Satellite based LoRa® unlocks Europe-wide IoT

White Paper

EchoStar Mobile™

Contents

The Internet of Things

Big data is the dominant economic currency in a changing world moving at an increasingly accelerated pace. The speed and frequency with which data is collected, processed, and actioned is crucial to delivering the core promise of the Internet of Things (IoT) – either saving money through optimized operations or enabling new business models to generate new revenue streams.

The IoT consists of physical objects that have "smart" capabilities to collect data about their physical world. This data is transmitted through communication networks to application servers that process, store, analyze and produce actionable information through the use of specific algorithms. Whether it's reporting on the status and condition of electrical transformers, tracking vehicle fleets, or reporting on pressures and temperatures in a process plant, IoT provides a powerful tool to transform data into information, knowledge and wisdom.

By giving industrial companies and the wider society easy access to this wealth of data, IoT technologies help improve profitability, reduce costs, control pollution and can promote safer, healthier working and lifestyles.

There are numerous challenges to making the best use of IoT, however a primary challenge is choosing the optimal network architecture. Issues affecting this choice include requirements to scale from thousands to millions of nodes, densely or sparsely populated unit distribution, fixed or mobile operations, and areas remote from terrestrial infrastructure.

Getting this architecture right and adopting a capable and flexible connectivity method are the keys to successfully using IoT and realizing its benefits.

Using IoT

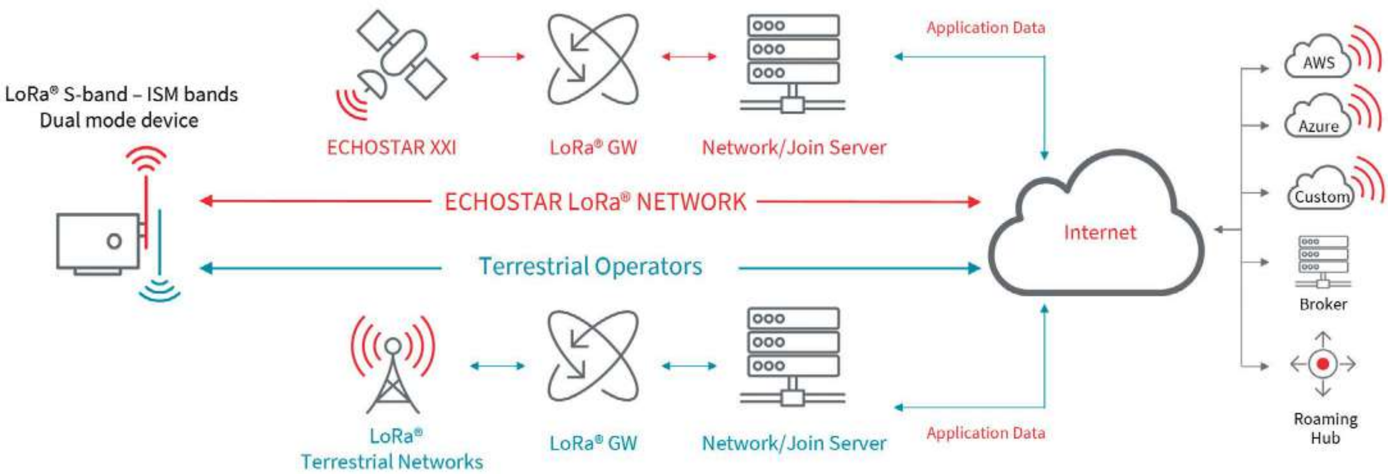
Many companies from different sectors are looking at the Return on Investment (RoI) that IoT can bring to their operations, particularly massive IoT where small amounts of data are sent from hundreds or thousands of connected devices. Utilities, rail, transportation, logistics, agriculture, oil & gas and the maritime sector can all benefit from IoT.

