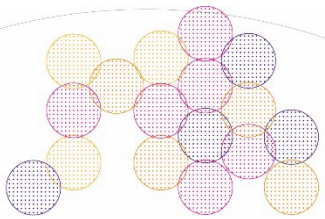
The economics of satellite broadband: a primer

Karim Bensassi-Nour



Satellite broadband technology was once seen as the domain of remote outposts, maritime communications and specialised industries. In the past few years, the convergence of cutting-edge advancements in satellite technology, reduced space launch costs, and new business models has increased the profile of satellite technology in the connectivity ecosystem. Satellite broadband is now considered a viable alternative to terrestrial networks, especially in remote areas, making it a potential solution to bridge the global digital divide. This paper delves into the intricacies of the satellite broadband market dynamics, providing an overview of the underlying key economics. It explores the market potential and cost structure, the competitive landscape, as well as the main policy and regulatory issues that need to be addressed.

Introduction

The satellite broadband era did not start with the launch of Elon Musk's Starlink constellation in 2021. Satellites have long been a key component in the connectivity ecosystem, with traditional players providing communication services to government agencies, navigation systems, specialised industries and individual customers for many years.

Traditionally these services have been provided using Geostationary Orbit (GEO) satellites orbiting at close to 36,000 km from earth, and capable of delivering larger amounts of capacity to high-traffic areas[1].

Technical progress in the satellite industry has enabled the development of Non-Geostationary Orbit (NGSO) satellites. These smaller and closer-to-earth types of satellites offer new possibilities depending on their orbits. The Low-Earth Orbit (LEO) satellites provide high speed broadband at lower latency compared to GEO satellites which make them more suitable to support modern use cases such as video calls, video streaming, monitoring devices and working with cloud-based applications. Meanwhile, Medium Earth orbit (MEO) satellites operating between GEO and LEO offer a compromise in performance but at significantly less cost as shown in Figure 1..

Figure 1: Key features of GEO, MEO and LEO satellites

	GEO	MEO	LEO
Orbit	35,800 km	8,000 – 20,000 km	400 – 2,000 km
Satellites required to cover earth pop	3	6-20	Thousands
Capacity per satellite	Up to 1 Tbps	~100 Gbps	5-20 Gbps
Latency	>500 ms	100-200ms	25-100ms
Typical satellite lifespan	15 years	12 years	5-7 years

Source: ITU[2]

NGSO constellations, especially those in LEO are reshaping the satellite broadband market in many ways: Firstly, the number of satellites launched into orbit has surged over the past decade[3], with close to 10,000 active satellites now in orbit, of which 90% are LEO satellites [4]. This remarkable increase is largely driven by the recent deployment of large LEO constellations such as Starlink[5] and OneWeb.

Concurrently, the market structure has undergone significant changes, particularly following the entry of Starlink and the announcement of Amazon's Project Kuiper. These developments have intensified competition and innovation within the sector, leading to a dynamic and rapidly evolving market landscape.

Finally, policymakers and regulators are showing greater interest in satellite broadband as a means to bridge the digital divide

[1] GEO satellites have an overall higher throughput. They can cover a larger area which translates to a lower capacity per connection.

[2] ITU 2024. Regulation of NGSO Satellite Constellations. Available here: https://digitalregulation.org/regulation-of-ngso-satellite-constellations/

[3] After the launch of the world's first communication satellite by NASA in 1962, it took 50 years to reach the 1,000 active satellites in orbit milestone and only 12 years to reach the 10,000 active satellites.

[4] Astrophysicist Johnathan McDowell 's tracking website. Available at: https://planet4589.org/space/stats/active.html. Accessed 15 June 2024

[5] Starlink alone accounts for more than 60% of all active satellites in orbit.

globally[6]. Whether this is indeed the right technology to do so is a strategic question that each country has to seriously investigate.

A market with strong potential

From a business perspective, the satellite broadband sector is expected to generate substantial revenue. Morgan Stanley's space team estimates that the Internet and consumer broadband segment alone will account for over half of the projected $1 trillion space industry revenue by 2040, translating to $507 billion[7].

