Chapter 6

A NEW SATELLITE COMMUNICATIONS ENVIRONMENT

The chapter briefly reviews the state of play in satellite communications, which is undergoing significant transformation. For decades, satellite communications have been the fastest growing commercial space market, driving innovation and growth along the space sector's value chains. New technologies, business models and consumer behaviours are disrupting markets (e.g. television, broadband and the Internet of Things), with impacts throughout the space sector's value chains.

The state of play in satellite communications

Telecommunication services rely on the complementary capabilities of different types of networks, whether they be fixed and terrestrial mobile networks, or satellite networks (OECD, 2016[1]). In this complex infrastructure, satellite networks occupy a special niche based on their technical capabilities, as they can broadcast signals over large geographic areas. They have the capacity to deliver data, voice and video services to remote and rural locations, as well as to provide telecommunication services to users on the move (e.g. ships at sea, aircrafts). In this context, satellite communications have been the fastest growing market for the space industry, representing at times almost half of commercial satellite manufacturing revenues, driving innovation and growth along the space sector's value chain (OECD, 2014[2]). But the state of play in satellite communications have recently been changing.

As key actors in the broader telecommunications environment, satellite network operators lease or sell bandwidth capacity from their satellites in-orbit. Many of them have in parallel developed full turn-key solutions and equipment to bring value-added services and expand their customers' base. These network operators have traditionally branched out between providers of fixed satellite services (i.e. leasing capacity for video, voice and data traffic – more than 50 operators around the world) and providers of mobile satellite services (i.e. addressing specifically users in maritime and aeronautical markets in particular – around a dozen operators). But this line, based on different technological solutions and international spectrum sharing allocations, is blurring ever more, as all satellite network operators diversify their activities, invest in different types of satellites to complement their fleet, and increasingly compete in existing markets (OECD, 2016[3]).

Satellite networks operators link up with suppliers of electronics equipment, and value-adding services providers supporting the consumer markets. These include direct-to-home (DTH) providers and very small aperture terminal (VSAT) suppliers, many of which deliver full network solutions to users. Lines are also increasingly blurring between network operators and multimedia providers, as vertical integration and concentration of telecommunications and content companies are accelerating in many parts of the world (OECD, forthcoming[5]). Estimates for satellite communications markets vary, but fixed satellite services could amount to USD 17.9 billion in 2018 (i.e. backhaul, broadcasting); mobile satellite services around USD 4 billion (i.e. networks of communications satellites intended for use with mobile terminals); satellite radio some USD 5.8 billion and satellite broadband representing some USD 2.4 billion in revenues (Bryce Space and Technology, 2019[4]).

As seen in previous chapters, the space industry is currently being transformed by new manufacturing processes and technological innovations. Focussing briefly on satellite communications in this chapter, the state of play is particularly affected by:

- General developments in communication networks and services' markets around the world, with expanding terrestrial networks (see the OECD extensive analysis of telecommunication markets and their policy environment on the *OECD Broadband Portal* (OECD, 2019[6]);
- The roll-out of innovative space technologies in telecommunications (such as the new generation of High-Throughput Satellites (HTS); reprogrammable satellites that can adapt to changes in bandwidth demand from different regions and customers; new ground segment equipment) with significant increases in total amounts of capacity in orbit, leading to satellites services' declining prices;
- Evolving customer needs and requirements, particularly when accessing television services and connectivity on the move (see section 6.2);
- New entrants' business models and the possible impacts of large satellite constellations, particularly for future satellite broadband services (see section 6.3 and OECD (2017[7])).

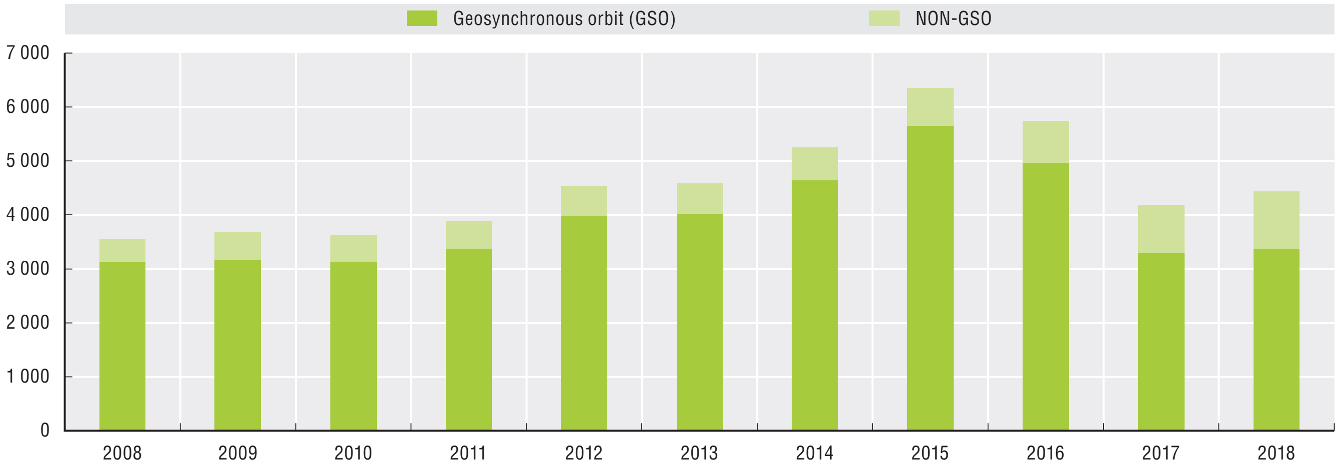
These elements are impacting commercial satellite network operators' strategies, as many have been postponing their procurement orders for new geostationary communications satellites (that usually last for fifteen year or more), with possible lasting effects in the commercial space sector.

