Fiber-to-the-Home vs. Emerging LEOS

Broadband Networks Capability Assessment

FIBER BROADBAND ASSOCIATION
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Introduction

Emerging Low Earth Orbit Satellite (LEOS) broadband networks are promising global "high-speed connectivity" to underserved areas. Fiber-to-the-Home (FTTH) has been built to over 50 Million of the 136 Million US households and deployment is reaching over 6 Million additional homes annually driven by fiber's unique capability to cost effectively meet current and future bandwidth demands on the same infrastructure. In comparison with FTTH networks, LEOS broadband networks offer much lower data rates that drop proportionally to the number of subscribers and may be suited to serve niche applications of extremely remote areas, cruise ships, commercial airliners, military applications, and penetrating emerging markets that have no internet connectivity for online shopping.

Today, most satellite communications are using geostationary (GEO) satellites orbiting the Earth at an altitude of ~36,000km. Over such long distances, latency (delay) is excessive and unsuitable for today's essential real-time broadband applications like video conferencing. In addition, GEO satellites each cover huge areas so bandwidth per user is severely limited. As a result, users of GEO satellite-based services experience download speeds of 19 Mbps upload speeds of 9 Mbps, and latencies of 1116 millseconds, according to RVA end user surveys in 2021. LEOS networks are aiming to overcome some of the limitations of GEO systems. LEOS networks orbit at altitudes of <2,000 km to reduce latency. The second limitation to overcome is the amount of bandwidth delivered per square km, which in turn requires thousands of satellites in a trade-off between worldwide coverage and bandwidth per subscriber. This paper will describe how the intrinsic architecture of proposed LEOS networks severely limits the capability to provide sufficient data rates to subscribers compared to FTTH Networks.

The Landscape

The most prominent LEOS projects are SpaceX (project Starlink), OneWeb, Telesat and Amazon (Project Kuiper). The capabilities of each network are primarily driven by satellite constellation design and network architecture. The constellation is basically characterized by the number of satellites, altitude, and orbital paths, as shown conceptually for a 4000 node LEOS Network on the left side in Figure 1[1], and on the right side the basic network architecture is shown[2]. The network architecture consists of satellites launched into low orbits, and each satellite can communicate with user terminals and ground stations to provide internet connectivity.

FIGURE 1

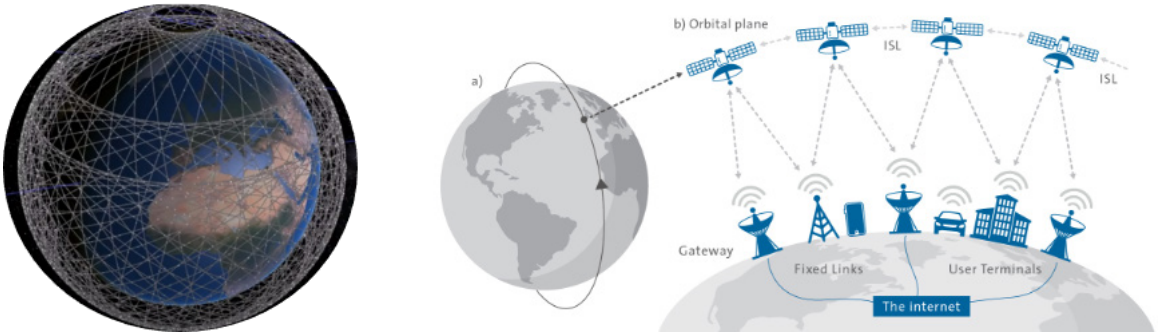

TABLE 1
SUMMARY OF KEY PARAMETERS AND DEPLOYMENT STATUS OF FOUR BIGGEST LEOS BROADBAND PROJECTS

Network	OneWeb#	SpaceX	Telesat	Amazon (Kuiper)
Altitude	1,200 km	340-1,150 km	1000-1240 km	590 – 630 km
Total # of satellites	720	1,584-initial phase, 12,000 by 2026	300	3,236
# of satellites deployed	74	420	1	0
Average Capacity per satellite	8.8 Gb/s	20.1 Gb/s	35.7 Gb/s	TBD
Beam size	75,000 km²	28,000 km²	960-250,000 km2	TBD
Architecture type	"Bent Pipe"	Mesh/ISL	Mesh/ISL	Mesh/ISL
Service launch	2021#	2020-US&Canada 2021-Global	2022	TBD

Comparison

While the architectures vary, the above proposed LEOS networks share the same limitation of much lower bandwidth density compared to FTTH. The data rate that can be supported per subscriber is driven by the shared capacity over the area of a beam formed by the LEOS phase array antenna (see reference [3] for details). The capacity of 9-36 Gb/s is shared by a huge area (960 to 250,000 km²) compared to existing FTTH broadband networks. For example, today a FTTH GPON network will share 2.4 Gb/s downstream and 1.2 Gb/s upstream with up to 64 subscribers. FTTH using XGS-PON increases FTTH capacity by a factor of 4 and 8 respectively, to 10 Gb/s symmetrical and is being deployed in volume today.

If we consider the area covered by a single Starlink LEOS vs. the same area covered by FTTH, assuming a rural density of 2 subscribers per square KM, the differences are striking. The Starlink LEOS claims to provide up to 20 Gb/s (20,000 Mb/s) of capacity to cover 28,000 km², or 56,000 subscribers. FTTH with XGS-PON technology would have 1000 OLT ports each providing 10,000 Gb/s (10,000,000 Mb/s), **500 times higher than provided by LEOS** in this example.