From a socio-economic perspective, the market holds immense promise for fostering digital inclusion, extending connectivity to unserved and underserved areas worldwide. In theory, the potential addressable market[8] includes roughly one third of the global population, or around 2.6 billion people[9], who remain offline. Most of these individuals reside in developing countries where the lack of terrestrial digital infrastructure and Internet access has perpetuated economic disparities and limited access to essential services such as education, healthcare, and financial services[10].

Beyond individual consumers, the market also includes a diverse range of institutional and commercial customers with unique connectivity needs. Government agencies, for instance, require reliable and secure communication channels for public administration, emergency response, and national security operations. Hospitals and healthcare providers need robust broadband access to support telemedicine, patient data management, and remote diagnostics, which are critical for improving healthcare outcomes in remote and rural areas. Schools and educational institutions represent another significant segment, as they seek to provide digital learning opportunities and bridge the educational gap for students in underserved regions.

Additionally, businesses operating in remote locations – such as mining, oil and gas, agriculture, and maritime industries – depend on satellite broadband for operational efficiency, real-time data transmission, and connectivity to global supply chains.

These diverse customer segments highlight the multifaceted demand for satellite broadband services, each with distinct requirements and challenges. Addressing these needs effectively requires tailored solutions and innovative business models that can cater to the varying levels of affordability, data consumption, and reliability demanded by different users.

A dynamic competitive landscape

Although Space X's Starlink and Amazon's Kuiper are getting most of the spotlight, the satellite broadband market includes several other global players, many of whom have long-standing experience and established presence in the industry. Figure 2 below shows an overview of key satellite market players.

Companies in this market have adopted diverse strategies regarding the types of satellites they deploy. While some focus exclusively on LEO or GEO constellations, others embrace a multi-orbit approach, combining GEO, MEO and LEO satellites. These diverse strategies reflect different market positioning and target customer segments, though there are overlaps that drive competition.

Figure 2: Overview of key Satellite broadband operators

Company	Start of operation	# of satellites in orbit (planned)	Customers segments
Starlink (US)	2018	LEO: 5950 (30,000)[11]	• Residential • Businesses • Telcos
Viasat–Inmarsat (US)	2011-2005	Leo: (175) Geo: 17 (3)	• Residential • Businesses • Specialised industries • Telcos
SES–Intelsat (EU)	1964-1985	LEO 51 (7) MEO: 26 GEO:26	• Businesses • Specialised industries • Telcos • Broadcasters
Eutelsat–Oneweb (EU)	1977-2012	LEO: 600 GEO: 35	• Residential • Businesses • Broadcasters • Specialised industries
Kuiper (US)	2018 (available in Q4 2024)	LEO: (3226)	• Residential
Avanti (UK)	2002	GEO:4	• Businesses • Telcos • Specialised industries
Telesat (Canada)	1969	LEO:198 GEO:14	• Broadcasters • Telcos • Specialised industries

Source: Plum analysis

The residential market segment is presently dominated by Starlink whose entry has had a strong impact on the whole market. Firstly, it has spurred a growing appetite for competition from Amazon that started research and development on its project Kuiper the same year[12]. Six years later, Kuiper is not yet operational although full scale deployment is scheduled for the first half of 2024 and

[6] BEREC 2022. Report on Satellite Connectivity for Universal Service. Available at: https://www.berec.europa.eu/system/files/2022-12/BoR%20%2822%29%20169%20Report%20on%20satellite%20connectivity%20for%20universal%20service_0.pdf

[7] https://www.morganstanley.com/Themes/global-space-economy

[8] The actual capturable market share for satellite solutions depends heavily on the availability of terrestrial network solutions in each country.

[9] ITU figures 2023

[10] There are other factors affecting the digital divide besides the availability of networks: affordability, awareness and digital skills.