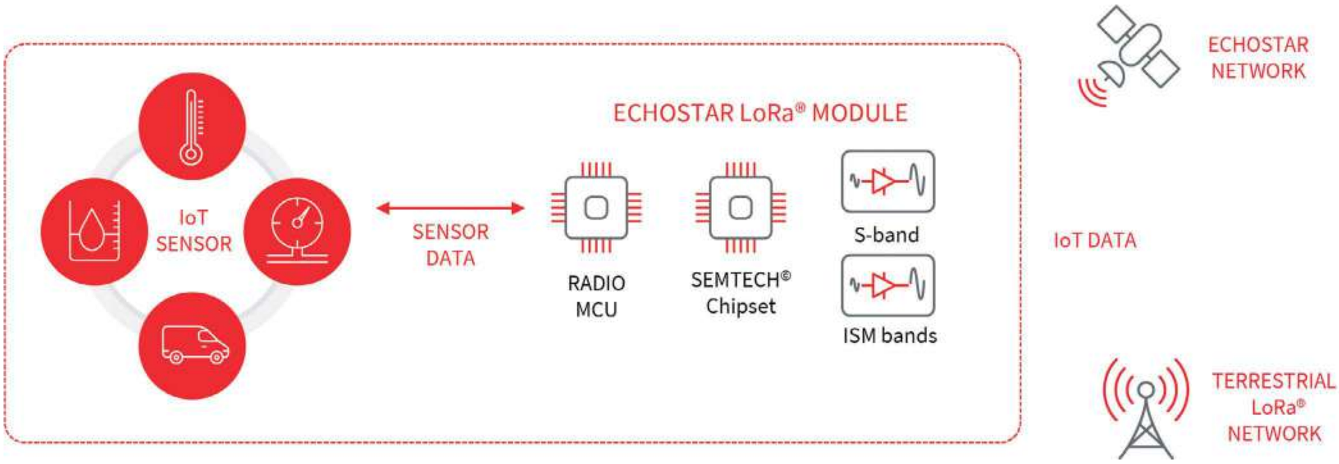
Any company involved with either the transportation or distribution of goods or managing assets in the field faces operational constraints that are often improved by IoT solutions to track location, condition and status of those goods and assets. Using IoT can improve their operational efficiency.

Utilities, for example, can access data about line voltages and performance from remote and difficult to reach sites. With better visibility of facilities, they can send maintenance crews to the exact site of an incident or breakdown, ensuring that repair costs and time are kept to a minimum. By reducing the time needed to get distribution networks back online, they can cut the chance of incurring large fines for interruptions to service.

The Internet of Things consists of physical objects that have "smart" capabilities to collect data about their physical world. This data is transmitted over a communications network and analysed to transform it into knowledge about facilities or processes.

Utilities, agriculture, oil & gas and the maritime sector, rail and logistics and asset tracking can all benefit from IoT. Facilities such as pipelines and electrical transformers can be checked remotely, avoiding the need for costly routine visits, while fleet management is also made much easier.





IoT devices can be connected using either wired or wireless methods. Wired methods are well known but can be costly to implement. Wireless systems such as cellular can be less expensive to deploy but may not be optimized for critical communications.

Rail operators have infrastructure and assets spread over huge areas. Operators can take advantage of IoT to know the condition and location of mobile assets such as rail cars, monitor earth works and track beds for geologic movement, and monitor fixed infrastructure for correct operation.

Agriculture is also embracing the digital revolution, using IoT to report on temperature, humidity, soil conditions, and animal health.

Maritime companies are also increasingly benefiting from IoT to report the status of critical equipment and make it easier to exchange data with maintenance resources on shore.

Choosing an IoT connectivity method

LoRa® is an open source network architecture increasingly being chosen for IoT connectivity. It is designed to connect battery operated 'things' wirelessly to the Internet. Its benefits include two-way communications between device and control centre, low power consumption, security and mobility.

Connectivity for IoT can be achieved in several ways. The two major categories are wired and wireless and the choice of a particular technology will depend on numerous factors. These include whether there is a source of power or if it has to operate for a long time on batteries, the financial value of what is being monitored, the consequences of lack of network coverage, how often data is sent, the amount of data, the location of the IoT device, whether the device moves or remains stationary, the propagation conditions and distance between the originating device and the corresponding network equipment.

Wired systems can be time consuming and expensive to deploy and maintain and are not suitable for mobile assets. They are also difficult to deploy outside buildings.

Wireless systems include Wi-Fi, which is only suitable for short range access and typically is installed for in-building coverage with sensors that are not battery powered. Cellular based systems such as NB-IoT and LTE-M offer wide area coverage. While standardized technology enables devices to roam onto the networks of other Mobile Network Operators (MNOs), unexpected roaming charges may be incurred. Industrial users have started to deploy private LTE in licensed or unlicensed spectrum. This is a good solution to provide high data throughput for a limited area - anything beyond this will mean relying on the consumer infrastructure provided by MNOs, which is not optimized for critical communications.

