Internet from space: how new satellite connections could affect global internet governance

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SWP Research Paper

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How New Satellite Connections Could Affect Global Internet Governance

Stiftung Wissenschaft und Politik
German Institute for International and Security Affairs

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- A number of companies from the US and China plan to build networks of several thousand satellites each to enable access to the Internet from any point on Earth. These satellites will be stationed in low Earth orbit.
- If these plans are put into practice, the global Internet infrastructure will acquire a whole new dimension. This would have far-reaching consequences for Internet access, the security and resilience of Internet infrastructure, and power relations in global Internet governance.
- The home countries of the leading companies — above all the US, followed by China — would have extensive potential for political influence. They would be able to control, at the level of the Internet's global infrastructure, the worldwide flows of information.
- This research paper draws two scenarios to illustrate the range of possible developments and the corresponding potential responses: one describes the development of global oligopolies, the other a form of politically regulated global competition.
- German and European political decision-makers should use regulations and public funding to work towards a future Internet infrastructure that is secure and reliable. The basis for this is the redundancy and diversity of the underlying technology. To this end, the new satellite constellations can be an important part of an appropriate mix of technologies.
- It would be both politically and economically desirable for Europe to build its own constellation.

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Internet from Space How New Satellite Connections Could Affect Global Internet Governance

It may sound like science fiction but could soon be reality: a number of companies invest heavily in new satellite constellations to provide high-speed Internet access anywhere on Earth. The plan is to use satellites in low Earth orbit, that is, in relatively close proximity to the Earth's surface. A world-spanning network of thousands of such satellites is supposed to enable quick data connections and the transfer of large quantities of data. The leading company is the US's Starlink, which has already stationed the first satellites for a planned network of tens of thousands of satellites, a so-called "mega constellation". Several other US companies pursue similar plans. Like Starlink, they can count on the support of the US government. Their competition comes from China: its large state-owned companies in the space technology sector have announced that they too will be building their own constellations.

These plans for new satellite networks reflect the ever-increasing demands placed on the global Internet infrastructure — and the growing awareness of its political significance. Today, access to the global Internet is a key factor for a country's economic development. But it also has a political dimension: more and more countries are attempting to tighten their control over the Internet's infrastructure and the flow of information. As with the construction of the first telegraph networks from the late 19th century onwards, they want to expand their own communication possibilities. They also want to exert influence at the interface of technology and politics on the conditions under which information is exchanged worldwide.

For now, it remains an open question whether the highly ambitious plans for satellite mega constellations can be put into practice. All the companies involved are facing a multitude of technical and economic challenges. If they overcome these challenges, however, the consequences would be far-reaching for Internet access, for the security and resilience of Internet infrastructure, and for power relations in global Internet governance.

To illustrate the range of possible developments and potential responses, this research paper considers two scenarios. In the first scenario, titled “Global Oligopolies”, three satellite mega constellations become operational, two under UK-US control and one Chinese project as part of the Belt and Road Initiative. The enormous concentration of economic power in this scenario also has political consequences: the availability of the constellations’ services is defined by political lines of conflict. As a result, the Internet further fragments. The operators of the mega constellations and the countries behind them have fine-grained control over exactly how data within the respective systems, and between them, is exchanged. In this scenario, European countries, including Germany, find themselves virtually powerless to shape the use of digital infrastructures according to their own political interests and values.

The second scenario is titled “Regulated Competition” and describes a world in which the new satellite constellations are regulated to ensure a certain level of competition. In particular, new World Trade Organisation (WTO) agreements stipulate that — with only a few exceptions — the operators of the constellations may not themselves offer services for end users on Earth, but must instead cooperate with local companies for this. Targeted public investment and a close technological partnership with Japan also make it possible to build a European constellation. For Europe itself, but also for many other countries in the world, this produces an alternative to the US and Chinese systems. Close cooperation between the European Union and the African Union for the first time allows a large number of people in developing countries to access the Internet cheaply and reliably. This scenario sees the constellations partly become an instrument of vested geopolitical interests. But it does preserve the common global foundation of the Internet.

It is unlikely that one of these two scenarios will become reality its entirety. However, the purpose of exploring them is not to provide prognoses for a probable future. Rather they illustrate the far-reaching political consequences that developments in the Internet satellite sector could have — and what possibilities exist for shaping these developments politically.

In the past few years, the German government and parliament have repeatedly committed themselves to the goal of an open, free and truly global Internet. Thus, the plans for new Internet satellite mega constellations are both an opportunity and a challenge. They offer the prospect of a more efficient and much more inclusive Internet. Simultaneously, they carry the risk of an enormous concentration of economic and therefore also of political power.

To meet this challenge, German and EU policymakers should use targeted regulations and public funding to work towards a European and global Internet infrastructure that is secure and reliable thanks to technological redundancy and diversity. As part of a balanced mix of technologies, the new satellite mega constellations could be an important complement to digital infrastructure without creating political dependencies.

Furthermore, Europe should aim to build its own European mega constellation. This would enable it to remain economically and politically independent, and be involved in the debate over the future of the global Internet with a specific technological alternative. Here it will be important to deepen strategic partnerships, strengthen relevant multilateral institutions such as the WTO and the International Telecommunication Union (ITU), and preserve the structures of Internet governance. This is particularly important where those structures are most productive, namely when developing open standards using the established forms of voluntary cooperation.

There is still time to participate in shaping developments in the Internet satellite sector in Germany’s and Europe’s “enlightened self-interest” (de Tocqueville). Even if current plans turn out to be impossible to implement, a more proactive approach would be an important contribution to the debates over the future of the global Internet infrastructure that will take place in the coming years, irrespective of individual technologies.

On the Political Significance of Global Communications Infrastructure

In many ways, the planned new mega constellations of Internet satellites build on genuinely new technological developments. The underlying political dynamics, however, are anything but new. To understand these dynamics, it is helpful to revisit the political history of world-spanning communications systems from the early telegraphs in the 19th century to the global spread of the Internet since the late 20th century.

Countries' Strategic Interests

The introduction of new communications technologies creates opportunities for new forms of social interaction. Social scientists have long emphasised that technology does not pre-determine social developments. A lot depends on *how* societies adopt new technologies.[1] In the case of international communications systems, moreover, their transformative influence is not limited to individual societies. They also have the potential to significantly affect power relations between countries.

First, having access to a global communications system expands a government's administrative and military capabilities. The creation of the first world-spanning telegraph systems was driven, to a large extent, by the needs of colonial powers. They sought the ability to get information about developments in their colonies and to respond quickly by sending orders to their local representatives.[2] Ever since, the security and reliability of communications systems for military and diplomatic purposes has been of the utmost importance. Historically, the military significance of global communications became evident when, at the outset of World War I, one of the first steps of the British forces was to cut the German cables, thus severely limiting Germany's ability to communicate internationally. More recently, the publication of confidential US diplomatic cables in 2010 emphasised the high stakes of secure diplomatic communication.

Second, access to global communications networks has enormous economic significance. When the first transatlantic cable connected Great Britain and the United States in 1866, the amount of information it could submit was very limited. And yet, even basic information on commodity prices and the developments on the stock markets were of huge value to private companies.[3] This explains why privately operated communications systems in this period matched the paths of the global trade system — which more often than not overlapped with the structures of colonial rule.

1 Sandra K. Evans et al., "Explicating Affordances: A Conceptual Framework for Understanding Affordances in Communication Research", *Journal of Computer-Mediated Communication* 22, no. 1 (2017): 35–52.

2 Nicole Starosielski, *The Undersea Network* (Durham and London: Duke University Press, 2015), 31ff.; Daya K. Thussu, *International Communication. Continuity and Change*, 3rd ed. (London: Bloomsbury Academic, 2019), 3–9.

3 Heidi J. Tworek, *News from Germany. The Competition to Control World Communications, 1900–1945* (Cambridge: Harvard University Press, 2019), chapter 4.

We still face a global digital divide between those who can enjoy the many opportunities that the Internet has to offer and the 3.6 billion people who do not have any access to the Internet at all.

The Internet adds a new element to this part of the story: today, information is not only important relative to other economic activities, but information itself in the form of various digital services has become a product. Despite the enormous success of the Internet, however, we still face a global digital divide between those who can enjoy the many opportunities that the Internet has to offer and the 3.6 billion people who do not have any access to the Internet at all.[4] It is a bitter twist of history that this problem particularly affects countries that suffered through colonialism. The kind of global connectivity that once served colonial rulers well is now missing, thus depriving these states of an important tool for their economic and societal development.

Third, control over global communications infrastructures is seen by many countries as a means to project power internationally. As Heidi Tworek recounts in her book *News from Germany*, in the early 20th century many states, including Germany, began to realise the political potential of controlling the international flow of information. They already saw that this kind of control would serve their political goals by allowing them to prioritise information, manipulate unwanted information or simply block access to their networks.[5] It was also already clear that any global communications system would require a minimum of international coordination — and that the terms of that coordination could have enormous political consequences. Given the strategic thinking in Germany at the time, it is not too surprising that in 1906 the German Reich decided to host the first World Radio Communication Conference in Berlin.[6]

The Role of Private Companies

Large parts of the Internet's global infrastructure are owned and operated by private companies. For instance, around 95 percent of all submarine Internet cables are owned by private companies.[7] Likewise, the majority of Internet Exchange Points (IXPs) are operated by private entities, among them almost all the IXPs with the largest data traffic volumes.[8] Historically, again, this is not too surprising. The first telegraph cables were built and operated by private companies; the creation of the first world-spanning communications systems a few decades later, likewise, lay in the hands of private companies.[9]

The relationship between states, private companies and wider society was already uneasy back then. States prefer to see "national" companies as extensions of state power; the latter like to support that perception if it leads to state support for their commercial endeavours. Simultaneously, they pursue their own business interests and are unwilling to align their commercial operations with considerations of the "national interest". Supposedly, civil society is the beneficiary of all these activities. However, it is often controversial whether the services provided fit the needs of society.

Stationing and operating global communications systems is a lucrative enterprise in itself. For many companies, however, these activities are also a means to serve other goals. They seek to expand their control over the communications infrastructure necessary for producing goods and providing services. Recently, this thinking has spread beyond the traditional actors in this field: Some of the biggest companies providing new digital services — Google, Apple, Facebook, Amazon, Microsoft, in short: GAFAM — now increasingly turn to expanding their own physical communications infrastructure. This is evident in these companies growing global networks of data centres. It also shows in their substantial investments in new sub-

4 See https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx.

5 Ibid.

6 "International Radiotelegraph Conference (Berlin, 1906)", *International Telecommunication Union* (online), https://www.itu.int/en/history/Pages/RadioConferences.aspx?conf=4.36 (accessed 11 December 2020).

