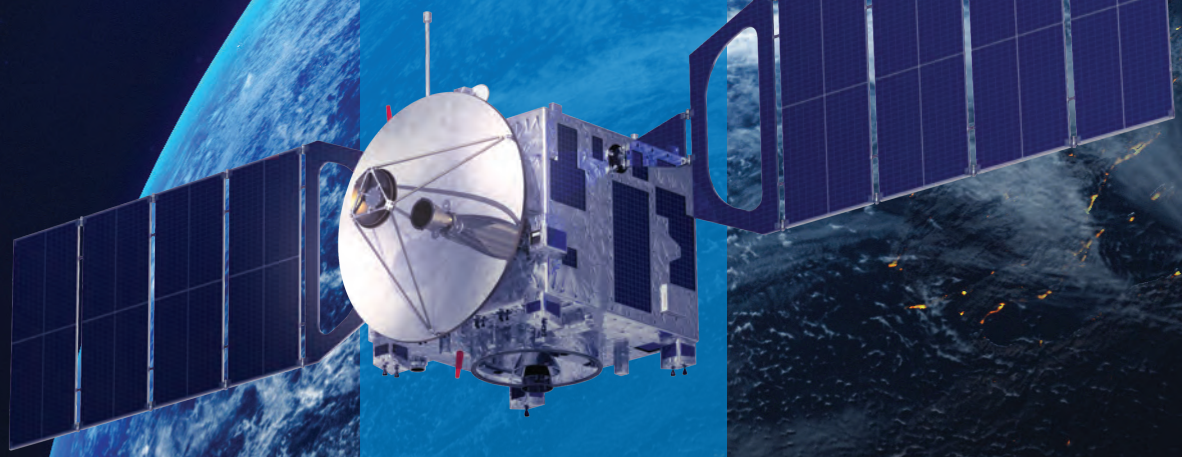
LEO SATELLITES:

THE NEXT DISRUPTOR FOR GLOBAL CONNECTIVITY



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Introduction

Over the past few years, there has been tremendous focus on providing connectivity globally. Since 2015, 1 billion people have gained access to the internet through a mobile phone – many for the first time. By the end of 2019, almost half the world's population was using mobile internet.[1] The need of connectivity is only growing with time, much beyond connecting people to address use cases across industries. There are several use cases related to industries like maritime, logistics, energy & utilities, automotive etc. where ubiquitous connectivity is required, sometimes with a mix of terrestrial as well as connectivity over oceans.

While the aspirations are to drive connectivity everywhere, there are several challenges in deploying networks using conventional methods like building wireless network towers, fiber, or copper networks due to cost, deployment feasibility and return on investment which hinder connecting the unconnected. In terrestrial networks, at remote locations satellite backhaul has been used in past. Various types of activities are ongoing to address these challenges & inventing new ways of providing cost effective & feasible connectivity solutions, the most talked about being Aerial networks.

There has been lot of action to try different type of Aerial networks initiatives in the past few years like Google Loon, Facebook Aquila, and very fascinating activities around Low Earth Orbit (LEO) satellites driven by companies like SpaceX, One Web, Amazon, etc. There have also been initiatives to drive higher throughput and better experiences via the conventional satellites.

Using satellites for communications is not something new in the world, during the 1950-60's the initial communication satellite launches happened, and they have been evolving over time. Satellite communications have played a significant role in providing connectivity for private and government organizations. During 2019, the overall global space economy grew to $366 billion including the satellite services, ground equipment, government, and spaceflight related budgets.[2]

Satellites have been instrumental in various areas such as scientific purposes, military surveillance, navigation, R&D, space activities, government communications and commercial purposes. For common people, the most common use cases were about TV, sending a WhatsApp message over via Wi-Fi on an airline or giving a call to a friend from a cruise ship via a satellite phone, but there a many areas where satellites played a role.

