Legal Approaches to Network Driven Space Applications

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Abstract

New investors foresee large satellite constellations for establishing privately owned space based global networks. This involves diverse new technical approaches, not only the space hardware of the constellations, but also new information technology that has not yet been used in space. It will include also information storage and computing on space based platforms. Once the new hardware is in space, we will see, in addition, a dynamic growth of new (space based) applications through software. The full range of capabilities of the future 5th generation mobile networks standard will unfold in space. As a result, the traditional technologies used for space based communication, navigation and remote sensing will be re-shaped and merge. Key will be the network structure of direct communication links among satellites in Earth orbits, rather than the traditional 'bent-pipes' which relay communication flows among terrestrial stations. Consumers will be able to directly access these space based networks. The legal implications of multifunctional networks detached from national territories are manifold. At the centre are issues of jurisdiction and legal and factual control. When new investors make use of the freedom of use of and access to outer space to establish new space based networks, they bring new global networks under the control of a single entity. This paper explores approaches to these issues in light of the technical, business and legal factors.

1. Introduction

The steadily increasing demand for bandwidth and truly global internet access has stimulated a number of 'New Space' entrepreneurs, but also well-established aerospace businesses to explore the feasibility of large non-geostationary satellite constellations for establishing an internet infrastructure in outer space. The plans for large or mega constellations with hundreds or thousands of satellites surpass the contemporary dimensions, ways of manufacturing, launch and in-orbit operations of space hardware. New information technologies are another dynamic driver that can add new

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software based applications on a daily basis and will thus lead to a constant increase and improvement of functionalities of the new systems. During the last years, the Federal Communications Commission (FCC) of the United States has received 19 proposals for satellite constellations and the International Telecommunication Union (ITU) several dozens.[1] It is quite clear that only a much smaller number of mega satellite constellations will materialize and that many proposals were only filed to reserve rights for the future use of the orbital and spectrum resources. Some of the more prospective candidates are:

- OneWeb with a Low Earth Orbit (LEO) constellation of 720 and a Medium Earth Orbit (MEO) overlay constellation of 1280 satellites – the first satellites are already manufactured by One WebAirbus[2]
- Boeing with a LEO constellation of 1396 – 2956 satellites[3]
- SpaceX with a LEO constellation of 4425 satellites[4]
- TeleSat, Canada, with a LEO constellation of 117 satellites[5]

These projects raise the question how the emerging technology of space based networks will impact existing space applications, technically, business-wise and legally.

2. The Impact of Network Connectivity on Space Applications

Network connectivity adds a new dimension to traditional space applications. Existing space application can be merged and will blur. Supported by the system architecture, and perhaps proprietary access restrictions, operators can exploit quantitative scale effects and follow new business models.

1 Peter B. de Selding, ITU, FCC: Satellite constellation surge requires new rules, Space Intel Report, 16 March 2017, https://www.spaceintelreport.com/itu-fcc-satellite-constellation-surge-requires-new-rules/, accessed 08 August 2017.

2 Caleb Henry, FCC gets five new applications for non-geostationary satellite constellations, Space News, 2 March 2017, http://spacenews.com/fcc-gets-five-new-applications-for-non-geostationary-satellite-constellations/, accessed 05 August 2017; Thierry Dubois, Mass Production – Output for OneWebAirbus factory planned at one satellite per day, AW&ST 10-23 July 2017, p. 32.

3 Peter B. de Selding, Boeing proposes big satellite constellations in V- and C-bands, Space News, 23 June 2016, http://spacenews.com/boeing-proposes-big-satellite-constellations-in-v-and-c-bands/, accessed 05 August 2017.

4 Caleb Henry, SpaceX, OneWeb detail constellation plans to Congress, Space News, 26 October 2017, http://spacenews.com/spacex-oneweb-detail-constellation-plans-to-congress/, accessed 08 December 2017.

5 Peter B. de Selding, Telesat prepares shareholder payday, outlines 117-satellite constellation, Space News, 17 November 2016, http://spacenews.com/telesat-prepares-shareholder-payday-outlines-117-satellite-constellation/, accessed 05 August 2017.