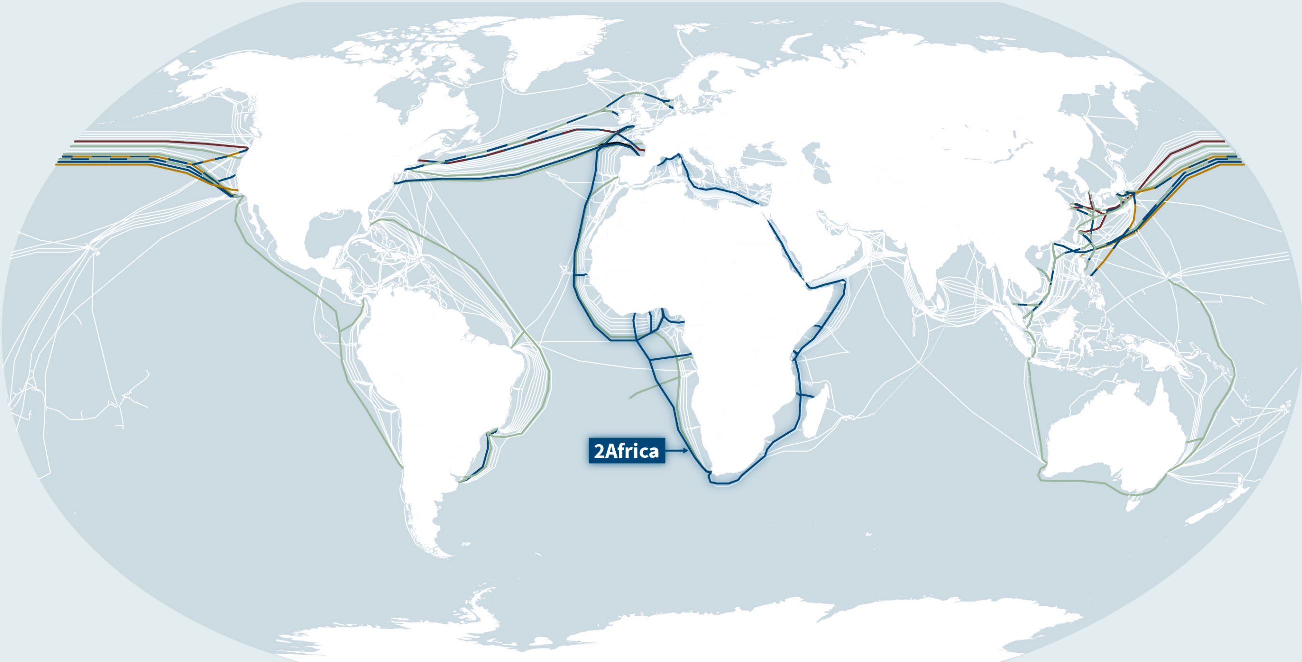
7 *Submarine Cables: The Handbook of Law and Policy*, ed. Douglas R. Burnett, Robert C. Beckman and Tara D. Davenport (Leiden: Martinus Nijhoff Publishers, 2013), 9.

8 "Internet Exchange Directory", *Packet Clearing House* (online), https://www.pch.net/ixp/dir (accessed 11 December 2020).

9 Dwayne Winseck, "The Geopolitical Economy of the Global Internet Infrastructure", *Journal of Information Policy* 7 (2017): 228—67 (232ff.); Thomas Lenschau, *Das Weltkabelnetz*, Angewandte Geographie, ser. 1, no. 1 (Halle: Gebauer-Schwetschke, 1903).

Figure 1

Changes in the submarine cable network
Submarine cables (partially) owned by
— Facebook — Amazon — Microsoft — Google — Others



As of November 2020

marine cables to allow for the transfer of the huge amounts of data necessary for their services (see Figure 1).

Germany's Policy Objectives

Awareness of the strategic importance of Internet infrastructure has been growing in Germany as well. For instance, the debate over whether the Chinese firm Huawei should participate in the construction of the 5G network in Germany garnered much attention. The intensity of this controversy and the robust behaviour of the US administration under Donald Trump made visible to a larger public that seemingly very technical issues in digital infrastructure are linked to geopolitical confrontations over political and commercial influence.

In 2019 the German parliament and government took advantage of Germany's role as host to the Internet Governance Forum (IGF) to state their own priorities in terms of global Internet governance. For example, in her opening speech Chancellor Merkel explicitly emphasised the value of the global Internet infrastructure: "This shared Internet infrastructure has become a cornerstone of the global economy."[10]

The German Chancellor issued a warning about the fragmentation of the Internet, saying it was crucial to "to protect the heart of the Internet as a global public good".

In the run-up to the IGF, a Bundestag resolution also emphasised the goal of a free and truly global Internet, and explicitly rejected its political fragmentation: "it is vital to act to prevent countries or even entire regions from breaking away from the central infrastructure of the shared address system (DNS)."[11]

10 "Speech by Federal Chancellor Dr Angela Merkel opening the 14th Annual Meeting of the Internet Governance Forum in Berlin on 26 November 2019", https://www.bundesregierung.de/breg-en/news/speech-by-federal-chancellor-dr-angela-merkel-opening-the-14th-annual-meeting-of-the-internet-governance-forum-in-berlin-on-26-november-2019-1701494 (accessed 6 April 2021).
11 German Bundestag, 19th legislative period, *Antrag der Fraktionen der CDU/CSU und SPD. One World. One Net. One Vision —*

In her speech at the IGF, the Chancellor also warned that any fragmentation of the Internet would endanger the stability of the global infrastructure and facilitate surveillance and censorship. To prevent this, Merkel said, it was crucial to "protect the heart of the Internet as a global public good."[12]

In recent years, the German government has increasingly adopted the idea of "digital sovereignty". This disputed expression is mostly used to link a number of issues: these range from a proactive industrial policy, to measures for growing digital competence in public administration, to individual data sovereignty. In her IGF speech in 2019, Chancellor Merkel differentiated sovereignty in the sense of democratic self-determination from protectionist and nationalist conceptions of sovereignty as isolation. It is thus also not surprising that the programme for Germany's presidency of the EU Council in the second half of 2020 put digital sovereignty centre-stage.[13]

Internet Governance Forum für ein offenes und freies globales Netz, Drucksache 19/15059, 12 November 2019, point III.4, https://dip21.bundestag.de/dip21/btd/19/150/1915059.pdf.

12 "Speech by Federal Chancellor Dr Angela Merkel opening the 14th IGF" (see note 10).

13 German Foreign Ministry, *Gemeinsam. Europa wieder stark machen. Programm der deutschen EU-Ratspräsidentschaft 1. Juli bis 31. Dezember 2020* (Berlin, 2020), https://www.eu2020.de/blob/2360246/d0e7b758973f0b1f56e74730bfdaf99d/pdf-programm-de-data.pdf.

Internet by Satellite

A number of companies are pursuing plans for supplying fast and comprehensive Internet access via satellites in low Earth orbit. A dense network of satellites orbiting the Earth is supposed to provide coverage for the entire Earth's surface. If the companies involved manage to implement their projects and put the satellite mega constellations into service, this would create a whole new dimension of global Internet infrastructure.

The Technology

Since the Soviet Union sent the first satellite, named Sputnik, into space in 1957, the importance of satellites has vastly increased. Today they are essentially used for three purposes: for positioning and navigation systems on Earth, such as the US Global Positioning System (GPS) or the Automatic Identification System (AIS) used in shipping; for Earth observation for civilian purposes, such as weather or environmental research, or for satellite-supported military reconnaissance; and for communications and satellite television.

As a first approximation, it is possible to distinguish between satellites in geostationary Earth orbit (GEO) and those in low Earth orbit (LEO). GEO satellites are 35,786 km above the Earth at the Equator and move at the speed of the Earth's rotation. Viewed from the ground, they thus appear to be stationary in the sky. By contrast, LEO satellites circle the Earth at the relatively modest distance of 160 to 2,000 km. They move faster than the Earth rotates, and are therefore only ever accessible for a limited time from any fixed point on the ground (see Figure 2, p. 12).

GEO satellites have so far been of only limited use for Internet connections. Their greater distance to Earth means that data transfers take longer. This delay is barely noticeable when accessing websites. However, it does make itself felt with real-time applications, such as video telephony.

The shorter delay (latency) in data transfer of LEO satellites is one of the key reasons why the planned mega constellations want to use them. However, the challenge here is that LEO satellites, as described above, continuously orbit the Earth. They are therefore only ever accessible for a short period of time from any one point on Earth. To provide lasting and reliable Internet connections nevertheless, the plans stipulate the construction of comprehensive webs of LEO satellites. Despite the satellites being permanently in motion, connecting to at least one satellite should thus always be possible.

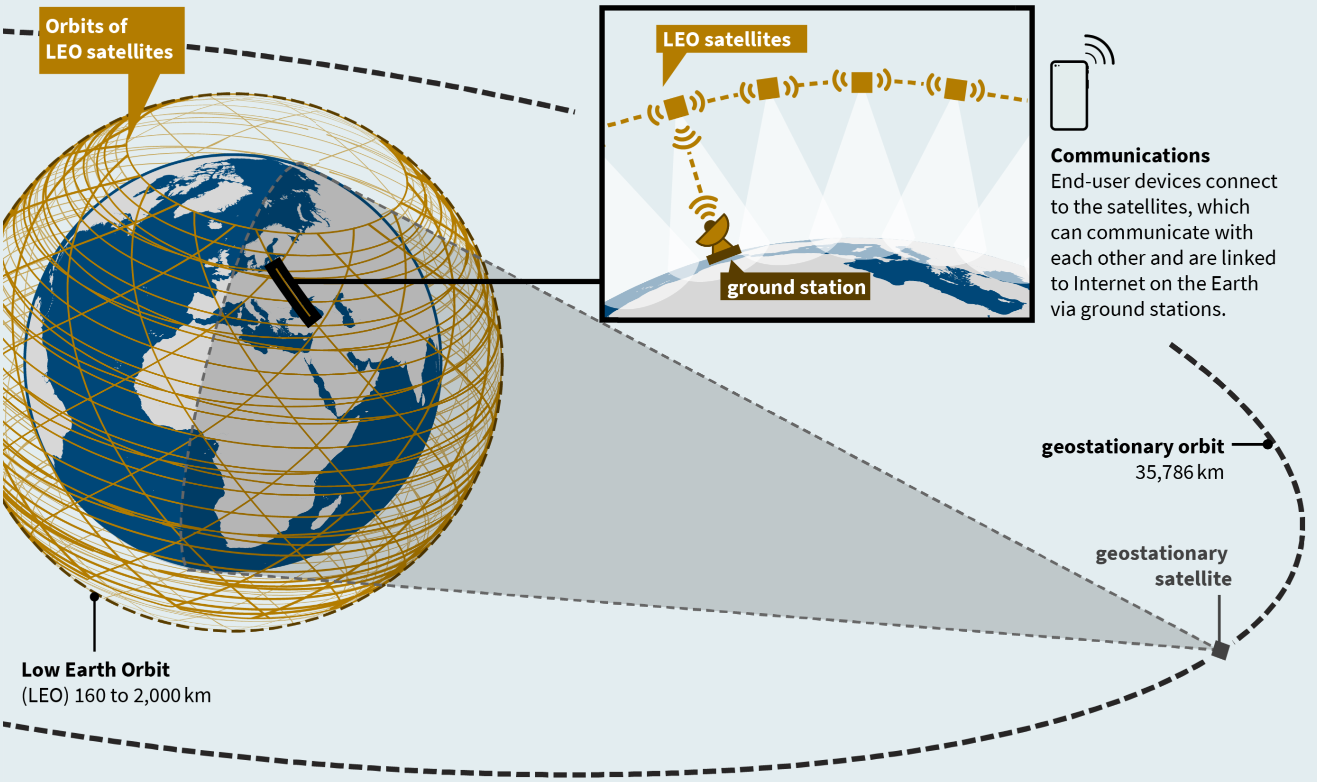
What we know about the bandwidth of LEO satellites

In recent news reports, Starlink representatives claimed that individual Starlink satellites can reach a data throughout of 17 Gbit/s. If Starlink were to station 10,000 satellites, this would theoretically lead to an overall data transfer capacity between the satellites and users on Earth of 170,000 Gbit/s, or 170 Tbit/s. In the event of a full deployment of the planned 48,000 satellites, this capacity would rise to 816 Tbit/s. To put these numbers into perspective: the recently announced Facebook-owned submarine cable "2Africa" that connects the entire African continent with Europe is supposed to have a transfer capacity of 180 Tbit/s. In March 2020, during the first wave of the Covid-19 crisis in Europe, the Internet Exchange Point (IXP) DE-CIX in Frankfurt reported a new world record of data throughput amounting to 9 Tbit/s.[a]

a Eric Ralph, "SpaceX Says Upgraded Starlink Satellites Have Better Bandwidth, Beams, and More", *Teslarati* (online), 12 November 2019, https://www.teslarati.com/spacex-starlink-satellite-upgrade-more-bandwidth-more-beams/; Bernd Mewes, "23 Länder, 37,000 Kilometer: Neues Unterseekabel für stabiles Internet in Afrika", *heise online*, 16 May 2020, https://www.heise.de/newsticker/meldung/23-Laender-37-000-Kilometer-Neues-Untersee kabel-fuer-stabiles-Internet-in-Afrika-4722687.html; "DE-CIX mit neuem Weltrekord: Mehr als 9 Terabit pro Sekunde Datendurchsatz am Frankfurter Internetknoten", *de-cix.net*, 27 July 2020, https://www.de-cix.net/de/about-de-cix/media-center/press-releases/de-cix-sets-a-new-world-record (all accessed 27 July 2020).

