

SATELLITE COMMUNICATIONS

The LEO, MEO and GEO revolution

The Inside View

21 September 2022



“Ubiquitous connectivity with a first-class experience, at an acceptable cost anywhere in the world.”

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Introduction

We are witnessing a revolution in the satellite communications industry with the commercial launch of the first LEO (low Earth Orbit) constellation Starlink from SpaceX. It has been in development over the last few years along with various others. Starlink is disrupting the communications infrastructure at every level from satellite operator and provider, even the cellular communications operators to the antenna manufacturers and the systems integrators.

For the first time in our experience as specialists in satellite communications, we are receiving questions from our clients about the new LEO constellation Starlink, which have been prompted by the extreme performance and low price when compared to conventional VSAT. Plus, the fact that this has been developed by Elon Musk the founder of the Starlink project and SpaceX. His own company SpaceX also launches the Starlink satellites using his re-usable rockets. Word has spread like wildfire in the yachting marketplace on the dock and by social media. Some clients have become obsessed!



The two most advanced constellations are Starlink and OneWeb. Starlink is between beta test evaluation and commercial. The others which we are monitoring are Rivada Space Networks, Amazon’s Kuiper constellation, Telesat’s Lightspeed and China’s Galaxy Space.



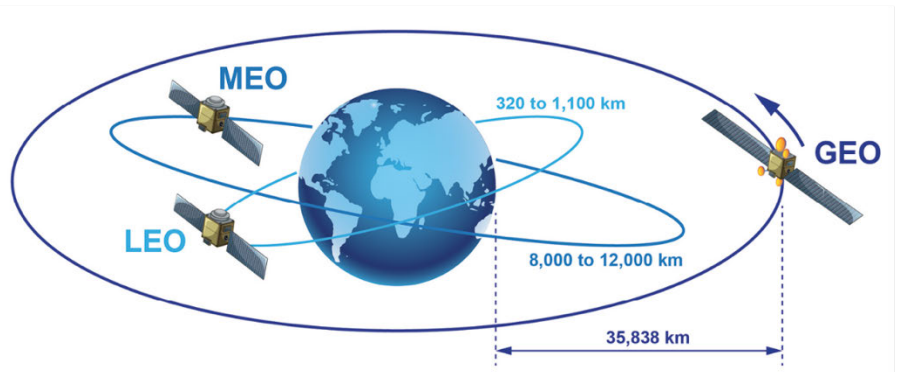
Rivada could be the next to go commercial. Telesat after that, but they have halved the number of satellites planned due to the increases in costs and might run out of funding. Even with this reduction, providing a commercial service is not expected before 2025 at the earliest.

Kuiper is years off a commercial launch, possibly between 2026 and 2029 but, being Amazon, it is extremely well funded. Galaxy Space has sixty satellites in space with a target of 1,000, but it is based in China, so we have no information as to their commercial target.

CONSTELLATION	Target Size	Launched	When global	Beta testing	Expected date commercial	Marine antenna	Commercial airtime price
Starlink	42,000	2300+	1Q23	yes	1Q23	yes x2	yes
OneWeb	648	400+	2Q23	yes	2Q23	yes x1	no
Rivada	600	0	2025	no	?	?	no
Lightspeed	188	1	2025+	no	?	?	no
Kuiper	7,774	0	50% 2026 100% 2029	no	?	?	no
Galaxy Space	1,000	60	?	no	?	?	no

