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Smart Logistics: Designing Integrated 5G and Satellite Solutions for Global Asset Tracking

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SMART LOGISTICS: DESIGNING INTEGRATED 5G AND SATELLITE SOLUTIONS FOR GLOBAL ASSET TRACKING

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Executive Summary

The integration of 5G and satellite technologies is fundamentally transforming asset tracking and supply chain operations, offering unprecedented global coverage, reliability, and cost-effectiveness.

This evolution comes at a crucial time when efficient logistics management is essential for ensuring safe and timely freight delivery across increasingly complex supply chains. Modern asset tracking solutions now extend far beyond simple location monitoring, with the latest generation of trackers providing comprehensive monitoring capabilities including temperature fluctuations, light exposure, handling conditions, inventory management, and impact detection. This enhanced visibility enables proactive risk management and significantly improves operational efficiency throughout the supply chain.

Integrated 5G and satellite tracking solutions are designed to deliver reliable, affordable, and universal connectivity across diverse applications. While cellular networks cover 99% of populated areas in developed countries, they typically cover less than 25% of total geographic area.

Satellite integration fills these coverage gaps, enabling truly global asset visibility. The market opportunity spans multiple sectors including global supply chain and fleet management, remote industrial operations, smart agriculture and construction, maritime and rail freight logistics, cold chain logistics, emergency response and disaster management, healthcare equipment tracking, and autonomous vehicle support.

Early trials with integrated trackers demonstrate promising results. These devices intelligently switch between networks (Bluetooth, Wi-Fi, LTE-M, NB-IoT and satellite) based on availability, with satellite serving as a reliable backup when terrestrial networks are unavailable. Power management is optimised through adaptive polling rates, with reduced frequency during satellite connectivity to conserve battery life. Current challenges include higher power consumption during satellite transmission, additional costs for integrated modules are currently (approximately 25% more than standard modules), and higher satellite connectivity costs.

All these challenges are being addressed through continued device and platform technological advancement, increasing production volumes, growing competition in the satellite sector, and implementation of global standards. Early test results indicate that modern solar powered trackers combined with intelligent asset management platforms are able to effectively manage power issues, more complex network switching and connectivity.

The market outlook is promising with widespread integrated asset tracking solutions being rolled out in 2025 by numerous companies including BeWhere Inc. and Telit Cinterion. By 2030, total IoT devices are projected to reach 38 billion, with 2-3 billion devices (10-15%) addressable for satellite integration, representing a potential revenue uplift of $10 billion annually from satellite connectivity, according to GSMA Intelligence.

Active satellites in orbit are expected to grow from 3,000 to approximately 20,000, and by 2032, 68% of 57.7 million satellite IoT units will use 5G or standard protocols. This technological convergence is enabling new business opportunities in remote inventory and asset management, sharing economy applications, AI-powered logistics solutions, predictive maintenance, automated inventory management, and supply chain optimisation.

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Defining business goals, requirements, and desired outcomes

Smart logistics management is crucial for ensuring the safe and timely delivery of freight across supply chains. It coordinates the complex processes of transportation, warehousing, inventory management, and information flow to optimize efficiency and minimize risks. Effective logistics reduces costs, improves customer satisfaction, and maintains the integrity of goods during transit. By carefully planning routes, managing resources, and leveraging technology, logistics managers can overcome challenges like weather disruptions, traffic congestion, and ensure regulatory compliance. Ultimately, strong logistics management is the backbone of successful freight operations, enabling businesses to meet delivery commitments, maintain product quality, and gain a competitive edge in the global marketplace.

Mobile asset tracking significantly enhances logistics management by providing real-time visibility and control over freight movements and inventory. While location tracking remains crucial, the latest generation of trackers offers far more comprehensive monitoring capabilities. These advanced devices can now assess various aspects of asset condition, including temperature fluctuations, exposure to light, instances of poor handling, and availability of inventory and even detect crashes or impacts. By utilizing multiple mobile networks, these trackers transmit a wealth of data from GPS-enabled devices attached to assets, vehicles, or cargo. This continuous stream of information allows logistics managers to not only monitor shipments' precise locations and predict arrival times, but also ensure that goods and assets are maintained under optimal conditions throughout their journey and at their destination.

The ability to track both location and condition in real or near real-time enables proactive responses to potential issues, reducing the risk of damage or spoilage. This comprehensive approach to asset tracking leads to improved inventory management, enhanced security against loss, and significantly boosts overall operational efficiency in the supply chain.

