibits the appropriation of outer space, whether void space itself or celestial bodies. However, this fundamental principle of space law suits uneasily with the broad freedoms to access, explore, and use outer space, along with the national interests of States to foster domestic industrial space capacity and pioneering space activities.

Normative Background of Space Law Applicable to Satellite Constellations

Constellations of numerous small spacecraft present challenges to the current legal and regulatory regimes governing space activities. However, their emergence will not pose fundamental threats to this regime. From the lawyer's perspective, the major difference between existing space projects and very numerous small satellites projects are the following: these missions use *smaller spacecraft* than the larger, more expensive, and often unique spacecraft of previous decades. These missions involve the use of satellites in *greater numbers* than these previous space activities. These missions are often *cheaper* and *quicker* to develop and execute. Next, these missions are often *in orbit for less time* than traditional space activities. The spacecraft used *may lack propulsion* necessary for on-orbit maneuvers, and/or they *may fail at higher rates* than traditional satellites. Additionally, the organizations and

individuals developing and operating these projects are different than the traditional aerospace companies and large governmental agencies.

In summary, smaller spacecraft deployed; more numerous; cheaper and quicker to get to bring into use; shorter missions; and less capable or reliable spacecraft. Additionally, younger and more diverse teams, in smaller and more agile organizations.

These are the hallmarks of the ongoing small satellite revolution, which has been successful for precisely these attractive qualities. While these differences have interesting and attractive characteristics, such as allowing startups to get to space quicker and cheaper than in previous years, these differences also pose administrative and oversight challenges to regulators, raise difficult questions regarding the interpretation and application of space law, and raise concerns and challenges regarding the long term sustainability of outer space activities. In principle, the legal regime for outer space activities is sufficiently robust to address these innovations. However, the small satellite revolution is one where oversight, control, and space sustainability issues continue to exist.

Various specific space law topics will be discussed in more detail in other chapters, but it is worthwhile to briefly highlight here some basic principles and sources of law which are applicable to large constellations in LEO. While some of these principles may be said to be vague in nature, they are nevertheless applicable and serve as “guard rails” to the use of LEO by any constellations of satellites. These norms comprise the regulatory context for any discussion on whether mega-constellations violate international law by impermissibly appropriating outer space as their own.

Freedom of Exploration and Use

According to the Outer Space Treaty of 1967, States are free to explore and use outer space. Article I of the Outer Space Treaty establishes that States which are party to the treaty are permitted to access, use, and explore outer space, including the Moon and other celestial bodies. Because this is such a fundamental principle of space law, upon which all other obligations and prohibitions are balanced, it is worth quoting in full.

The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.

Outer space, including the Moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.

There shall be freedom of scientific investigation in outer space, including the Moon and other celestial bodies, and States shall facilitate and encourage international cooperation in such investigation.

In many respects, the language of Article I speaks for itself. The second sentence of Article I makes it clear that States are free to access and explore space without first seeking permission from any other State, or group of States, or from the United Nations Security Council, or any other authority or body. That States can freely explore space by themselves was not a foregone conclusion at the dawn of the space age, but was a right, negotiated among them, within the United Nations. First made clear by a lack of international resistance to the USSR's launch of *Sputnik-1*, this right to unilaterally access space was then enshrined in a declaration of principles at the United Nations in the early 1960s and then finally made a clear and explicit right under binding international treaty law with the Treaty on the Principles Governing States on the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies (also known as the "Outer Space Treaty") This treaty was negotiated at the United Nations in 1966, opened for signature in January 1967, and came into force in October of 1967. As of 2019, the Outer Space Treaty has a total of 110 States Party to the treaty (UNOOSA 2019a), including all of the other large historical space powers, emerging space powers, and many States just entering into space activities.

It is worth noting that the subject of the first sentence is "the exploration and use of outer space," rather than merely "outer space," which is deemed to be "the province of all mankind." As we shall see in the Outer Space Treaty's Article II, outer space does in fact not belong to anyone. Conversely, nor is it the property of everyone collectively. Rather, States are free to access, explore, and use it — provided such activity conforms with any and all other applicable rights, obligations, and prohibitions in international law.

Nonappropriation

Article II of the Outer Space Treaty contains the famous, or possibly infamous, prohibition on national appropriation. Just a short 30 words long, this article has caused decades of debate regarding its interpretation and application.

Outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.

This bold sentiment, that outer space is simply not a permissible subject for national appropriation, was present in even the very first discussions on outer space at the United Nations level. One of the earliest UN General Assembly resolutions on space, General Assembly Resolution 1721 A and B (XVI) of December 20, 1961, entitled 'International cooperation in the peaceful uses of outer space', first announced this principle. In 1963, the UN's Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, which is seen as a draft precursor of the binding Outer Space Treaty negotiated just a few years later, again reiterated this principle of nonappropriation.

This prohibition, placed on States, essentially means that outer space – both void space and celestial bodies – cannot be lawfully appropriated as some sort of extraterrestrial territory ripe for annexation and possession. Drafted in an era of both Cold War tensions and rapid global decolonization, the major space powers did not want to kick off a new colonial land grab for territory outside Earth’s atmosphere. Historically, unilateral sovereign claims of territory were a legitimate method for expanding a State’s territory. However, such a rush to claim territory on, say, the Moon, might trigger tensions between space powers. It was better to simply say that outer space, whether it be particular celestial bodies or even particular orbits, cannot come under the direct, permanent territorial sovereign possession of any single State.