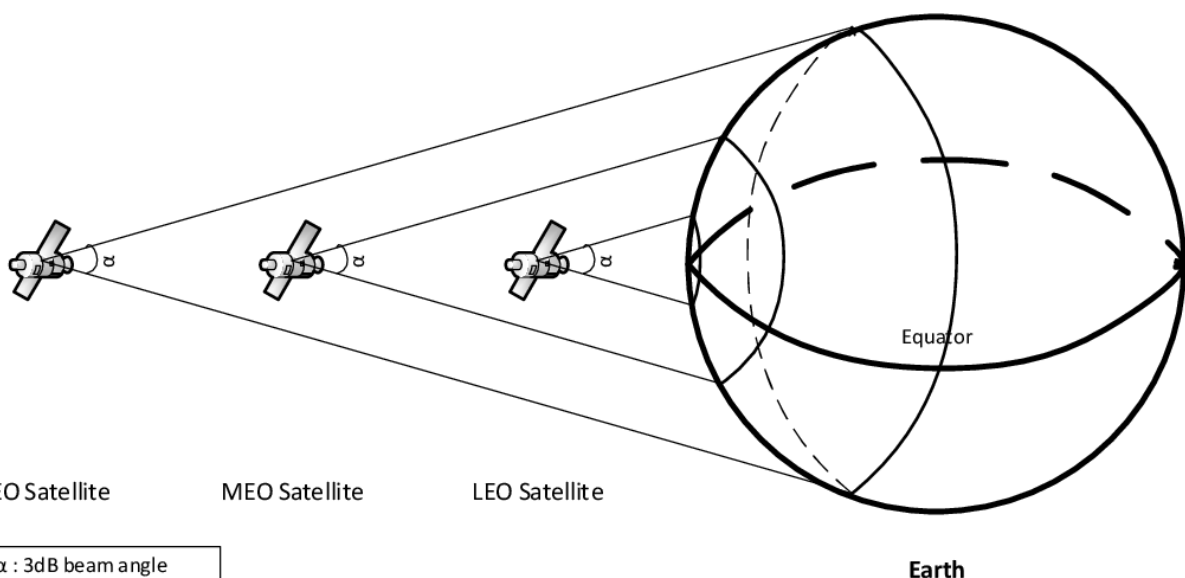
What is a LEO satellite constellation?

A LEO satellite constellation is a group of small satellites working together as a system. Unlike a conventional single geosynchronous (GEO) satellite, a constellation can provide permanent global or near-global coverage, so that at any time, everywhere on Earth, at least one satellite is visible. Satellites are typically placed in sets of complementary orbital planes and connect to globally distributed ground stations. If they are over the oceans, they use inter-satellite links. At altitudes typically between 450km to 2,000km above the earth LEO satellites move rapidly across the sky, with a relatively small coverage area on earth. LEO operators need 100 satellites to provide complete earth cover from an orbital height of 750km. This number increases to thousands of satellites for an orbital height of 450km.



What’s the difference between MEO and LEO satellites

A Medium Earth Orbit (MEO) satellite is a happy medium between LEO and GEO. A MEO satellite orbits the earth at an altitude above that of a low earth orbit (LEO) satellite and below that of a geostationary earth orbit (GEO) satellite. MEO provides a vast range of options to those deploying satellites and strikes a balance between the costs of higher altitude constellations and the coverage of low orbit satellites.



α : 3dB beam angle

Satellite operator SES is due to launch its new MEO constellation mPower in 2023 using a wide range of domes from 0.85m to 1.5 m. Expectation for the bandwidth is up to a 750 Mbps downlink. The coverage will be limited as were the previous O3B generation satellites, available only from 50°N to 50°S.

What are GEO satellites?

GEO satellites operate significantly higher at about 35,786 km and match the rotation of the earth, therefore appearing to be stationary in the sky. GEOs can be tracked with simple low-cost antennas, and their very wide coverage across almost an entire hemisphere are GEOs greatest strengths.

They are powerful and as large as a bus. Their strengths are secure, reliable, and guaranteed communications.

The GEO satellite owners are reacting to the approaching competition from LEOs and MEOs. They have already ordered software defined payload type of satellites. This will allow them and their network resellers to adapt to the market evolution but still keeping their strengths.

The business model of LEO constellations is still to be proven to be sustainable when compared to a couple of GEOs providing global coverage. We can expect massive improvements from the current GEO ecosystem.

When making a decision as to what satellite communications system or systems to use, VSAT using GEO makes a strong case for the guarantee of service, traffic shaping, reliability (above 99.9%), high level of support and trouble shooting.

Some basic facts about LEO and Starlink

A LEO service is fast, and the latency is low. The latency is the lag between requesting something and getting it back. This is great for traders or online gamers. High bandwidth with no data limits at very low cost is the **Holy Grail**.