The number of geosynchronous (GSO) satellite filings (i.e. an indicator of potential future GSO demand, as operators need to secure orbital slots and spectrum allocations, before they procure and launch satellites) has significantly risen over the last decade almost doubling from 2008 to 2015, before slowing down the following years (Figure 6.1). This is an imperfect indicator as many companies go through the filing process (first domestically then national administrations register the satellite networks at the ITU on behalf of the operators) to reserve orbital slots and frequencies, and do not always pursue development. Still, even with slowing-down trends, the current downturn in the sales of geosynchronous telecommunications satellites has been rather brutal, with only five commercial satellite orders in 2017, down from 17 in 2016 and 24 in 2015. As a consequence, out of the 15 different space manufacturers around the world able to design and produce geostationary satellites (a record number of companies for an ever smaller market), several are now starting to exit the commercial GSO market, to compete on institutional and defence-related space markets (see Chapter 1).

In parallel, international filings for non-geosynchronous satellites, i.e. satellites in lower orbits, have continuously grown over the period 2008-18, from 438 filings in 2008 to a record 1 066 in 2018, with more recent domestic filings to be included (International Telecommunication Union (ITU), 2019[8]). The list of satellite network operators and projects are growing, as many actors are investing in large satellite constellations.

Figure 6.1. Satellite filings by orbit type

Total number of filings



Source: ITU (2019), "ITU Radiocommunication Bureau (BR) 2018 Annual Space Report to the STSC 2019 Session on the use of the geostationary-satellite orbit (GSO) and other orbits".

The next two sections provide a brief overview of satellite television markets, and of broadband services and the Internet of Things.

Satellite television at a crossroad

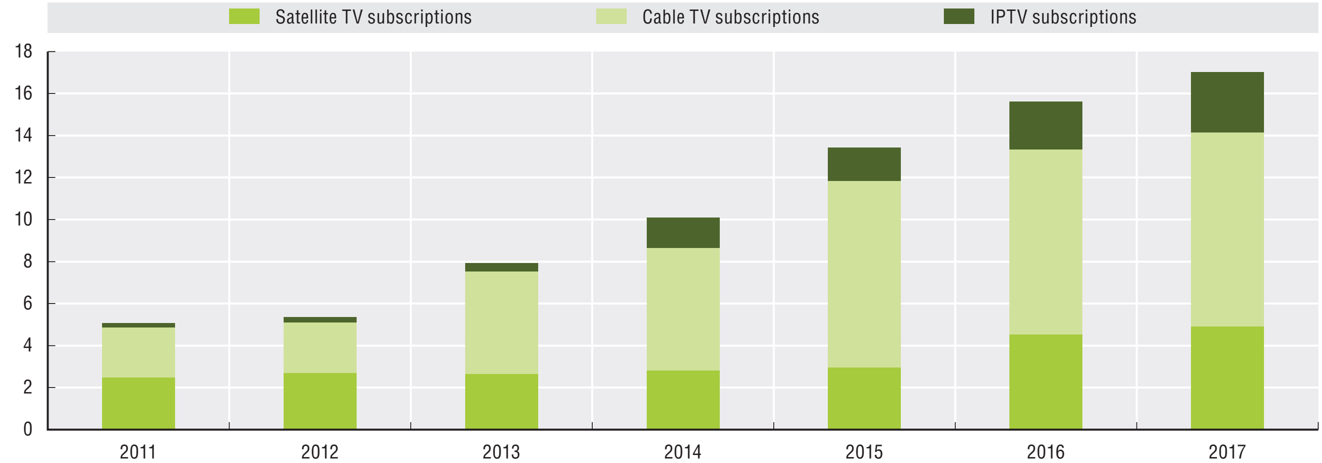
For many years, satellite networks have been the only way for millions of people to receive television programming in remote and rural areas, offering also for populations in urban areas different choices of channels. Satellite television or direct-to-home television broadcast (DTH) is today widely available in OECD countries via one or more suppliers, with signals received by satellite dishes and set-top boxes, often complementing other subscription based television services (pay-TV) provided by cable operators.