2.1 Quantitative Scale Effects

Long gone by seem to be the days of 1945, when Arthur C. Clarke foresaw a system of three geo-stationary satellites that could provide global communication coverage for the entire Earth.[6] The concept was revolutionary and, at that time, seemed to imply that three satellites could handle the inter-continental communication traffic volume. Today's volume requirements for broadband internet connectivity rather follow Moore's Law.[7] Starting in 1965, Gordon E. Moore postulated that the integration of semiconductor components would constantly multiply and thereby constantly reduce production cost of computing power and electronic memory. Today the same exponential growth is projected for the bandwidth required for (mobile) access to the internet. It is thus not surprising that the expansion of the capacity of data communication links has started to follow business models based on economies of scale. Small, mass manufactured satellites are considered to offer a cost advantage over large, hand-crafted ones produced in small batches.[8] Moreover, light weight satellites are cheaper to launch and can be accomplished by the dozen at a time. The concepts of mega satellite constellations forming a space based internet backbone is a plausible result of this school of thought.

2.2 Integration of Space Services

Under the traditional terminology of space applications, internet connectivity falls under telecommunications. However, the integration of numerous applications that we have witnessed in terrestrial mobile communication will also have an impact on the functionalities of the planned mega constellations for internet connectivity. In other words, the development of cellular phones to smart phones will not only have an impact on end-user units, but also change the design and functionality of the satellites of the mega constellations and their services. The distinction between telecommunication, remote sensing and navigation satellites will not any longer persist. We will rather see multifunctional satellites with a broader range of functionalities and even an increase and change of their services during their lifetime, enabled by new software applications, as we know them from smartphones. Users of these space based networks can use navigation functions, geo-location, optical and other special sensors. The communication exchanges of users can be co-related with the navigation, surveillance and remote sensing information. This functional integration is already foreseen by the emerging standards and

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6 Arthur C. Clarke, Can Rocket Stations Give World-wide Radio Coverage?, Wireless World, October 1945, pp. 305-308.

7 Gordon E. Moore, Cramming More Components onto Integrated Circuits, Electronics, April 19, 1965, pp. 114-117, reprinted in Proceedings of the IEEE, Vol. 86, No. 1, January 1998.

8 Jen DiMascio, Fortune Hunters – Small satellites are in vogue, but realizing profits from them could prove elusive, AW&ST, 24 July-13 August 2017, p. 31.

architecture for the fifth generation (5G) mobile wireless infrastructure.[9] In addition, the new generation of satellites can also be designed for system or cloud based information storage and computing and enable functionalities of the real-world through the so-called 'internet of things'.[10] All these functionalities combined will create a new quality of the relationship, in practical and legal terms, between users and system operators.

2.3 System Architecture

Given the versatile functionalities, the increasing bandwidth and the highly flexible adaptability, satellite mega constellations will be based on a different network architecture than traditional satellite systems. As opposed to conventional telecommunication satellites that work like a 'bent-pipe by relaying information streams from one ground station via a satellite transponder to another, satellites of large constellations will transmit large volumes of data between each other and thus form a space based network. For mobile radio access with relatively low signal levels, satellites need to be in low Earth orbits, which results in small coverage areas of each individual satellite, so that large numbers of satellites are required to achieve permanent global access. The footprint of the coverage of an entire constellation looks like the cellular structure of terrestrial mobile networks. This structure is an additional reason for the increase of the data volumes transmitted among them. Not only the increasing up-link and down-link data volume generated by users, but also the multiply relayed data traffic, via inter-satellite links, will contribute to an exponential growth of data volumes.

