Satellite Internet: Old Yet New—How Starlink Is Changing the World

Starlink's emergence has transformed the conventional view of satellite[*1] Internet. And, inspired by Starlink, a host of new players also continue to emerge. In this focused research report, we look back on the history of satellite Internet and take a closer look at Starlink. We also explore the possibilities for where satellite Internet may be headed.

3.1 Satellite Internet

3.1.1 Satellite Orbit Types and Characteristics

The orbits of satellites circling Earth can be classified into three types based on altitude: GEO, MEO, and LEO (Figure 1). To summarize the characteristics of each, a GEO (Geostationary Earth Orbit) is at an altitude of around 36,000km and is synchronized with Earth's rotation. GEO satellites remain in a fixed position over ground stations and can cover a wide area, but with the drawback of large latency. A MEO (Medium Earth Orbit) ranges from around 2,000km to 35,000km and is used for systems such as GPS satellites. MEO offers moderate latency and balanced coverage. LEO (Low Earth Orbit) ranges from around 160km to 2,000km. It has the advantages of low latency and high bandwidth, but covering the entire Earth requires many satellites, increasing operational costs (Table 1).

3.1.2 The Era of Research Networks

SATNET (Satellite Network, also known as the Atlantic Packet Satellite Network) was a satellite-based network developed in the 1970s by the U.S. Defense Advanced Research Projects Agency (DARPA). This was an experimental project to connect ARPANET (Advanced Research Projects Agency Network) to Europe via satellite (Intelsat IV) and can be regarded as the forerunner of satellite Internet.

Research from Japan includes the AI3 (Asian Internet Interconnection Initiatives) project by WIDE Project (Widely Integrated Distributed Environment Project). Using satellites from Japan's JSAT (SKY Perfect JSAT) to connect research institutions across the Asia-Pacific region, especially Southeast Asia, the purpose of AI3 is to build Internet infra-structure and conduct R&D on networking technologies. The project began some 20 years after the research on SATNET, during a period when the Internet was spreading across the globe as a research network. The project developed and deployed Unidirectional Links (UDL) and contributed to standardization of UDLR (Unidirectional Link Routing) technology. By operating IPv6 and multicast over UDL, it contributed to connectivity across a broader area of Asia.

3.1.3 Development of Commercial Services

Commercial Internet services using GEO satellites began in earnest in the late 1990s. In 1996, Hughes Network Systems launched DirecPC as the first consumer satellite broadband service. In 2004, WildBlue provided high-speed service using Ka-band satellites, but it was acquired by

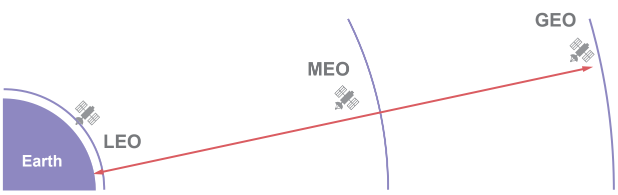

Figure 1: Relative Positions of Earth and Satellites

Table 1: Characteristics of Satellite Orbits

Characteristic	GEO (Geostationary Earth Orbit)	MEO (Medium Earth Orbit)	LEO (Low Earth Orbit)
Altitude	~36,000km	~2,000–35,000km	~160–2,000km
Latency	~500–600ms	~100–300ms	~25–80ms
Apparent motion	Stationary (always in same position)	Moves slowly	Moves rapidly
Orbital period	24 hours (synchronized with Earth's rotation)	Several hours	~90–120 minutes
Global coverage	A few satellites (3–4)	Several dozen satellites	100s–1000s of satellites
Coverage area	Wide (one satellite covers ~1/3 of Earth)	Medium (multiple for global coverage)	Narrow (many needed)

*1 "Satellite" in this article refers to artificial satellites, not natural satellites such as the Moon.

Viasat in 2009. Today, services are available from providers such as Hughesnet, Viasat, Konnect, SES Astra, Inmarsat, ExBird, SKY Perfect JSAT (EsBird), and China Satcom.

Commercial Internet services using MEO satellites began with the launch of four satellites in 2013 by O3b Networks, founded in 2007. O3b was acquired by SES in 2016, with its services now being offered as O3b mPOWER (second generation; launches began in 2022; operations began in April 2024) as part of SES Networks. Currently, 10 satellites are in service.

Turning to commercial services using LEO satellites, Iridium launched its service in November 1998 and Globalstar in February 1999. Both companies collapsed once but later recovered and continue to provide services, mainly for voice communications. The Teledesic broadband concept began in the early 1990s (founded in 1990) and progressed to FCC approval in 1997 as a competitor to Iridium/Globalstar, but it was discontinued in 2003.