Beyond that, the nuances of this article are frankly unclear, especially in its implementation on particular activities and on how it applies to modern and emerging space missions. Some clarity is necessary regarding the structure of the phrases, however. Pared down to its subject, verb, and direct object, the sentence states that outer space (the subject) is not subject to (verb) national appropriation (direct object). From there, it lists ways that outer space is not subject to national appropriation: claims of sovereignty, by means of use, by means of occupation, or, indeed, by any other means. In other words, there is no lawful, permitted means which will legitimize the national appropriation of outer space, as space is not “subject to” or capable of “national appropriation.” The list ends with the inclusive “by any other means,” as a kind of a capstone to the sentence, just to make it clear that the listing of actions is not exhaustive and to prevent any loopholes. It is used out of an abundance of caution, to make it clear that outer space cannot be brought under the sovereign domain of any State, and that no State may claim exclusive rights in these areas. Consequently, there is no way for a State to appropriate space, or subsets of space, such as locations on celestial bodies or particular trajectories or orbits. Whatever they do, it does not constitute appropriation that will be recognized.

The Outer Space Treaty was negotiated on behalf of the United States of America by Ambassador Arthur Goldberg. When the treaty was finalized within the UN, and then opened for States to sign, Ambassador Goldberg returned to Washington D.C. to testify before the US Senate as to its worthiness as a treaty (US Senate 1967). In explaining Article II to the Senators before him, the following exchange occurred.

Mr. GOLDBERG: Article II is a statement that outer space is not subject to national appropriation by means of sovereignty, by means of use or occupation or by any other means, which means that outer space is the province of mankind. It is complementary to article I.

The CHAIRMAN: Any further questions?

Senator CHURCH: It cannot be claimed for Ferdinand and Isabella.

Mr. GOLDBERG: That is correct.

This brief exchange seems to reflect the limited extent of investigation that State legislators, in considering whether or not to ratify the treaty, investigated the limits of

the prohibition on appropriation in Art. II. It seemed evident to them that the provision was meant to oppose and formally ban State appropriation of outer space.

As Article II follows directly from Article I in any direct reading of the Outer Space Treaty, the freedoms of Article I would be foremost in any readers mind when they arrived at their understanding of Article II, and logic seems to dictate that these two articles were meant to be read and applied in an internally consistent and coherent manner. This investigation as to the intent of the drafters and negotiations of Article II's prohibition on national appropriation is relevant to today's constellations of numerous satellites as it forms the normative background for these activities.

Registration

A requirement placed on States active in space is that they notify the United Nations about these activities, as well as list them on their own national registry. International registration is the expression of a desire for openness and international awareness about what objects are in outer space, where they are, where they are launched from, and what they are doing. Conversely, national registries of space objects is linked to States seeking to assert their sovereign jurisdictional powers over objects (and personnel thereof) which are physically outside of their territory.

International Registration

The United Nations Office for Outer Space Affairs (UNOOSA) keeps two international registers for objects launched into outer space. One is older and kept pursuant to UN General Assembly Resolution 1721, from 1961. A separate one was created pursuant to the 1975 Registration Convention. The explanation for the existence of two registers is that the 1961 resolution is not mandatory; it is a recommendation from the UN General Assembly to UN Member States. Conversely, registration pursuant to the 1975 Registration Convention is mandatory for States which are party to that Treaty. In practice, however, the registers are very nearly identical. States which are not party to the Registration Convention – and are therefore not compelled to registry with the UN – still register with the UN pursuant to the Resolution 1721. UNOOSA maintains an online index of space objects listed on its register, as making information of this sort available online furthers the purpose of having an international register – namely, transparency and public awareness about what is actually in outer space (UNOOSA 2019a).

National Registration

Another type of registry exists, and for different purposes and maintained by different actors. States themselves keep national registries of their launched space objects. This is done as a consequence of Article VIII of the Outer Space Treaty, which grants them the right to assert legal jurisdictional authority of those space objects.

A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body. Ownership of objects launched into outer space, including objects landed or constructed on a celestial body, and of their component parts, is not affected by their presence in outer space or on a celestial body or by their return to the Earth.

This is more important than it may appear. Remember that Article II severely limits State sovereignty in space. How can States have any legal authority over things that they launch to space, if there is no sovereignty there? Article VIII permits this exercise of a State's jurisdictional powers in an extraterritorial manner by creating a link between a national registry and the treaty right. The article creates an internationally recognized mechanism for asserting jurisdiction (a component of sovereignty) into outer space. Consequently, States have a right to assert jurisdiction over their space object. This is important to keep in mind as this right is then balanced with the obligations of international responsibility, duty of obligation and supervision, and duty of compliance, as discussed below.

National Responsibility for National Activities, Whether Governmental or Nongovernmental (Private)

Crucially relevant to the legal status of satellites constellations and the concerns about appropriation are the unique and onerous obligations placed upon States regarding private activities and enterprises in outer space. In international law, the subject (or actors) which are bound by international law are sovereign States. States are the principal entity of the international political order. More recently, international organizations such as the United Nations, the European Union (EU), the International Committee of the Red Cross and Red Crescent (ICRC), and other organizations are also bound by the international law. In this sense, they are considered the "subjects" that international law regulates. However, the substance of international law can address many various activities. The subject matter or the "objects" of international law can be wide and diverse and include organizations of individuals and institutions, such as corporations, and even individuals. As such, international space law can impose norms for private actors such as corporations.