2.4 Interoperability and Interconnection

Even though the technical details of potential mega constellations for global internet access are not yet published, the system architecture with a myriad of access cells for mobile users connected by inter-satellite links indicates that it can work as a giant 'intranet'. Access to such a network does therefore not necessarily mean access to the internet, as we know it today, but access to a proprietarily owned and operated sub-network. Access to the 'rest of the internet' can be accomplished by interfaces, operated by and subject to the conditions of the operator of the mega constellation. The system architecture of inter-satellite links permits operators to by-pass Earth stations and, possibly, to limit interconnection to the internet we know today. The access to such a mega constellation will not necessarily be based on an open, but may use a proprietary standard. In this case, end-user terminals could only link up to the

9 See for example Jono Anderson, The Coming Satellite Revolution, AW&ST 15-28 August 2016, p. 58.

10 See also: Internet of Things: Science Fiction or Business Fact?, Harvard Business Review Analytic Services Report, 2014, https://hbr.org/resources/pdfs/comm/verizon/18980_HBR_Verizon_IoT_Nov_14.pdf, accessed 04 August 2017.

'sub-network' of one mega constellation and be barred from access to another. Without too much imagination, it becomes clear that operators could take an advantage of keeping an end-user, as far as possible, within their sub-network, and obtain all relevant personal data, including those from the integrated functionalities of sensors, navigation, cloud storage and computing. A proprietary access could thus be used as a tool to keep users within their sphere of influence.

3. Resource Issues

3.1 Orbital Resource and Space Debris

The proposed mega-constellations will add thousands or even tens of thousands of space objects in the LEO region. This will enhance the collision risk and the generation of space debris. In the event of a debris cloud in this orbital region, the collision risk with the large number of operative satellites of the constellation will significantly rise. The tipping point will be reached earlier, at which the cascading effect for follow-on collisions with a subsequent increase of debris will set in. The enhanced risk of generating space debris is generally seen, also by the future operators,[11] but it is yet unclear how to regulate and manage it. To minimize these risks, three elements can be identified:

3.1.1 IADC Guidelines

First of all, compliance with the space debris mitigation measures established by the Inter-Agency Space Debris Coordination Committee (IADC) becomes a high priority for high density space traffic. The IADC Space Debris Mitigation Guidelines focus, in essence, on spacecraft design and procedures to mitigate collision risks and the generation of space debris during all operational phases and post mission disposal.[12]

In 2016, the IADC addressed the impact of the planned large constellations in LEO and recognized the limits of the existing guidelines, when it deemed large constellations as

> "… a step change in the number of satellites operating in the low Earth orbit regime … [that] … may question the validity of the assumptions used to derive the

11 Debra Werner, 'On My Tombstone, It Should Say Connected the World, Not Created Orbital Debris', interview with Greg Wyler, founder of OneWeb, Space News, 8 December 2015, http://spacenews.com/on-my-tombstone-it-should-say-connected-the-world-not-created-orbital-debris/, accessed 03 August 2017.

12 Inter-Agency Space Debris Coordination Committee, IADC Space Debris Mitigation Guidelines, September 2007, IADC-02-01, www.iadc-online.org/index.cgi?item=docs_pub, accessed 06 August 2017, also endorsed by UNGA Res. 62/217 of 22 December 2007.

> existing space debris mitigation guidelines … [and] … the robustness of the existing debris mitigation guidelines to effectively manage the new constellations and their impact on the orbital environment in a sustainable manner." The IADC also considered "… that significant improvements in the reliability of the disposal function at end of life will be needed for the new constellations compared with that currently demonstrated by space systems on orbit."[13]

3.1.2 Space Situational Awareness (SSA)

As a tactical measure, the increased traffic density will demand an intensified monitoring[14] of the LEO region and an enhanced management of collision avoidance manoeuvres of the mega constellations. To that effect, in preparation for its constellation, OneWeb has already invested in an orbital debris-tracking start-up firm.[15]

3.1.3 Strategic Management of the LEO Resource

As a strategic measure, it is to be considered to internationally coordinate, plan and manage the use of the LEO resource. Even without the planned mega constellations and even with a presumed 90% implementation of the IADC mitigation measures, an IADC study of 2013 expects the LEO debris population to increase by an average of 30% in the next 200 years.[16] An increasing number of operational satellites in combination with the growing debris population will sooner or later require a proactive capacity planning of the LEO resource, similar to the procedures of the International Telecommunication Union (ITU) for the equitable, rational and efficient use of the limited resource of the frequency spectrum. This strategic space resource management could be addressed by the Committee on the Peaceful Uses of Outer Space (COPUOS) as an element of a future system of Space Traffic Management to assure the long-term sustainability of space activities.[17] This may take a long time. In the meantime, Boeing and OneWeb have already taken

13 Inter-Agency Space Debris Coordination Committee Steering Group, IADC Statement on Large Constellations of Satellites in Low Earth Orbit, February 2016, IADC-15-03, www.iadc-online.org/Documents/IADC-15-03%20Megaconstellation%20Statement.pdf, accessed 06 August 2017.