During the last few years, there have several activities in the satellite space to improve the capabilities, one of these has been about constellations of LEO satellites to offer affordable and universal connectivity solutions. Mega constellation business models are propped up by reduced manufacturing costs from either the use of commercial off-the-shelf components in software-defined satellite systems or vertical integration; lower launch costs due to smaller satellites and near-earth orbits; and E2E, consumption-based connectivity targeting untapped markets in rural regions.[3] This is being driven by players like SpaceX Star link, Amazon Kuiper, One Web, etc. to drive global coverage and potentially disrupt the connectivity space.

> Over the past several years, we have supported our Telco clients in various activities related to wireless, wireline and satellite networks. While there is exponential growth in the consumption of data, there are several initiatives with respect to cost-takeout and digitization which our teams are addressing to drive the next generation networks to stay competitive in the markets

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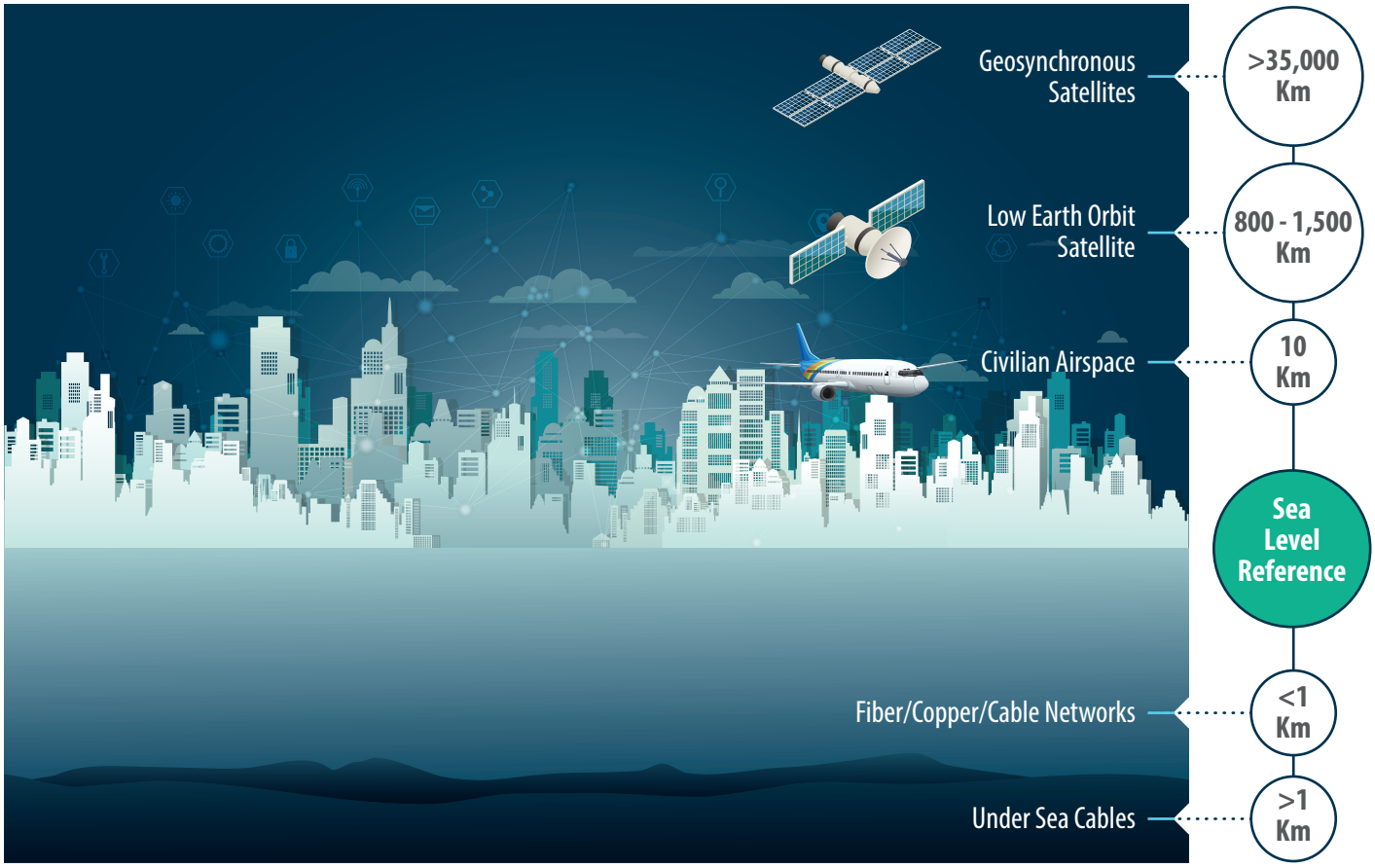

