Globalstar™

EBOOK

Two-Way Satellite Communications at the Edge

Real-time communications via satellite for worldwide IoT applications

The demand for real-time, global IoT connectivity is rapidly growing as industries push for smarter, more autonomous solutions. One-way satellite communication has long been a reliable foundation for transmitting critical data, enabling businesses to gain valuable insights from remote sensors and devices.

However, as IoT evolves, the need for two-way communication is becoming essential – allowing devices to not only send data but also act on analysis without direct human intervention. With two-way satellite connectivity, IoT solutions can now operate intelligently in real-time, automating responses and optimizing performance in even the most remote or hard-to-access locations, ensuring seamless, always-on connectivity anywhere in the world.

Why One-Way Works

The Internet of Things (IoT) was just burgeoning in the 1990s and satellite technology was a part of supporting these machine-to-machine communications. In the beginning, satellite systems for IoT were designed around one-way communication to maximize efficiency and complexity.

Demand has supported one-way communications as the main framework for satellite communications in the early days of IoT and continues to support IoT applications.

Demand

Early IoT communications demand was relatively simple. Small amounts of data were transmitted from low-complexity sensor device monitoring in use cases such as remote weather stations, oil pipelines, animal tracking or maritime vessels. These low data transmissions typically use low bandwidth to send these periodic, small data packets with information like temperature, GPS location and pressure location.

Simply put, one-way satellite communications are sufficient for certain use cases.

The Shift to Two-Way

Similarly as with one-way, demand and opportunity are converging as the need grows alongside technology developments that make two-way a lot more attainable.

Demand

IoT connectivity is growing in complexity as is the need for resilient communications, worldwide. Transmitting data is transforming into action-driven data communications, which is where bidirectional messaging in satellite connectivity is burgeoning.

IoT is iterating in a way where, for example, gathering data points on soil conditions is massively helpful, but the next iteration is an irrigation device receiving back information that the soil is too dry and, therefore, signals the device to begin irrigating.

The need for real-time data and remote control is driving advancement in IoT connectivity technologies to respond to these requirements. Low Earth Orbit (LEO) satellites are helping answer that call.

Technology Opportunity

- **Advancements in Satellite Technology:** The development of LEO satellites has drastically reduced the cost and size of satellite systems, making it much more feasible to use in widespread, lower-complexity applications – ideal for IoT.

- **Low Power, More Efficiency:** Advancements in power-efficient hardware and protocols, such as low power wide area (LPWA) networks and newer satellite IoT protocols have made it possible for IoT devices to engage in two-way communication without draining excessive power. One powerful example of this is the Non-Terrestrial Network (NTN) NB-IoT, which is an LPWA cellular network delivered through satellite – which creates an exciting opportunity to see terrestrial and non-terrestrial merge.

The LEO Breakdown

What does LEO mean?

LEO satellites orbit Earth at relatively low altitudes. By comparison, LEO satellites orbit between 500 to 2,000 kilometers compared to traditional geostationary satellites (GEO), which orbit around 35,786 kilometers above the Earth.

Why does this matter?

Since LEO satellites are closer to Earth, it is more cost-effective to manufacture and deploy them. LEO satellites are usually smaller and lighter than GEO satellites. This is for several reasons:

- **Lightweight design:** LEO satellites don't have the same radiation shielding as satellites designed for GEO orbit, so they can be built with simpler, lighter components.
- **Less Material-Intensive:** The materials used for LEO satellites don't need to withstand harsh environments for as long, so materials can be lighter.
- **Smaller communication systems:** Because LEO satellites are closer to Earth, their signals are stronger, which results in needing less complex communication systems compared to GEO satellites.

