

A visualization of a Low Earth Orbit (LEO) satellite constellation. It shows a view of Earth from space with several satellites in orbit. Dashed blue lines represent communication links between the satellites and ground stations on the Earth's surface. Solid blue arcs represent the coverage areas of the satellites. The word "LEO" is written in large, white, 3D-style letters in the lower-left quadrant of the image.

# LEO

## Constellation is a Game Changer for SATCOM

Today, satellite communications are key to many terrestrial networks, transportation systems, airlines, marine services, and rural broadband Internet. With the increased number LEO (Low Earth Orbit) satellite deployments, SATCOM operators are now able to provide higher bandwidth and better communications solutions to every part of the globe. Thousands of satellites are in plan for deployments under various LEO constellations, this greatly improves potential for Internet and 5G communications from space. These SATCOM (satellite Communications) technologies powered by LEO constellations poised to usher in a new era in terrestrial communications system especially where physical connectivity is difficult to obtain.

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# overview

Unlike its predecessor, LEO constellations provide greater promise for satellite broadband services. The signal from LEO satellites is much stronger due to its earth proximity and less vulnerable to atmospheric interferences. The LEO based SATCOM is thus slated for future terrestrial networks where physical connectivity is difficult to obtain. At Trimble, we are enabling LEO based SATCOM services through precise synchronization.



## New Era in SATCOM

Historically dominated by GEO (geosynchronous) satellite technologies, the SATCOM market is now expected to make a paradigm shift towards Low Earth Orbit (LEO) satellite technology. Though there have been proposals for hybrid SATCOM services of bouncing signal from GEO, MEO and LEO satellite constellations, LEO based SATCOM is becoming a common for future of Internet and 5G services from space. While hybrid SATCOM could be a consideration for future, LEO satellites are increasingly deployed for global terrestrial network services.

And, that is for good reason, more constellations possibilities, stronger signals and higher bandwidth capabilities. A number of space operators have already deployed LEO broadband services in various parts of the globe. LEO is also enabling the reach of Internet to remote part of the globe and poised to augment 5G services for hard to reach places where physical connectivity is not cost effective.

The following table depicts a comparative performance of LEO based broadband services & technologies.

Characteristics	LEO	GEO	Fiber	5G	FWA (4G/5G)
Speed	100 Mbps	<25Mbps	1-10Gbps	Upto 1Gbps <sup>1</sup>	50 Mbps sustained speed <sup>2</sup>
Latency	<30 ms	> 500 ms	<15 ms	<30 ms	<50 ms
Coverage	Global	Near Global	Urban areas	Urban & Suburban areas <sup>3</sup>	Urban, Suburban & rural areas <sup>4</sup>

Note:  
1. 5G services offers 300 mbps to 1gbps 2. FWA deployments remains at 50 Mbps sustained speed with possibility of 1 Gbps peak rate. 3. 5G coverage till date is limited to Urban and Suburban areas. Rural deployment is yet to be realized. 4. Some countries have deployed 4G/LTE FWA to few rural areas in addition to Urban and Suburban.

## Hyper Connectivity

The explosion of ubiquitous connectivity is staggering and the world is entering a new period of hyper connectivity, an evolving state of communications in which everything is talking: person to person, person to machine and machine to machine. The ensuing impact on our systems will transform how we produce, manage and govern our world and ourselves. LEO is offering unparalleled possibilities for hyper-connectivity for smart cities, smart industrialization, transportation, maritime services and global Internet coverage. Additionally, LEO provides improved capabilities for military and government services.

## Internet and 5G Services

Unlike VSAT broadband services, LEO brings Internet and 5G services to places where laying fiber and/or providing other terrestrial network services are impossible. The 3GPP release 17 will allow 5G services to be extended through non-terrestrial network services of LEO satellites. These unique capabilities will bring 5G services closer to even the remotest part of the earth.