At the very outset of solution design you need to identify and define your priority business goals. By focusing on your priority business outcomes you're much more likely to get an affordable, practical technology solution that delivers what you need for your business. The best providers of mobile asset tracking will be able to provide agile customization to quickly achieve your business goals.

Successful mobile-enabled logistics management solutions delivers a wide range of strategic benefits:

1. **Enhance supply chain visibility:** Real-time tracking of assets provides a comprehensive view of the entire supply chain, enabling proactive management and rapid response to disruptions.
2. **Improve asset utilization:** Accurate tracking allows for optimal deployment and use of assets, maximizing return on investment and reducing idle time. Real-time asset tracking can improve asset utilization rates by 10-25% (Source: Gartner Supply Chain Research).
3. **Enhance operational efficiency:** Automated tracking streamlines processes, reduces manual errors, and allows for more effective resource allocation. Companies using real-time asset tracking report up to 30% improvement in labor efficiency (Source: Zebra Technologies' Warehousing Vision Study).
4. **Reduce operating costs:** By optimizing asset use, maintenance, and reducing losses, companies can significantly lower their operational expenses. Companies using IoT and real-time tracking in logistics report a 12% reduction in overall operational costs (Source: DHL and Cisco IoT Trend Report).
5. **Enhance decision-making capabilities:** Data-driven insights from asset tracking enable more informed strategic and tactical decisions across the organization.
6. **Reduce asset loss and theft:** Advanced tracking systems deter theft and quickly locate missing assets, minimizing financial losses and operational disruptions. Asset tracking solutions can reduce cargo theft by up to 76% (Source: National Cargo Security Council).
7. **Optimize maintenance schedules:** Predictive maintenance based on real-time asset condition data reduces downtime and extends asset lifespan.
8. **Improve customer service:** Accurate asset tracking enables better delivery estimates and faster response to customer inquiries, enhancing overall satisfaction.
9. **Ensure regulatory compliance:** Automated tracking and reporting help meet industry regulations and standards, avoiding penalties and legal issues.
10. **Increase workforce productivity:** Eliminating manual tracking tasks and providing real-time asset information allows employees to focus on higher-value activities.
11. **Enable predictive analytics:** Accumulated tracking data supports advanced analytics for forecasting and strategic planning and increasing AI platforms.
12. **Improve safety and risk management:** Monitoring asset conditions and usage patterns helps identify potential safety issues before they become critical.
13. **Enhance inventory management:** Real-time visibility into asset locations and status improves inventory accuracy and reduces carrying costs.
14. **Support sustainability initiatives:** Efficient asset utilization and optimized routes contribute to reduced environmental impact and support green initiatives.
15. **Streamline audit processes:** Automated asset tracking provides accurate, real-time data that simplifies and accelerates auditing procedures.

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3.0

Market opportunities, value propositions, and cost-effectiveness

Integrated 5G and satellite asset tracking is designed to deliver reliable, affordable and universal connectivity to enable a range of applications and use cases. The assets may or may not have access to power and will move in and out of network coverage and between networks, while maintaining asset tracking integrity.

Mobile trackers will automatically adapt to different networks, locations, and conditions changing polling/data reporting rates to optimize power consumption, costs, and data to provide enough information for the solution logistics platform. Satellite specifically increases geographical coverage, while 5G provides power efficient and cost effective coverage enabling a range of global applications:

Global asset tracking:

- **Global supply chain management:** Seamless tracking of goods across international borders and diverse terrains.
- **Fleet management and logistics:** Real-time global monitoring of vehicles, optimizing routes and improving delivery accuracy and coverage.
- **High-value asset tracking:** Continuous monitoring of expensive equipment or sensitive cargo.
- **Remote industrial operations:** Monitoring assets in oil fields, mines, or offshore platforms.
- **Smart agriculture:** Tracking livestock and monitoring large-scale farming equipment.
- **Construction and heavy equipment management:** Monitoring usage, location, and maintenance needs of machinery.
- **Maritime operations:** Monitoring ships, containers, and offshore assets.
- **Rail freight logistics:** Tracking shipments and optimizing railcar usage
- **Cold chain logistics:** Ensuring temperature-sensitive goods maintain proper conditions throughout transit.
- **Luxury goods and art logistics:** Ensuring security and proper handling of high-value items.