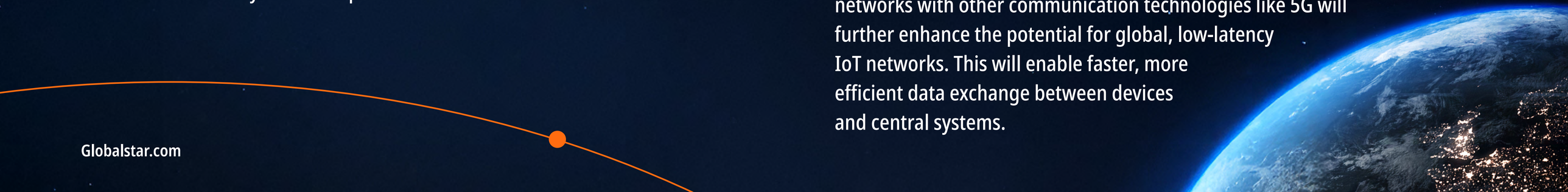
On top of the manufacturing simplicities, there are also reasons why LEO satellites are easier to launch:

- **Less energy to launch:** Since LEO satellites are closer to Earth, they require less rocket power to reach orbit compared to GEO satellites, which ultimately reduces fuel costs and launch expenses.
- **Frequent launch opportunities:** Many satellite providers typically launch several rockets during a single deployment, which reduces the overall per-launch cost and helps drive down the price of each satellite.

Are these going to stick around?

Communication technologies have a lifecycle (as we've seen with 2G and 3G), and others have challenges ever getting off the ground (such as some low-power cellular technologies), but LEO satellites promise longevity for two key reasons:.

1. **Increasing IoT applications:** With more LEO satellites being launched, IoT applications will continue to expand across industries such as agriculture, manufacturing, logistics, smart cities, and healthcare. These satellite communications offer solutions to challenges such as remote locations, congested cellular areas, or difficult-to-reach locations.
2. **Integration with other technologies:** The convergence of LEO satellite networks with other communication technologies like 5G will further enhance the potential for global, low-latency IoT networks. This will enable faster, more efficient data exchange between devices and central systems.



The Value of Two-Way Satellite Communication

Satellite companies are shifting and adapting to meet the needs of real-time IoT communications across the globe by offering two-way communications. Questioning whether an organization should move from one-way to two-way communication includes evaluating whether it is worth adopting a new technology model and if it fits the use cases at hand.

Essentially, it's increasing the functionality of an existing use case by enhancing capabilities, or it's deploying a next-generation solution, depending on where organizations are utilizing IoT.

Overall, the ability to send and receive messages through two-way satellite communication offers a host of benefits for IoT applications:

Real-Time Monitoring

Two-way satellite communication allows IoT devices to not only send sensor data but also receive control commands. This is particularly useful in scenarios where immediate action or adjustments are needed. For example, in logistics, satellite-enabled tracking devices can provide location data for shipments and receive updated route instructions or emergency alerts.

This allows for instant decision-making because organizations can respond to critical solutions without delay. An example would be in oil and gas; if equipment failure or environmental changes demand immediate action, two-way communication can trigger real-time actions, such as shutting down machinery or alerting employees in real-time.

Reduced Operational Costs

Two-way communication allows for remote diagnostics of IoT devices, which reduces the need for site visits. This is particularly useful in remote or hard-to-access areas. Not only does this reduce the cost of on-site visits, but it also can reduce downtime if a device is experiencing issues.

For example, if a fleet vehicle with IoT sensors can send data about its performance, troubleshooting is much easier to do from a distance, and predictive decisions can be made before downtime even occurs.

Flexibility & Coverage

Two-way communication is essential in mobile IoT devices. In environments where devices are constantly on the move, such as shipping containers, trucks, or satellite-connected drones, the ability to both send and receive data allows for continuous communication and control.

This can also extend critical IoT communications worldwide. A significant portion of the Earth is not covered by cellular service, which can leave considerable coverage gaps for moving devices or solutions in remote locations.

Improved Security and Risk Management

Security can be enhanced through two-way messaging by allowing instant alerts when something goes wrong and the ability to address issues remotely. This can be critical in environments where human intervention is limited or access is difficult. For example, wildfires. IoT devices in remote portions of forests can send early warning signals when a fire outbreak occurs and then receive instructions to initiate automated countermeasures, such as activating a fire suppression system.

Additionally, remote locking, control, or disablement can be supported through two-way messaging. This is particularly pertinent for devices that might be exposed to tampering or theft. If devices are locked, stolen or compromised, the device can essentially shut itself down so that it cannot be used. This is helpful in instances such as supply chain management, where high-value goods can be tracked and controlled remotely. If a GPS tracker on a high-value shipment is stolen, the system can send a “disable” comment to prevent it from being tampered with or accessed.