But the market structure for television programming and broadcasting activities has changed significantly, as all countries have introduced digital television and many have switched off analogue television in the past decade. Telecommunications operators now routinely offer television services bundled with other services, via Internet Protocol Television (IPTV) as part of triple play or quadruple play packages (i.e., television and telephone; broadband, adding mobile for quadruple play) (OECD, 2018[9]). Video on demand has also become an important channel to distribute audio-visual content, with an increasing number of suppliers offering streaming or downloads on the Internet. For example, increased competition now comes from streaming platforms and Subscription Video on Demand providers such as Netflix and Amazon Prime, which were relatively negligible five years ago. Many of the large media companies that are traditional customers of satellite capacity to deliver television programmes via direct-to-home platforms (e.g. Sky, Dish, DirecTV, Tata Sky Ltd) are also launching their own streaming platforms. As business models, products and services are changing rapidly, the role of telecommunication operators are evolving, with important policy implications (OECD, forthcoming[5]).

In this context, when comparing satellite TV, cable TV and IPTV subscriptions, cable-TV leads, but the number of satellite TV subscriptions has more than doubled since 2011, reaching 4.92 subscriptions per 100 inhabitants in 2017 (Figure 6.2). Internet Protocol Television (IPTV) subscriptions have also been rising steadily since 2014, supported by smartphones' developments.

Figure 6.2. Subscribers of TV broadcasting by technology

Number of subscriptions per 100 inhabitants

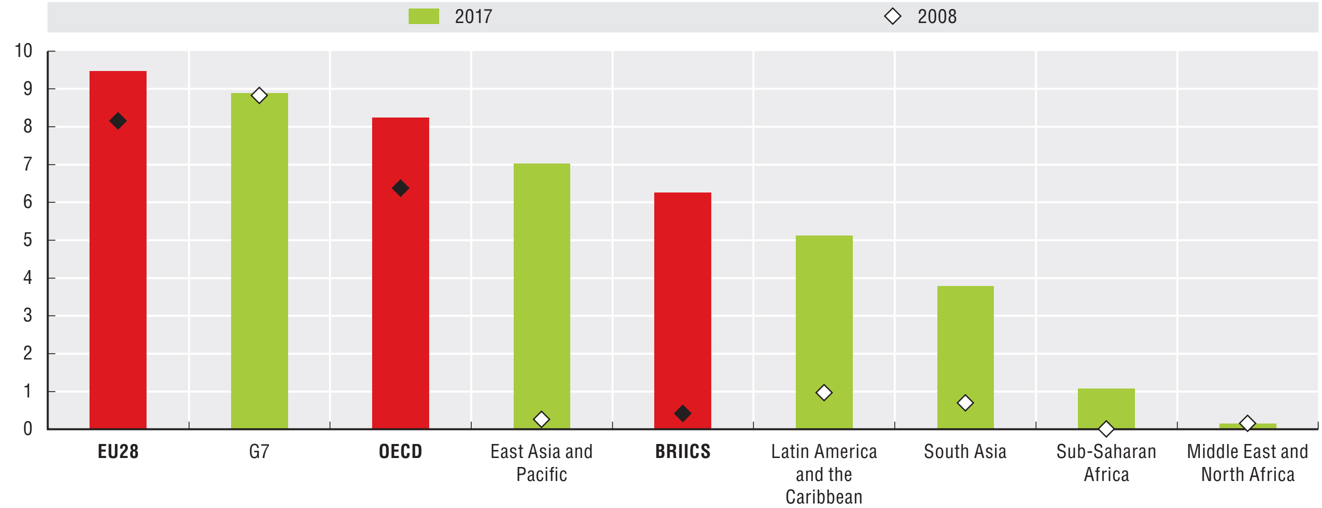


Source: Calculations based on ITU World Telecommunication/ICT Indicators 2019 database.

In terms of geographic coverage, Europe has the highest penetration of satellite TV subscriptions (Figure 6.3), and the recent downturn in satellite television has so far been limited to some regions (mainly concentrated in North America). When examining the rates of subscriptions Sub-Saharan Africa and East Asia are the fastest growing regions (Figure 6.4). However, they both had a very low penetration of satellite TV at the beginning of the period. East Asia registered an annual growth in subscriptions as high as 44.2%, followed by BRIICS (35.1%), and other developing regions including South Asia (20.6%) and Latin America and the Caribbean (20.3%).