Other market opportunities beyond asset tracking

- **Aerospace and aviation:** Tracking aircraft, drones, and aerospace components.
- **Emergency and disaster response:** Coordinating and tracking resources during crisis situations including ground vehicles, specialist equipment and drones.
- **Utilities and energy sector:** Monitoring remote infrastructure like pipelines or wind turbines.
- **Environmental and wildlife monitoring:** Tracking migratory patterns or environmental conditions in remote areas.
- **Healthcare equipment management:** Tracking valuable medical devices across hospital networks or in transit.

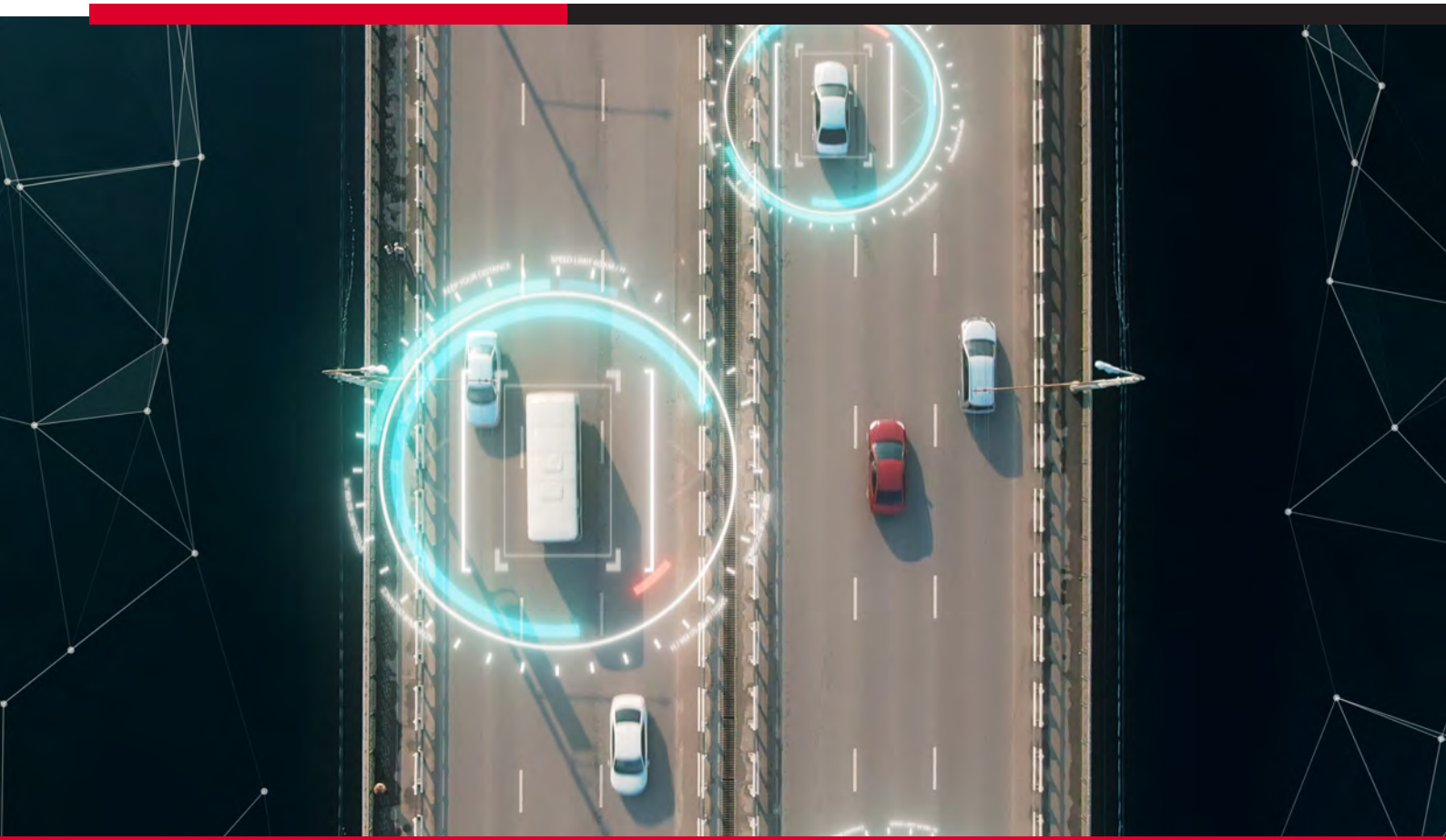
- **Outdoor sports equipment:** Tracking health and location of people exercising in remote locations.
- **Autonomous vehicle support:** Providing reliable connectivity and location data for self-driving vehicles.