Figure 2

Satellites in Low Earth Orbit (LEO)
Schematic representation



The designs of the planned constellations vary greatly. Some companies want to station networks of several tens of thousands of satellites while others “only” aim for hundreds.

Many of the companies that are new to the market of satellite-supported communications — for instance SpaceX and Amazon, and some Chinese firms — have declared that their goal is to offer users a direct connection to the satellites. Users are supposed to be able to link up with satellites directly via antennas specially designed for the purpose (so-called “phased array antennas”). These antennas are currently about the size of a pizza carton. They are designed to attach to buildings or to mobile objects such as cars, trains and boats. Other companies, including AST & Science, aim to provide direct satellite access using standard mobile phone technology. It is clear that a large number of satellites will be required to offer a large number of users fast reliable Internet access, whatever the technology used for the connection. Accordingly, the companies plan constellations of several tens of thousands of satellites.

The company TeleSat, by contrast, represents a totally different approach: it plans to station relatively small constellations to act as a backbone provider for local Internet Service Providers (ISPs). The initial thinking was for 300 satellites. By now, the company aims for up to 1,671 satellites. In principle its business model is similar to today’s submarine cables. End users will be employing technology that is common today to connect to the local ISP. The ISP will then use special equipment to enable a link-up with the global Internet — in this case via satellite. Such a system can theoretically manage with a much smaller number of satellites since local ISPs can use much more efficient antennas than those that SpaceX, for example, is planning for its end users, and since local ISPs pool end user requests.[14]

14 Jeff Foust, “Telesat Remains Optimistic about Prospects for LEO Constellation”, *SpaceNews* (online), 11 November 2020, https://spacenews.com/telesat-remains-optimistic-about-prospects-for-leo-constellation/ (accessed 2 December 2020).

To offer Internet access via satellite, the satellite systems have to be connected not only to end users but also to the physical Internet infrastructure on Earth. At the moment, most companies do not plan for each LEO satellite to connect to these ground stations. Rather, the satellites are meant to form a network so that data can be directly transmitted between them. It would thus be sufficient if certain units within the network communicated with the ground stations.

A number of companies are working on technical solutions based on laser beams to make exchanging data between satellites possible. These are called Inter-Satellite Laser Links (ISLLs). In principle, this technology has the potential to transfer data at the speed of light. Unlike today's underground and submarine cables, it will require no elaborate or delicate "cabling". Some approaches aim to use this laser technology also for the connection between satellites and Earth. The Bavarian company Mynaric, among others, works in this field. In a decision that became public knowledge in July 2020, the German government blocked Mynaric from exporting its products to China.[15] This shows how crucial this technology is believed to be.

Advances in rocket and satellite technology have turned the stationing of mega constellations into a commercially viable project.

The Most Important Companies

Advances in rocket technology and the mass production of satellites have reduced the expected costs of stationing mega constellations in low Earth orbit to such an extent that these projects have become economically conceivable. With few exceptions, the business model for satellite-supported communications has so far been based on stationing a small number of geostationary satellites. Manufacturing and stationing costs for these satellites are very high, at approximately US$150 to 500 million per satellite.[16]

In contrast, the planned LEO mega constellations will be using new launch vehicles such as those developed by SpaceX. A key factor in this context is that SpaceX's carrier systems can be reused, which substantially reduces the costs of launches. SpaceX CEO Elon Musk has told the press that the cost of manufacturing and stationing the satellites currently stands at US$500,000.[17] Based on these numbers, building a constellation of 10,000 satellites would cost around US$5 billion in total.

The high initial investments, however, are only one of the economic challenges to be overcome if the plans for new LEO constellations are to be implemented.[18] Urban centres, for example, are attractive markets with many solvent customers — but there is also already a lot of fierce competition in these markets. Moreover, substantial additional investments would be required to be able to provide reliable Internet connections by satellite for large numbers of people concentrated in relatively small areas. Another challenge is the low purchasing power of end users in developing countries. Billions of people there still have no access to the Internet. One major reason for this is that it has so far not seemed lucrative to telecommunications companies to provide access. If the operators of the mega constellations want to offer their services in developing countries, they too will have to confront the low purchasing power of potential customers.

This research paper focuses on companies whose objective is to offer broadband Internet connectivity using LEO constellations (see Figure 3, p. 14). Alongside the big players, several smaller companies have announced their plans to provide such connections for the "Internet of Things" (IoT). For broadband-connections, most of the companies plan to use radio frequencies in the Ku and Ka bands; some are also considering the V and Q bands.

15 "DGAP-Adhoc: Mynaric AG: Mynaric gibt Einstellung der Geschäftsaktivitäten auf dem chinesischen Markt bekannt (deutsch)", *Finanznachrichten* (online), 30 July 2020, http://bit.ly/3qSI1fP (accessed 31 July 2020).

16 Caleb Henry, "Geostationary Satellite Orders Bouncing Back", *SpaceNews* (online), 20 January 2020, https://spacenews.com/geostationary-satellite-orders-bouncing-back/ (accessed 28 July 2020).

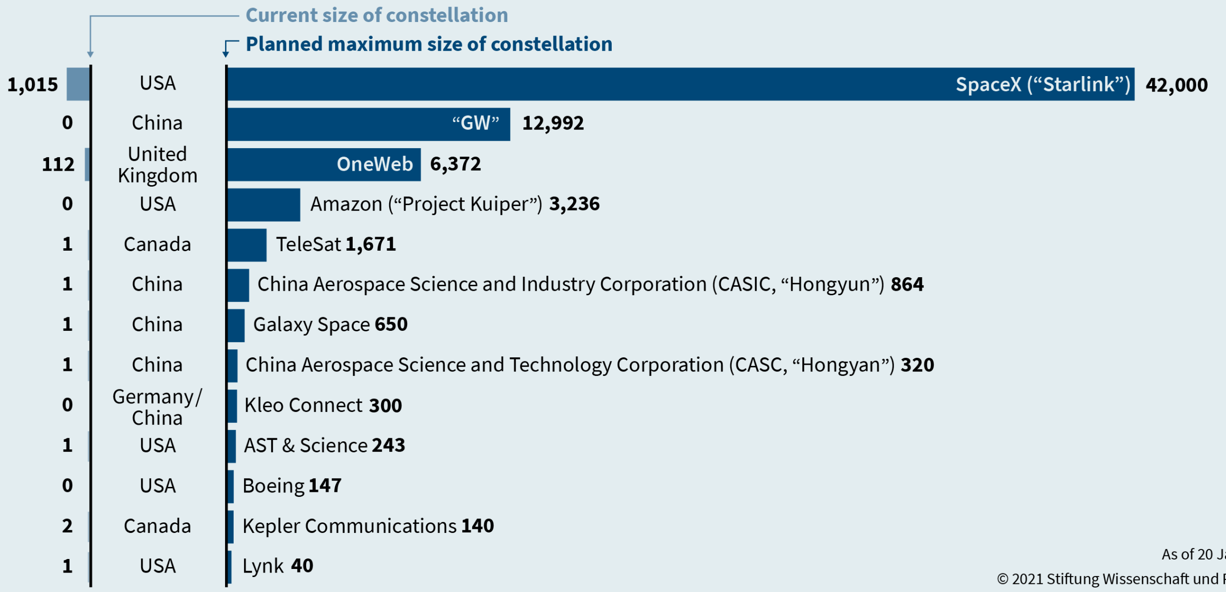
17 Brian Wang, "SpaceX Starlink Satellites Could Cost $250,000 Each and Falcon 9 Costs Less than $30 Million", *NextBigFuture.com* (online), 10 December 2019, https://www.nextbigfuture.com/2019/12/spacex-starlink-satellites-cost-well-below-500000-each-and-falcon-9-launches-less-than-30-million.html (accessed 6 August 2020).

18 Chris Daehnick et al., "Large LEO Satellite Constellations: Will It Be Different this Time?" *McKinsey & Company*, 4 May 2020, https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/large-leo-satellite-constellations-will-it-be-different-this-time# (accessed 3 July 2020).

Figure 3

Data availabe (in German) at http://bit.ly/SWP21Satellit

The most important companies' plans



As of 20 January 2021

Other companies are banking on satellite connections with a more limited transmission capacity, as Iridium Communications did as long ago as the late 1990s. Using VHF and UHF bands, the idea is to provide specialised IoT services, for which low transmission capacity is sufficient.

The Market Leaders from the US, UK and Canada

Starlink's projects are currently garnering the most attention. One reason is that Starlink is more advanced in implementing its plans than all other companies in the sector. At the beginning of 2021, Starlink had already stationed just over 1,000 satellites, far more than all its competitors. It wants to offer the first services for customers in southern Canada and the northern US in early 2021. Another reason is that Starlink is a subsidiary of the space travel corporation SpaceX, founded by Elon Musk. Notwithstanding Elon Musk's ambivalent public persona, this gives Starlink the advantage of reduced prices when using SpaceX launch vehicles for building its LEO constellation. In turn, SpaceX benefits from Starlink's substantial competitive edge over other companies and the revenues for its own carrier systems.

Along with Starlink, Project Kuiper, an Amazon subsidiary, is widely perceived to be among the most promising US companies. Like Starlink, it is a new arrival on the market for satellite communications. Currently, Project Kuiper plans to build a constellation of around 3,236 satellites.[19] As with Starlink, the plans of the Amazon subsidiary build on the premise that the stationing costs for Internet satellites will drop in the future. Project Kuiper only received its authorisation for operating a satellite constellation over the United States in July 2020. At that time, Amazon announced its intention to invest at least US$10 billion in the project.[20]

One advantage for Project Kuiper compared to Starlink is that it can draw on the experience of Amazon Web Services (AWS). This subsidiary of the online mail order company runs data centres and data connections. In fact, AWS is one of the largest cloud providers worldwide and has a correspondingly extensive network of data centres. Moreover, Amazon has been involved in installing new submarine cables in recent years (see Figure 1, p. 9). It is therefore not surprising

19 Federal Communications Commission (FCC), *Application of Kuiper Systems LLC for Authority to Launch and Operate a Non-Geostationary Satellite Orbit System in Ka-band Frequencies – Technical Appendix* (Washington, D.C., 4 July 2019).

20 "Amazon Receives FCC Approval for Project Kuiper Satellite Constellation", *Amazon Company News* (online), 30 July 2020, https://www.aboutamazon.com/news/company-news/amazon-receives-fcc-approval-for-project-kuiper-satellite-constellation (accessed 11 December 2020).

that Amazon is already jockeying for position as a service provider in the telecommunications sector.