Figure 6.3. Subscribers of satellite TV by region

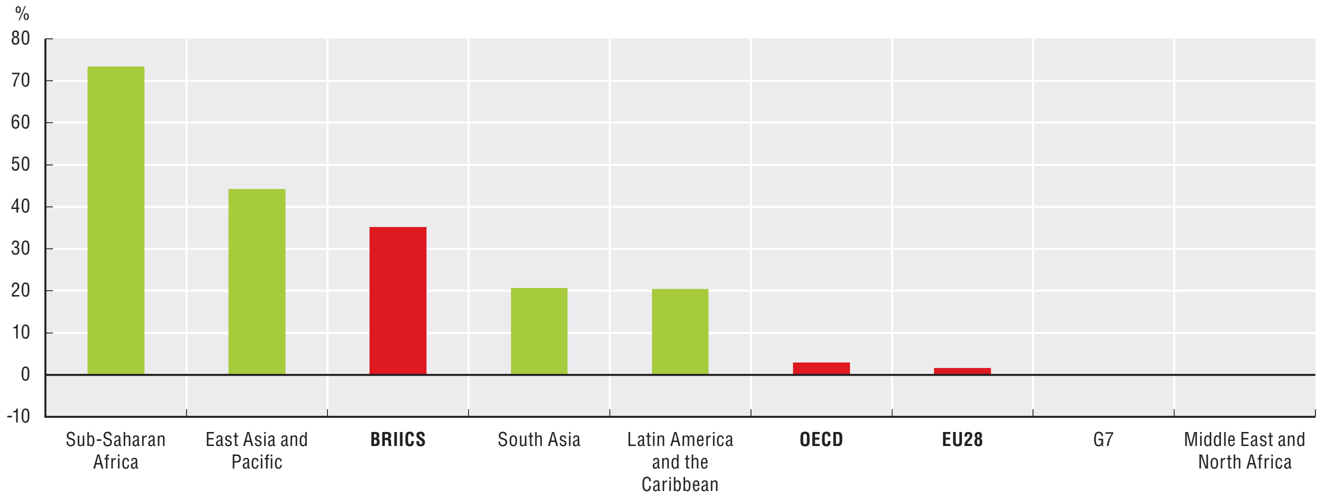
Number of subscriptions per 100 inhabitants



Source: Calculations based on ITU World Telecommunication/ICT Indicators Database, January 2019.

Figure 6.4. Growth of satellite TV subscriptions by region, 2008-17

Average annual growth rate



Source: Calculations based on ITU World Telecommunication/ICT Indicators Database, January 2019.

Looking ahead, direct-to-home television markets could continue to grow in some parts of the world, where advanced terrestrial solutions for television and video streaming platforms are often not yet deployed. But satellite networks operators are looking at emerging applications for their satellite fleets, such as consumer broadband and the Internet of Things (IoT).

Consumer broadband and Internet of Things on the rise

Broadband connectivity is becoming a crucial driver for economic activity around the world (OECD, 2019[10]). In addition, the Internet of Things may rapidly transform business processes and even our societies at an unprecedented scale with possibly 25 billion devices connected by 2020 (OECD, 2016[11]).

Broadband services to regions unserved or underserved by terrestrial technologies represent therefore a growth market virtually every satellite network operator is now addressing. In this context and as recent OECD analysis reveals (OECD, 2017[7]), satellite systems could increasingly:

i) fill the coverage gap to deliver broadband service to residential and business users in remote and isolated geographic areas by offering ubiquitous and easy to deploy solutions (“last mile” solution);

ii) provide backhaul or backbone network interconnection to the global Internet for terrestrial fixed or mobile telecommunication network service providers (the “middle mile” solution);

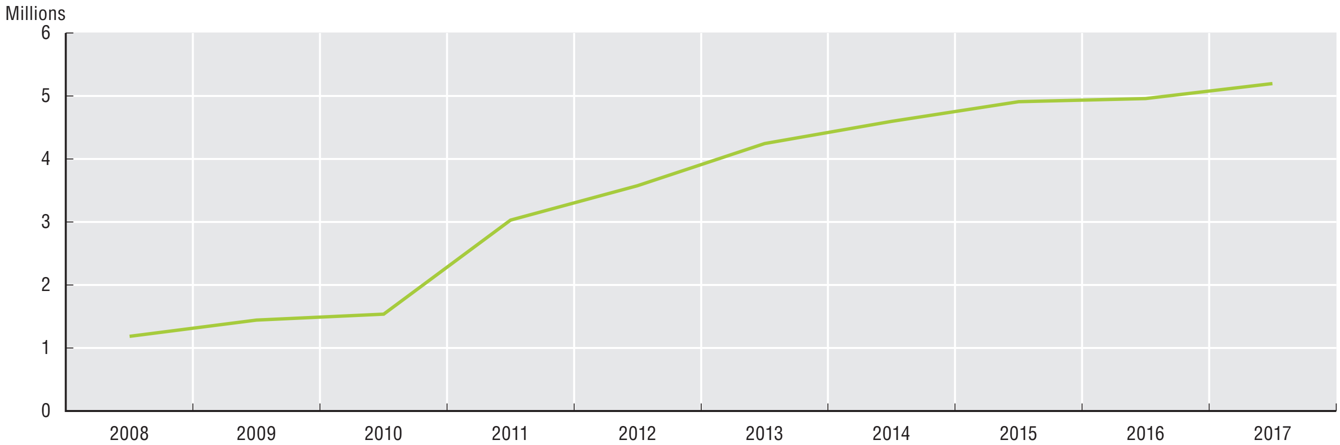
iii) and potentially expand the market for satellite broadband through the use of satellites in low-earth orbit to deliver broadband to lower density areas closely adjoining urban areas (OECD, 2017[7]).