OneWeb marked a leap forward for LEO, and Starlink was a major success. On the heels of Starlink, Project Kuiper is currently in preparation for launch, and Chinese players are also attempting to catch up.

OneWeb was conceived by Greg Wyler in 2012 and started operations in 2019. Overcoming funding difficulties and geopolitical challenges, it merged with Eutelsat in 2023. Now as Eutelsat OneWeb, it operates 648 satellites and is expanding its services mainly in Europe and the United States.

Starlink was born out of Elon Musk's vision. Announced in 2015, the project takes advantage of the mass production of satellites and reusable rocket technology, with over 8,500 satellites having been deployed. It has over 7.5 million users and provides service in over 150 countries.

Project Kuiper is an Amazon subsidiary established in 2019 and is preparing to launch services by the end of 2025. It has around 129 satellites in orbit.

Qianfan (Thousand Sails) is a Chinese satellite initiative led by Shanghai Spacecom Satellite Technology (SSST). Developed with Starlink in mind, it conducted its first launch in August 2024 and is reported to have around 90 satellites in orbit.

GuoWang is a Chinese national project led by China SatNet. It too is being developed with Starlink in mind. Its first launch was in December 2024, and it is reported to have around 95 satellites in orbit.

3.2 Starlink

3.2.1 Starlink Overview

Starlink is a service of SpaceX (Space Exploration Technologies Corp.), a private American company. Founder Elon Musk announced the idea in 2015. Since launching a limited beta service in 2019 with 60 satellites, it has grown rapidly. As of October 2025, it has over 8,500 or so satellites in orbit, with around 7.5 million users across more than 150 countries. In Japan, service has been available since October 2022.

Figure 2 shows Starlink's architecture.

Connections to the Internet are made via the User Terminal → Starlink constellation → gateway → POP → Internet.

A Starlink User Terminal is required to connect to Starlink. Aside from purchasing one from the official website or

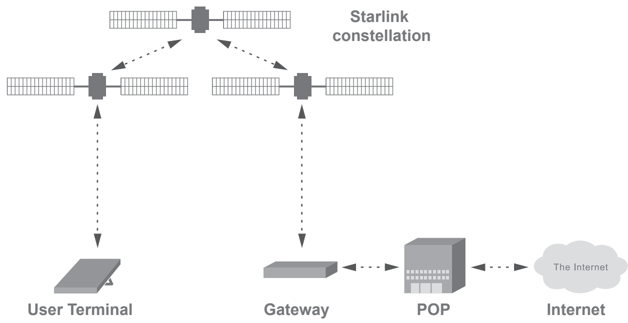

Figure 2: The Starlink Architecture

authorized retailers, there are various other ways to obtain one.

Several types of User Terminal are available. In addition to the Standard model, there is an ultra-compact Mini, as well as a Performance model designed for harsh environments and maritime use (Figure 3).

The User Terminal uses its location and Starlink satellite orbital data to select a Starlink satellite with which it can communicate. A phased-array antenna electronically steers the beam automatically, so users do not need to make any adjustments. Starlink satellites operate in low Earth orbit and form a constellation. Around 8,500 satellites are said to be in service, but because satellites are continually being added and maintenance is ongoing, the exact number is known only to SpaceX.

The satellitemap.space website for tracking satellite constellations and satellites is quite well made. It uses public data from space-track.org to provide a visualization of constellations and satellites based on orbital information (Figures 4, 5, and 6).

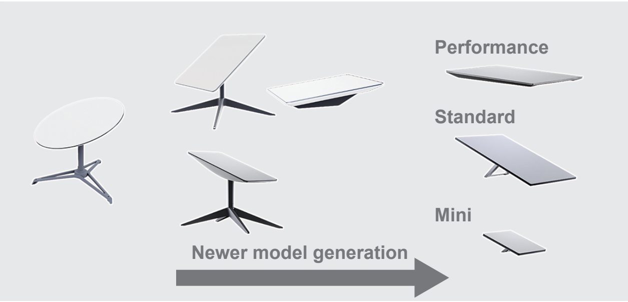

Figure 3: Different Generations of the User Terminal
The design transitioned from a movable stand to a kickstand.