A third major actor alongside the two US companies is the British company OneWeb. OneWeb had to file for bankruptcy in spring 2020. However, in July of that year it was sold for US$1 billion to a consortium consisting of the British government and the Indian company Bharti Global.[21] So far, OneWeb has stationed 74 satellites. To produce the required satellites, OneWeb has founded a joint venture with Airbus and established production sites in Europe and the US.[22]

Finally, Canadian company TeleSat, unlike the above companies, has been active in the satellite communications sector for a long time. In 2018 TeleSat stationed its first LEO satellite for testing, as part of its TeleSat LEO project. The objective of TeleSat LEO is to achieve worldwide coverage with a relatively small number of satellites. For this, its satellites are to be connected with its own ground stations. Alternatively, the Canadian company also promotes its system for mobile phone network providers. The idea is that they can connect their local networks to the global Internet via the TeleSat constellation.[23] TeleSat has announced that it will be ready to commence comprehensive service as early as 2022. It has concluded a contract for stationing the satellites with Jeff Bezos's company Blue Origin.[24]

State-Owned Companies from China

According to media reports, Chinese companies also have high ambitions for building LEO constellations. It should be assumed that these activities are, to varying degrees, supported or even steered by the Chinese government.

The state-owned company China Aerospace Science and Industry Corporation (CASIC) aims to build a worldwide network of 156 LEO satellites: the Hongyun Project. A first satellite was sent into space from China in December 2018.[25] Another state-owned company with an almost identical name, China Aerospace Science and Technology Corporation (CASC), has also stationed a satellite as a starting-point for an LEO constellation project, called Hongyan. Yet another Chinese firm, Galaxy Space, launched its first satellite in January 2020. In the next five years, that number is projected to rise to 144 and enable Internet access via 5G.[26] It is not clear from publicly accessible information whether the satellite constellation is intended for direct connection of 5G end user devices, or for connection to 5G ground stations. In late 2020 there were reports of an additional Chinese LEO constellation with the somewhat obscure name "GW", with a planned size of almost 13,000 satellites.[27]

European Suppliers

Of the companies mentioned so far, at least one, OneWeb, comes from Europe — though not from within the EU. An interesting case is Munich-based KLEO Connect. This start-up aims to build a constellation of up to 300 satellites to offer data connections for networked IoT-devices.[28] According to media reports, however, a Chinese company has since become the main investor, and is actively involved in the operational management.[29]

21 Jonathan Amos, "OneWeb Sale to UK-Bharti Group Gets Court Approval", *BBC* (online), 10 July 2020, https://www.bbc.com/news/science-environment-53370930 (accessed 31 July 2020).
22 Caleb Henry, "How OneWeb Plans to Make Sure Its First Satellites Aren't Its Last", *SpaceNews* (online), 18 March 2019, https://spacenews.com/how-oneweb-plans-to-make-sure-its-first-satellites-arent-its-last/ (accessed 23 July 2019).
23 "Telesat LEO", *Telesat.com*, https://www.telesat.com/leo-satellites/ (accessed 11 December 2020).
24 Caleb Henry, "Telesat Signs New Glenn Multi-launch Agreement with Blue Origin for LEO Missions", *SpaceNews* (online), 31 January 2019, https://spacenews.com/telesat-signs-new-glenn-multi-launch-agreement-with-blue-origin-for-leo-missions/ (accessed 5 August 2020).
25 Echo Huang, "China Got on the Bandwagon to Provide Global Satellite Internet", *Quartz* (online), 24 December 2018, https://qz.com/1506358/china-got-on-the-bandwagon-to-provide-global-satellite-internet/ (accessed 17 July 2019).
26 Andrew Jones, "China Launches Yinhe-1 Commercial Low Earth orbit 5G Satellite", *SpaceNews* (online), 16 January 2020, https://spacenews.com/china-launches-yinhe-1-commercial-low-earth-orbit-5g-satellite/ (accessed 20 March 2020).
27 Larry Press, "A New Chinese Broadband Satellite Constellation", *CircleID* (online), 2 October 2020, http://www.circleid.com/posts/20201002-a-new-chinese-broadband-satellite-constellation/ (accessed 8 December 2020).
28 "KLEO Constellation", *KLEO* (online), https://kleo-connect.com/constellation (accessed 11 December 2020).
29 Jeff Foust, "Space Industry Sees Growing Effects of Coronavirus Outbreak", *SpaceNews* (online), 9 March 2020, https://spacenews.com/space-industry-sees-growing-effects-of-coronavirus-outbreak/ (accessed 6 August 2020).

From a European perspective, however, it is more important that certain European companies have become crucial, even indispensable, suppliers of crucial components. First place goes to Airbus with its mass production of communications satellites. In addition, there are also companies offering single components or services. One example is OHB from Bremen, which was the principal contractor for developing the satellites for the European satellite navigation system, Galileo.[30] Another example is Munich-based Mynaric. Among other things, it is working on systems for intra-satellite communications using laser.

Political Choices

The future development of the Internet satellite sector will largely depend on whether remaining technical issues can be solved and companies can conceive viable business models. In addition, non-foreseeable events, such as the Covid-19 pandemic in 2020 can abruptly slow down or even terminate progress on Internet satellite projects, or else give them new momentum.

Alongside these factors, however, there is also room for governments to deliberately exert influence. As described in the first chapter, countries have always tried to shape the development of global communications systems to their benefit.

Such state activities take place within the framework of international law.[31] Its pivot is the "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies" of 1967 — often referred to simply as "The Outer Space Treaty".[32] It has been ratified by 107 nations, including Germany, and lays out their fundamental rights and duties in outer space. Importantly, Article VI clearly articulates the responsibility, and liability, of states for all national activities in outer space, "whether such activities are carried on by governmental agencies or by non-governmental entities" (Article VI). This article is likely to gain greater significance in light of the ever-expanding role of private companies in space.

Frequency Allocation

Since 1959, the ITU has had the mandate to coordinate the international allocation of radio frequencies, including those needed for satellite communications. It also coordinates orbital positions of satellites. This work is today carried out by ITU's Radiocommunication sector (ITU-R). Major decisions are made at the World Radio Conferences, which convene at least every four years.

ITU-R's function in coordinating radio frequencies essentially consists of a rather elaborate procedure to confirm whether a justified interest exists in using a specific frequency range.[33] The basic principle guiding this decision can be simplified as "first come, first served". Whoever files first has priority. All other countries and companies that might subsequently wish to use the same or neighbouring frequency ranges will have to come to an arrangement.

Private businesses cannot represent themselves in this procedure. Instead, governments act on their behalf and notify the ITU of the use of certain frequencies. Often, countries apply for frequency use by companies from other nations. In 2015, for example, Norway registered 4,527 satellites and the corresponding need for frequencies on behalf of SpaceX.[34] Companies seem to find it an attractive option to register their interests with the ITU via a number of different countries. This allows them to circumvent specific rules of individual national regulatory bodies. Many countries, for their part, deliberately do not distinguish between domestic and foreign companies. They have an interest in receiving the relevant fees, and hope for intensified economic relations with the companies.

30 "KLEO Constellation", *KLEO* (online), https://kleo-connect.com/constellation (accessed 11 December 2020).

31 Frans von der Dunk, "International Satellite Law", in *Oxford Research Encyclopedias*, ed. Peter L. Read (Oxford: Oxford University Press, 2016), 2ff., https://doi.org/10.1093/acrefore/9780190647926.013.39 (accessed 12 January 2021).

32 For the complete text, see the "Treaty on Principles Governing the Activities of States in the Exploration and Use *of Space, Including the Moon and Other Celestial Bodies*", *Europa-Universität Viadrina – Juristische Fakultät* (online), https://www.vilp.de/treaty_full;jsessionid=6F8797641CFA55A17BDE19A74E47FC92?lid=en&cid=197 (accessed 12 January 2021).

33 ITU, "Process Diagram Concerning Coordination and Notification of Satellite Networks", *ITU* (online), 14 January 2014, https://www.itu.int/en/ITU-R/space/elearning/presentations/diagramFilingProceduresNonPlan.pdf (accessed 2 December 2020).

34 Peter B. de Selding, "Signs of a Satellite Internet Gold Rush in Burst of ITU Filings", *SpaceNews* (online), 23 January 2015, https://spacenews.com/signs-of-satellite-internet-gold-rush/ (accessed 7 July 2020).

It is becoming increasingly problematic, however, that the ITU's coordinating function was originally devised for a different practice. The enormously time-consuming procedures date from a time when the total number of satellites stationed in space was manageable. The growing number of applications for mega constellations risks overburdening this allocation system. The size of the constellations currently being planned also challenges the ITU's basic mechanism of frequency attribution. If financially powerful companies with plans for mega constellations lay claim to large ranges of frequencies that are attractive for data transmission, these frequencies became a rare commodity. The "first come, first served" principle then risks becoming a hurdle for new arrivals. Back when there were fewer satellites, the parties involved were, in most cases, perfectly able to reach a voluntary agreement. Now real distribution conflicts are looming.

At the global level, the use of radio frequencies in space is coordinated by the ITU. However, countries reserve the right to regulate the use of radio frequencies on their territory, including their airspace. They can bring to bear security considerations, but also efforts to protect existing forms of use against disruption. In Germany it is the Federal Network Agency (Bundesnetzagentur) that is in charge of such matters.

Market Access

The activities of commercial satellite operators are further regulated through the World Trade Organisation (WTO). The regulatory framework of the General Agreement on Trade in Services (GATS) also applies to telecommunications services. In addition, the GATS contains an annex specifically dealing with these services. As of today, 108 WTO member states have made commitments concerning trade in these services, which include "cross-border transmission of telecoms services".[35]

The WTO's broad definition of telecoms services also applies to satellite communications and therefore — at least in principle — also to the planned new LEO constellations. That means that all states that have made the relevant commitments will have to grant companies operating these constellations access to their telecommunications markets.

While one can subsume the planned new LEO constellation under the existing GATS arrangements, an alternative would be to negotiate new agreements within the GATS framework to specifically regulate the services provided through these constellations. For instance, states could agree on rules that require satellite communications providers to provide their services in a non-discriminatory way. A broad interpretation of this would be to apply the principle of "net neutrality", i.e. the idea that network operators must treat all data equally, whatever the content and whoever the sender/receiver may be.[36]

Within the framework of the WTO, moreover, states also can regulate services nationally. What is important within the logic of the GATS agreement, however, is that the same regulations apply for both domestic and foreign companies. Within Europe, it is the EU which sets the majority of these regulations. Existing rules for telecommunications services providers, for example on data protection or net neutrality, would also be relevant for the planned LEO constellations.

Finally, the WTO's body of rules allows countries to play a "trump card", namely national security. Thus there were media reports that in 2018 OneWeb planned a joint venture with the Russian space organisation Roscosmos. This was blocked, the reports claim, by an intervention by the Russian domestic intelligence service FSB, which considered the intended cooperation a threat to national security.[37]

Public Funding for Research and Development

Nearly all companies that currently pursue plans for LEO mega constellations claim that their systems will allow the 3.6 billion people access to the Internet who have so far found themselves on the wrong side of the digital divide, without any Internet access at all. However, it seems unlikely at present that these potential new customers will generate the kind of revenues that the businesses require to build and operate the constellations.

35 "Telecommunications Services", *WTO* (online), https://www.wto.org/english/tratop_e/serv_e/telecom_e/telecom_e.htm (accessed 12 January 2021).

36 Volker Stocker, Georgios Smaragdakis and William Lehr, "The State of Network Neutrality Regulation", *ACM SIGCOMM Computer Communication Review* 50, no. 1 (2020): 45–59.

37 Maria Kolomychenko, "Exclusive: Russia Opposes U.S. OneWeb Satellite Service, Cites Security Concerns", *Reuters*, 24 October 2018, http://reut.rs/3p3S4ho (accessed 17 July 2019).