Compared to other technologies, satellite broadband still accounts for a very small share of total fixed broadband subscriptions (less than 1% in most countries). Digital subscriber line (DSL) is still the dominant technology, making up 38% of fixed broadband subscriptions in the OECD area, but it is gradually replaced by fibre (OECD, 2019[10]). Satellite subscriptions have grown steadily over the last decade, thanks to the rolling out of new technologies. The number of subscriptions in absolute terms rose from around 1.2 million in 2008 to more than 5.2 million in 2017 (Figure 6.5). The number of satellite broadband subscriptions per every 100 inhabitants almost quadrupled from 2008 to 2017, increasing from 0.018 to 0.07.

G7 and OECD countries display the highest satellite broadband penetration, with 0.23 and 0.14 subscriptions respectively per every 100 inhabitants in 2017, with a doubling in the number of subscriptions since 2008. The United States and Australia have the largest number of subscriptions per 100 inhabitants (around 0.5), in view of their geography and availability of services (Figure 6.6).

Figure 6.5. World-wide satellite broadband subscriptions

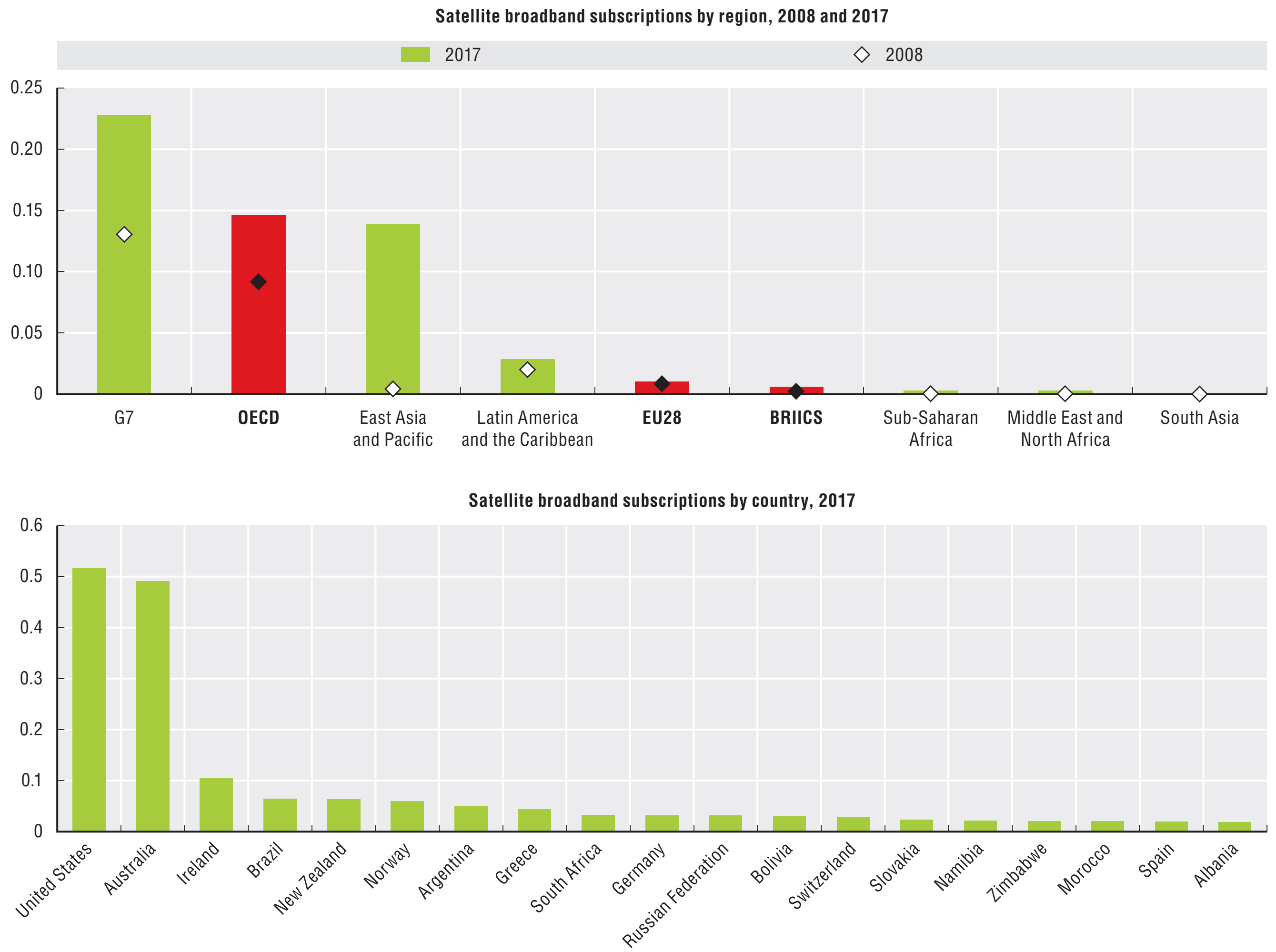
Total number of subscriptions



Source: OECD, Broadband Portal, *http://www.oecd.org/sti/broadband/broadband-statistics*; ITU World Telecommunication/ICT Indicators Database, January 2019.