[11] https://spacenews.com/spacex-submits-paperwork-for-30000-more-starlink-satellites/

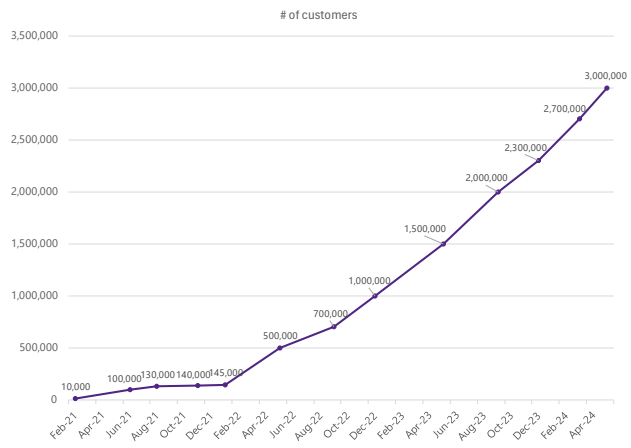
[12] https://www.aboutamazon.com/news/innovation-at-amazon/what-is-amazon-project-kuiper

early customer pilots are expected for the second half of the year[13]. While Starlink is currently in a market leader position, we expect significant competitive pressure from Kuiper in the upcoming years.

Starlink's market entry has also driven consolidation among established players as evidenced by four major mergers and acquisitions in the satellite market in the past two years alone: SES-Intelsat (Apr 2024), Eutelsat-OneWeb (September 2023), Viasat-Inmarsat (May 2023) and EchoStar-Dish Network (December 2023). These consolidations are strategic, aimed at enhancing synergies, expanding service portfolios, and achieving deeper market penetration. Most importantly they reflect an industry bracing itself for the intensified competition and technological innovation spearheaded by Starlink and potentially the imminent market entry of Kuiper.

Starlink's business model leverages significant vertical integration which seems to play a key role in its success. Unlike any other player, Starlink benefits from SpaceX's ability to launch its satellites, drastically reducing dependency on external launch providers and lowering operational costs through reusable rocket technology[14]. This integration has allowed Starlink to achieve rapid deployment and cost efficiency, setting a formidable benchmark in the industry as evidenced by the impressive customer growth[15] reported by the company (Figure 3).

Figure 3: Estimation of Starlink customer growth worldwide



Source: Plum analysis based on Starlink's online publications[16]

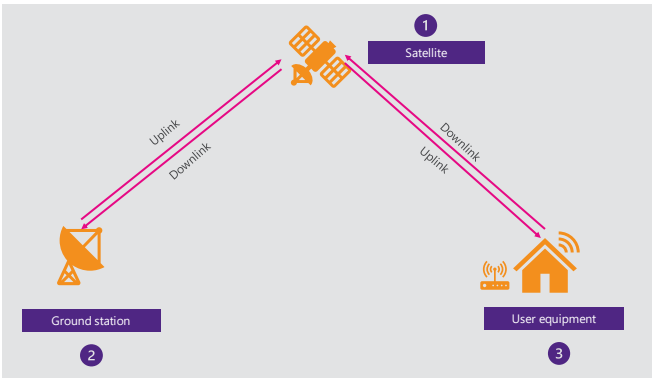
A key question remains though. How does the evolution of the satellite broadband market impact the telecommunications industry? While some appear concerned by a potential competitive pressure on terrestrial communications services providers (CSPs), this has yet to materialise. In urban and densely populated areas, current satellite broadband offerings are not (yet) able to deliver a fibre-like performance or a 5G-like latency. Besides prices do not offer any incentive to switch from a terrestrial solution to a satellite service, particularly in countries where internet access is relatively cheaper.

In fact, there seems to be more cooperation than competition as evidenced by the growing cases of collaboration and partnerships around the world: In Australia for example, Telstra announced that it is moving its remote mobile base stations to OneWeb's LEO network. In the UAE, Etisalat and Eutelsat agreed to use Eutelsat's network to extend the operator's 5G coverage to areas currently unreachable by terrestrial connectivity[17].

An evolving cost structure

Understanding the cost structure of satellite operators requires an understanding of the basic satellite network architecture (see Figure 4). This architecture includes three main components representing the key cost drivers[18], each requiring significant capital expenditure (CapEx).