Enhanced Data Processing and Analytics

IoT devices using two-way communication are often able to handle edge processing, which is performing data analysis at the device level. Adaptive systems can also be supported through two-way communication. In adaptive systems, IoT devices can adjust their behavior based on external conditions and real-time data, which creates a more responsive environment that can improve efficiency and productivity.

An example of this can be found in smart grids, where IoT-enabled smart meters and grid devices can adjust their operations based on feedback from the central system and, in return, send their status back for grid optimization, ensuring the efficient distribution of power based on current needs.

Scalability and Future Proofing

Two-way communications allow for more dynamic and scalable IoT systems. As devices and networks grow, the ability to interact with each device and control them remotely means the system can expand more efficiently without the need for major manual interventions. For example, in logistics, two-way communications can support connectivity in a ship from port to sea with handoff so no connectivity is lost. A port where a ship could continue its connected path from the port out into the ocean without interruption for critical communications.

Two-way communication also lays the groundwork for future innovations in IoT. IoT technology will continue to advance, and the need for more autonomous applications will emerge. Two-way communication can enable the development of new use cases, including machine-to-machine automation and autonomous vehicles, among others. Take, for example, autonomous vehicles: two-way satellite communication will allow vehicles to send operational data to control centers and receive traffic, weather, and safety updates in real-time.

These future applications of IoT are a lot closer than they look when it comes to widespread adoption, so preparing with two-way communication enables a pipeline into simplified scalability.

LEO, MEO, or GEO for Two-Way?

Two-way satellite communications can be supported through further-orbit satellites, including GEO, which is the furthest, and middle Earth orbit (MEO) satellites. So, what makes LEO the preferred technology?

One of the key values of two-way communication is supporting real-time communications, and therein lies the unique value of LEO satellites in supporting real-time two-way communications.

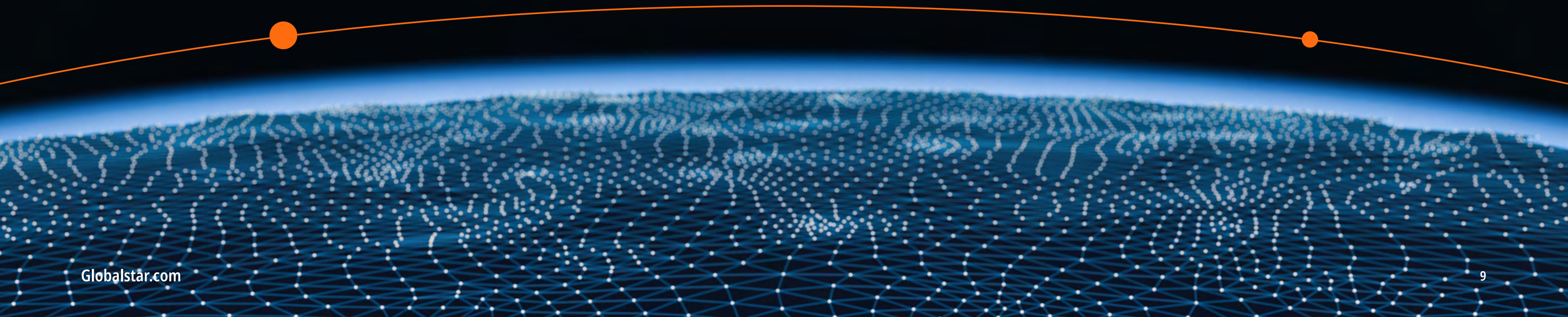
Lower Latency

As previously mentioned, LEO satellites are much closer to Earth, resulting in significantly lower latency, so the signal travel time is significantly shorter. Meanwhile, MEO and GEO satellites are further away from Earth, so the latency will extend.

Here's the breakdown:

- **Latency for LEO:** 20 to 50 milliseconds
- **Latency for MEO:** 30 to 120 milliseconds
- **Latency for GEO:** 500 to 600 milliseconds

Latency is the rate of data transmission, so for real-time communications, the lower the latency, the better, positioning LEO as an ideal choice for two-way communications.