International Responsibility

Most international law does not make States responsible for the actions of private individuals. This is not the case in space law. Article VI of the Outer Space Treaty places the responsibility and even liability of private actors firmly upon the shoulders of States.

States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty.

Authorization and Continuing Supervision

The second sentence of Article VI then gives States a positive obligation to undertake authorization and continuing supervision of nongovernmental entities.

The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty.

Consequently, it is not merely sufficient that governments allow private actors to access and explore space. States have a duty to authorize and supervise them. Looking again at the first sentence of Article VI, above, gives some indication as to what standard this supervision must meet. The first sentence of Article VI ends with "... and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty." Consequently, States must authorize and supervise private entities to make sure that these private entities conform with the Outer Space Treaty.

Additionally, Article III of the Outer Space Treaty creates a link between the treaty and the rest of international law, including the UN Charter. Therefore, and to the extent that other sources of international law create norms applicable for private entities in outer space, all national activities – including private, nongovernmental activities – must conform with said laws. Some of these other sources include the other UN treaties on outer space, such as the 1968 Astronaut Rescue and Return Agreement, the 1972 Liability Convention, and the 1975 Registration Convention. Other specialized treaties on outer space, like the international telecommunications regime of the International Telecommunications Union Convention and Constitution, international environmental law, international humanitarian law, and other special regimes also form the rest of the normative order for outer space.

Potential Liability

Supplemental to international responsibility for acts in space committed by private entities is the potential for liability for damage resulting from their activities. Article VIII of the Outer Space Treaty establishes a liability provision, and the 1972 Liability Convention expands the mechanisms for dealing with liability claims. Liability is a requirement to pay compensation to an injured party for the damage or suffering that has been caused to them. In space law, liability is for physical damage to a space object by another space object. These provisions on liability have not yet been enforced relating to any actual claims of damage in space. However, and just like the obligation to be internationally responsible for private actors mentioned in Article VI, the potential for liability serves as a strong motivator and incentive for States to oversee, monitor, and regulate what private actors are doing in space.

Due Regard

Article IX of the Outer Space Treaty creates some interesting and unsettled normative principles guiding space activities. And while the treaty uses the word States as the entity that it is addressing, it is important to remember Article VI. As a consequence of Article VI, the behavior of private entities is also bound by the terms of the treaty. The first sentence of Article IX creates obligations placed upon States to show due regard to the corresponding interests of others active in space, and to abide by general principles of cooperation and mutual assistance.

In the exploration and use of outer space, including the Moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of cooperation and mutual assistance and shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty.

It must be admitted that these obligations are of a general nature. What the principles of cooperation and mutual assistance mean is not explicitly defined in the treaty, and no real examples are given. Similarly, the due regard obligation is not refined further.

Perhaps looking elsewhere into the Outer Space Treaty gives some examples. Elsewhere in the treaty, Article V talks about rendering assistance to astronauts. This assistance be seen as adhering to the principles of cooperation, mutual assistance, and due regard to the activities of others. The notification measures (international and national registration) also show a certain amount of regard for others.

Frequencies and Orbits

To also understand these obligations of cooperation, mutual assistance, and due regard, we can look to the actual history of space activities and see what States have, for themselves, determined to be its requirements. Even since before the Outer Space Treaty came into force, States were abiding by the requirements of coordinating frequencies and orbital positions – as internationally governed by the International Telecommunications Union (ITU), and administered by national frequency administrators, such as the Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA) in the United States of America, or by the Office of Communications (Ofcom) in the United Kingdom. The coordination of frequencies is to prevent harmful interference between users of space systems – as each and every satellite must communicate on frequencies along the electromagnetic spectrum, and these frequencies must be coordinated between users.

Additionally, Earth's Geosynchronous orbit (GSO) is both of intrinsic value and is of a limited nature, so the coordination of orbital "slots" is necessarily required. That this coordination happens successfully across the world on an international and domestic basis is certainly a great example of cooperation, mutual assistance, and of due regard to the corresponding interests of other States.

Space Debris

We can also look at the growing coordination around space debris. Here, space agencies and the scientific community have pooled their expertise and reflected on the growing issue of space debris, especially in lower orbits and other useful orbits. First with the Inter-Agency Space Debris Coordination Committee (IADC) and later at the multilateral level within COPUOS, the development of space debris mitigation guidelines reflect strongly show a due regard to the interests of others, and a spirit of cooperation in their development and observance.

Much more could be written about how the principles of cooperation, mutual assistance, and due regard has developed along various fields of space activities in the previous decades. In sum, they show that States often observe these general principles, and in a manner dependent on the issue at hand (frequency and GEO orbit coordination, space debris mitigation) and in various other manners, including national implementation of previously agreed standards at the international level.

Harmful Contamination

The second sentence of Article IX prohibits the harmful contamination of outer space and celestial bodies and requires that States shall adopt appropriate measures to fulfill this requirement.

States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose.

Again, and like previous principles, harmful contamination is not defined or made clearer with an example. However, and linked with the obligation of due regard, the mitigation of space debris is a concrete example of what contamination of space is considered to be.