LEO Satellites

LEO satellites have an orbit 2,000 kilometers above the earth with a short orbital period of approximately 90 to120 minutes. These satellites cover only a portion of the earth's surface thus there is a need of a constellation of satellites for global coverage.

The concept of LEO constellations is again not new, there have been some activities previously without much success. For instance, the Iridium LEO constellation of 66 active satellites—initially deployed in the late 1990s and early 2000s to provide global voice and data services—never gained the subscriber base to make it commercially successful, although it eventually found a niche market and continues to operate today using a new generation of satellites, Iridium NEXT. [4] There have been other initiatives like Teledesic which closed down in 2002 and One Web which filed for bankruptcy but received further funding to restart their activities and have recently been very active in launching new satellites and receiving new funding. The goal of the satellite players is to offer more commercially viable offerings which can generate profitable business. SpaceX Starlink is undoubtedly one of the most talked about initiatives in this space.

LEO satellite constellation has the advantages of low propagation delay, small propagation loss and global coverage. This opens multitude of use cases to be supported right from remotest of monitoring, more accurate weather predictions and Ocean tracking. LEO satellites are not expected to impact consumer retail connectivity market unless there is significant development in device.

For expanding the use of LEO connectivity into common man use, the handshake between LEO Constellation IoT system and the Terrestrial IoT System need to be studied further and Satellite instruments need to be made more economical.[5]

SpaceX Starlink

Back in 2015, Elon Musk, CEO of SpaceX announced their plans to leverage satellites to meet the global demands of connectivity. Few years were spent in engineering and they looked at a new orbital regime of low orbit satellites with nearly 340km altitude. The Starlink system is designed to have far better performance than comparable satellite communication systems because of the increased number of satellites. SpaceX named this initiative Starlink and put an aggressive cost of their 12,000-satellite system at $10billion.[6] The significantly lower cost to orbit per kilogram than most rocket launches was part of the reuse strategy by SpaceX.

By end of Q1 2021, SpaceX Falcon 9 launched a new batch of 60 Starlink internet satellites into orbit pushing the total launch to date1, 445 satellites. There is a great reuse story also, Falcon 9 rocket that lofted this payload toward orbit, was making its ninth flight. This helps in cost effectiveness for the program. SpaceX ambition is to fly each vehicle 10 times before needing significant maintenance.

SpaceX has received funding from FCC worth$885.5 million over 10 years to support rural broadband customers. Several other countries like Greece, Australia, Germany, France, New Zealand, South Africa, India, Japan, the Philippines, Argentina, Brazil, Chile, and Colombia are exploring the Starlink capabilities. SpaceX's goal is to offer Starlink internet to almost anyone on Earth.

Starlink services have been offered in selected markets under a program Better Than Nothing Beta test at a cost of $99 per month subscription and a $499 upfront cost of a router and antenna for the service. As per public

sources, SpaceX presented the Federal Communications Commission (FCC) Starlink internet performance tests, showing it was capable of download speeds of between102 Mbps to 103 Mbps, upload speeds of 40.5 Mbps to not quite 42 Mbps, and a latency of 18 milliseconds to 19 milliseconds. As they launch more satellites and install more ground stations, the experience will improve.