Better Bandwidth and Throughput

Because of the shorter distance from Earth, LEO satellites can support higher data throughput with less signal degradation. The shorter distance between the satellite and the devices means less signal attenuation, which allows LEO systems to transmit more data efficiently and at faster speeds. This is particularly useful for IoT applications that require real-time updates, continuous data flow, or frequent communication.

By comparison, MEO and GEO satellites can support high-bandwidth communication, but they are exposed to signal loss challenges due to their greater distance. Interferences such as weather or other obstacles can create signal loss, as well.

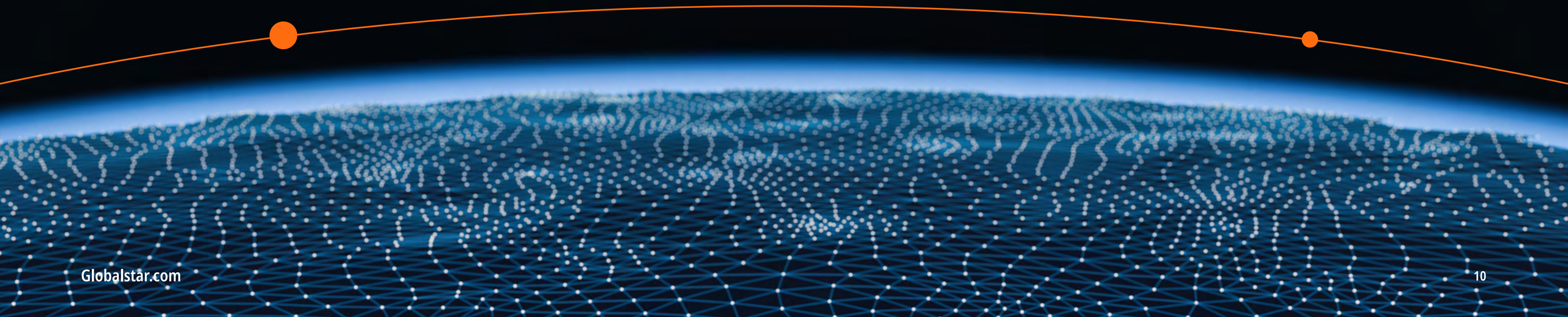
Coverage and Frequent Passes

Because LEO satellites work as constellations (groups of satellites working together), continuous global coverage is much more possible as opposed to MEO or GEO satellites. GEO satellites have more fixed locations, and MEO can offer broad coverage, but their distance from the Earth can leave gaps.

LEO satellites also frequently pass the same region multiple times per day, with an orbit rate of once about every 90 minutes[1].

LEO for Two-Way

While GEO and MEO satellites are still important for certain applications (such as wide-area communication or fixed coverage), LEO satellites provide significant advantages in terms of latency, cost, and coverage flexibility, making them the best choice for many two-way satellite communication IoT applications, especially those requiring real-time interaction, global and cost-efficiency.



The Use Case Snapshot

Two-way satellite communication can move IoT into real-time applications by enabling real-time, next-generation capabilities. Two-way -communication allows for remote control, instant adjustments, and automated decision-making across industries. From smart grids optimizing power distribution to pipeline systems preventing leaks, this technology enhances efficiency, reduces operational costs, and ensures faster responses to critical events. As IoT continues to evolve, two-way satellite connectivity is becoming essential for intelligent, adaptive, and resilient networks.

Agriculture and Livestock Management

Farmers can use GPS tracking and environmental sensors to monitor the health and location of livestock in real time and receive feedback on animal behavior or health status. In case of emergency, commands can be sent to take action, such as activating a collar alert. With one-way, only location or health data Is transmitted without the ability to adjust settings or intervene.

Precision agriculture can see an advantage in moving from one-way communications to two-way, as well. Smart irrigation systems can adjust watering schedules based on weather patterns and soil moisture data, and farmers can change settings or activate irrigation remotely. One-way can report soil moisture data but doesn't support the ability to act or adjust in real-time.