International Governance for the Geostationary Orbit

Headquartered in Geneva, Switzerland, the International Telecommunications Union (ITU) coordinates the use of usable portions of the electromagnetic spectrum, and the use of orbital allocations (“slots”) at the Earth’s Geostationary Orbit (GEO) at 35,786 km above the Earth’s equator. ITU coordination is designed to foster the rational, equitable, efficient, and economical use of these resources. Both usable portions of the spectrum and orbital locations are regarded as limited resources, and these limited resources require coordination between actors. Consequently, there is weight given to those who first apply for rights according to a “first come, first served” basis. However, there is also respect given to potential future users. This

balancing of present users with future users is difficult, but it ensures that no State or other actor can rush to seize orbital or spectrum resources.

For the purposes of ITU orbital allocations, there are only two categories of spacecraft: Geostationary (GSO) and Non-Geostationary (NGSO). Currently, the ITU only coordinates GSO. Because of the limited and unique nature of these positions in GSO, coordination there has long been regarded as a necessity. Current capabilities dictate that there are only about 1800 orbital “slots” at GSO. Consequently, GSO is relatively well ordered, especially when compared to other orbits (as shown in Fig. 1 below). It may develop that other orbits closer to Earth may one day soon require coordination, but this is currently not done.

It should also be noted that the orbital “slot” given to users at GSO is a relatively small, three-dimensional “box” in space in which to operate. These slots are therefore quite different from the multiple orbital planes of numerous satellites to be used by constellations (called orbital “shells”), which essentially envelop the entire Earth inside them. The ordered GSO region is in stark contrast to LEO and Medium Earth Orbit (MEO), where satellites owned by many users and for many different purposes are travelling in periodic transits around the Earth, where congestion and the risk of collision persist and are increasing, and where rules on the use and governance of these regions are lacking much specificity.

National administrators of frequencies, such as the Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA), which administer commercial and governmental frequencies, respectively, grant licenses to operators in conformity with their interpretation of their international obligations under space law, including both the Outer Space Treaty and the regime of the ITU. To date, the granting of licenses for constellations has progressed without any noticeable qualms about these constellations.

MegaLEO Constellations

In light of the foregoing governance regimes, comprised of rights, obligations, and principles, there remains a lack of clear limits to the extent that constellations can be deployed and operated in increasingly valuable and congested orbits. Recent estimates for various commercial constellations in LEO give pause and should provoke caution. The SpaceX Starlink constellation is currently envisaged to consist of nearly 12,000 satellites in LEO by the mid-2020s, although recent filings for frequencies for an astounding potential 30,000 possible additional satellites (Henry 2019) would bring SpaceX’s constellation to a truly mind-boggling 42,000 spacecraft in total. OneWeb’s constellation is planned for 2000 satellites. Amazon’s Kuiper system will constitute 3000 satellites. These three planned systems alone total around 17,000 new spacecraft placed into Earth orbit over the next decade. To put this in perspective, the UNOOSA online index of objects launched into outer space lists slightly less than 5300 objects currently in Earth orbit (as of the time of writing) (UNOOSA 2019a). It is true that these constellations may likely bring many benefits to society.

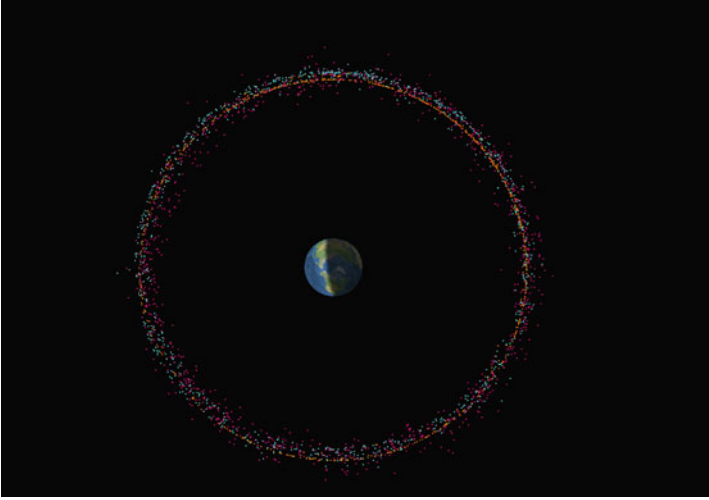


Fig. 1 The relatively well-ordered orbital regime of the Geostationary Orbit (viewed from above), as coordinated by the International Telecommunications Union (ITU). (Image with permission of Moriba Jah, University of Texas at Austin, <http://astria.tacc.utexas.edu/AstriaGraph/>)

It is also fairly certain that, in regards to outer space activities, the era of constellations will be an entirely new and unprecedented era of space activity.

SpaceX Starlink

SpaceX is one of the most visible companies with plans to create a large constellation of small satellites for commercial purposes. The SpaceX Starlink constellation is envisioned as a constellation of small satellites (227 kg/500 lbs) to provide low latency Internet services from space. The value proposition for Internet from space is twofold: faster times than terrestrial fiber optic cables is tremendously attractive to some clients, and wider access to Internet for rural and developing States is also an attractive market. Consequently, Internet from space using a constellation of small satellites is seen as a commercially attractive and achievable endeavor.