Figure 6.6. Satellite broadband subscriptions by region and by country

Number of subscriptions per 100 inhabitants

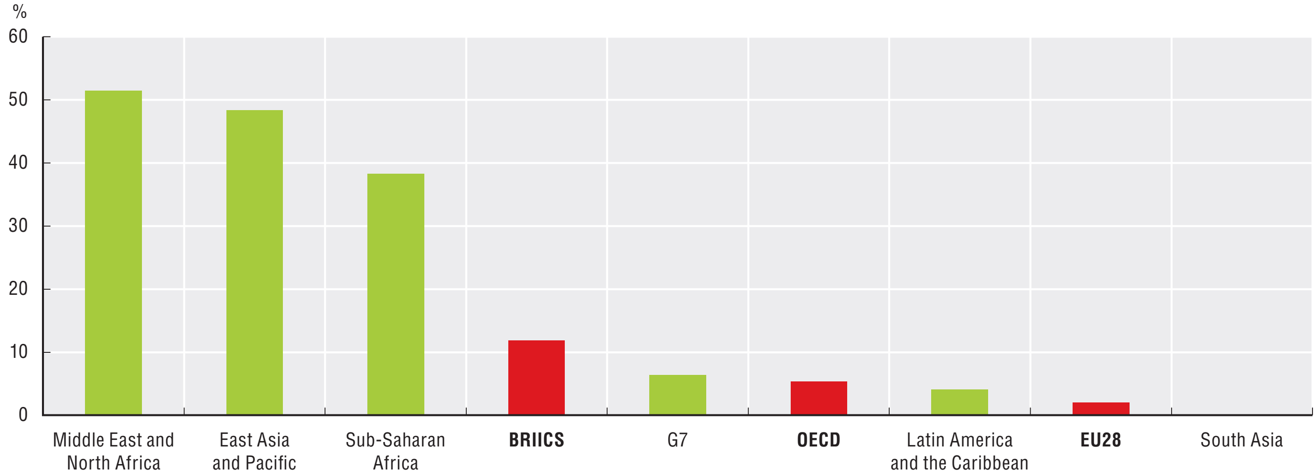


Source: OECD, Broadband Portal, *http://www.oecd.org/sti/broadband/broadband-statistics*; ITU World Telecommunication/ICT Indicators Database, January 2019.

The Middle East and North Africa have the highest average annual growth rate of satellite broadband subscriptions over the 2008-17 period (51.45%), but this is mainly due to the initial very low diffusion of the technology at the beginning of the period (Figure 6.7). Subscriptions in East Asia and the Pacific grew on average at a rate of 48.4% per year, while OECD countries registered growth rates of 5.4%.

Figure 6.7. Growth of satellite broadband subscriptions by region, 2008-17

Average annual growth rate



Source: OECD, Broadband Portal, *http://www.oecd.org/sti/broadband/broadband-statistics*; ITU World Telecommunication/ICT Indicators Database, January 2019.

Satellite's marginal role in broadband delivery has been mainly due to costs and latency (i.e. time-lag when communicating, viewing videos or downloading documents). Relaying a signal through a satellite stationed above the earth at 36 000 km may add up to half a second of latency round-trip due to the distances involved. As mentioned previously, some of these issues are alleviated by maturing technologies and the launch of new geostationary high-throughput satellite (HTS) systems, which significantly increase the quality of signals (see also chapter 4 on digitalisation trends).

In addition, the ongoing developments of satellite constellations in low-earth orbit could further reduce latency effects, depending on how close to the earth the satellites are placed. The 25 to 50 millisecond latency that some operators anticipate is still much higher than the expected next generation of wireless networks (5G) single-digit latency.

Almost twenty companies have announced plans to launch new fleets of satellites in the next five years to deliver broadband services (Table 6.1). However, most satellite broadband solutions at present are mainly complementary to existing networks in order to reach rural and remote areas. Some of these companies are backed either by existing satellite operators (e.g. O3b with SES; LeoSat with Hispasat and Sky Perfect JSAT) or manufacturers (e.g. OneWeb with Airbus; Starlink with SpaceX), but all have filed or will file for spectrum and orbital resources allocation. The investments required could range from USD 3.5 to 12 billion for a first-generation constellation, depending on the number of satellites, and the space and ground-based infrastructure chosen.

Beyond satellite constellation development, one challenge will be the actual terminal devices to reach consumers, with needed mass production of low-cost broadband receivers, using flat-panel and automatically steerable antennas.