Utilities

In utilities, two-way satellite communication is valuable because it enables not just data collection but also real-time control and decision-making – allowing utilities to be more responsive, efficient, and proactive in maintaining infrastructure and ensuring a stable energy supply.

Oil and gas can use two-way communications for remote control and monitoring. Operators can monitor equipment status, receive alerts for malfunctions, and remotely shut down or control machinery to prevent damage. With one-way, there is no ability to intervene remotely.

Fleet and Assets

Real-time updates on vehicle or container location can be sent and received, which allows logistics teams to adjust routes, provide updated instructions, and send emergency alerts based on location data. With one-way tracking, it is limited to location reports and does not allow users to adjust or interact with the device.

The same holds true for fleet management. One-way communications allow for location tracking, but two-way allow fleet managers to send route changes, safety instructions, or maintenance schedules to drivers in real time. Drivers can also report issues or request assistance.

Emergency Response and Disaster Management

Rescue teams in remote locations can send location data, request additional resources, and receive critical instructions or updates from central commands.

In disaster situations, emergency teams can communicate with command centers to receive updated evacuation routes, emergency protocols, and resource allocation. The ability to receive real-time information is crucial for adapting to rapidly changing conditions.

Smart Cities

Traffic lights or street cameras enabled with IoT devices can send data about traffic flow and receive commands to adjust traffic lights, reroute traffic, or activate warnings. This can alleviate traffic congestion and create throughways for emergency vehicles.

For energy management, providers can monitor grid performance, detect anomalies and send commands to adjust loads, repair, or reset systems remotely through two-way. One-way limits this ability by only reporting issues without supporting real-time response.

Military

Two-way communications could support military training exercises. For example, soldiers can wear IoT-enabled gear (such as helmets, vests, and GPS trackers) that monitor vital signs, movement, and weapon usage. Vehicles and weapons can be equipped with IoT sensors, as well, to track performance and engagement. Sensor data from soldiers and equipment is sent via two-way satellite communication to command centers, even in areas without terrestrial networks. Commanders receive live inputs on troop positions, health status, and environmental conditions.

Additionally, Beyond Line of Sight Command and Control in the military is the ability to remotely operate and monitor with forces, vehicles, and drones that are located beyond the visual or direct radio range of the operator. With two-way communication, the command centers are able to communicate, whereas one-way would limit to tracking.

For defense communications, military units in remote areas can send encrypted status reports, request supplies, or receive critical orders, intelligence and updates on strategic moves. One-way communication would allow for sending reports, which limits the ability for immediate, responsive action.