The Starlink constellation will actually be comprised of many satellites at different altitudes. According to at least one version of their constellation, based on applications to the US Government, Starlink is envisioned as 1584 satellites at 550 km altitude; 1600 satellites at 1110 km, 400 satellites at 1130 km, 375 satellites at 1275 km, and lastly, 450 satellites at 1325 km. That plan would therefore envision a total of 4409 satellites during its first phase and will grow to (as mentioned above) an envisioned 12,0000 satellites by the middle of the 2020s. In July 2019, SpaceX launched the first 60 satellites which will comprise Starlink. The effect on ground based astronomy from the Starlink satellites was almost immediate, and shocking. Within hours, the Starlink deployment was affecting ground based astronomy and the astronomical community was noticing and discussing the situation.

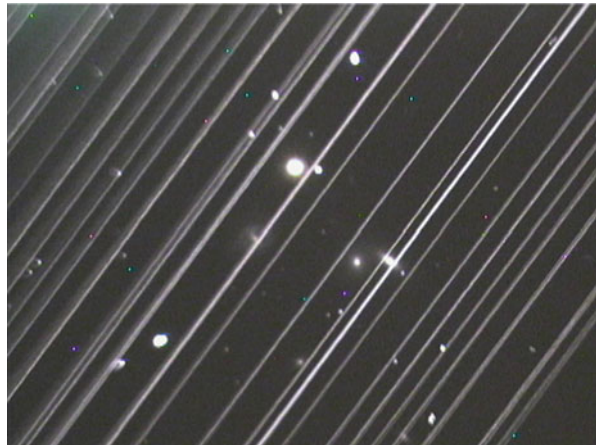
From the Earth and to the naked eye, viewing them in real time, the Starlink satellites appeared to be in a straight line. Figure 2 shows the satellites before they were moved up to a higher orbital altitude and thus became dimmer to the naked eye. This unprecedented sight is noteworthy and unique, like something out of a science fiction movie. Many found it a startling sight.

To ground based astronomers peering much further beyond this stream of satellites, Starlink obscures distant objects behind them. Figure 3 shows the effects of the Starlink satellites over the course of a 25 s exposure looking at the distant galaxy NGC 5353, now obscured in the background. Even nonastronomers should be able to get a feel for the impact that these constellations might have on astronomy, especially taking into account the large numbers of satellites proposed, and of the low altitude of their orbits.

Fig. 2 The SpaceX Starlink satellites seen from the ground 22.5 h after launch. (Image: Marco Langbroek, Leiden, the Netherlands; <https://vimeo.com/338361997>)



Fig. 3 SpaceX Starlink satellites passing through the ground based observation of the distant galaxy NGC 5353 on May 25, 2019. (Image with permission of Victoria Girgis/ Lowell Observatory)



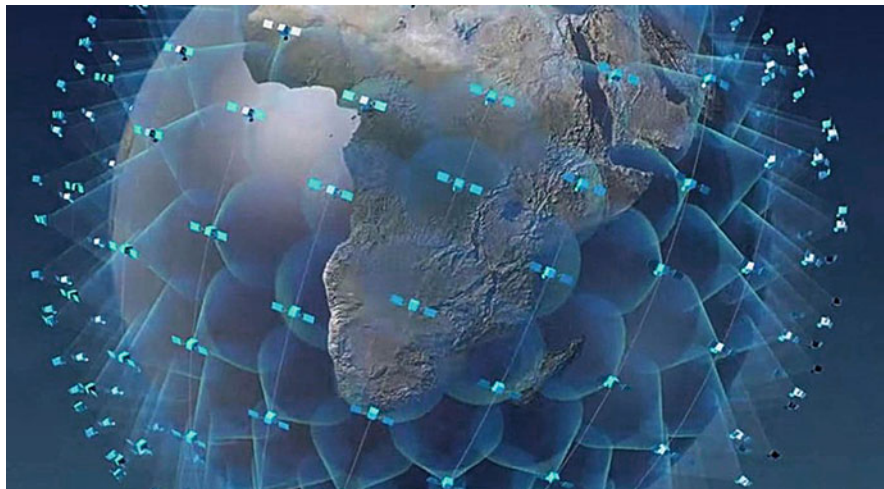


Fig. 4 OneWeb representation of its LEO constellation, upwards of 600 satellites at 1200 km in 24 individual orbital planes. One Web Small Satellite constellation (Graphic courtesy of One Web)

Of this initial deployment of 60 satellites in the Starlink formation, it was later announced that three spacecraft have ceased to operate (Foust 2019). This high failure rate should also be considered in weighing Starlink's observance and adherence of international space law.

OneWeb

OneWeb has proposed and is planning to deploy another satellite constellations, also for Internet from space, and especially aimed at delivering Internet services to people in underserved communities such as in the Arctic. The proposals for the OneWeb constellation are envisioned as 49 satellites (plus on-orbit spares) in 12 individual orbital planes at 1200 km altitude. At close to 600 satellites, this is also a serious deployment of satellites (Fig. 4).

In 2017, OneWeb announced that they were increasing this proposed 600 satellites with an additional 2000 more, which they have already secured the orbital rights for (Pultarova and Henry 2019). This plan would bring their total to 2620 potential OneWeb satellites.

Amazon, Teleset, Boeing, and Other Proposed Constellations

The particulars of the plans listed above will undoubtedly be updated and change. Additionally, other constellations are currently proposed by Amazon, LeoSat, SES, Kepler, and Telesat. Others will follow. Leosat has announced a constellation of 84

spacecraft, and Telesat plans for 300 (Pultarova and Henry 2019) (Werner 2019). Kepler Communications has plans for a constellation of up to 140 satellites between 500 and 600 km altitudes, in 7 orbital planes.