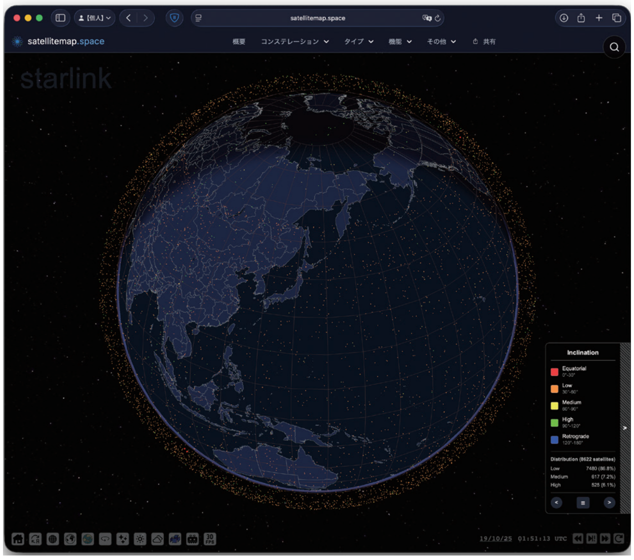

Figure 4: Starlink Satellites Distributed Around the Globe
At this point, there appear to be 8,622 satellites.

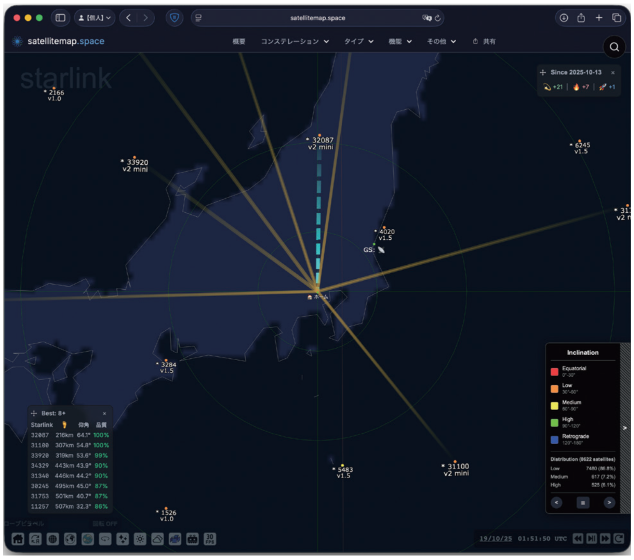

Figure 5: Satellite Positions as seen from Tokyo (Author's Location) at a Particular Time
This depicts the User Terminal selecting a nearby satellite.
The selection algorithm is undisclosed, so this is strictly a guess.

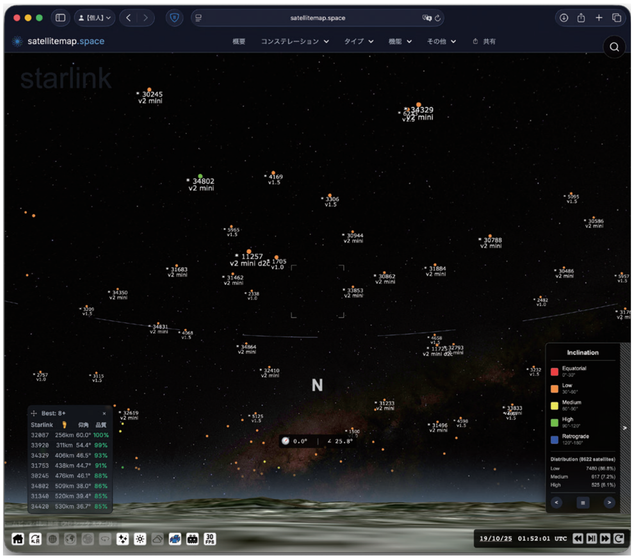

Figure 6: Positions of Satellites Visible from the Ground in Tokyo
Several dozen satellites are within the field of view.

Since SpaceX does not disclose the visualization algorithm, the information is provided solely for reference purposes, but it should convey the general picture.

Starlink currently has V1.5 and V2mini satellites in service. The upcoming generation of satellite is the V3, which is to be deployed on SpaceX's new Starship rocket system (Figure 7). V3 reportedly has 10 times the performance of previous satellites, and together with new model User Terminals, the plan is to support communication speeds of 1 Gbps.

SpaceX plans to improve the capabilities of its overall constellation by adding more satellites and replacing legacy models with newer ones.

Gateways serve as bridges between satellites and the terrestrial Internet. They relay data from satellites and send it to POPs. They are known to have been installed at four locations in Japan: Hokkaido, Akita, Ibaraki, and Yamaguchi (Figure 8).

A POP (Point of Presence) is an Internet access point, and the segment from the User Terminal to the POP appears as a Layer 2 network. For IPv4, the POP assigns an ISP Shared Address (100.64.0.0/10) via DHCP, and users reach the Internet over IPv4 via CGNAT. Some plans allow users to obtain a public IPv4 address via DHCP. For IPv6, a routable public IPv6 prefix is delegated via DHCPv6-PD.