14 For the general status and legal aspects of Space Situational Awareness, see Stefan A. Kaiser, Legal and policy aspects of space situational awareness, Space Policy, Volume 31, February 2015, pp. 5-12.

15 Graham Warwick, Debris Police – Set to build LEO satellites for OneWeb, Airbus invests in orbital debris-tracking start-up, AW&ST, 6-19 March 2017, p. 23.

16 IADC, Working Group 2, Stability of the Future LEO Environment, January 2013, IADC-12-08, p. 17, www.iadc-online.org/index.cgi?item=docs_pub, accessed 07 August 2017.

17 See also United Nations, Report of the Committee on the Peaceful Uses of Outer Space, section C. 9. General exchange of views on the legal aspects of space traffic management, Fifty-ninth session, 8-17 June 2016, A/71/20.

a bilateral approach by an agreement in March 2017 on a spatial separation of their two proposed constellations in LEO.[18]

3.2 Spectrum Resource

The increasing data traffic volume combined with the rising number of data links among the satellites, fixed and mobile ground stations of the proposed mega constellations lead to an exponential demand of bandwidth and require new frequency bands. As of March 2017, the Federal Communications Commission (FCC) of the United States had received six applications of potential constellation operators with the intention to also use radio frequencies in the V-band.[19] This band in the frequency range from 40 to 75 GHz is above the Ka and Ku-bands that had so far been foreseen and is at the moment not strongly used for commercial purposes. The V-band is subject to line of sight limitations and atmospheric attenuation, for example by rain. Despite these limitations, the ITU needs to consider whether a broad allocation of the V-band to space-based broadband data services can be supported in light of other potential uses. By Article 44 of the ITU Constitution,[20] member States recognize that radio frequencies are a limited natural resource that must be used rationally, efficiently and economically, so that countries have equitable access. Another aspect is potential harmful interference of LEO satellites with geostationary satellites in the Ka and Ku-bands.[21]

4. Market Position and Protection of Users

Considering the limited space and spectrum resource and the huge investment, there will only be a limited number of mega constellations for global broadband connectivity. It is not unusual that access to telecommunication and data service is solely available through a limited number of networks, but in the case of mega constellations for internet access, several additional factors become relevant for assessing their market impact and for safeguarding the rights of users.

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18 Peter B. de Selding, OneWeb, Boeing settle constellation orbit issue; SpaceX questions OneWeb ownership, Space Intel Report, 16 March 2017, https://www.spaceintelreport.com/oneweb-boeing-settle-constellation-orbit-issue-spacex-questions-oneweb-ownership/, accessed 08 August 2017.

19 Caleb Henry, *supra* note 2.

20 Constitution of the International Telecommunication Union, 22 December 1992, 1825 UNTS 330.

21 Jeff Foust, Low Earth Orbit Constellations Could Pose Interference Risk to GEO Satellites, Space News, 26 October 2015, http://spacenews.com/low-earth-orbit-constellations-could-pose-interference-risk-to-geo-satellites/ accessed 03 August 2017; Peter B. de Selding, Intelsat Asks FCC To Block SpaceX Experimental Satellite Launch, Space News, 22 July 2015, http://spacenews.com/intelsat-asks-fcc-to-block-spacex-experimental-satellite-launch/, accessed 03 August 2017.