Are Constellations Appropriation?

The astronomy community has already voiced concerns about the impact that constellations will have on astronomy (AstronomyNow 2019). Constellations also bring potential risks from space debris and radiofrequency interference, both of which will have an effect on space sustainability. Starlink's 1584 satellites in the 550 km region would effectively triple the number of satellites in the 400–600 km region, for example.

Leaving these important concerns aside, constellations should also be considered in the context of their general legal status – and specifically whether large swaths of Low Earth Orbit are being impermissibly claimed and possessed by individual actors (whether the commercial actor itself, or by the authorizing national government).

For example, and as mentioned above, the OneWeb constellation will be in 12 orbital planes at 1200 km. Phase 1 of the SpaceX Starlink constellations will fly 66 satellites in 24 orbital planes, for a total of 1584 satellites in its initial constellation.

Do these megaconstellations constitute an impermissible appropriation (or ownership) of particular regions of outer space? Without offering a definitive conclusion, the following sections first argue why, and then why not, these large constellations in LEO constitute impermissible appropriations of sections of outer space. The reader can consider for themselves which of the following opposing arguments they find more convincing.

Yes, This Is Impermissible Appropriation

Article II of the Outer Space Treaty, discussed above, is clear on the point that the appropriation of outer space, including the appropriation of either void space or of celestial bodies, is an impermissible and prohibited action under international law. No means or methods of possession of outer space will legitimize the appropriation or ownership of outer space, or subsections thereof.

Excludes Others

The constellations above, because they seem to so overwhelmingly possess particular orbits through the use of multiple satellites to occupy orbital planes, and in a manner that precludes other actors from using those exact planes, constitute an appropriation of those orbits. While the access to outer space is nonrivalrous – in the sense that anyone with the technological capacity to launch space objects can therefore explore space – it is also true that orbits closer to Earth are unique, and when any actor utilizes that orbit to such an extent to these proposed constellations will, it means that other actors simply cannot go there.

To allow SpaceX, for example, to so overwhelmingly occupy a number of altitudes with so many of their spacecraft, essentially means that SpaceX will henceforth be the sole owner and user of that orbit (at least until their satellites are removed). No other actors can realistically expect to operate there until that time. No other operator would dare run the risk of possible collision with so many other spacecraft in that orbit. Consequently, the sole occupant will be SpaceX, and if “possession is 9/10th of the law,” then SpaceX appears to be the owner of that orbit.

Done Without Coordination

Additionally, SpaceX and other operators of megaconstellations are doing so without any real international conversation or agreement, which is especially egregious and transgressive of the norms of outer space. Compared to the regime for GSO, as administered by the ITU and national frequency administrators, Low Earth Orbit is essentially ungoverned, and SpaceX and others are attempting to seize this lack of authority to claim entire portions of LEO for itself; and before any international agreement, consensus, or even discussion is had. They are operating on a purely “first come, first served” basis that smacks of unilateralism, if not colonialism.

Governments Are Ultimately Implicated

As we know, under international space law, what a nongovernmental entity does, a State is responsible for. Article VI of the Outer Space Treaty requires that at least one State authorize and supervise its nongovernmental entities and assure their continuing compliance with international law. As such, the prohibition on nonappropriation imposed upon States under Article II of the Outer Space Treaty applies equally to nongovernmental private entities such as SpaceX.

Nevertheless, through the launching and bringing into use of the Starlink constellation, SpaceX will be the sole occupant, and thereby, possessor, both fact and in law, of 550 km, 1100 km, 1130 km, 1275 km, and 1325 km above our planet (or whatever orbits they finally come to occupy). The same is true for the other operators of these large constellations which will be solely occupying entire orbits.

Long-Term Occupation Constitutes Appropriation

These altitudes are additionally significant, as nonfunctional spacecraft in orbits lower than around 500 km will re-enter the Earth’s atmosphere in months or a few years, but the altitudes selected for the Starlink constellation, while technologically desirable for their purposes, also mean that any spacecraft which are not de-orbited from these regions may be there for decades, or possibly even hundreds of years. By comparison, the granting of rights for orbital slots at GSO is in 15-year increments, a length of time much less than what the altitudes of the megaconstellations threaten. Such long spans of time at these altitudes by these megaconstellations further bolster the contention that this occupation rises to the level of appropriation of these orbits.

Prevents Others from Using Space

Article I of the Outer Space Treaty establishes that the exploration and use of outer space is “the province of all mankind.” It further requires that this exploration and

use shall be by all States “without discrimination of any kind, on a basis of equality and in accordance with international law. . .” However, when one private corporation so overwhelmingly possesses entire portions of outer space, their use is discriminatory to other potential users and interferes with their freedom to access, explore, and use outer space. So long as these actors are so dominantly possessing and occupying those orbits, their actions exclude others from using them. What other operator would dare use orbits where there are already hundreds of satellites operating as part of a constellation? It would be an extremely unwise and risky decision to try to share these orbits with a mega constellation, so they will likely choose other altitudes and orbits. This massive occupation of particular orbits effectively defeats others from enjoying the use of outer space. While a State can issue permits for one of its corporations allowing them to launch and operate satellites to this extent, that does not automatically mean that their activities in outer space, an area beyond national sovereignty, are therefore in perfect accordance with the strictures of international law. Indeed, national permissions offer no such guarantee.