SpaceX is in talks with the UK government about expanding its satellite-internet service Starlink to rural areas as part of the nation's$6.9 billion "Project Gigabit" plan. Starlink was being considered for getting internet to hard-to-reach communities in the UK. SpaceX has also signed a deal with British telecoms company Arqiva to build ground stations and infrastructure to connect satellites to fibernet works and servers.

SpaceX is building mobile connectivity for connecting aircrafts, ships and large trucks, eventually once terminals are matured, more cost effective and available in smaller in formfactor, we could see them over Tesla cars in the future.

Other LEO satellite initiatives

While SpaceX Starlink has one of the largest LEO satellite constellations already, there are several other initiatives in this space.

After being founded in 2014 as World Vu and renaming as One Web, it gained funding from Qualcomm, Virgin, Airbus, Bharti and later a$1 Billion from Softbank. Unfortunately, in 2020, **OneWeb** had filed for bankruptcy due to funding issues but soon after few months they were acquired by UK government and the Bharti group. With this acquisition, plans to build initial constellation of 650 satellites are back on track. In Jan'21, OneWeb got more funding from Hughes, Softbank and Eutelsat. Acquisition of Bharti Airtel will act as the testing ground for OneWeb's services and applications. One Web's plan is to broadcast internet via its satellites could help Bharti's business in Africa and India where laying Fiber is expensive and difficult. In India, OneWeb network could help Bharti Airtel to bridge the gap with Jio, which

currently boasts 700,000 km of Fiber as opposed to Bharti Airtel's 280,000 km.[7]

Telesat amongst the old players in the satellite industry space, announced their launch of LEO constellation of 120 satellites in 2016 and planning to expand the satellite count to its LEO constellation to over 1600satellites. Telesat got the license to provide services in the Canadian region and their future goal is to expand their reach in the new countries.

Amazon has also shown their ambition to invest in the satellite business and in 2019 they announced that they would fund a large broadband satellite internet constellation called Project Kuiper. In Project Kuiper initial target is to build the LEO constellation of 3,236 satellites to provide internet to "tens of millions of people who lack basic access to broadband internet."

Why are LEO satellite programs considered to be disruptive?

LEO satellite programs have varying responses across the telecom industry landscape, particularly with the CSPs, with some considering them as potential disruptors, some assuming that they will not be able to make the economics work and looking at collaboration opportunities.

In the past several years, the CSPs have invested heavily in building infrastructure required for communication services via fixed and wireless networks. These investments were made particularly from the perspective of connecting people & driven by ROI. The places where there was not potential uptake, they were not focused on unless some regulations mandated coverage. This has resulted in concentration of connectivity around inhabited areas and several areas are left unconnected. With LEO satellites, the global coverage is possible and thus the connectivity can reach remotest of the areas. If the LEO satellite solutions are economically viable, then they can disrupt the business of CSPs in those areas, or potentially be an opportunity to collaborate.

There are several other areas, such as maritime connectivity, like Telenor maritime which provide mobile experience at sea. Such players would get direct competition from LEO satellites which can offer seamless global coverage over land and sea without any complexities of roaming agreements. Further use cases related to logistics would be able to work in an E2E mechanism leveraging one LEO connectivity with further extensions to cloud solutions. There are several aspects related to device costs and network feasibility which may take time to mature.

Challenges for LEO satellite programs

As of Q1 2021 SpaceX Starlink is amongst the programs with maximum number of satellites, there are several other programs like OneWeb, Amazon Kuiper etc. which are establishing to compete in this space. However, there are major hinderances in the large-scale ambitions for these initiatives which will determine the overall success and uptake of these services in the coming years. Some of the main challenges observed are,

- Commercial feasibility and cost implications for deploying large scale satellite constellations, including launching costs is imperative for offering affordable services to end customers. This competition is not only in terms of cost of LEO deployments, but also to ensure competitiveness against the GEO/MEO satellites, which could provide a global coverage with lesser number of satellites.
- The user equipment for the LEO satellites must include advanced electronically steered antennas and the cost must significantly go down to compete with the terrestrial solutions. Higher ground system infrastructure requirements.
- Higher complexity in operations of LEO satellites due to larger number of satellites and associated handovers.