LoRa® leads the way to wide adoption of IoT

LoRa®, short for Long Range, is a low power, terrestrial wireless platform for IoT, and is based on a series of integrated circuits developed by Semtech.

Transceivers configured with these LoRa® devices are embedded into end nodes, or sensor devices. These capture data and transmit it to gateways, which in turn send it over the air to the network.

Compared to terrestrial connectivity technologies such as 4G and fibre, LoRa® offers rapid deployment over a wide area, reducing both capital and operational costs. It offers advantages over cellular technologies such as Narrowband IoT (NB-IoT), whose devices consume a lot of power, and which therefore need frequent battery replacement.

LoRa® devices are particularly suitable for Distribution System Operators (DSOs), who need to monitor equipment that could be in remote or difficult to reach locations and for companies that need to keep track of mobile assets.

LoRa® (Long Range Wide Area Network) is the open-source network architecture standardized for LoRa® devices and developed by the LoRa® Alliance. LoRa® is recognized as an International Telecommunication Union (ITU) Standard under Recommendation ITU-T Y.4480 “Low power protocol for wide area wireless networks.”

LoRa® is designed to connect battery operated ‘things’ wirelessly to the Internet. It offers the key demands of IoT users – two-way communications between devices and the data processing facility, low power consumption, end-to-end data security, mobility and localization services.

According to the LoRa® Alliance, LoRa® is spreading rapidly across the globe, with 166 LoRa® networks currently in operation. Figures from IoT Analytics show LoRa® connections increasing 31% year-on-year from 2020 to 2021. [1]

The advantages of LoRa® will see it increasingly adopted as the IoT access method of choice - combined with satellite technology, LoRa® becomes an enabler of massive IoT across the entire planet.

Satellite links offer flexible connectivity

Less than 20% of the Earth’s surface has terrestrial connectivity. Due to the significantly lower density user base in remote areas and the practical difficulty of providing a network at sea, it’s unlikely that terrestrial services will ever expand significantly beyond their current deployment. This leaves a requirement for connectivity that is best served by satellite.

Today there are several satellite services in operation and many others have been proposed. However, almost all satellite networks use proprietary technology, leading to additional complexity and costs to integrate a smaller population of satellite units into the overall IoT solution that may contain orders of magnitude more incompatible terrestrial network units.

There are also very few satellite-only applications. Most applications benefit from adding low-cost terrestrial connectivity such as LoRa®, combining this with the wide geographical access of satellite systems to give a highly flexible connectivity system.

EchoStar Mobile chose to deploy LoRa® and LoRa® compatible technologies as central

Combining terrestrial LoRa® with satellite systems offers great flexibility. This provides LoRa®’s low-cost terrestrial connectivity with the wide geographical access of satellite systems.

Comparing connectivity methods for IoT applications

	Wired	Cellular	LoRa® - ISM band connectivity over LEO	LoRa® - S-band connectivity over GEO
Coverage	Limited	Widespread	Widespread but intermittent	Widespread and constant
Availability	High	High but can depend on quality-of-service agreements	Variable	High
Data rate	High	High but depends on cellular generation	Low but suitable for most IoT applications	Low but suitable for most IoT applications
Interference	Low	Low	Can be high	Low
Cost	High	Variable	Low	Low

elements in its pan-European satellite IoT network. As well as connecting to the satellite network, the EchoStar Mobile LoRa® Transceiver also operates on terrestrial ISM band LoRa® networks. Critically the dual mode capability enables IoT solution developers to use a single technology in their solution design, which can use terrestrial or satellite as needed, without having to undertake an expensive integration with satellite hardware.

For example, a vehicle tracking solution would use a terrestrial network when the vehicle is in an underground car park, however when on a remote delivery route, no terrestrial service is available, and the tracking solution would switch to the satellite network. This ensures reliable and timely transfer of data from LoRa® devices to data processing or control centres.

Low Earth Orbit versus Geostationary Orbit

Satellite communications service can be provided in two main ways – either by satellites in a Geostationary Earth Orbit (GEO), or from satellites in Non-Geostationary Earth Orbit ((NGSO). NGSOs are further broken down into Medium Earth Orbit (MEO) and Low Earth Orbit (LEO).

Orbiting at some 36,000 kilometres above the Earth, GEO satellites have been used for more than 50 years. GEO satellites travel at the same angular velocity as the Earth and therefore they appear to remain fixed above the same point on Earth. This means that satellite antennas on the ground do not have to track the satellite and can remain pointed at a fixed place in the sky.