The market is being disrupted by Starlink offering exactly that when they launched their land based Residential and RV systems. As a result, Starlink have had 400,000 subscriber's sign-up on-line in the first 12 months. None of the other LEO services have published any prices. The land based Residential prices for Starlink are subsidised whilst in its beta phase to entice many people to test and load the service. Also, this is for the fixed service. The prices for their maritime mobile service were announced in early July and, not surprisingly, they are some 40 times higher. I will explain why.

The LEO cost per bit of data to provide connectivity for mobility is considerably higher than that for LEO fixed Residential. The satellites over the oceans are more expensive as

they must relay the connection from one satellite to the next before it can reach a ground station. These satellites have laser intersatellite links (ISLs) which are costly. The cost per bit to operate a LEO network is significantly higher than GEO due to the huge cost of the whole constellation when compared to just one GEO satellite. We are talking about figures in the range of \$300 million vs \$10 billion. GEO satellites are also making major progress with software defined payloads able to adapt to market requirements while already in orbit.

Apart from the cost per bit, the main weakness of LEO is the drop in performance caused by the density of users. In the last year Starlink has sold about 400,000 residential antennas, so let's assume about 200,000 are in the USA. A number of those users in the USA have now said, on social forums, that the original 100 Mbps they experienced has now dropped to 20-40 Mbps, and that has occurred over only one year. In comparison Viasat, which provides a GEO residential service in the USA for 500,000 users still provide a consistent speed of 100-150 Mbps.

If the capacity of a LEO network needs to be increased, another layer or constellation of satellites needs to be launched, or the existing ones replaced by higher power satellites. Starlink have already planned to do this with a target of 42,000 satellites but do not have FCC approval for any more than 8,000. To increase the capacity of GEO satellites, you launch another GEO satellite. As already mentioned, it is considerably less expensive to launch another GEO satellite rather than repopulate a LEO constellation, especially when rocket launch prices have dropped over the last 5 years.

Starlink is currently providing their service on a beta test licence, where almost anything can be done. As of 1st July, the Federal Communications Commission (FCC) granted approval to Starlink for a Mobility licence. A Mobility licence has responsibilities. Mobility often destroys the efficiency of the service, and it can cause adjacent interference with other satellites. This is sacrosanct and must never happen. For those that follow this on social media, this is the concern that other satellite operators are voicing. An operator will lose their licence completely if this happens. Starlink have launched with a maritime antenna which is larger with more gain, and it will reduce the risk of adjacent satellite interference. It is, in fact, their Business antenna. As expected, it is 10 times the price of the residential antenna, and you are supplied with two. However, it is only rated at IP56, lower than conventional maritime antennas and not designed to withstand a gale at sea, and easy to be tangled by halyards and sails.

Our Starlink Maritime evaluation

The Starlink Maritime system was launched on 7th July. We began our hands-on evaluation followed by the installation of the system on a client's yacht.

Delivery and installation

As soon as the Starlink Maritime system was announced we ordered one to be delivered to our USA office and shipped it to Europe. We then evaluated it with one of our clients. After organising the delivery, setting up the account with Starlink, activating and providing installation guidance after our setup and test in Mallorca, the crew completed a fixed installation on their yacht in the east Med with both panels operating in both the configuration options.



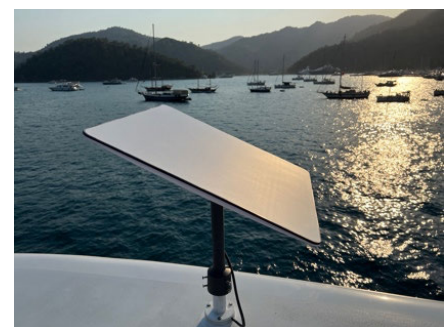
The Maritime system consists of two Starlink Business systems with a power supply wi-fi router and panel on a pole with a pipe adaptor. The systems work independently and there is no interconnection connectivity between them. That must be provided by the integrator or the yacht to provide either failover or aggregation.

It was proven the systems worked in the Balearics and in Greece.

We and the yacht have monitored and evaluated the performance and outages under all conditions. The installation only took 4.5 hours! It was up and running with 250 Mbps down and 18 Mbps up with between 60 - 100ms latency.