Figure 4: Satellite broadband network key components



Source: Plum

Satellites in orbit serve as the backbone of the satellite network, relaying data traffic between gateway antennas on the ground

[13] https://www.aboutamazon.com/news/innovation-at-amazon/amazon-project-kuiper-oisl-space-laser-december-2023-update

[14] An innovation brought on by Space X that has reshaped the space vehicle and launch markets.

[15] Starlink commercial approach varies by country. In some, it has a direct-to customer sales model, in others it provides wholesale services to MNOs only. In some markets it does both.

[16] It is not clear what type of customers is being reported by the company in these figures. We assume that these are end-users and could include both individuals and businesses.

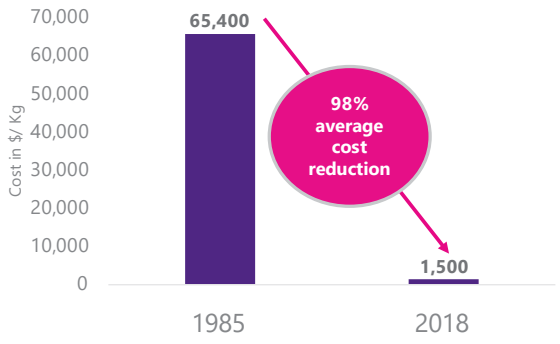
[17] https://www.capacitymedia.com/article/2bea21d03zdouori2zuo0/news/etisalat-to-deliver-5g-services-from-eutelsat-satellite

[18] We should also mention spectrum acquisition costs for uplink and downlink transmission which are not covered in this paper. For more information on spectrum use by satellite operators see Plum report commissioned by GSOA in 2023 on the use by satellite services of spectrum in the 7 to 24 GHz bands. Available at: https://gsoasatellite.com/wp-content/uploads/Assessing-the-use-by-satellite-services-of-7-24-GHz-spectrum.pdf

and end-users. The production and deployment costs associated with satellites are substantial and influenced by various factors such as design complexity, manufacturing processes, and launch expenses. While exact figures are hard to find, estimates suggest that a single LEO satellite costs $500,000 to $1 million. By comparison, GEO satellites cost $100 to 400 million[19]. While significantly more expensive, GEO satellites typically have a longer lifespan of 15+ years compared to the approximately 5-year lifespan of LEO satellites. This means that unlike GEO operators, LEO operators must replace their satellite every few years. In addition, LEO operators intend to deploy thousands of satellites which means that the scale of production is a significant cost factor. By producing satellites in large quantities, economies of scale can be achieved, resulting in reduced manufacturing costs per unit.

While previously the cost of launching a satellite was restricted to well-funded government agencies and a few large companies, technological advancements and increased competition have led to a significant cost reduction[20]. For example, the average launch cost to low earth orbit was about $65,400/kg in 1981 and only $1,500/kg in 2018. This significant reduction is due to innovations such as reusable rocket technology, pioneered by companies like SpaceX.

Figure 5: Payload cost to low earth orbit in 1984 and 2018[21]



Source: CSIS Space Security Project

Ground infrastructure[22] includes gateway antennas that communicate with satellites and user terminals. These ground stations are connected through fibre optics and are often located close to data centres to facilitate connectivity. The cost of establishing and maintaining ground infrastructure is significant, as it involves the installation of sophisticated equipment and infrastructure to ensure seamless communication between satellites and end-users.