3.2.2 Starlink in Action

The volcanic eruption in Tonga on January 15, 2022, was one of the largest underwater eruptions in recorded history. Submarine cables were severed, and Tonga was cut off from data communications, but Starlink moved quickly and ended up being key to restoring connectivity. When Russia invaded Ukraine in February 2022, Starlink was rapidly deployed as an alternative to ground communication infrastructure that had been destroyed, supporting Ukraine's military and civilian communications. In the aftermath of Japan's Noto Peninsula earthquake of January 1, 2024, KDDI, SoftBank, and Docomo turned to Starlink to support the restoration of communications in affected areas. And Starlink has continued to play a role in disaster-stricken areas around the world since.

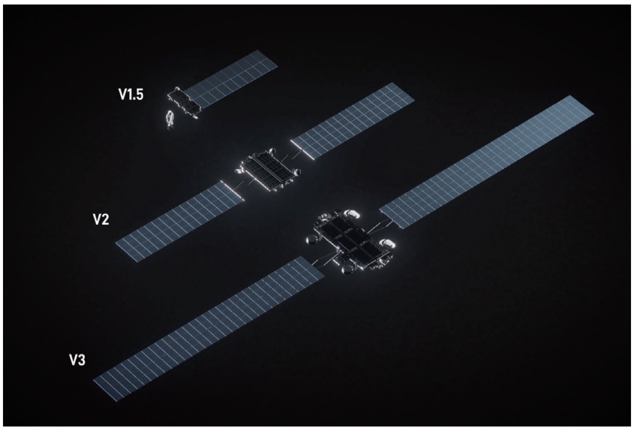

Figure 7: Starlink Satellite Size Comparison[*2]
V3 satellites are to be deployed once Starship enters service.

Figure 8: Gateways in Japan
There are four gateway sites: Hokkaido, Akita, Ibaraki, and Yamaguchi. Traffic is aggregated at the POP in Tokyo.

*2 SpaceX, October 24, 2025 post on X (https://x.com/SpaceX/status/1977873370688700846).

3.2.3 Starlink's Strengths

Starlink founder Elon Musk's vision is to "make humanity a multi-planetary species." The target is Mars. Fulfilling the roadmap to Mars will require massive levels of funding and technological breakthroughs. Starlink is the funding source for technological development (Figure 9).

The key to Starlink's success was the rocket (Falcon 9) it developed to carry satellites (Figure 10). A defining feature of the Falcon 9 is that the first stage and the fairing can be reused. Once used, the rocket returns toward the launch site and lands on a droneship positioned at sea, and from there it is recovered and then refurbished.

Once a rocket is recovered, it takes around 10 days to refurbish and make it reusable again. Reusability is evidently quite high, with some boosters having been reused over 30 times. Some 30 rockets are currently in service. In 2024, SpaceX carried out 132 launches, and as of this writing it had 170 launches planned for 2025. Each launch inserts 26 Starlink satellites into orbit, which translates into annual deployment capacity of over 4,400 satellites.

SpaceX also manufactures the many satellites it places into orbit. The rockets also have a second stage, which is not reused, and SpaceX manufactures those as well. With the ability to produce thousands of satellites, the infrastructure to launch them, the capabilities needed to operate a satellite constellation, the development and testing of new rockets, the vertical integration of operations from satellites through to rockets, and a strategy of funding operations with revenue from Starlink and launch services for other companies, SpaceX is taking on challenges no one has ever tackled before.

Make humanity a multi-planetary species

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Target Mars

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Develop rockets and network
Starship and Starlink

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Provide Starlink services
Procure funds