Switching and Integration into the IT System on-board

On every yacht there are bound to be losses in the IT infrastructure, which in this case initially reduced the inboard performance to 90 Mbps. The networks on most, ten plus year old yachts, have been grown organically and have often never been updated. There are many ways to improve the performance, one of which we and the crew implemented, and the owner is now receiving 250Mbps down and 27Mbps up on his iPhone, when connecting by Wi-Fi on his unrestricted LAN.



The Antennas and Equipment

The antenna is the weak link as it is only IP56 and will be vulnerable in a gale. They have motors in them, so they do move, but very slowly after a good five-minute wait, when nothing seems to be happening! The cables and connectors are all good quality, but they are of various fixed lengths. All available from the Starlink Shop. There is a power supply and a wi-fi router for each antenna and both need power.

Starlink will replace the antennas with 2 phased array, non-moving flat panels from October 2022 free of charge.

They will start shipping at the end of September, and existing Maritime customers will be notified first. Two panels will be supplied with each order, as they have done with the two Business panels they initially supplied with a Maritime order.

The illustration here is an artist’s impression of their new panel.

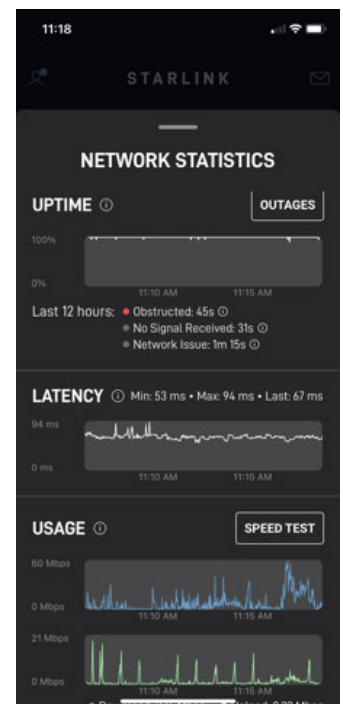
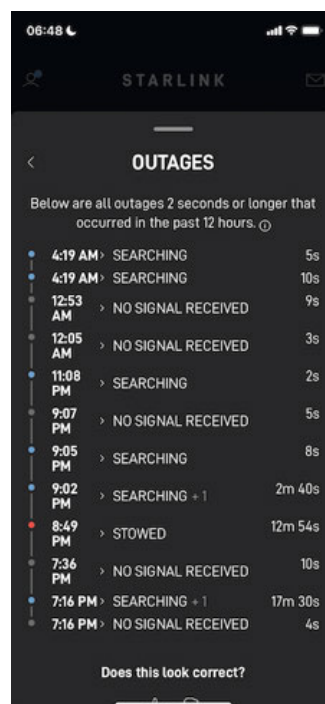
We understand it will be about 500x580mm with a depth of about 80mm.



The App, Configuration and Monitoring

The configuration is done by downloading the app on your smartphone and connecting to the router’s wi-fi.

The app also provides live feedback on the Network Uptime, Latency, Outages and Usage on-board from anywhere in the world.



Initial Starlink Support feedback

We have tested the Starlink Support Service several times and a request is launched using the App. You ask a question, and they confirm back to the App that they have received it quite quickly and by email, saying they will get back to you and then, both times, they reply about 24 hours later. Not a good response time if the system is down. If the system is down and it's your primary and only method of communication, you won't be able to use the App, so make sure you have a backup! I hope the response time doesn't degrade as it gets busier.

They do not offer any suggestions as to how to integrate it into the yacht's network. The yacht will still need support from their Systems Integrator.

A lesson in geofencing – the use of technology to establish a virtual geographic boundary

We witnessed Starlink introducing a geo fence in August. Our client sailed to Turkey from Greece initially and then back to Greece in the first week of August and both the Maritime and RV system on-board were working well. Everyone was very pleased and impressed. However, shortly after this they then sailed back the ten miles to Turkey and after five miles both systems stopped working.



Starlink support was contacted, and they replied saying they were using the system in a location where there was no service! Obviously, we and our client were surprised by this, as it had been working in the same location only the week before!

Finally, it transpired that SpaceX had created a geofence on the edge of Turkey's territorial waters and along their entire coastline in early August. It was activated without notice. We can only guess as to why this was done – no explanation was given! The owner of our evaluation yacht was initially very upset, but he has now simply decided to give Turkey a wide berth in the future. This is when it's critical to have an alternative backup service which the yacht had with our BIG DATA 4&5G Pay as you Go service.