No Due Regard for Others

That these megaconstellations violate the prohibition on appropriation in Article II is additionally supported by Article IX of the Outer Space Treaty. Article IX requires that in the exploration and use of outer space, States “shall be guided by the principle of cooperation and mutual assistance and shall conduct all their activities in outer space. . . with due regard to the corresponding interests of other States. . .” There is hardly any way to view this deployment of megaconstellations as showing any type of due regard to the corresponding interests of others. This lack of regard further supports the notion of their unilateral transgressive violations of the purposes of space law norms.

Harmful Contamination

The impacts of the spacecraft on the pressing issue of space debris need not be gone into detail here. Suffice it to say, megaconstellations threaten mega-debris. The failure rate of these comparatively cheap satellites should give pause, because if 5% of a constellation of 100 satellites fails, this is 5 guaranteed new pieces of debris intentionally introduced to the fragile space domain. Article IX of the Outer Space Treaty warns of harmful contamination of the space environment and requires States to take appropriate measures to prevent this harmful contamination. A responsible government could not, in all seriousness, permit the intentional release of such amounts of space debris, especially in the already fraught orbits that many megaconstellations are headed towards.

While the threat of space debris is not directly relevant to the accusation of appropriation of outer space, it goes towards the argument that these actors are conducting activities in a manner lacking in regard to others, and in fact, amounts to excluding others from using the space domain. By excluding others, this has the effect of taking orbits for themselves, which IS occupation.

If This Isn't Appropriation, Then What Is?

Arguing in the alternative, if these megaconstellations — in their dominant occupation of entire orbits in orbital planes with numerous satellites — could be considered (merely for the sake of argument) to not be appropriation, we must therefore ask: what *would* be appropriation? What use of void space, including orbits of the Earth, would constitute actual appropriation? What further, additional fact of these uses of space, if added to the scenario, would cause that constellation to cross over the line into clearly prohibited appropriation? Perhaps the exact same scenario, but supplemented with an actual, formal claim of sovereignty, issued by a government, is the only element which could be added to megaconstellations which would then cross the threshold into appropriation. However, a formal claim of sovereignty would be merely an act occurring on Earth and would not change any actual facts in the space domain. Consequently, the lack of a formal claim of sovereignty should not be the deciding criteria in arriving at the conclusion that megaconstellations constitute appropriation of orbits.

Conclusion

In conclusion, these megaconstellations effectively occupy entire orbital regions with their vast fleet of spacecraft and in so doing effectively preclude other actors from sharing those domains. They have done so, or are attempting to do so, without any international consensus or discussion, which is most egregious for a domain outside of State sovereignty and which no State can own. Governments will ultimately be responsible for this appropriation, and both are prohibited from appropriating space. In distinction to GSO, their permission to go there means that they could occupy these regions for incredibly long periods — which again shows their appropriation. These constellations significantly prevent others from using those regions, which therefore interferes with others' right to explore and use space. And ultimately, this reckless ambition shows absolutely no due regard (as per Article IX) for the corresponding rights of others. As such, these megaconstellations constitute an impermissible appropriation of particular regions of outer space, regardless of any formal, official claim of such by a responsible, authorizing government.

No, This Is Not Impermissible Appropriation

An opposite conclusion can also be reasonably arrived at when approached along the following lines. The counter argument would assert that the deployment and operation of these global constellations, such as SpaceX's Starlink, OneWeb, Kepler, etc., are aligned with and in full conformity with the laws applicable to outer space. These constellations are merely the exercise and enjoyment of the freedom of exploration and use of outer space and do not constitute any impermissible appropriation of the orbits that they transit.

Freedom of Access and Use Permits Constellations

Rather than being a violation of other's rights to access and explore outer space, the deployment of these constellations is more correctly viewed as the exercise and enjoyment of the right to access and use outer space. Article I of the Outer Space Treaty establishes a right to access and use space without discrimination.

Not allowing an actor to deploy spacecraft, regardless of their number or destination, would be infringing with the exercise of their freedom. It would be discriminatory. Additionally, actors do not need permission from any other State, or group of States, to access and explore outer space.

Aligned with the Intentions of the Outer Space Treaty

This use of outer space by constellations in LEO, while not explicitly mentioned by the drafters of the Outer Space Treaty or other space law, actually is the fulfillment of their visions for the use of outer space. The preamble to the Outer Space Treaty (which contains the subject matter and purpose of the treaty and can be used for interpreting the operative articles of the treaty) speaks of the aspirations of humanity in exploring and using outer space. It is easy to see constellations that will provide Internet access to the world as fulfilling the visions of the drafters:

The States Parties to this Treaty,

Inspired by the great prospects opening up before mankind as a result of man's entry into outer space,

Recognizing the common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes,

Believing that the exploration and use of outer space should be carried on for the benefit of all peoples irrespective of the degree of their economic or scientific development,

Desiring to contribute to broad international cooperation in the scientific as well as the legal aspects of the exploration and use of outer space for peaceful purposes,

Believing that such cooperation will contribute to the development of mutual understanding and to the strengthening of friendly relations between States and peoples,

As such, subsequent article of the Outer Space Treaty should be read in a permissive light, as permitting constellations, rather than a restrictive light which only sees potential negative aspects of constellations.