The major advantage of a GEO satellite is that a single satellite can provide coverage to one third of the Earth. Three GEO satellites can provide services to any location on the Earth except the polar regions.

A LEO satellite has a much smaller coverage area than that offered by GEO, providing a ground footprint of between 2000 and 3000 km. This is because they typically orbit at distances of between 500 and 2000 km from the Earth's surface. In order to compensate for the smaller coverage from an individual satellite, many LEO satellites are required to provide the same coverage area as a GEO.

LEO systems also operate in a much harsher environment than GEO satellites. This can include radiation and atmospheric drag that can lead to a much shorter lifetime of approximately five years, requiring frequent replenishment of the satellite constellation to maintain continuous network service. The radiation environment in GEO is much less demanding on the spacecraft's systems, contributing to enhanced reliability and thus an extended service life.

To provide sufficient coverage for a particular location, numerous LEO satellites must work together in a constellation. This compares with GEO satellites where a single satellite could cover the same area. LEO satellites can also only provide real-time service in an area where there is a local gateway Earth station. This is because the satellite must be visible from both the user's location and the gateway - a distance that typically extends for 1000 km around the gateway. An alternative approach for LEO satellites is to use intersatellite links to connect to a gateway Earth station, which however adds significant costs.

There is also the issue of ground track. LEO satellites are constantly moving relative to Earth, and they spend much of their time over oceans, deserts, and other unpopulated areas. This means that LEO constellations are generally not good at matching capacity to demand - they tend to distribute service evenly across a number of satellites and most LEO constellations have too few satellites to provide real time coverage. By contrast, GEO satellites are able to focus capacity on specific geographic areas, ensuring a higher quality of service in high demand areas that some LEO satellites cannot serve.

A practical example could mean having to wait for critical data or alarms from a remote pump using a LEO system – the same data could be accessed instantaneously via a GEO system. A related issue is the lack of a practicable bi-directional signal functionality, as users need to wait for the satellite to cross overhead before sending and receiving data. For example, a user may need to receive an alarm from a critical infrastructure asset that needs to be monitored. If the alarm can only be sent 15 minutes after the event because of the need for the satellite to pass overhead, the alarm may have very little value in terms of operations. Having a satellite constantly overhead removes these constraints, making GEO satellite-based systems a key enabler of many critical, time dependent use cases.

Many LEO satellite networks operate in what's called 'store and forward' mode, in that there is often no actual connectivity from the satellite to a gateway to maintain continuous transmission of the message. Although there may well be a satellite in range every 15 minutes, it may take some time from that satellite receiving the data message from the device, to being in line of sight of a gateway Earth station to offload the message. The satellite will pick up the data and store it until it sees the gateway where it can download the messages, introducing two periods of latency. This second period of latency is often a surprise for application developers.

GEO satellites are also usually larger and more powerful than LEO satellites, allowing them to carry significantly more traffic. Their size also allows for extra components to ensure redundancy, making them more reliable and resilient. GEO satellites have a typical design life of 15 years and often operate 5-10 years beyond their design life. LEO satellites' lifetimes are typically five years.

LEO systems are more complex and challenging to design and operate. Orbits must be carefully managed and risks from collisions with space debris assessed. Gateway Earth stations require real time tracking antennas to communicate with the satellites.

Although LEO satellites are smaller and less expensive to manufacture and launch than GEO satellites, building an effective communications network typically requires many more of them to be deployed. LEO satellite systems become very complex because of the number of gateways required on the ground, driving up costs. Antennas for GEO satellites are also much simpler and cheaper than those required for other systems.

Geosynchronous satellites offer better availability than those in low Earth orbit. Orbiting at higher altitudes, they provide continuous cover, give real-time access to data and also remain in operation for a longer time. They also offer two way connectivity, important for use cases that need to send commands to the field devices on the ground.

Licensed spectrum avoids interference

Unlike unlicensed, freely available frequencies, users of licensed spectrum do not face interference from devices like microwaves and Wi-fi networks. The spectrum can only be used by the owner of the license or with their permission. Transmitters on unlicensed bands can also only transmit at certain times, introducing a delay in data transfer.

A major factor in the success of any wireless IoT solution, whether purely terrestrial or based on the use of satellite links, is the radio frequency spectrum it will use to send and receive data.