It is very likely that satellite companies will attempt to obtain financial support from international development budgets.

We should therefore expect companies to attempt to obtain financial support from international development budgets. UNICEF and ITU, for instance, have jointly founded the GIGA initiative, whose objectives include providing every school on the planet with access to the Internet.[38] Secretary-General António Guterres explicitly referred to the initiative in his opening speech for the 2019 Internet Governance Forum.[39] GIGA's initiators emphasise that it is a technology-neutral campaign. But it seems very likely indeed that at least a few companies from the Internet satellite sector will bid for the upcoming tender.

Along with their commitment to international development assistance, some countries systematically support domestic businesses in building LEO constellations. Evidently, this is the case for Chinese state-owned companies, even though the details are difficult to determine from the outside. The final declaration of the 2019 World Internet Conference, which takes place annually in Wuzhen, China, however, left no doubt that the Chinese leadership is aware of the global importance of communications infrastructure in space: "Countries should make joint efforts to advance cross-border and international submarine optical cables and improve information infrastructure in space."[40]

The US and Canada proceed differently: their governments act as customers, thus guaranteeing the companies an income for a certain period of time, and as financers of research and development. In the US, the latter has so far mostly been for military projects, but also for civilian programmes to fund Internet access in sparsely populated parts of the country.[41] In Canada, the government is supporting TeleSat with public monies for building an LEO constellation.[42]

Development of Standards and Protocols

Data transmission within constellations of tens of thousands of satellites that are constantly in motion, as well as data transmission between the constellations and users on Earth, will necessitate entirely new software protocols, or at least the adaptation of existing protocols. Thus far, it is organisations such as the Institute of Electrical and Electronic Engineers (IEEE), the Internet Engineering Task Force (IETF) and, for specific areas, the ITU, that have developed such standards and protocols.[43]

Discussions on this subject have in fact been opened within the IETF.[44] In late 2019 China proposed at the ITU that an entirely new Internet protocol, to be known as "NewIP", be developed. It has since dropped the idea in the face of massive criticism. One aspect is nevertheless interesting: China once again linked its proposal with the plans for LEO mega constellations.[45]

38 ITU and UNICEF, *Giga*, https://www.gigaconnect.org/ (accessed 12 January 2021).
39 United Nations Secretary-General, "Remarks to the Internet Governance Forum", 26 November 2019, https://www.un.org/sg/en/content/sg/speeches/2019-11-26/remarks-internet-governance-forum (accessed 2 December 2020).
40 "Jointly Build a Community with a Shared Future in Cyberspace", *China Daily*, 17 October 2019, https://www.chinadaily.com.cn/a/201910/17/WS5da7d7b3a310cf3e3557106a_3.html (accessed 12 January 2021).
41 Sandra Erwin, "Air Force Laying Groundwork for Future Military Use of Commercial Megaconstellations", *SpaceNews* (online), 28 February 2019, https://spacenews.com/air-force-laying-groundwork-for-future-military-use-of-commercial-megaconstellations/; Alan Boyle, "SpaceX's Starlink Satellite Network Wins $885M in Federal Aid for Rural Broadband", *GeekWire* (online), 7 December 2020, https://www.geekwire.com/2020/spacexs-starlink-satellite-network-wins-885m-federal-subsidies-rural-broadband/ (both accessed 12 January 2021).
42 Telesat Canada, "The Government of Canada and Telesat Partner to Bridge Canada's Digital Divide through Low Earth Orbit (LEO) Satellite Technology, over $1 Billion in Revenue for Telesat Expected", *Globe Newswire*, 24 July 2019, http://bit.ly/3p5Qn32 (accessed 25 July 2019).
43 Daniel Voelsen, *Cracks in the Internet's Foundation. The Future of the Internet's Infrastructure and Global Internet Governance*, SWP Research Paper 14/2019 (Berlin: Stiftung Wissenschaft und Politik, November 2019), https://www.swp-berlin.org/en/publication/cracks-in-the-internets-foundation/ (accessed 12 January 2021).
44 See, e.g., Internet Engineering Task Force, N. Kuhn and E. Lochin, "*Network Coding and Satellites*", *ietf.org*, July 2018, https://tools.ietf.org/html/draft-kuhn-nwcrg-network-coding-satellites-05 (accessed 12 January 2021).
45 See ITU, Telecommunication Standardization Sector, *"New IP, Shaping Future Network": Propose to Initiate the Discussion of Strategy Transformation for ITU-T (TSAG-C83)* (September 2019), https://datatracker.ietf.org/liaison/1653/ (accessed 12 January 2021).

Possible Futures: The Global Internet in 2035

Table

Degree of competition in the two scenarios

		Number of constellations	
		low	*high*
Vertical Integration	*low*		Scenario 2: Regulated Competition
	high	Scenario 1: Global Oligopolies	

It is not possible to *predict* future developments in the field of Internet satellites. Yet we can systematically explore the range of possible, and plausible, future scenarios. One entirely plausible scenario is that we will never see a fully operational mega constellation of Internet satellites. The technological, economic and political challenges are huge, and may eventually turn out to be insurmountable even for the most ambitious actors in the field.

In what follows, however, I want to take a closer look at how things might develop if these challenges can be tackled (see Figure 4). Exploring two scenarios, I will examine the implications for three key aspects of global Internet governance: Internet access, the security and resilience of the global Internet infrastructure, and power relations in global Internet governance. Related issues of space governance — from the modifications that will need to be made to space legislation to concerns over increasing space debris — cannot be covered here.

It is unlikely that actual developments will precisely follow one of the scenarios developed below.

To structure the range of possible developments, I sort them along a spectrum defined by the *degree of competition*. This variable, in turn, has two components (see Figure 4). First, it reflects how many operators of planetary mega-constellations compete in the market for broadband satellite Internet connectivity. Second, it captures the degree of vertical integration. The question here is whether the mega constellations "only" serve as backbone operators for terrestrial telecommunication providers or, instead, turn into full-service operators that directly service individual customers. It is not very likely that the actual development will neatly correspond to one of these scenarios. Rather, we can expect to see a mix of elements from both scenarios. Instead, the goal is to illuminate the range of possible developments — and their political implications.

This heuristic approach also helps to inform upcoming political decisions. Put simply, given the objectives German policymakers have set themselves for global Internet governance (see chapter 1, p. 7ff.), the first is a worst case scenario that must be avoided. Developments are not straightforwardly positive in the second scenario either. Yet it at least clarifies the building blocks and preconditions of a worthwhile development.

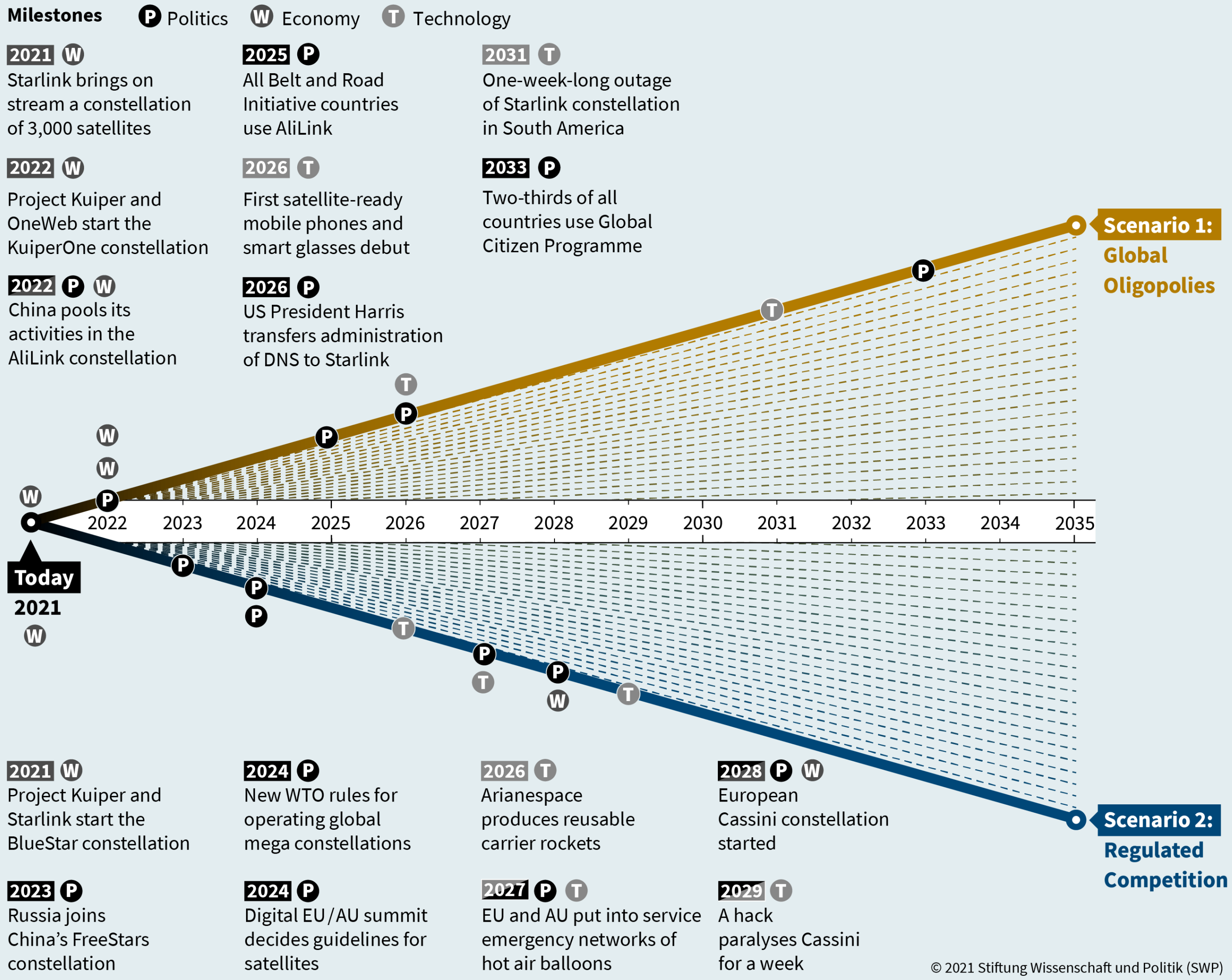
To sketch a vivid picture of these two possible futures, I use the names of specific companies and countries. Although the results of my analyses in the previous chapters feed into the scenarios, I want to emphasise here that the narratives are fictional.

Scenario 1: Global Oligopolies

With some delays, in late 2021 Starlink extends its LEO constellation to 3,000 satellites, covering 60 percent of the Earth's surface. The constellation focuses on regions in the Northern hemisphere, with a particular emphasis on the US and Canada. At about the

Figure 4

Milestones



same time, Amazon subsidiary Project Kuiper and OneWeb form a joint venture called KuiperOne. In 2022 KuiperOne commences regular operations of its satellite constellation. Starlink and KuiperOne offer backbone services, i.e. high-performance background networks, for local Internet service providers and data centres. They also enable direct connections for end users. In rural parts of the US, they cooperate with Verizon and AT&T, whose customers can resort to satellite connections when local networks are insufficient. Starlink and KuiperOne are also targeting the end user directly. For a starting price of US$99 a month, customers can book a data package of 100 Gigabyte (GB), for which they can connect directly to the satellite constellation. The special antennas required for this resemble the first mobile phones in their unwieldiness.