Will super broadband increase your vulnerability to cyber-attack?

With this level of bandwidth available the yacht will become more vulnerable to cyber-attack. With more bandwidth there will be more IP addresses, more exposure and typically, there will be no asset management of IP addresses. This will be a new environment that the bandwidth enables with a significant increase in M2M connections with devices talking to each other. We provide a range of new monthly cyber services.

The Risks of being an Early Adopter

At e3 we have always been innovating and launching new technology. As a result, we know there are always potential issues and we recommend a conventional backup, particularly when you have the owner or charter guests on-board. In this case our client is primarily using our **BIG DATA 4&5G Pay as You Go** service as a backup as if there is an issue then you only pay for it when needed. They also have their conventional VSAT which has been reduced to its base rate for now and will probably be suspended if the reliability is proven.

The use of RV systems at sea will be blocked

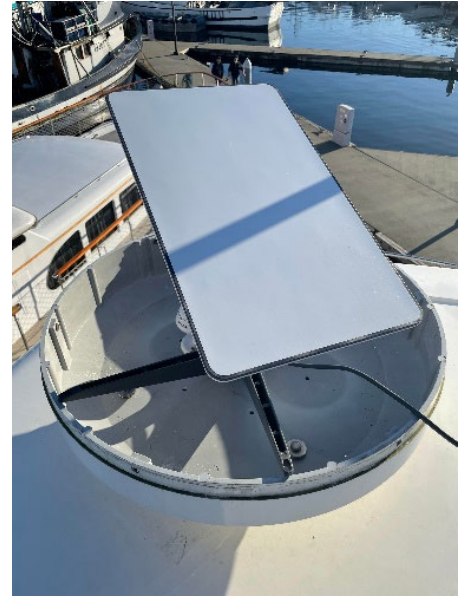
Most yachts using Starlink this summer in the Med have been using the RV system, and it has worked well. The RV system is intended to be used on land for Recreational Vehicles and is only licensed to be “portable” not “mobile”. However, it has worked around the Med, bar Turkey, this summer. The RV system costs a few hundred dollars as opposed to \$10,000 for the Maritime system. The monthly airtime for the RV system costs less than \$200 as opposed to \$5,000 per month for the Maritime system. So, many have questioned why they should pay for the Maritime system. We have been asking the same question, so we brought it up during our discussions with Starlink. If you think about it, Starlink didn’t introduce the Maritime business model for fun. Currently, they are losing out on the bigger bucks in their business model, and this loophole is not going to last much longer.

We have been told by Starlink that they can geofence each of their systems, and they have already started to geofence RV systems so that they do not work at sea. We questioned how precise they could be if, for example, a yacht is at anchor close to shore. Their firm answer was that they can be very precise indeed. This will start to make the use of the RV system at sea unreliable, if not impossible.

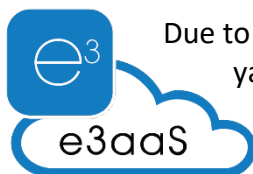
We have also heard that they could introduce a Firmware Upgrade for both Residential and RV systems which will stop them connecting if they are on the move. This could be imminent.

We are discovering that Starlink move fast when they decide to act, so we would predict the Starlink RV system will start to become very unreliable for use at sea over the next few months, other than in port.

I fear it's a waste of resources and time to mount your RV or Residential antenna in an old dome.



How we are helping yachts implement Starlink



Due to our experience over the last months, and from requests from yachts, we have launched a new service called “**e3 as a Service**” for Starlink Maritime at this time but this will also cover OneWeb services once launched.

We offer our expertise and knowledge “as a Service” to a vessel wishing to implement Starlink Maritime.

- We can organize the order process, advise, install, and commission the equipment.
- Advise on the best installation location and integration into the vessel network.