A Note for Developers

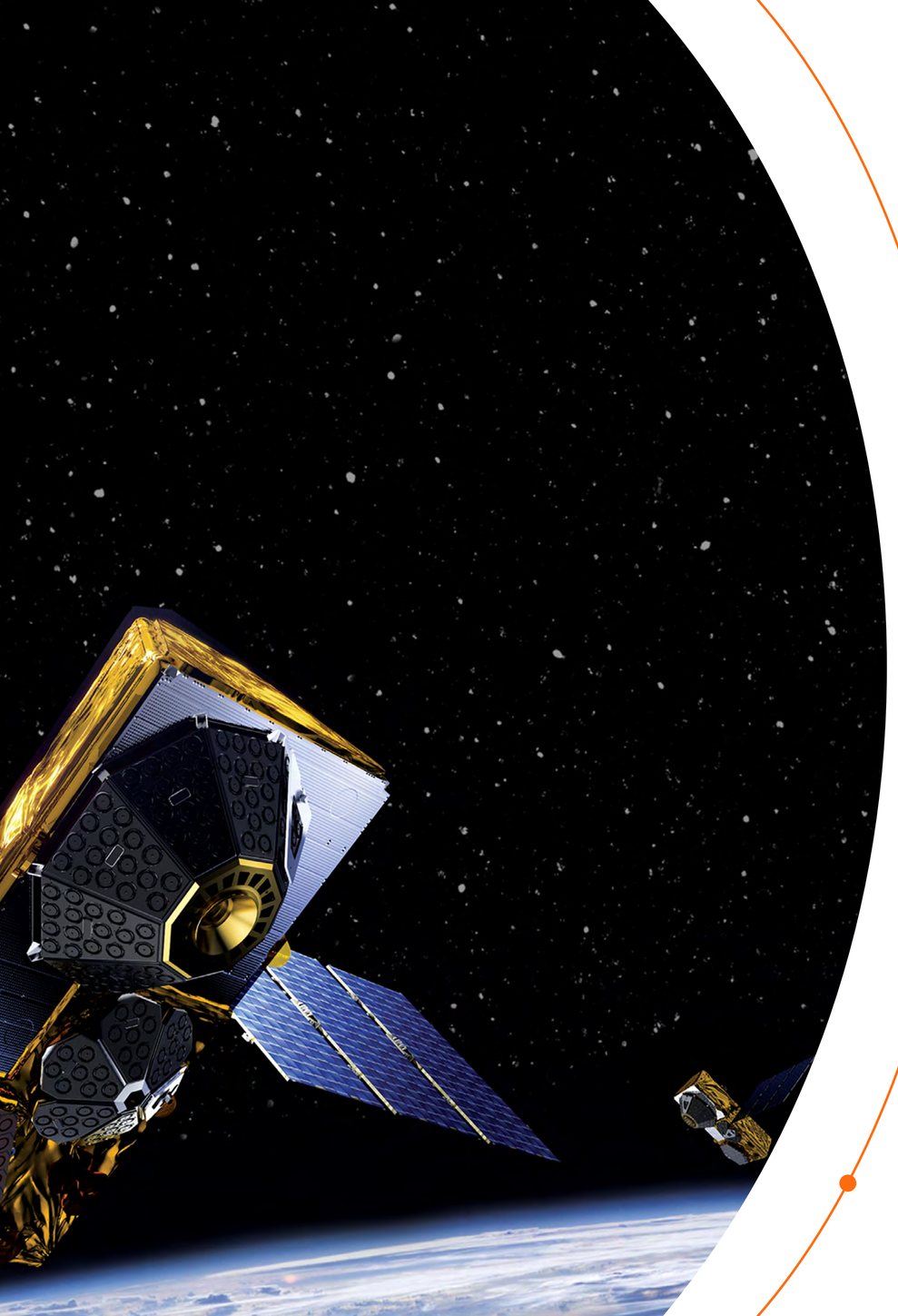
Globalstar has engineered an IoT module for integration into your IoT solution and provides two-way service over Globalstar's affordable, reliable LEO satellite network. Hardware is just the beginning, however, because our Realm Edge Application Platform provides access to firmware for configuring applications, managing hardware interfaces and accessing an extensive and growing library of sensor APIs. This low-code edge application platform can slash hundreds of hours of development time for the industry-specific solutions that deliver the greatest value.

Together, the platform delivers:

- Subscriber management
- Device management
- Health monitoring
- Extensive application library, including APIs
- BLE libraries for sensors, updates, configuration, and data

Using Realm, you can enable full automation of remote processes to save money, increase productivity, improve margins, and enhance safety. This combination of custom software and powerful hardware can not only detect change but take immediate and high-value actions, such as:

- Response to potentially dangerous pressure changes detected in pipelines
- Automatic start/stop of irrigation systems based on input from soil-moisture sensors
- Remote engine disablement if GPS location detects a vehicle moving outside the geofence



Ready for Powerful, Two-Way Connectivity?

Globalstar has 30 years of experience in the connectivity industry and our goal is to lead the satellite mobile services industry through reliability, flexibility, simplicity, and affordability. We have excelled in delivering low-latency, low-power data messages, and now RM200M, alongside our Realm Edge Application Platform, is our next-generation approach for delivering two-way smart data from the edge through our LEO (Low Earth Orbit) satellite network. Through this powerful combination, we enable speed to market with open standards architecture that makes development more efficient.

Let's achieve next-generation connectivity together. Get the conversation going by reaching out to our team of experts.

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[1] https://www.spoc.spaceforce.mil/News/Article-Display/Article/3462529/leo-meo-or-geo-diversifying-orbits-is-not-a-one-size-fits-all-mission-part-1-of#:~:text=That's%20because%20satellites%20in%20LEO,to%20achieve%20continuous%20global%20coverage