Elon Musk has stated that "Starlink will effectively serve the three or four percent hardest to reach customers for telcos, or people who simply have no connectivity right now. Or where the connectivity is really bad."[4] That is an optimistic assessment. Analysts at MoffettNathanson Research found SpaceX's total addressable U.S. market at full deployment at between 300,000 to 800,000 households, or less than 1% of the market.[5] Financial analyst firm Cowen has attempted to predict the capability of SpaceX's new mega constellation of small Starlink LEOSs, which they claim should eventually be able to serve 485,000 simultaneous data streams in the USA with 100Mbps speeds or 1.5 million streams with over-subscription, by 2026 after launching 12,000 Satellites.[6] Even assuming over subscription, and only one stream per household, 1.5 million streams would cover a mere 1% of US households by 2026, while FTTH in 5 years is expected to cover over 60% of US households.

Based on intrinsic limitations we expect that LEOS based internet service will be adopted only where fixed networks are not available and the density of subscribers is very low e.g., in-flight connectivity, cruise ships, or in remote areas. "If they think they're competing against terrestrial providers, they're deluded," says Tim Farrar, a satellite communications consultant, adding that satellite broadband is for last-resort customers who don't have any other choice for connectivity.[7]

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As an early pre-beta example, the recently launched Starlink LEOS network produced speed test results of 36 Mbps to 60 Mbps download, and 5 Mbps to 17.7 Mbps upload, as reported on August 13, 2020.[8] These speeds are barely compliant with the FCCs current, and many would say obsolete, *minimum* 25/3 definition of broadband and are measured on a lightly loaded pre-beta network. More recently U.S. subscribers using Space X's Starlink LEOS broadband service experienced median download speeds between 40 and 93 Mbps in the first quarter of 2021, according to tests conducted using Ookla's speed test technology.[9] This is far short of the 100 Mbps minimum download speed Space X committed to in its RDOF application. A detailed analysis by Cartesian of the Space X RDOF proposal revealed that if SpaceX commits all of its capacity to only the 642,925 locations in 35 States for which it received a tentative award to serve, 56% - 57% of locations will experience service degradation during peak times and not meet the RDOF public interest requirements. Further, Cartesian estimates that 25–29% of locations will receive an average of less than 10 Mbps of bandwidth during peak times.[10]

Broadband speeds are 3000 times faster today than in 1995, from 0.05 Mbps at the dawn of residential internet in the mid-1990s to an average of 179 / 65 in 2021 according to Ookla.[11] New applications under development will drive demand to 1,000 Mbps (1 Gbps) for both download and upload within the next decade, and to multiple Gigabits thereafter. Can LEOS networks keep pace with bandwidth hungry new applications, or will their subscribers be left far behind? Will tens of thousands of LEOS with their associated space junk and environmental impacts be tolerated?[12]

Conclusion

LEOS broadband networks have extremely limited capacity due to each satellite covering huge areas. This configuration may enable LEOS broadband networks to serve very low subscriber densities in remote areas, on cruise ships, in commercial airliners, or for military applications, and to penetrate developing country markets that have no internet connectivity. U.S. subscribers using Space X's Starlink LEOS broadband service experienced median download speeds between 40 and 93 Mbps in the first quarter of 2021, far short of the 100 Mbps minimum download speed Space X committed to in its RDOF application. As a newly emerging technology, with years of thousands of LEOS launches planned, LEOS technology remains unproven. FTTH networks use mature technology offering 1 Gb/s data rates widely available today to millions of homes and 10 Gbps FTTH is rapidly emerging to keep pace with continuing bandwidth demand growth.

References

1 https://www.reddit.com/r/Starlink/comments/87ltmb/what_a_4000_node_leo_satellite_constellation/

2 Corning illustration of basic LEOS network architecture

3 Inigo del Portillo, et. al. 69th International Astronautical Congress (IAC), Bremen, Germany 2018.

4 https://www.lightreading.com/services/musks-starlink-is-not-some-huge-threat-to-telcos/d/d-id/758092

5 Report: SpaceX Threat to Rural Broadband Providers? Maybe in a Few Years, Maybe Never - Telecompetitor

6 https://www.lightreading.com/4g3gwifi/starlinks-network-faces-significant-limitations-analysts-find/d/d-id/764159

7 https://spectrum.ieee.org/tech-talk/aerospace/satellites/amazons-project-kuiper-is-more-than-the-companys-response-to-spacex

8 https://www.telecompetitor.com/first-spacex-starlink-satellite-broadband-speeds-revealed

9 Ookla Finds Starlink Speeds Would Have Trouble Meeting FCC RDOF Requirements (telecompetitor.com)

10 https://www.ntca.org/sites/default/files/federal-filing/2020-12/NTCA-FBA%20Section%20706%20Ex%20Parte.pdf

11 https://www.speedtest.net/global-index/united-states#market-analysis

12 https://spacenews.com/viasat-asks-fcc-to-perform-environmental-review-of-starlink/#:~:text=WASHINGTON%20%E2%80%94%20Viasat%20has%20petitioned%20the,in%20space%20and%20on%20Earth

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