Already for many satellite networks operators, much of their revenues are driven by products, antenna systems and ad-hoc receivers (e.g. inflight connectivity terminals) beyond satellite capacity provision. The links with suppliers of consumer electronics, software and enterprise equipment will therefore play a key role for the market success of constellations, as they will provide essential layers of services on top of the satellite broadband connection (i.e. a bit like multimedia equipment and air conditioning contribute to the purchase of a car). Strategies differ, as some satellite operators are developing partnerships with key electronics equipment players or are anticipating further vertical integration to design their own consumer equipment solutions. The importance of developing and rolling out ready-to-use consumer electronics will be one of the markers for the future of satellite broadband and, like other downstream space activities, may become the main source of profit, far beyond the initial investments in the satellite infrastructure.

Table 6.1. Selected planned satellite constellations in low- and medium-earth orbits

Name of the constellation	Expected number of satellites (altitude)	Operator / Manufacturer	Comments
Astrome Technologies (India)	600 (1 400km)	Astrome / TBD	Planned launch of 150 satellites weighing 175 kg each by 2020-21. The startup is currently fundraising.
Boeing V-Band (USA)	2956 (1 030-1 080km)	Boeing	Boeing has secured radio spectrum rights for 1 400 satellites.
Commsat (China)	72 (600 km)	Commsat	Seven small satellites were launched in 2018 to test Internet of Things services, with full constellation planned to be launched by 2022.
Hongyan (China)	300 (1 100km)	China Aerospace Science and Technology Corporation	First demonstrator launched in 2018, 9 satellites orbited by 2020 with the 300+ satellite system to be completed by 2025. A facility with the capacity to manufacture 130 satellites per year is being built in Tianjin.
Kuiper Project (USA)	3200 (590-630km)	Amazon, Kuiper Systems / TBD	Project announced by Jeff Bezos (Amazon) in early 2019
LeoSat (USA)	108 (1 432km)	LeoSat / Thales Alenia Space	Plans to launch satellites in 2021-2022.
O3b Networks (The Netherlands)	27 (8000km)	SES Networks / Thales Alenia Space	One of the precursors in satellite broadband, which started deploying its 1st generation of satellites in 2013 (20), with a new generation of 7 satellites by 2021 (customers in 50 countries)
OneWeb Satellites (USA / UK)	900 (1 200km)	OneWeb Satellites (Airbus Defence and Space et OneWeb) / Airbus Defence and Space	The first six satellites were launched in early 2019, and enough private capital raised to cover the production of 650 satellites (15 satellites per week), with services expected by 2021
Starlink (USA)	4425 (1 100-1 325km)	SpaceX	First demonstration satellites flew in 2018, a second generation may consist of 7500 satellites.
Telesat LEO (Canada)	117 (1 000km)	Telesat / TBD (Blue Origin for first launches)	Selection of satellite and ground station manufacturers by mid-2019. Global coverage planned by 2022.
Samsung (Japan)	4600 (1 500-2 000km)	TBD	
ViaSat-3 (USA)	20 (8 200km)	Viasat / Boeing	Three ultra-high capacity satellites planned for launch in 2021 and 2022 to complement existing services.
Xinwei (China)	32 (TBD)	TBD	
Yaliny (Russia)	135 (600km)	TBD	

In addition to broadband consumer markets, the Internet of Things (IoT) is also expected to grow significantly. The IoT connects everything and everyone to the internet through sensors and devices, leading to the need to develop relevant metrics to assess the effects of the IoT in different policy areas (Box 6.1) (OECD, 2018[12]). As the network of objects grows and seeks to collect and exchange data, satellites could play a role in enabling communications in the wireless infrastructure. It is important to highlight that satellite connectivity is complementary to existing IoT network solutions. IoT solutions are supported by several connectivity providers, all playing an important and complementary role, such as Low Power Wide Area Network providers (e.g. LoRa, SigFox), mobile network operators, fixed broadband and satellite providers (OECD, 2018[12]).

Many actors in the space sector have decades of experience in tracking objects, with for example the Iridium and ORBCOMM constellations which already addressed the burgeoning machine-to-machine (M2M) business some twenty years ago. Inmarsat and other mobile operators have also connected "objects" that move, such as planes, trains, automobiles, ships, and cruise lines, since the 1980s. Others monitor endangered wildlife with tags. According to the World Meteorological Organization's *Satcom*

Handbook, which provides guidelines to scientists considering the use of satellite communications for collecting data from remote instrumentation on land or at sea, at least ten satellite systems are currently operating and taking on new users (e.g. Argos, DCS, Globalstar, Gonets, Inmarsat, Iridium, O3B, Orbcomm, Thuraya) (WMO/IOC, 2018[13]).