4.1 Global Use of Limited Resources

By definition, mega constellations will get worldwide market access, even though only one national authority may grant permission for the exploitation of the limited orbital and spectrum resources. However, if limited resources are assigned to a private venture for worldwide use in all countries, that operator has to be a good steward of this resource and he should be compelled to comply for the entire duration of his use with similar principles under which he was initially assigned that resources. This means, for example, that once he has established the global system he needs to comply with the principles of Art. 44 ITU Constitution, namely the rational, efficient and economical use of the orbital and frequency resources, so that countries or groups of countries and their people have equitable access to this *system*, taking into account the special needs of the developing countries and the geographical situation of particular countries. As it is likely that only a small number of operators will succeed in establishing these global systems, there must be mechanisms to safeguard misuse of monopolies and dominant market positions when operating mega constellations. These mechanisms should be established at the international plain, because the resources to be used are international, and frequencies assignments will not only be regional or national. Neither ITU rules, nor the current international space law have adequate mechanisms for ensuring the proper conduct of market dominant global operators of this kind of space based networks and the resulting market implications.

4.2 Information Dimension

At the moment, it is not really clear what are the business plans of the proponents of mega constellations. Despite their published plans for space based systems to provide global broadband internet, at least technically these systems permit a broad range of information services. Looking at the proposed systems from the perspective of the technical feasibility, one should therefore study their potential for running a highly complex and diversified global *information* business. The system architecture, the merging of services and the related quantitative scale effects point to such an approach. Any combination of the embedded technologies of networking, information processing, cloud computing, cloud storage, remote sensing, navigation, geolocation, voice and face-recognition, signal intelligence, the internet of things and automation indicate that these systems have a high potential for becoming *information* systems and the future backbone for artificial intelligence and for controlling our world.

Leaving aside what are the business plans, who is involved and what is the purpose of their participation, these new systems must also be considered as combining the capabilities of information, marketing and social media platforms with the physical control over (parts of) the internet. Considering further, that (personal) information is viewed as kind of a currency with which users pay for the use of the system, the broadened scope of services offered by mega constellations will make users even more dependent on disclosing their personal information to partake in the social, economic and political life. Whenever personal information is involved, the privacy of individuals and also their intellectual property rights need to be protected. The degree of the use of personal information and intellectual property is a matter of the business model, and their protection poses a jurisdictional challenge for a space based system whose users are located in (almost) all countries of the world.

4.3 Access and Interconnection

A space based internet system has other networking capabilities as the internet access providers we know today. At least technically it appears feasible that operators of mega constellations will control not only the access of users to their network,[22] but also if, when and to what extend they interconnect with the internet at large. They could indeed establish their own giant *intranet* that may feel like a parallel internet – with all possible implications on information flows and control over information. The larger the *intranet,* the smaller the need to interconnect to the *remainder* of the internet. There could be many reasons why to limit interconnection, for example cyber security, but also political and commercial reasons. Network operators who run an information business may limit access and interconnection to market their information content. This could be the beginning of a fragmentation of the internet we know, or the start of a new era of competing internets.

5. Jurisdiction and National Authorizations

The existing regime for authorizing and supervising space activities by national authorities is too narrow to address the global commercial activities foreseen by the emerging operators of space based broadband internet and the connected information business. Authorizations for operators to undertake space activities are granted by national authorities under national rules in conformity with the internationally agreed regime of Article VI of the Outer Space Treaty (OST).[23] Under this article, States Parties to the OST also bear international responsibility for their national activities in outer space and they are required to maintain continued supervision. However, the provision of space based broadband internet and information services do not qualify as space activity. Space activities are limited to the physical operation of space objects and this defines how far the States' responsibility and supervision reaches. Likewise, the jurisdiction and control of States under Article VIII OST is linked to objects launched into outer and over any

22 Access to the networks could be controlled by proprietary standards for limiting the access of ground based user terminals to one specific network.
23 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 1967, 610 U.N.T.S. 205.

personnel thereof, but does not extend to telecommunication and information services undertaken through networked space objects that have no physical impact in outer space.

In addition to the authorization for space activities, national authorities also hold the responsibility for permitting the use of the frequency spectrum – following ITU coordination procedures for the allocation of types of radio services and the assignment to States. In the United States, this authorization for the frequency spectrum is executed by the FCC. Similar to the national authorization and supervision of space activities, the national spectrum licensing to users has its functional limits.