Two main options are available here - unlicensed and licensed bands. The unlicensed band, which is often called the Industrial, Scientific, and Medical (ISM) band, is free to use. However, free is a powerful motivator and the ISM band attracts a lot of usage across a range of technology platforms.

This band is widely used by devices such as microwave ovens, Wi-Fi- networks, Bluetooth devices and certain types of medical equipment.

Any device can use the ISM band so long as it conforms to the standards laid out for the band by the relevant regulatory authority. Some of the key parameters for these devices are transmit and receive power. They also need the ability to withstand interference from any other approved devices operating in the band. Signals from other devices using other technologies look like interference to dissimilar devices. The larger the number of devices and the higher the density of these devices, the greater the interference, which can affect the range and reliability of device transmissions.

If a company is using unlicensed bands for IoT deployments and experiences reliability and performance issues, there is no regulatory protection against the devices causing the interference, providing those devices meet the standards set by the ISM band regulatory authority.

A number of companies plan to offer connectivity via LEO satellites operating in the unlicensed ISM bands. While technically possible, there is no government regulatory approval for such usage. Such companies will need to petition to change the radio regulations in each country that they wish to operate. Such LEO satellites, in addition to detecting signals from their customers' devices, will also pick up a lot of noise from other devices broadcasting on the same spectrum.

There is also the issue of dwell time, also known as duty cycle - in the unlicensed band, transmitters are only allowed to transmit a certain number of times in a particular period. This duty cycle impairs real-time and larger amounts of data being sent. For example, if a sensor detects an out of tolerance value, it could be desirable to send more data more frequently than the normal reporting scheme. Limitations on duty cycle can prevent such data from being sent in a timely manner.

Licensed spectrum offers many advantages over unlicensed. Licensed spectrum is created when a regulatory authority, such as the Federal Communications Commission (FCC) in the United States or the Electronic Communications Framework adopted by the EU, assigns a specific spectrum band to a licensee, often exclusively. The spectrum can only be used by the owner of the license or with the owner's permission. Interference is reduced by careful frequency planning.

This use of licensed spectrum is the method adopted by MNOs who obtain the rights to use specific radio frequency bands. As no-one else can transmit on those frequencies, MNOs using them can guarantee availability and Quality of Service (QoS) to their cellular customers.

Powerful satellite brings massive IoT for companies across Europe

EchoStar Mobile offers LoRa® coverage across Europe, the UK, and Scandinavia for massive IoT, providing LoRa® compatible access to customers' IoT devices via its EchoStar XXI satellite. IoT sensors such as temperature, humidity, flow, current and GPS tracking devices, send data to an EchoStar Mobile LoRa® module. The module then uses licensed S-band frequencies (see boxed item) to send the data to EchoStar Mobile's own satellite. From there, it is sent to the Internet via a satellite gateway Earth station and a LoRa® compatible network infrastructure.

EchoStar XXI is a powerful GEO satellite with an 18-metre antenna. It also features advanced beam forming technology that provides high quality service in focused geographic areas. Operating in the S-band, the satellite has an uplink and downlink capacity of 100 Mbit/s.

Combining this large bandwidth with high beam power means a very strong signal is received on the ground. In addition, because of the sensitivity of the LoRa® protocol, which is very close to the noise floor, about minus 20 dB, the network achieves excellent performance with small antennas on the modules. The very low sensitivity of LoRa® means the EchoStar Mobile solution can receive signals in conditions where traditional ISM services would struggle to work.

The antenna frequency is also tuned to collect the minimal amount of noise, allowing very efficient reception of the ground signals at the satellite.

The combination of the high-power satellite with the characteristics of the LoRa® waveform gives a significant reduction in the size and power consumption of the terminal. Modules can be battery powered, requiring no mains power, and their low power consumption means that batteries can last for long periods before needing replacement.

Further benefits are gained from the use of LoRa® Frequency Hopping Spread Spectrum [LR-FHSS] in licensed S-Band. Developed by Semtech, LR-FHSS allows direct to satellite data links from IoT devices with greater reliability, higher performance, and lower power consumption. The use of LR-FHSS provides several advantages over conventional LoRa®, including enhanced data rates, increased network capacity and additional robustness to interference, allowing many new deployment opportunities.

The satellite itself is sized to handle broadband services, meaning that with the small size of IoT messages, it can handle data messages from millions of modules, making massive IoT a reality for thousands of companies across Europe.