- Different countries have several different regulations and policies, thus global offering have its challenges.
- Perceived competition with new developments in terrestrial wireless communication with technologies like5G which can support a plethora of different use cases.
- Environmental issues related to multiple satellite constellations.

Some of the conventional satellite players offering services to industries like maritime, government, aviation, enterprise etc. are relooking at their business models, building collaborations and technologies to remain relevant in this competitive space, expanding their businesses into Retail business with e-Commerce from remote connectivity they offer.

The competitiveness also needs to be looked at from the offerings in the home broadband scenarios. Below is a representation of approximate reference values for some of the global players from public sources as of April 2021. SpaceX Starlink will need to rework their pricing model further in a market driven by reduction of their own costs.

Terrestrial Connectivity will remain relevant?

While the Aerial networks are focused on the opportunity to connect the unconnected, several initiatives are being driven via terrestrial initiatives as well, via wireless networks like 2G/3G/4G/5G and fixed networks like Copper/Fiber networks.

The cost of laying fixed networks everywhere with profitable returns on investment has been a challenge for the providers. Many of the legacy networks using copper are being modernized to fiber networks for better TCO. Many private or government led national initiatives Like NBN in Australia and Open reach in UK have been established to provide the infrastructure which is then leased to various businesses. In the EU, a third of all households (34%) had access to FTTH services in 2019, but only 18% of Europeans living in rural areas had the same opportunity. Notably, the gap between total and rural FTTH coverage does not seem to be closing over time.[8]

Wireless networks have been growing across the globe rapidly as well. By the end of Q4 2020 there were 5.95 billion LTE subscriptions worldwide accounting for 62.2% of all global mobile subscriptions. 5G subscriptions have increased to 400million globally representing 4.19% of the entire global mobile market.[9] Wireless networks also have a requirement of fiber network for backhaul purposes to deliver rich customer experience.

In the ongoing standardization activities for 5G with 3GPP for future releases, there are work items related to having satellite components in the 5G architecture and several other convergence related areas for communications. For decades, satellite communication has remained self-sustaining technology, but in the future, we would potentially get to see the wider integration to facilitate use cases requiring different type of modes of communication.

The deployment of terrestrial networks is very country specific and have a local nature in accordance to the requirements of the markets and demographics. Several policies, licenses and government regulations are followed for the development of these terrestrial networks. Generally, the networks are established by local players or specific service provider groups operating in specific geographies. The associated costs of services and devices are aligned to the local market landscape. For terrestrial wireless networks, harmonization of spectrum strategy globally helps to improve device costs.

Terrestrial networks are here to stay, but they may require competition or collaboration in unconnected areas.

Operator	Price $/month	Speed
Starlink	99$	50-100 Mbps
Verizon	70-80$	300-940 Mbps
AT&T	35-60$	300-940 Mbps
Vodafone UK	30-60$	100-900 Mbps
Deutsche Telekom	24-38$	50-1000 Mbps
Telstra	80-110$	25-100 Mbps
Bharti	7-55$	40-1000 Mbps
JIO	6-117$	30-1000 Mbps
British Telecom	38-47$	35-75 Mbps

Under Sea Connectivity growing rapidly

Global interconnections are essential for global connectivity, to connect all the terrestrial networks and bring the ability to exchange large amounts of data over fixed cable networks. Submarine cable plays a crucial role and have been in existence since the 19th century. There were approximately 378 submarine cables in service as of early 2019, traversing roughly 1.2 million kilometers, connecting virtually all countries with a coastline.[10]