National authorizations for space activities and frequency spectrum are important tools for the efficient use of the orbital and spectrum resources, provided international mechanisms are established to accommodate mega constellations and space based broadband internet services. This leaves many aspects untouched, for example the information dimension of mega constellations. When new investors make use of the freedom of use of and access to outer space to establish new space based networks, they bring new global networks under the control of a single entity. Neither national authorizations for space activities under Article VI OST, nor national authorizations for spectrum use that follow the ITU mechanisms, take care of end-users' protection of rights, for example their privacy and data protection. Equally important and not covered is their protection as consumer against unfair conditions. Such unfair conditions can result from various aspects connected to the specifics of the envisaged mega constellations, like the potential misuse of their dominant market position, and the already existing business practices of the internet and information industry, like biased terms and conditions and payment by providing (personal) information. Future providers of a 'segregated internet' could try to establish their own rules in a regulatory void or by-pass national regulations of the States, where their users are located. They could use the control over their quasi stand-alone internet, for example by limiting access, interconnection and interoperability, and thus affect users' rights of freedom of information and speech. For all these reasons, it is therefore indispensable that international regulations are established covering all these aspects for the operation of future mega constellations for global broadband internet access. The existing regime of authorization and supervision of Article VI OST and of the spectrum assignments do not suffice.

6. Conclusion

Even though we do not know yet details of the plans of OneWeb, Boeing, SpaceX and the other ventures longing for mega constellations for global broadband internet, the technical opportunities and current business practices of the IT industry merit a critical look at the deficiencies of the existing international regulatory framework and at the approaches for improvements. The proposed mega constellations should not be viewed as just a new generation of telecommunication satellite networks. The issues in regard to the limited orbital resource – and the implications on space debris and sustainable access and use of LEO – and the limited spectrum resource are already in the spotlight, but there are by far more critical aspects.

We are going to see a complex combination of technical and commercial aspects with many new interdependencies. Relevant technical features will be the integration and linking of traditional space and other IT services in new global system architectures, the information dimension, a single entity exercising the control over a huge global network and over the degree of this network's interoperability and interconnection. On the business side, aspects like quantitative scale effects, the global use of a limited resource will be a leverage for creating a strong, possibly dominant, market position.

Only international regulation can cope with global networks that use a limited resource. It must be prevented that such systems operate in a regulatory void. States have the responsibility for the space activities of their licensed nationals, but Article VI OST was not tailored for businesses on the Earth established by space infrastructure. It was neither intended that States have the national prerogative to undertake businesses[24] in other countries, solely for the reason that their licensed space infrastructure technically enables them to do so. Space based global internet systems are designed to provide network access, regardless of national borders, possibly without local infrastructure authorized by the respective State. Global connectivity is an intended concept, not merely a spill-over effect of radio communication.

It needs to be assured that the businesses on the ground of operators of global space based networks *do not by-pass national regulations* and *States have oversight*. An international regulatory framework is required, *de lege ferenda*, for *avoiding the misuse of a dominant market position* and for the *protection of privacy*, of *intellectual property* and for the protection of consumers against *unfair and biased terms and conditions* – considering that (personal) information is used as the currency of information services. When global networks that resemble 'segregated internets' are under the control of a single entity, they need to be obliged to establish non-discriminating functionalities for *interconnection and interoperability*, and it needs to be determined which State bears the responsibility and the duty to police the network in case of misuse and (cyber) criminal activity.

Today we approach an era of increasing dependency of ground-based businesses on space-based infrastructures. The scope of Article VI OST is limited to space activities and does not suffice as a cornerstone for a global broadband network regime. This does, however, not imply that States are free

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24 Or have such businesses undertaken by licensed private providers.

to establish their own national rules for businesses using space based infrastructure, but with a business impact in other States. It must be prevented that 'New Space' entrepreneurs use space activities as a technical and jurisdictional leverage to escape regulations that are commonly recognized for the type of businesses they are planning to establish.