The EchoStar satellite can capture data from low power LoRa® modules across Europe. It can receive signals in conditions that would be difficult using unlicensed bands. In addition, improvements to LoRa® allow enhanced data rates, increased network capacity and additional robustness to interference.

S-band frequency resists atmospheric fading

S-band is a frequency band designated by the Institute of Electrical and Electronic Engineers. It is a part of the electromagnetic spectrum covering frequencies from 2 to 4 GHz. The band is most often used for mobile communications, including satellite communications, as well as radar systems used in weather tracking and for marine applications. The unlicensed 2.4 GHz ISM band is also in the S-band.

EchoStar Mobile's access to licensed S-band spectrum enables its mobile service provider partners to operate in the 2 GHz S-band range. Unlike some other bands, such as the Ku and Ka bands, S-band offers significant resistance to signal fading caused by rain, snow and ice. This means it can continue to provide access during changing atmospheric conditions, such as inclement weather often experienced in Europe.

S-band is also very good for providing mobile communications.

S-band is a frequency band covering 2 to 4 GHz. The band is ideal for satellite communications in high rainfall areas such as Europe.

EchoStar Mobile works with partners to ensure customers get the solution they need. Systems integrators receive radios and service from EchoStar Mobile and integrate them into IoT product to meet the needs of end-users.

Building a customized solution

Different customers will have different use cases for IoT connectivity, each with their own requirements and industry regulations that they must meet.

To meet these needs, EchoStar Mobile has adopted a business model based on system integrators - EchoStar Mobile provides the radios and service to an integrator who integrates them into an IoT product or solution. The integrator then sells that product or solution to end-user customers.

This allows customers to get the IoT product or solution they need from a partner with deep expertise in their area of interest. For example, a particular systems integrator may specialise in deploying LoRa®-based solutions for railway networks. They will understand the physical railway environment as well as the business and operational environments. The integrator develops specialized railway solutions to meet the needs of railway operators.

In the maritime field, specialist system integrators will know the devices and use cases and understand the intrinsic safety needs of a particular device. For example, in the oil and gas industry, users may well need an ATEX certified LoRa® device in order to retrieve data from a particular ATEX specified Zone.

EchoStar Mobile also works with sensor manufacturers to ensure their new or existing products can operate with LoRa® protocols.

Integrators, sensor manufacturers, end users, and service providers are the experts in their particular deployment scenarios – the role of EchoStar Mobile is to ensure they have the best-in-class network to connect to in order to achieve all the many benefits of LoRa®.

EchoStar Mobile unlocks massive IoT

Companies from different sectors are looking at the advantages that IoT can bring to their operations. They see value to be gained in a number of applications, whether tracking vehicles and other mobile assets, reporting on pipeline flow rates, voltage levels in utility distribution networks or monitoring the performance and availability of critical infrastructure.

Key to making the most of these IoT opportunities is using a data transfer and connectivity technology that meets the needs of the application, such as coverage, latency, availability, reliability, capacity and cost.

One piece of the puzzle is LoRa®, a major wireless technology platform for IoT. LoRa® is already deployed in over 180 countries and offers a vibrant ecosystem of technology and solution providers. LoRa®'s success is based on easy to deploy modules, at low capital and operational cost when compared with conventional cellular networks.

Combining the LoRa® technology platform with the continent spanning connectivity available from the EchoStar XXI geo-synchronous satellite provides a pan-European LoRa® service.

Users have complete, uninterrupted access to data across country borders. Two-way communication allows both uploading and downloading of data and commands to sensors.

Satellite based LoRa® is the perfect complement to terrestrial LoRa®. Its range and coverage provide the best solutions to the challenges of LoRa® terrestrial network deployment, such as low-density deployments in areas unserved by a terrestrial LoRa® network or mobile applications that require full contiguous coverage.

EchoStar Mobile provides the first real-time, pan-European, LoRa® compatible network via satellite, enabling existing LoRa® applications to extend their reach.

Low costs, high reliability, minimum latency and high data capacity make EchoStar Mobile's satellite based LoRa® compatible network the key to unlocking the power of massive IoT.

References

[1] https://iot-analytics.com/wp/wp-content/uploads/2021/09/Global-LPWA-connections-growth-rates-of-key-technologies-v2-min.png

EchoStar Mobile provides the first real-time, pan-European, LoRa® compatible network via satellite, enabling existing LoRa® applications to extend their reach. Combining LoRa® with our powerful satellite gives access to millions of devices across Europe.

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Want to know more?

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