- Provide an IT network audit to investigate potential bandwidth bottlenecks.
- Provide data monitoring and management for super broadband services.
- Provide a high level of cyber security monitoring of equipment, software, and crew.
- Provide seamless failover with connectivity backup using VSAT and/or 4&5G.
- Provide GMDSS compulsory carriage requirement services using L-band.
- 24/7 Proactive Support on all* connectivity services, network and IT.
(* excluding Starlink currently but we are in talks for this to include Starlink)

Services we offer that are enabled by super broadband

- An IPTV service for every TV on-board.
- CCTV and security.
- Digital PBX with VoIP.
- Digital and print worldwide newspapers and magazines.
- AR (Augmented Reality) support services.
- Holographic teleconferencing.

Other LEO service updates

No other LEO or MEO service has made the leaps and bounds forward that Starlink has.

OneWeb will be next to market then Rivada and possibly Telesat will follow.

OneWeb using Kymeta

We understand the maritime OneWeb service will require 3 stabilised domes which is not a solution that will be welcomed or used on yachts. The way forward is to use the Kymeta u8 panel that has been developed over the last ten years. A single panel will do the same job as the three domes, it transmits and receives using the one panel and it can switch between LEO, GEO and 4&5G. The price has just been reduced to compete with Starlink.

A sea trial took place from Monaco in early September 2022 using a Kymeta flat panel. Results indicate that the trial was successful, with the antenna acquiring and tracking well. Solid throughput was achieved. Kymeta tell us they plan a full market release in February or March 2023.

We know the Kymeta panel is a proven maritime panel, and we are told the bandwidth will be 195Mbps down and 16 or 32 Mbps up per panel at an equivalent price point to Starlink.



Rivada Space Networks

We have only just heard about this new LEO constellation, but it has been in the planning since 2014. They filed their two FCC applications at the same time as SpaceX and OneWeb.



It was formally presented at Satellite 2022 in Washington DC earlier this year after they had their FCC filings approved.

This constellation is fundamentally different to all others in that it will be “gateway less” and as a result it is not constrained by coverage. All current LEO constellation satellites communicate back to earth through land gateways. Rivada’s architecture will not have the cost of building ground stations around the world, all the processing is done on the satellite with a regenerative payload. Connectivity will be uniform throughout, from the middle of the ocean to the middle of the desert to the middle of a big city.

The architecture is the equivalent of having a fibre network in the sky, only faster. It will provide point-to-point Ka- Band connectivity with high data throughput, ultra-low latency and network transparency. All the satellites communicate with each other using laser inter satellite links, so there are very few touch points, thus reducing the opportunities for cyberthreats and creating a very secure network. Also, unlike all the other LEO constellations it is a full duplex, symmetrical system with bandwidth limited to a huge 10Gbps!!!

Six hundred satellites are to be launched starting in 2024, and the service will start in 2025.

The point-to-point connectivity will allow a yacht to breakout in a country of choice removing the need for VPNs. Any two points on Earth can connect, and it can also be used for broadcast, multicast, Global Corp Networks and leased line equivalent services.

Their claim for ultra-low latency is based on the fact that the satellites will be 35 times closer to the earth than GEO satellites, resulting in the latency of a connection to the opposite side of the world (for example, Madrid to Wellington) to be <260ms for Rivada, whereas fibre is >350ms and GEO >1000ms. Typical Round-Trip Time will be <150ms. It is also faster than the current LEO systems as they are limited by using ground stations.

This is a very interesting constellation development to watch over the next couple of years as the concept is quite different.

Getting the best from the new LEO services

The new LEO services are an exciting additional communications connection (WAN), that will be worth adding to many yachts. When carefully integrated with traditional GEO and 4&5G services the new LEO super broadband service offers significant diversity and a massive bandwidth boost when owners and guests are on-board to truly fulfill the desire of every yacht owner and charter guest to be able to do:

“Everything they do at home and in the office on-board!”

As a result, we recommend a managed service approach to keeping the vessel fully connected and fully supported. The core to this is our **HYBRID** communications solution, which can connect using any combination of connections.

The selection of connections vary by type of technology, satellite, frequency, reliability, bandwidth speed, data limits, coverage, flexibility and cost.

The key is to incorporate these pathways into the managed service, with seamless transitions to achieve the Holy Grail which is:

“Ubiquitous connectivity with a first-class experience, at an acceptable cost anywhere in the world.”

THE ULTIMATE e3 HYBRID SOLUTION

HD4 Configuration