Box 6.1. Defining the Internet of Things (IoT)

There are many definitions of the Internet of Things (IoT) currently co-existing. Based on the Cancun Ministerial mandate on the Digital Economy (2016), which highlighted the importance of developing metrics to assess the effects of the IoT in different policy areas, the OECD has developed the following working definition:

> *"The Internet of Things includes all devices and objects whose state can be altered via the Internet, with or without the active involvement of individuals. While connected objects may require the involvement of devices considered part of the "traditional Internet", this definition excludes laptops tablets and smartphones already accounted for in current OECD broadband metrics."*

To support measurement, a taxonomy has been developed to provide a breakdown of IoT into categories given that many connected devices will have different network requirements. For example, critical IoT applications such as remote surgery and automated vehicles will require high reliability and low latency connectivity, whereas Massive and disperse Machine-to-Machine (M2M) sensors used for agricultural applications may not be that sensitive to latency or network speeds. Within the IoT proposed measurement framework, the two main categories of IoT proposed are: Wide Area IoT, and Short Range IoT. The Wide Area IoT category includes devices connected through cellular technology as well as those connected through Low Power Wide Area Networks, whereas the Short Range IoT category includes devices using unlicensed spectrum with a typical range up to 100 metres. Within the category of Wide Area IoT, two subcategories are further suggested: 1) Massive M2M devices (e.g. sensors for agriculture or smart cities), and 2) Critical IoT applications (e.g. remote surgery applications, fully automated vehicles and other industrial robotics applications).

Source: OECD (2018), IoT measurement and applications, *OECD Digital Economy Papers*.

Satellite-related IoT activities are multiplying, demonstrating the increased linkages with terrestrial based networks but also strategic reorientations of many satellite network operators. For example, on top of satellite television broadcasting and communication services, Eutelsat is also exploring the possibility to develop a constellation in low-earth orbit to provide new Internet of Things services for many sectors like agriculture, energy, or logistical supply chains (e.g. track objects and provide basic information, like temperature). The operator ordered a nanosat dubbed ELO (Eutelsat LEO for Objects) to be launched in 2019, and cooperates with the French firm Sigfox, which already operates a ground network in more than fifty countries dedicated to the Internet of Things, covering some 658 million people.

As a final note, the roll-out of the fifth generation (5G) mobile systems, and the seamlessl integration of satellite into a larger IoT framework will provide opportunities for terrestrial and satellite network operators alike. 5G is anticipated to be the first generation of wireless networks conceived to connect tens of billions of devices and sensors via the Internet (OECD, 2019[14]). It should provide higher speeds (i.e. 200 times faster than 4G), faster data transfer (i.e. 10 times less than 4G), and networks that better support a wide diversity of applications. International standards and a globally harmonised spectrum framework (see Box 6.2 on selected satellite-related issues) will be needed to enable economies of scale and facilitate cross border coordination to allow seamless connections between different networks (OECD, forthcoming[15]).

The new environment for satellite telecommunications will certainly be shaped by different elements, including further technological changes, competition between incumbents and new actors, possible consolidation, international industry-led standardisation and regulations.

Box 6.2. Selected spectrum issues for satellite networks

The next World Radiocommunication Conference (WRC-19) will take place in late 2019 to discuss updates to the Radio Regulations, which set out the basic international rules of spectrum use between the 193 member countries of the ITU. Many issues will be examined, including spectrum allocations for the fifth generation (5G) mobile systems, the introduction and use of the Global Aeronautical Distress and Safety System, and a much expected review of the regulatory framework for satellite networks. A variety of spectrum sharing issues will be addressed, and decisions will have impacts in equipment development and production, as well as interoperability issues. They particularly include for satellites:

- Possible changes in the frequency assignments procedures for satellite networks.
- The coexistence and possible new sharing of frequency bands between geostationary and non-geostationary satellites, which have been historically allocated to the fixed satellite services.
- The allocation of portions of this band for new terrestrial services, mainly the fifth generation (5G) mobile systems / International Mobile Communications (IMT) services.
- The protection of passive services (i.e. earth observations satellite, radio astronomy, and space research services) in adjacent frequency bands. For example, there are risks that new services interfere in the spectrum band allocated so far to radar location services, used already by a number of satellite earth observation programmes such as the European Copernicus (Sentinels-1, -3 and -6), NASA and CNES' Jason programme, and Canada's RADARSAT-2 and -3.
- New spectrum allocations to maritime mobile-satellite services, to deal with the growing number of autonomous maritime radio equipment which uses spectrum designated originally to the Automatic Identification System (AIS) for maritime safety (see also chapter 7).
- And a review of the spectrum needs for non-GSO satellites with short duration missions (typically very small satellites), to assess the suitability of existing allocations to the space operation service and, if necessary, to consider new ones.

All these issues to be discussed internationally before the end of 2019 will have impacts for the space sector's near-term future.

Overall, satellite networks should be able to play on their strengths and specific capabilities, to become further integrated and optimised in the broader telecommunications infrastructure. As useful complements to terrestrial networks, particularly in underserved geographic areas, they will contribute to maximise the development of an inclusive digital economy.

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