Figure 9: SpaceX's Purpose

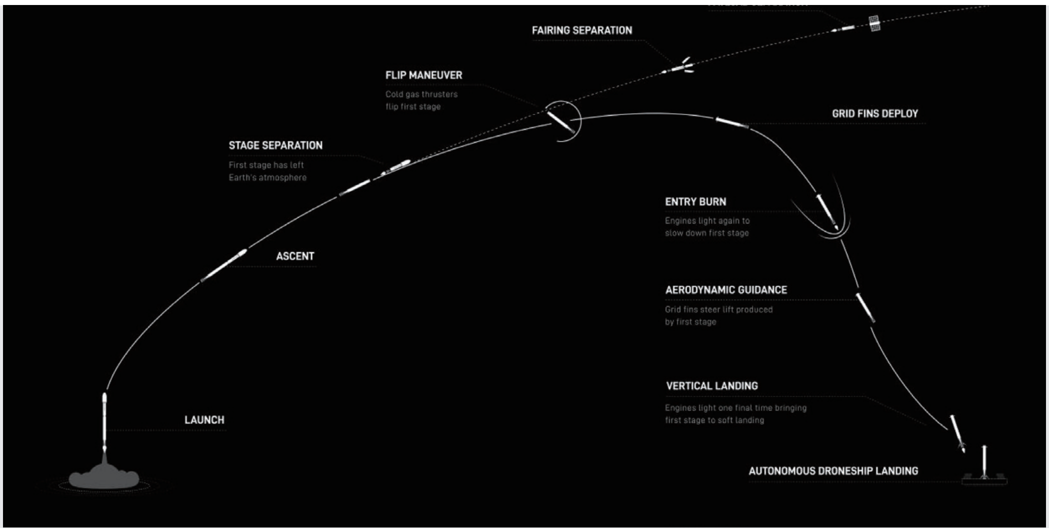

Figure 10: Falcon 9 Sample Mission Profile
The rocket makes an autonomous landing on a droneship[*3].

*3 SpaceX documentation (https://www.spacex.com/assets/media/falcon-users-guide-2025-05-09.pdf).

3.3 The Future of Satellite Internet

3.3.1 The Changing Face of Internet Infrastructure

The terrestrial communications network is what supports today's Internet. It uses optical fiber to provide not only land-based connections but also intercontinental connectivity via submarine cables, thereby linking the world. Even mobile wireless network base stations are connected by these communications paths. However, deploying and maintaining this terrestrial network is highly expensive.

Communications networks based on Low Earth Orbit satellites have emerged as a potentially new type of infrastructure. Sections previously deployed using optical fiber could be replaced by optical links between satellites. Satellites are equipped with laser communication devices called inter-satellite links (ISL), and building a mesh network across multiple Starlink satellites can facilitate the efficient processing of communications from the ground. It is because SpaceX has dramatically reduced the cost of launching satellites that we can now conceive of these possibilities.

3.3.2 Will Space-Based Communications Be Faster?

Optical links between satellites have some advantages over optical fiber. The speed of light in a vacuum is 300,000km/s, but it drops to around 200,000km/s in optical fiber. For example, the distance from the East to the West Coast of North America is about 8,000km. If the distance from the ground to a satellite is 550km each way, that puts the total path length at around 9,100km. Traveling 8,000km through terrestrial optical fiber takes light about 40ms. Via satellite, the distance increases to 9,100km, but in principle it should take around 30ms. If it does work out to 10ms faster one way or 20ms faster for a round trip, there appear to be many advantages for satellite Internet (Figure 11).

Starlink's inter-satellite laser links have already achieved speeds of 200 Gbps. There are plenty of terrestrial systems offering faster speeds, but if the satellite network becomes dense enough to maintain routes via a mesh, satellite-based infrastructure may offer advantages in more and more scenarios. Looking ahead, if laser-capable terminals are mass produced and adopted by users on the ground, low-cost, ultra-high-speed networks could conceivably be built on satellite infrastructure.

3.3.3 Extension to Interplanetary Communication

SpaceX's Mars plan involves the further evolution of Starlink. Communication time from Earth to Mars ranges from 3 to 22 minutes depending on planetary distance, meaning a round trip of 6 to 44 minutes. Absorbing such delays with conventional TCP/IP will be difficult. In the world of satellite Internet, research toward a multi-planetary future will no doubt continue. What sort of research outcomes will we see? How will this affect life on Earth? There is much to look forward to ahead.

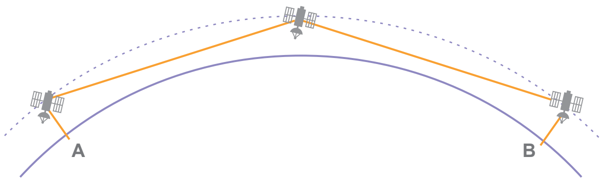

Figure 11: Relationship between Inter-satellite Communications and Distances on Earth
Simple comparisons are difficult due to a range of factors including the Earth's surface being curved, connections to satellites not always being made over the shortest distance, slack in submarine cables, and delays in repeaters.

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Mr. Taniguchi joined IIJ in 1995, working in infrastructure construction and operations for consumer services. From 2006, he was seconded to the games industry, where he worked on system development and operations for AAA titles and social games, returning to IIJ in 2022. Prompted by the emergence of Starlink, he became even more interested in the space field, where he draws on his past experience to take on bold new challenges. He has a cousin who is a world champion in fighting games.