Due Regard and Harmful Contamination Will be Addressed

Operators in LEO are well aware of the challenges to space sustainability that their constellations will pose and will be taking efforts to mitigate the creation of debris. OneWeb is keenly focused on space sustainability and has even argued that the current norm, whereby spacecraft are not in space for longer than 25 years and are deorbited from lower orbits at the end of their lifetime (aka post mission disposal), is not sufficient

to keep outer space clean and that shorter lifespan limits should be imposed on operators, especially operators in LEO, and operators of small satellites.

Additionally, these systems will be able to cooperate with emerging space safety and space traffic management plans and can operate in ways that do not restrict or impinge on other users of the space domain. Because due regard is therefore displayed for the space domain, and to the interests of others, these constellations do not prejudice or infringe upon the freedoms of use and exploration of the space domain and are therefore not occupation, or possession, much less appropriation.

This Does Not Constitute Possession, or Ownership, or Occupation

The use of LEO by satellite constellations is substantially similar to the use of GSO, and therefore permissible. In each region, individual actors are given permission - either from a national administrator or from an international governing body (the ITU) via a national administrator - to use precoordinated subsections of space. In a way that is overwhelmingly similar to the use of orbital slots in GSO, the placement of spacecraft into orbits in LEO or higher orbits does not constitute possession, ownership, or occupation of those orbits. This is because States (and their companies) have been occupying orbital slots in GSO for decades, and these uses of GSO have never been accused of “appropriating” GSO. The users have never claimed to be appropriating GSO, and their exercising of rights to use GSO is respected by other actors in the space domain. This is the same situation for other orbits, including LEO and other non-Geostationary orbits.

And while GSO locations are relatively stable (subject to space weather and other perturbations, and require stationkeeping), spacecraft in LEO are actually moving through space and are not stationary, so it is even more difficult to see this use by constellations as occupation, much less appropriation. Moreover, Space Situational Awareness (SSA) and Space Traffic Management (STM) will allow other uses to use these orbits, and nothing about the use of any one user necessarily precludes others. Lastly, there is no intention by operators of constellations to exclusively occupy, much less possess or appropriate, these orbits. Would not the appropriation of outer space be an intentional, volitional act? No such intention can be found in the operators of global constellations.

Conclusion

The development and deployment of constellations is certainly a unique and impressive technological development which will bring unprecedented advancements to both space activity and concerns here on Earth. It offers more benefits than risks. Rather than being multiple users which would threaten orbital safety, a single user at any altitude makes SSA and STM easier, and the actor merely has to govern their own spacecraft, rather than worry about others spacecraft. No such data sharing issues will exist with global constellations.

Consequently, and in conclusion, it is in the wider public interests to permit, and not prevent, actors from planning, developing, deploying, and operating constellations in LEO. This technological advancement, of plentiful, off-the-shelf spacecraft, is the wave of the future for space exploration and utilization. It should not only be

permitted, it should be positively authorized, fostered, and nurtured. It is a future we want, where all can benefit from space technologies and capabilities.

Conclusion

This chapter has gone over some basic foundational elements in space law, as found in the Outer Space Treaty and subsequent treaties, as well as the ITU regime for frequencies and orbits. Both regimes speak of the freedom of access and use of outer space, as well as the obligations respecting the rights of others to also explore and use outer space. Various articles of the Outer Space Treaty, either creating explicit rights or obligations, or other articles iterating more general concepts (such as due regard, harmful contamination) are applicable to constellations. Some pertinent facts from proposed near-term large constellations of small satellites in LEO were mentioned, and then the legal implications of these constellations were provided.

An argument as to why these constellations constitute impermissible appropriation outer space was made. To be balanced, this argument was followed by a counter-argument as to why these constellations are not an impermissible appropriation. The reader can weigh these arguments and consider which of them, if either, is the more valid and convincing.

It is hoped that this chapter will bring greater context and clarity to those concerned with constellations in LEO and that these novel activities, while certainly attractive for various reasons, have implications under space law and should give cause for concern when considered in the context of space safety and sustainability, as well as implications for international geopolitical reasons. Constellations of small satellites in LEO are certainly the wave of the future and will continue to be developed and deployed. They should be undertaken in a way that adheres to both national and international law, and in a sustainable fashion which protects the long-term sustainability of the space domain, and takes into account not just the interests of the operators, but other users of the space domain, as well as potential future users, and of generations to come who will inherit the space domain as a place for their exploration and use. Respect for the integrity of the space environment remains a lasting value to take into account in all present activities.

Cross-References

- ▶ [Capital Financing for New Small Satellite Ventures](#)
- ▶ [De-orbit Requirements and Adoption of New End of Life Standards](#)
- ▶ [Legal Issues Related to the Future Advent of Small Satellite Constellations](#)
- ▶ [Long Term Sustainability of Space and Sustainability Requirements](#)
- ▶ [New Financial Models and New Economic Systems Analysis for Small Satellites Systems](#)
- ▶ [Obtaining Landing Licenses and Permission to Operate Small Satellite Constellations on a Global Basis](#)

- ▶ Requirements for Obtaining Spectrum and of Orbital Approvals for Small Satellite Constellations
- ▶ “Rules of the Road” for Launch and Operation of Small Satellites and Related Issues
- ▶ Space Traffic Management and Control

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