Domestically, the US government financially supports Starlink and KuiperOne through a programme to expand broadband access in rural areas and as part of defence ministry projects. In their international activities, the two companies benefit from programmes run by the United States Agency for International Development (USAID) to support the construction of Internet infrastructure in developing countries. US foreign policy also backs them: on a State Department initiative, a memorandum entitled "Internet Satellites and National Security" is signed by the other four members of the Five Eyes intelligence alliance — the UK, Canada, Australia and New Zealand. They thus commit to supporting the activities of Starlink and Blue Origin. Other countries subsequently make the same voluntary commitment, including Poland and the Baltic states.

The Chinese government, for its part, organises the deployment of a Chinese mega constellation. As in the US, a number of Chinese companies initially compete with each other but in 2021 the government concentrates all these efforts. A new state-owned enterprise named AliLink is founded to integrate all previous efforts and the Chinese Communist Party creates a new sub-committee to efficiently coordinate its future development. Until 2025, the Russian government pursues plans for a Russian mega constellation that is supposed to build on the GLONASS satellite navigation systems. Due to ever greater economic constraints, however, in 2025 President Putin negotiates a strategic partnership with China. Russia's efforts up to that point are integrated into the AliLink system, which is now available in Russia too.

As part of these consolidations, many European suppliers are bought up by one of the three big operators. Only a few manage — with the support of their respective governments — to retain their independence and assert themselves in a niche of the global market.

The use of satellite Internet has a breakthrough when, in 2026, a first generation of new "satellite-ready" mobile devices reaches the market. They no longer require special antennas to link to satellites. Mobile phones and the now very common digital "smart glasses" can directly connect to satellites, using existing mobile telephone protocols as well as new protocols that are custom-made for satellite communications. Since the three big satellite operators employ different frequencies and are not technically compatible in further ways, connecting to the satellite constellations from end user devices requires specific hardware modules. These modules are licensed by the operators of the constellations. Citing fears of espionage and sabotage, the US and its allies ban the use of the Chinese hardware modules. Likewise, China and Russia ban the use of the US-based modules.

Data transfer between the three constellations takes place at Planetary Exchange Points (PXPs).

From 2024 on, within each of the three systems, data is transferred between satellites via Inter-Satellite Laser Links (ISLL). A growing number of satellites serve as distributed data centres. Like earlier terrestrial content-delivery networks (CDNs), these data-satellites cache frequently requested content such as video streams.

The transfer of data between the three constellations takes place at Planetary Exchange Points (PXPs). In an initial phase, these are operated on Earth. The US and China informally agree that roughly half of the PXPs are stationed in locations that are controlled by one of the two states. By 2030, the US and China publish plans for moving the PXPs into space, explaining that they want to avoid depending on the host states of the locations where the PXPs were previously stationed.

The continuous expansion of the three constellations also puts the operators in a position to compete directly with local telecommunications providers. Attempts by a few European countries to create new WTO rules to avoid this competition between the global satellite operators and local companies have failed. As a consequence, in rural and sparsely populated areas, local ISPs increasingly find it difficult to compete with the operators of the satellite constellations. In densely populated areas, the operators use local relay stations that simultaneously connect to multiple satellites for more bandwidth. End users can connect to the relay stations via different protocols, e.g. 6G and WIFI6. The satellite operators thus gradually turn into serious competition for local ISPs even in urban spaces.

By 2035 this results in three fully operational mega constellations. Two — Starlink and KuiperOne — are owned by private enterprises subject to the jurisdiction of the US and its closest allies. The third constellation, AliLink, is run by a Chinese state-owned business and actively supported by the Russian government. The two Western constellations dispose of over 10,000 satellites each, the Chinese one has over 14,000. Almost 60 percent of the world's Internet data flow passes through these three constellations. Around two-thirds of the Earth's population regularly use them to access the Internet. However, distribution is unequal: while rural areas almost exclusively use satellite Internet, many cities increasingly turn to fibre optic connections. What does it all mean for global Internet governance in 2035?

The AliLink constellations can be accessed from China, Russia and all Belt and Road Initiative countries.

Access

In principle, all three systems can be configured to cover every spot on Earth. In light of the intense political controversies over these systems, however, their actual coverage is shaped by political considerations. The two Western constellations primarily cover North and South America, allied states in Europe and the Pacific, and parts of Africa. The AliLink constellation can be accessed from China, Russia and all Belt and Road Initiative (BRI) countries. Since 2025 Hungary, Turkey, India and a number of African countries have joined the BRI. As promised by the operators, the constellations offer connectivity in many rural areas that, as recently as the 2010s, had no Internet access whatsoever.

By 2035, 1 billion people in developing countries have, for the first time in their lives, gained access to the Internet via the new satellite constellations. More than 70 percent of all schools in African states are also connected to the Internet through them. Using subsidies and credits, the World Bank, the Asian Development Bank and individual donor countries supported the expansion of the satellite constellations to give reliable coverage of the Southern Hemisphere as well. In the early years, however, the expense of the more specialised antennas and the still comparatively high user fees for satellite Internet were a substantial obstacle. The breakthrough came in the late 2020s when the first inexpensive mobile phones arrived on the market with integrated hardware modules for connecting to the satellite constellations.

When the mega constellations were first being built, the assumption was that developing countries would undergo a process similar to Western nations, which have connected to the Internet since the 1990s. Unlike then, however, governments in the early 2020s were well-prepared. From the offset Internet use was controlled by each country's political rules. Many Western companies rushed into the African market from the mid-2020s onwards, drawn by the millions of potential customers. Some countries, including Ghana, nevertheless managed to promote their own digital economy.

Security and Resilience

Since almost all essential network elements are in the hands of the big three operators, they have more control over what happens on the networks. For instance, they can rapidly install security updates for protocols and individual software components.

The US and Chinese governments also view this centralised structure as a security gain. Using the respective operator's special interfaces, they can comprehensively monitor the data flows within the networks. They can thus also decide in detail which data enter or leave "their" networks at the PXPs. Finally, both governments reserve certain capacities within the constellations for military purposes, for both themselves and their closest allies. By 2035 many countries have their own satellite networks for "network-centric warfare". However, it is considered a major strategic advantage to also be able to draw on the gigantic civilian constellations.

Soon, however, a previously unknown issue emerges. Since the constellations increasingly go their own ways in terms of technology, targeted attacks on individual constellations become possible without endangering one's own network.

Some observers had originally hoped that the mega constellations would complement the network of submarine cables and thus augment the resilience of the system as a whole by adding redundancy. However, after only a few years, the progress made in data transmission in space via ISSL led to investors withdrawing from plans for new submarine cables. While in 2025 90 percent of the intercontinental data flow still passed through the submarine cables, that figure has dropped to 20 percent by 2035.

The risks of increasingly relying only on the satellite constellations became evident during a large-scale outage in 2031. Starlink's constellation suffered from a serious and widespread malfunction, effectively cutting off Internet access for almost all South American states. The few remaining submarine cable connections were unable to fill the gap left by the malfunctioning satellites.

It soon became clear that the outage was caused by satellites that had been among the first to be deployed. Their necessary software update of earlier that year included a bug, which was triggered on 28 June 2031. With the help of KuiperOne, basic coverage was restored within a few days. For two weeks, however, Internet access was limited to public institutions and select private companies of strategic relevance. After two weeks, Starlink found the bug and updated the malfunctioning satellites. As soon as Internet access in South America was restored, social media was abuzz with mass criticism of Starlink and the governments of Latin America. In response to the protests, in early 2032 the three big satellite operators agreed on a Charter of Trust that contained measures to prevent such outages.

In 2035 the operators of the three satellite constellations combine almost all elements of the Internet infrastructure.

Power in Global Internet Governance

Many different actors used to operate the Earth's Internet infrastructure as it developed across the world from the 1990s onwards. Above all, there were a large number of private companies that managed its different parts – from submarine cables to IXPs to local ISPs. By contrast, in 2035 the operators of the three satellite constellations are characterised by a high degree of vertical integration: they combine almost all elements of the Internet infrastructure.

The reduced number of entities involved in running major parts of the global Internet infrastructure makes coordination between them much easier. The three companies – Starlink, KuiperOne and AliLink – jointly work on the standards necessary to enable the data exchange between the three systems at the PXPs. To formalise their cooperation on this issue, they establish the Planetary Connectivity Organisation (PCO).

In the early years, whenever they needed to agree on the use of certain frequencies, the operators still went through the procedure established by the International Telecommunication Union (ITU). Soon, however, it became abundantly clear that the ITU allocation process was not suited to such enormous constellations. In 2025, with the agreement of their governments, the three companies therefore decided to allocate frequencies within the PCO instead. While the ITU procedures still exist in 2035, the organisation is now essentially reduced to accommodating the PCO's decisions.

Shortly thereafter, in 2026, the US government under President Kamala Harris decided to transfer the task of managing the Domain Name System (DNS) to Starlink. It justified this as the next logical step in the process that had begun in 2016 with the handover of this responsibility to the Internet Corporation for Assigned Names and Numbers (ICANN). In response, China and Russia opted to build their own "sovereign DNS". This has been administered by AliLink since 2027. For some observers there was a certain irony in the emergence of the first truly global communications systems being accompanied by the long-feared, politically motivated fragmentation of the Internet. The three big satellite companies quickly agreed standards within the PCO to enable exchange between constellations, despite the two separate Domain Name Systems. Since the operators now also control the respective DNS, they have an added means of steering data flow between the constellations. For example, the Chinese system very quickly prohibited access to the Taiwanese top level domain .tw, which continues to be used in the West. All three systems also use DNS to prevent crime.

The three operators host regular multi-stakeholder conferences to discuss the future development of the constellations. The PCO, too, has a multi-stakeholder advisory board (MAB) that is open to governments, private businesses and civil society. In 2029, a group of Western civil societies jointly declares that they will no longer attend these meetings, calling them a mere façade meant to legitimise the extraordinary power of the three companies operating the constellations.

With the exception of the US, China and their respective allies, the influence of individual states on the operation and future development of the constellations is limited. All three constellations, however, offer special services for governments that allow them to configure their services in line with local laws and regulations ("Governance as a Service"). Many governments seize this opportunity, though some criticise the lack of transparency about how exactly the three operators implement their legal requirements.

As an additional service, all three operators offer "global citizen" programmes. These make it possible to apply certain regulations to citizens of a state wherever they find themselves on Earth. When citizens travel to other countries, their digital communications thus remain within the jurisdiction of their home state. In 2035 two-thirds of all countries use this programme. However, it also has its limits. To preserve the freedom of the Internet, the US government insists that, within the global citizen programme, Starlink and KuiperOne must not restrict freedom of expression or data protection more than in the US. Similarly, in matters of freedom of expression the Chinese government commits AliLink to adhering to the guidelines of the final declaration of the 2028 World Internet Conference in Wuzhen. In 2030 the EU decided to embed exceptions in its legislation that allow the satellite constellation operators to continue to offer their services legally in the EU. Its decision was based on an extensive debate and past experience with the Privacy Shield.

Scenario 2: Regulated Competition

In late 2021 Elon Musk and Jeff Bezos take the public by surprise when they declare that they will henceforth combine their efforts to build a global LEO constellation in a new company called BlueStar. Shortly thereafter OneWeb also joins. At the turn of the year 2022-23, BlueStar puts into service a constellation whose satellites cover the entire Northern hemisphere as well as South America and parts of Africa.

To remain competitive against BlueStar, the Chinese government decides in early 2022 to combine all its previous initiatives in an LEO constellation called FreeStars. In 2023 China and Russia announce that they will closely coordinate their activities in space as part of a strategic partnership. Russia then drops its plans for its own LEO constellation and joins FreeStars. The constellation comes on stream in late 2024 and provides satellite coverage for all of Asia, Russia, Eastern Europe and large parts of Africa and India.