User terminals (CPEs) usually include a small dish that sits outside the user's home or office and an indoor router. This represents a key cost driver for a satellite operator. For example, a Starlink CPE's initial cost was around $3,000[23] although the company has announced that they were able to reduce this by 50%. Reducing the manufacturing cost of CPE will undoubtedly play a key role in the adoption of the technology by customers as this has a direct impact on affordability. This also should represent a key competitive advantage as evidenced by Kuiper's ambition to design a customer terminal that costs less than $500 to build.[24]

Key policy and regulatory issues

The recent changes in the satellite broadband market have raised new policy and regulatory issues spanning a wide range of topics including the following:

1. **Licensing**. All satellite communication systems require licensing and authorisation from both national and international authorities. The principles of regulating space activities are described in the UN Outer Space Treaty. According to the Treaty, each state is internationally responsible and liable for its space activities. This covers activities carried out by non-governmental entities as well. In other words, each state must authorise and supervise the space activities of its non-governmental entities, while the UN must be informed by each state regarding the orbital parameters and basic function of space objects launched by that state. Satellite broadband operators need to navigate international and country-specific regulatory practices and licensing rules in order to launch their services.
2. **Spectrum**. Spectrum is a rare and valuable resource, essential for satellite communications. Effective spectrum management is crucial to ensuring that satellite broadband services can coexist with other wireless communications systems without causing interference. The significant increase in the number of satellites and the expansion of satellite services have increased the need for more spectrum, creating more competition between different spectrum users and even leading to the first satellites spectrum auctions[25]. Policymakers must navigate these competing interests and develop strategies for efficient spectrum allocation and

[19] https://www.te.com/en/industries/aerospace/insights/cots-components-in-leo-satellites.html

[20] In many cases, space launches are arranged through private or classified contracts which makes launch cost estimation very hard.

[21] Figures are in FY21 dollars. Averages are for heavy payload. For more information on launch costs see: https://aerospace.csis.org/data/space-launch-to-low-earth-orbit-how-much-does-it-cost/

[22] Some use cases also require Earth Stations in Motion (ESIM). For more information on ESIMs see Plum Insight 2023 "Regulating Earth Stations in Motion (ESIMs) for NGSO systems". Available at: https://plumconsulting.co.uk/regulating-earth-stations-in-motion-esims-for-ngso-systems/

[23] During the 2021 "LEO Digital Forum" virtual panel, SpaceX President Gwynne Shotwell revealed that the Starlink terminal's production costs have dropped by over 50% from its initial manufacturing prices of $3K.

[24] https://www.aboutamazon.com/news/innovation-at-amazon/heres-your-first-look-at-project-kuipers-low-cost-customer-terminals

[25] Brazil (2015), Mexico (2014 and 2020), Saudi Arabia (2022) and Thailand (2023). For more information see: https://www.policytracker.com/australia-proposes-an-auction-of-satellite-spectrum-in-2-ghz-band/

sharing. This involves international coordination through bodies like the ITU to harmonize spectrum use globally, protect existing services, and support the growth of new satellite broadband technologies.

3. **Space sustainability**. As the number of satellites in orbit continues to grow, space sustainability has emerged as a critical regulatory concern. It refers to the ability to maintain the long-term usability of the space environment. This includes addressing issues such as space debris, satellite collisions, and the long-term health of the orbital environment. With thousands of satellites being launched, particularly in LEO, the risk of collisions and the creation of space debris has increased significantly. Regulators and industry stakeholders must collaborate to develop and enforce policies that promote responsible behaviour in space. This includes guidelines for satellite design, end-of-life disposal plans, and active debris removal initiatives. In this domain as well, international cooperation is essential to establish norms and practices that can mitigate the risks of space debris and ensure the safe and sustainable use of outer space for future generations.

Conclusion

Despite significant advancements, the satellite broadband market remains in its nascent stages and faces several critical challenges. Affordability continues to be a major hurdle, especially in developing regions where the demand for connectivity is the greatest. Achieving ubiquitous connectivity through satellite broadband is still a distant goal. Current services have yet to reach mass adoption, hindered by high costs and accessibility issues.

Moreover, the profitability of satellite broadband ventures remains uncertain. Major players like Starlink are still striving to achieve sustainable financial performance, indicating that the market's economic viability is not yet assured. Additionally, the potential entry of Chinese companies into the satellite broadband market introduces further complexity to the competitive landscape, raising questions about future market dynamics and geopolitical implications.

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For more information contact Plum at:

info@plumconsulting.co.uk

karim.bensassi-nour@plumconsulting.eu