Mostly the submarine cables are being developed by large telco players like Telstra as well as global players like Google, Facebook, Amazon. The players who do not own their own cable system have to pay transit charges for the data transfer. CDNs were created to minimize the spend on these costs and enhance experience. The submarine cable deployment is very expensive, thus strategic routes are selected for deployment based on various global connectivity trends and data center locations. The content and cloud use the international cable infrastructure to distribute their content via servers located in data centers closer to the consumers of the content, thereby enhancing the experience of the Internet user.[11]

Under Sea connectivity is bound to grow with the enormous amount of data flowing around the world, which may not be cost efficient to be transmitted always via a LEO satellite ecosystem. These networks also would be essential for disaster recovery purposes. Thus, these do not compete but complement one another for global connectivity.

Hyperscale Players leveraging Global Connectivity

When we talk about global scale, players like Amazon, Microsoft, Google, Facebook are immediate points of discussion, specifically their ambitions in the Cloud business and in the wider 5G play. The vast investments in the cloud data centers across the globe require global connectivity where all the discussed mechanisms of connectivity are coming into play, and these players are also influencing the investments in several ways.

The collaborations of the Hyperscale players go beyond connectivity and are involved in the wider application of use cases across enterprises.

Google has recently announced a partnership with SpaceX to supply computing and networking resources to help deliver internet service through the Starlink satellites as well as for Starlink to leverage Google's private fiber optic network. This collaboration will further accelerate the uptake of enterprise use cases by facilitating a wider eco system of offerings now including global connectivity.

Earlier in October 2020, Microsoft announced working with SpaceX to bring Starlink internet connectivity to modular Azure cloud data centers that customers can deploy anywhere. This relates to a new service they refer as Azure Orbital to connect satellites directly to the cloud. Azure Space and the new partner shipset up Microsoft and SpaceX to compete further with Jeff Bezos' businesses Amazon and Blue Origin, which have announced plans for similar satellite services and more.

The collaboration of hyperscale players, with their own global undersea cable connectivity, and partnerships with terrestrial and satellite players can play disruptive roles in providing solutions for various industries, specifically like logistics, shipping, etc. by providing E2E solutions.

> Today when we speak to our clients, it is no longer about just connectivity or how to build the IT, it is about a much wider ecosystem of offerings and their business impact, which spans from connectivity to content. For the future, it is essential that the various partners of the CMT ecosystem come together and offer services which benefits the overall development of society and profitable business growth for all.
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Conclusion

Aerial, terrestrial, and undersea options, ultimately all are vital for global connectivity which drives global GDP growth. While the terrestrial and undersea cable are matured, the aerial networks must be proven for mass adoption. The opportunities which will get uncovered with aerial networks will lay the foundation for new partnerships and business growth with a global connectivity ecosystem, in many new business verticals such as a maritime, aviation, logistics, etc.

Hyperscalers are bound to drive global connectivity and solutions with global scale leveraging their vast investments in the cloud space. CSPs need to leverage their local strengths, infrastructure and drive the next generation solutions by establishing the correct partners for future growth. Satellite players can be potential partners for areas where CSPs do not see feasibility using their infrastructure for connectivity.

At the end, the future is about a partnership led ecosystem where each constituent brings their strength together to address the large-scale needs of connectivity and use cases for connecting people and industries globally.

Glossary

CDN:	Content Delivery Network
CSP:	Communication Service Provider
E2E:	End to End
FCC:	Federal Communications Commission
FTTH:	Fiber-to-the-home
GDP:	Gross Domestic Product
GEO:	Geostationary Equatorial Orbit
IOT:	Internet of Things
IT:	Information Technology
LEO:	Low Earth Orbit LTE Long-Term Evolution
MEO:	Medium Earth orbit
R&D:	Research and development
ROI:	Return on Investment
TCO:	Total cost of ownership

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