Also in late 2021 the European Council agrees to support the building of a European LEO constellation through a special funding programme. Proponents of the plan had pointed to the EU's experience with the satellite navigation system Galileo and the launcher knowhow gained over decades by Arianespace. But the project encounters resistance in Washington: President Harris criticises it for unnecessarily splitting the Western-liberal camp. Congress is even harsher, suggesting Europe should honour its NATO obligations rather than hurt American firms through illegal subsidies. The EU is not deterred and sticks to its plans. In 2022 it signs a new agreement with Japan to intensify cooperation in digital technology; this paves the way for closer collaboration in satellite communications.

In 2023 European companies form a joint venture called Cassini, with the objective of building an independent European LEO constellation.

The following year European companies form a joint venture called Cassini, with the objective of building an independent European LEO constellation. The European Commission supports Cassini financially for research and development. A number of EU member states also commit to using the system to connect public institutions in sparsely populated regions. It soon becomes evident that Cassini can benefit from a network of European subcontractors in the space technology sector. The joint venture receives a further boost in 2026 when Arianespace succeeds in producing a launch vehicle that, like the SpaceX systems, can land on Earth and can thus be used several times. The Cassini constellation begins operation in the summer of 2028. As a latecomer to the scene, it has to come to an arrangement with the already existing constellations for using radio frequencies. This is not a problem over Europe, but in some parts of the world Cassini can only offer a limited service. In late 2028 the US, China and Russia ban the system from operating on their territories with reference to national security issues. President Harris expresses her regret at being forced to take this step, pointing to NSA findings that the Cassini system is not sufficiently secure to operate in the US.

In the beginning, BlueStar, FreeStars and Cassini provide both backbone services for local ISPs and an end user service. For an average fee of US$100, users can connect directly to the constellation. As of 2024, however, new WTO rules change the market dynamics. Member states agree that constellation operators can henceforth only offer backbone services. In the preceding WTO debate, a number of countries pointed out that similar rules had proved very effective in the electricity market. The new WTO regulations also confirm that the GATS rules apply to satellite services as well, and emphasise that countries are obliged to treat domestic and foreign companies equally where access to national markets is concerned.

The WTO regulations, however, contain two exceptions. In areas where no local ISP provides Internet connectivity, the operators of the satellite constellations may apply for a license to serve as ISP. All three take advantage of this opportunity, especially in developing countries. By 2028 FreeStars subsidiaries have already built local ISPs in 50 countries; BlueStar is represented in 40 countries; Cassini in only 12. The second exception to the WTO rules is that the constellation operators are allowed to offer direct access to their constellation as a special service to certain customers with specific needs. In many countries, this service is initially limited to airplanes and ships. However, some soon begin expanding the circle of those eligible for the special service to officials and law enforcement authorities. Singapore additionally introduces an exception for "international business agents".

By 2035 three LEO constellations have developed: BlueStar has 13,000 satellites, FreeStars 12,000 and Cassini 6,000. Around 50 percent of global Internet traffic passes through the constellations, with about two-thirds of the world's population using them to access the Internet. In rural areas and developing countries, the systems often provide the most important Internet access. Densely populated economic centres, however, continue to rely primarily on fibre optic connections.

In 2035 vast parts of the world are divided into two digital spheres that are largely separate from each other.

Access

All three systems are technically capable of providing connectivity for every spot on Earth. As described above, BlueStar and FreeStars were able to reserve for themselves the most attractive radio frequencies. In some places, this limits the availability of Cassini's services. Decisions over local licenses, moreover, are often shaped by political considerations. As a result, the technical configuration of the constellations increasingly reflects political divisions. The US, China and Russia prohibit satellite networks on their territory that are not at least in part operated by domestic companies. Furthermore, the US and China emphatically try to convince their respective allies to adopt a similar policy. As a result, in 2035 vast areas of the world are divided into two digital spheres that are largely separate from each other. In each sphere, the Internet can only be used via one of the constellations.

The EU, however, is the centre of a group of countries that remains committed to the new WTO rules of 2024. It allows all three operators access to their markets. Within the EU, the decisions by the US, China and Russia not to allow Cassini access to their markets lead to a heated debate about retaliating by excluding the other two systems. In the end, however, the EU member states re-affirmed their commitment to the multilateral trade system and to free communication. In 2025 Brussels also tightens the rules on data protection by reforming the ePrivacy act. Local ISPs using one or the other of the non-European satellite constellations now have to take extra measures to protect their customers' data, for instance through appropriate forms of encryption or pseudonimisation, or informed user consent to data processing outside the EU. Finally, both FreeStars and BlueStar are banned from offering their services near strategically important sites such as military bases or energy plants. To enforce this ban, the EU sets up technical systems to locally block the frequencies used by these two systems.

Also in 2024 the EU and African Union (AU) hold a digital summit under the banner #Digital4All. The final document contains a series of targets that operators of satellite constellations must meet to be able to receive financial support from international development agencies. These include operators having to provide publicly accessible information on the real availability of their systems in developing countries and on costs for end users and local ISPs. Funds will also be linked to an operator providing free access for all schools in regions where the operator receives financial aid for offering its services. A number of large donor states implement these guidelines in the following years. The UN Secretary-General also publicly endorses them.

The EU also supports the AU with technical expertise in its application to the ITU for the use of radio frequencies suited to provide broadband satellite-connectivity over the entire African continent. The objective is to ensure that African companies retain the opportunity to enter the market at a later stage. Many democratic governments in Africa decide to use the European Cassini system in the meantime, so as to connect public institutions in remote areas to the Internet.

As a result, in 2035 all developing countries have connectivity to at least one of the three constellations. Following US and Chinese pressure, however, few countries have access to all three. This comprehensive availability, however, emphasises a problem to which the AU-EU summit already referred in 2024. To be able to actually use the new satellite constellations, many regions first need to invest in mains electricity supply, both for the necessary infrastructure on Earth and for running end-user devices.

Security and Resilience

The constellation operators had to make it possible to transfer large volumes of data within networks of tens of thousands of satellites, which additionally move continuously at high speeds and in different orbits. To this end, they developed new protocols both for directing the data flows *(routing)* and for identifying end devices in the network. Many of the innovations introduced here were subsequently also taken up by the terrestrial Internet infrastructure. In developing these protocols, the constellation operators were able to remove some weaknesses from the previously widespread protocols. At the same time, documents leaked in 2028 showed that BlueStar and FreeStars had also created new, undisclosed forms of "lawful access". These provide the governments of the US, China and Russia with powerful tools for monitoring the global data flows.

The introduction of the new protocols for the satellite constellations initially caused cyber attacks to drop slightly. From about 2026, however, the rate of attacks increased again. In the interval, attackers had apparently found flaws in the new protocols as well. And while there is no proof yet, there are also concerns that some hacker groups have succeeded in exploiting the interfaces built into the systems to provide access for national law enforcement agencies.

A particularly devastating attack occurred in 2029. Within just a few days, a virus spread globally through all satellite constellations. Although the virus was found on computer systems everywhere, the special twist of this virus was that it only harmed the European satellite constellation Cassini. It corrupted a standard setting in the transfer protocol used by Cassini and thus effectively brought to a standstill all data transfers within that network. Luckily, many users of Cassini were able to switch to the two other systems, use terrestrial networks or resort to emergency mobile networks that had been established in many European cities since 2027. After a week, Cassini experts managed to resume operation of the satellites and to update the system to protect it from similar attacks in the future. The event led to a heated debate, with many rumours circulating as to who might have an interest in specifically damaging the European satellite network. Since then, all three constellation operators have worried about further targeted attacks on one of their networks.

This new awareness of the satellite constellations' vulnerability also had an impact on how the network of submarine cables was viewed. With the activation of the constellations and the technical progress being made in Inter-Satellite Laser Links (ISSL), intercontinental data traffic had increasingly shifted into space. Accordingly, plans for building new submarine cables were stopped. After the 2029 attack on Cassini, however, priorities were revised. The EU organised a World Cable Summit in 2030 in the hope of using funding programmes to incite the private sector to make new investments in submarine cables. These initiatives turned out to be insufficient, however. No new cable projects were attempted until 2035.

The EU Commission therefore had to find other ways of raising the resilience of the Internet's infrastructure. In 2027 it started a public-private partnership (PPP), with governments and business from Europe and Africa working together on emergency mobile phone networks. Among other things, the PPP adopted technological ideas developed by Project Loon, a subsidiary of the US holding company Alphabet that was shut down in 2021. As with Project Loon, the fundamental idea is to create networks of hot air balloons that operate like traditional mobile phone networks, at only a few kilometres above ground. In the event of local outages of the terrestrial networks or even the satellite constellations, these mobile emergency networks can reach every spot in Europe and Africa within a few hours. Since 2028 five such networks have been on stand-by at any one time. They can be put into service within two hours.

Finally, EU member states have benefited from the massive investments in fibre optic connections that the EU had decided on as part of its measures to overcome the Covid-19 crisis. With the rise of the satellite constellations, these efforts were initially derided. In 2035, however, they are seen as a fundamental reason for the resilience of Europe's Internet infrastructure. Europe is the only part of the world that has blanket coverage by all three constellations *and* access to an extensive fibre optic network for 80 percent of all households.

Power in Global Internet Governance

Much has changed by 2035. But the existence of three independent constellations and the WTO rules from 2024 mean that it continues to be necessary for the international community to communicate on data transfer standards, including between the different networks. In 2026 an altercation arose between BlueStar and FreeStars after BlueStar announced its intention to modify the global protocols unilaterally. In response, the Internet Engineering Task Force (IETF), in cooperation with European scientists involved in Cassini, offered to mediate. The proposal was quickly backed by the EU and AU. Both BlueStar and FreeStars subsequently declared themselves willing to continue to leave the development of the necessary standards and protocols in the hands of open forums such as the IETF.

Under the new WTO rules, the satellite constellations are in principle restricted to providing backbone services and their operators can only exceptionally apply for a licence as a local ISP. This strengthens the position of countries to an extent. For many governments a fundamental reason for agreeing to the new WTO regulations was the added possibilities it afforded them for enforcing national legislation. In regions that only have access to BlueStar or FreeStars, however, it quickly became obvious that countries' influence over the operators was limited. For instance, BlueStar only provides its backbone services to local ISPs if they allow their users to access digital services from the US, which are supposed to be banned in the EU for data protection reasons. The Chinese constellation FreeStars very widely blocks access to news sources that are critical of the government in Beijing.

In 2025, BlueStar, FreeStars and Cassini jointly expressed their support for ICANN's role in managing the global DNS. However, at the same time all three operators also began building their own addressing systems. Therefore, by 2035 the DNS root zone system has changed quite fundamentally: it no longer directly links to the registries of top-level-domains (TLDs) but to the registries of the three operators. The operators coordinate the use of TLDs, but they also reserve the right to block specific TLDs within their system.

This is not the only possibility for constellation operators to control the data flows within and between their networks. To exchange data between the constellations, Planetary Exchange Points (PXPs) have been installed in Europe, China, Russia and the US — as well as in space. Especially at these PXPs, the three operators can decide in great detail which information may leave or enter their network.

Recommendations for Germany and the European Union

It remains an open question whether the highly ambitious plans for providing Internet connectivity via LEO satellite constellations can be realised. If they can, we should expect a massive impact on the security and resilience of the global Internet infrastructure, on access to that infrastructure — and on power relations in global Internet governance. The risks are substantial: a never-before-seen concentration of economic might, and a previously unknown extent of political control over global communication networks.