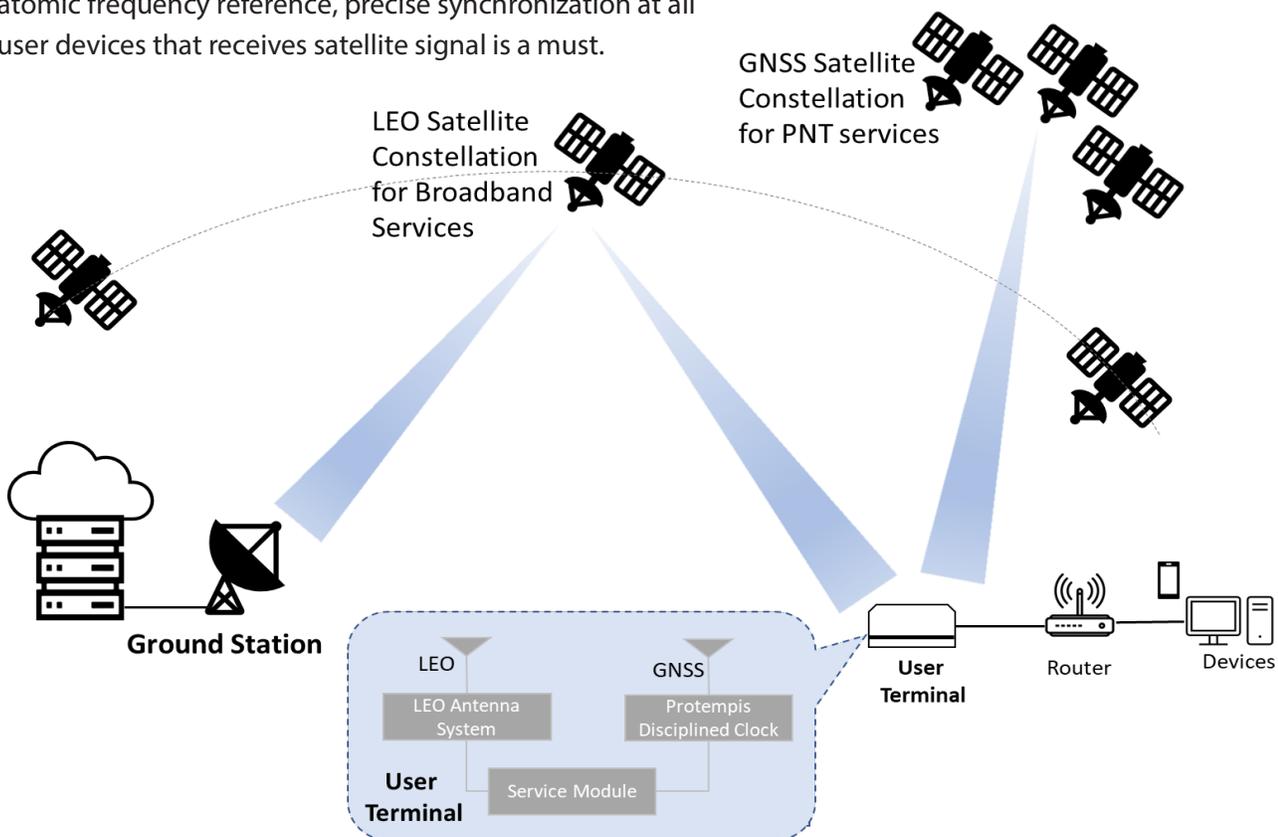


## Time is Critical

Time is everywhere, yet when it comes to terrestrial and non-terrestrial network services, we rarely think about it. All satellites services whether GEO, MEO or LEO must use precise synchronization at space, ground and user segments. For space services, satellites generally carry on-board atomic clock and similar atomic clock services also required for ground segment to monitor and control satellite services. The user segments while do not need atomic frequency reference, precise synchronization at all user devices that receives satellite signal is a must.

## Precise Synchronization

All satellites operational segments need precise synchronization including the user segment. Without precise synchronization SATCOM services is subject to catastrophic failure. The user terminal is at the core of user segment for SATCOM services. Trimble has deployed hundreds of disciplined clock specifically designed for user terminal and thus enabling LEO broadband services for the space operators.





**contd.**

Trimble disciplined clock offers unparalleled precision and hold over capabilities for SATCOM operators. Our embedded disciplined clock is ideal for user terminal. With GNSS dual-band (L1 and L5) capabilities, the disciplined clock also provides added protection against anti-spoofing and anti-jamming. Additionally, security of the device is further enhanced through encrypted firmware.

### Disciplined Clock

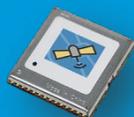
Devices needing precise synchronization can either implement Primary Reference Time clock (PRTC) of their own or rely on PTP (precision Time Protocol) to get PRTC source. Even in the case of PTP based time synchronization, the device must use physical link for clock back up in the form of SyncE, 1PPS, TOD or 10MHz depending upon underlying network configuration.

The PTP allows distribution of clock from its source Grand master (T-GM) clock to endpoints. Clock drift in between the hops are corrected through boundary clock (T-BC). This solution may not be appropriate in the cases where the device itself responsible for maintaining its own clock and PTP deployment is less likely of a scenario.

In such case, as in the example of SATCOM user terminal, the device requires local PRTC that not only provides stable clock but also continue to be reliable clock source even after periodic failure of GNSS Signal. The disciplined clock also known as GNSSDO (GNSS disciplined Oscillator) retrieves clock information SV signals from various GNSS satellites, triangulates it and get the best clock source. It is then use lock algorithm to provide best UTC source precisely with nanoseconds level accuracy. The device also have electronically steered oscillator that is precisely trained to provide backup source of clock for extended hours in case of GNSS satellite failure.

## Resilient Time for Resilient Terrestrial Networks

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