As a likely consequence, the trend towards the fragmentation of the Internet will intensify. A new world-spanning Internet infrastructure in the hands of a few companies (and the countries behind them) would make it possible to split the Internet along political lines of conflict into two largely separate spheres. Any exchange across the borders of these spheres would then only be feasible if, and to the extent that, the operators of the new infrastructure allow it. This would very likely lead to substantial restrictions on freedom of expression and the right to privacy. Countries such as Germany would thus be exposed to a situation in which self-determined democratic control over their own digital infrastructure — in other words, democratic sovereignty in the realm of technology — is increasingly limited. Similarly, the aspiration of participating as an equal in the global debate on the future of the Internet would come to nothing in this scenario.

What needs to be weighed up against these risks is the technically and socially fascinating prospect of providing all humans with access to the vast potential of digital communication via a "detour" into space — and of strengthening the common foundation of the global Internet by adding a new dimension to Internet infrastructure.

With a view to these potentially far-reaching consequences, it is politically imperative to start preparing for such a scenario: the time is now. Even though efforts to build the planned mega constellations are still in their infancy, a proactive policy of dealing with these developments needs a head start.

A proactive policy is also advisable in the event that the plans for the new mega constellations fail. The issue of how the physical infrastructure of the Internet can be adapted to new challenges will always require a solution, even if a specific technology turns out to be inadequate.

Promoting Technological Redundancy and Diversity

It is almost commonplace to say that the security and resilience of digital infrastructure can only be boosted by redundancy. What this means is the deliberate creation of excess capacities to ensure that disruptions of individual entities do not cause the entire system to collapse. The global Internet, for instance, with its decentralised structure was designed from the outset to generate resilience through redundancy. During outages of partial Internet networks, its basic protocols make sure that data flows are redirected.

These adaptive mechanisms of the Internet's basic protocols are truly elegant. However, the Internet's physical infrastructure shows up their limitations. Where the infrastructure is inexistent or inadequate, even the smartest algorithm is useless. The more we depend on the Internet, the more important it becomes to ensure an appropriate level of redundancy on the physical level as well.

Redundancy also has added value for security if it is combined with technological diversity. Technological monocultures are easier to hack since the attacker's resources can all be concentrated on a single system. Moreover, such monocultures are usually also synonymous with economic dependencies, which can be used as leverage for (geo)political influence.[46]

With a view to Europe's own Internet infrastructure and its connection to the global Internet, these observations suggest that strong or one-sided dependencies should be avoided. Europe should therefore push ahead with the widespread deployment of fibre optic cables, both for direct connections for end users and as the basis for future mobile phone networks. It should also take care to further develop the functionalities of strategically significant submarine cables — for example, across the Atlantic or to Africa or Asia. Here, continual technological renewal will be necessary to expand transmission capacities so as to meet growing demand and increase the security of landing points.[47]

In this context, the possible contribution of Internet connectivity via LEO satellites would not be as a replacement of terrestrial connections but as a *complement* to them. The objective should be to create a mix of technologies that reduces the dependence on any one technology — and the companies and countries behind it — to such an extent that Europe can safeguard its political autonomy.

This will require regulation, among other things. The satellite operators will need licences from governments to be able to use the respective frequency ranges on national territories. Issuing these licences can be made subject to conditions. Here it would be desirable to agree on a Europe-wide approach. This would be in the operators' interests, since they would not have to deal with many different rules in a comparatively small area. It would also strengthen Europe's negotiating position. Large US and Chinese corporations are also interested in accessing the European market. This is a leverage point for pushing through European targets.

These targets could then be used to secure a balance between the use of attractive frequency ranges by satellites and by terrestrial radio systems.

All of this would be an important contribution to an appropriate technology mix. Additionally, the targets could contain requirements for minimum availability of services, protection of personal data or security of satellite communications.[48]

Creating Leeway through a European Constellation

As described above, the US, China and Canada systematically use public funds to push ahead with the construction of LEO satellite constellations. It would be advisable for Europe to do likewise, and incentivise European companies through public investment to build Europe's own constellation. The necessary expertise exists in Europe: at this very moment, European firms are supplying important components for building LEO constellations. Europe can draw on past experience with Galileo, the satellite navigation system; with Copernicus, the satellite Earth observation system; and with the work done by Arianespace in developing launch vehicles. The EU Commission is also already funding the expansion of broadband access in rural areas and in regions and municipalities that use data from GEO satellites for various purposes.[49]

However, a look at other countries makes it clear that an infrastructure project of this magnitude requires substantial public investment. The EU Commissioner in charge, Thierry Breton, unequivocally advocated such EU investment in the summer of 2020. Since then the EU has taken the first preparatory steps. The final political decision backing a European constellation, however, is still pending.[50]

Setting up a European constellation could serve a number of objectives. *First*, Europe could use the opportunities of satellite-based Internet connectivity for its own purposes. *Second*, Europe could develop a

46 Matthias Schulze and Daniel Voelsen, "Digital Spheres of Influence", in *Strategic Rivalry between United States and China. Causes, Trajectories, and Implications for Europe*, ed. Barbara Lippert and Volker Perthes, SWP Research Paper 4/2020 (Berlin: Stiftung Wissenschaft und Politik, April 2020), 30–34.

47 Voelsen, *Cracks in the Internet's Foundation* (see note 43).

48 William Akoto, "Hackers Could Shut down Satellites — or Turn Them into Weapons", *Scientific American*, 22 February 2020, https://www.scientificamerican.com/article/hackers-could-shut-down-satellites-or-turn-them-into-weapons/ (accessed 20 March 2020).

49 See "Network of European Regions Using Space Technologies", https://www.nereus-regions.eu/.

50 Véronique Guillermard, "Thierry Breton: 'Il faut assurer la souveraineté numérique de l'Europe'", *Le Figaro*, 2 July 2020.

concrete alternative to the US and Chinese systems. This would enable it to demonstrate, not just in its regulations but also in its practical implementation, what the European vision for the future of the Internet looks like. Europe could thus convey an important message in the global debate and directly advocate preserving a free Internet based on a shared global foundation. *Third*, Europe would secure and deepen its own expertise at the interface of space technology and digital communications infrastructure.

Considering the remaining technical issues, it may seem risky to invest vast sums — several billion euros would definitely be needed — to fund LEO Internet satellites. However, even if the plans for mega constellations cannot be realised as envisaged today, we should expect significant technological progress to be made in the field — with results that cannot yet be gauged. Measured by what is at stake for Europe both politically and economically, such investments are therefore justified.

Deepening Strategic Partnerships

It is crucial for Germany and Europe to deepen strategic partnerships to adapt their own digital infrastructure to new challenges, but also to have some influence on the design of the global Internet infrastructure. In the narrower sense, this is about building the required technological capacities. But beyond that, it will also be increasingly important to seek out allies for political debates over the Internet's infrastructure.

With a view to digital infrastructure in general, and LEO mega constellations in particular, two lines of thought suggest themselves. First, partnerships should be intensified with countries that are obvious partners for sophisticated technological cooperation. Along with Japan, already mentioned as an example in Scenario 2, South Korea or Canada could also be considered. Second, Germany and Europe should use their longstanding international-development contacts. Developing countries are keenly aware of the importance of obtaining digital infrastructure and connecting the global Internet infrastructure. The companies currently planning LEO constellations know about this growing demand. Google's and Facebook's projects for new submarine cables and China's manifold activities as part of its Belt and Road Initiative also echo the increasing need for digital infrastructure. There is still an opportunity here for Germany and Europe to offer a technological and political alternative.

Protecting Multilateral Institutions

Deepening strategic partnerships also constitutes the basis for strengthening the position of multilateral institutions with a view to the planned mega constellations.

Since the ITU only has a coordinating role for the use of frequencies, it seems ill-suited to enforcing far-reaching political goals. Its technically demanding and protracted procedures elude direct political interference. Seeing that these procedures largely fulfilled their purpose in the past, they should not needlessly be drawn into political confrontations. Nevertheless, countries' strategic behaviour in this context should be closely observed and checked for political implications. It is not in the hands of Germany and the EU alone whether and in what manner political conflicts are carried out in the radio communications department of the ITU. Germany and Europe could, however, advocate within the ITU for reforms to prepare the organisation better for the challenges that the new mega constellations will bring. Failing this, the ITU's coordinating function risks being gradually hollowed out.

In principle, the WTO really is the ideal forum for avoiding any excessive concentration of economic and political power. As explored in the second scenario, new GATS rules could be used to specify that the operators of the satellite constellations are not allowed to offer services for end users as well.

However, the fact that multilateral institutions like the WTO are increasingly coming under pressure themselves is an obstacle to this potential of global regulation for increasing competition. The dual task for German and EU policymakers is therefore to fight within these institutions for new rules on how to deal with planetary communications systems — and simultaneously preserve the institutions themselves, their legal basis and procedures.

Supporting Open Standards

The current plans for LEO mega constellations risk bringing about a previously unknown concentration of economic power. Along with measures to promote technological diversity, Germany and the EU should champion retaining open standards and protocols. The fact that the Internet has so far been marked by such open standards is often interpreted as proof that it is inherently liberal. In fact, however, open standards and protocols were initially simply a technical necessity for maintaining sufficient interoperability between heterogeneous networks. However, this functional need for open standards diminishes as soon as the Internet infrastructure forfeits this very heterogeneity. If the infrastructure is in the hands of fewer and fewer actors, they will continue to need to coordinate with each other. However, this does not necessarily create a demand for open standards. Yet, retaining open standards and protocols can itself be an instrument for preserving the possibility of diverse heterogeneous networks: open standards in particular are the basis for perpetual innovation and "disruption", even for the breaking-up of concentrations of economic power.

The openness of standards can be directly supported through action, for instance by EU member states campaigning for them and making them legally binding. German and EU policymakers should also aim to protect established processes of standard development (in forums such as the IETF) from usurpation by governments. Finally, it is in this context that multistakeholder formats in global Internet governance — which German policy avowedly promotes — can show their strengths. Institutions such as the Internet Governance Forum (IGF) or the IETF offer the opportunity to drive the development of open standards at the interface of technology and politics using transparent and comparatively inclusive processes.

Global communications networks enable social exchange in the most diverse areas — from the economy to academia to culture. Since the first telegraph networks of the 19th century, there have been countries that try to gain control over the underlying infrastructure. Germany and Europe should counter such efforts with a view to the developments we might expect in the Internet satellite sector. A proactive and self-confident policy on global Internet governance can prevent problematic concentrations of power and so contribute to preserving the shared world-spanning foundation of the Internet and its pluralistic nature. As the two scenarios of this research paper have shown, future developments are not yet decided — to shape them politically, action must be taken now.

Abbreviations

AIS	Automatic Identification System
AU	African Union
AWS	Amazon Web Services
BBC	British Broadcasting Corporation
BRI	Belt and Road Initiative
CASC	China Aerospace Science and Technology Corporation
CASIC	China Aerospace Science and Industry Corporation
CDN	Content Delivery Network
DNS	Domain Name Service
EU	European Union
FCC	Federal Communications Commission (Washington, D.C.)
GATS	General Agreement on Trade in Services
GB	Gigabyte
Gbit	Gigabit
GEO	Geostationary Earth Orbit
GPS	Global Positioning System
ICANN	Internet Corporation for Assigned Names and Numbers
IEEE	Institute of Electrical and Electronic Engineers
IETF	Internet Engineering Task Force
IGF	Internet Governance Forum
IoT	Internet of Things
ISLLs	Inter-Satellite Laser Links
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union, Radiocommunication Sector
IXPs	Internet Exchange Points
LEO	Low Earth orbit
MAB	Multistakeholder Advisory Board
NATO	North Atlantic Treaty Organization
NSA	National Security Agency
PCO	Planetary Connectivity Organisation
PXP	Planetary Exchange Point
Tbit	Terabit
UHF	Ultra High Frequency
UN	United Nations
UNICEF	United Nations Children's Fund
USAID	The United States Agency for International Development
VHF	Very High Frequency
WTO	World Trade Organisation