The core value propositions and benefits of asset tracking will be enhanced by increased coverage and connection reliability offered by integrated 5G and satellite asset tracking.

Real-time location and status of assets is a cornerstone of effective asset management. This feature provides instant visibility of asset locations, allowing businesses to maintain a clear and up-to-date picture of their resource distribution. It enables tracking of asset movement and usage patterns, offering valuable insights into operational dynamics and resource utilization. Furthermore, this real-time information allows for quick decision-making based on current asset status, empowering managers to respond promptly to changing needs or unexpected situations.

Improved operational efficiency is a key benefit of asset tracking systems. By optimizing asset utilization and allocation, businesses can ensure that their resources are used to their full potential. The system significantly reduces time spent searching for assets, eliminating unproductive hours and improving efficiency. It streamlines workflows and processes by providing clear information on asset availability and location. Perhaps most importantly, it enables data-driven decision making, allowing managers to base their choices on accurate, real-time or near real-time information rather than guesswork or outdated reports.

Reduced asset loss is another crucial advantage. The constant monitoring provided by asset tracking systems serves as a powerful deterrent to theft, while also enabling quick recovery of lost or stolen assets. These systems can provide comprehensive audit trails for asset movement, creating account-



ability and traceability. As a result, businesses often see a reduction in insurance costs related to asset loss, as the risk of permanent loss or theft is significantly diminished.

Enhanced maintenance scheduling is a valuable feature that can extend the life of assets and reduce operational disruptions. By enabling predictive maintenance based on usage data, businesses can address potential issues before they become critical. This proactive approach reduces downtime through timely servicing, ensuring that assets are available when needed. Regular, data-driven maintenance extends asset lifespan, maximizing the return on investment for each piece of equipment. Additionally, it optimizes maintenance resource allocation, ensuring that maintenance staff and resources are used efficiently.

Improved inventory management is a significant benefit for businesses dealing with large quantities of assets or stock. Asset tracking systems provide accurate, real-time inventory counts, eliminating the need for time-consuming manual counts and reducing human error. This real-time data helps reduce both overstocking and stockouts, striking a balance between having sufficient inventory and avoiding excess. Many systems can enable automated reordering processes, ensuring that stock is replenished at the right time. Ultimately, this improved inventory management improves cash flow through optimized inventory levels, freeing up capital that would otherwise be tied up in excess stock.

Compliance with regulations and guidelines, such as Good Distribution Practice, is greatly simplified through asset tracking. These systems can help ensure adherence to industry-specific regulations, such as medicines, by making it possible to maintain accurate records of asset locations, usage, and maintenance. They are capable of providing comprehensive audit trails for regulatory inspections, helping to make it easier to demonstrate compliance. This reduces the risk of non-compliance penalties, which can be substantial in some industries. Furthermore, asset tracking systems often enable easy reporting for compliance purposes, streamlining what can otherwise be a time-consuming and complex process.

Cost-effectiveness. The growth in integrated 5G and satellite asset tracking is forecast to reduce both the current costs of global tracking devices and

associated network data charges. Costs of tracking devices are likely to fall due to standardization through 3GPP and higher production volumes, while network costs will be reduced through the choice of 5G or satellite networks.

The hope is to develop solutions with lower overall costs. It is believed that the key to low network charges will be intelligent selection and connection of optimum short range, mobile and satellite networks.

Integrated 5G and satellite asset tracking better enables these value propositions in 3 key ways:

1. Improved coverage and ubiquitous global connectivity
2. Operational capability through efficient tracker power management
3. Lower costs through intelligent switching between appropriate networks

4.0

Choosing the right connection technology and trackers

Mobile asset tracking has historically relied on 2G cellular networks and separate satellite technology, each offering distinct advantages. 2G-based trackers have been popular due to their wide coverage in populated areas, and relatively low device costs. They have been particularly useful for tracking assets in urban and suburban environments.

Satellite trackers, on the other hand, have provided global coverage, including remote areas where cellular networks are unavailable. While more expensive and power-hungry than 2G devices, satellite trackers have been crucial for monitoring assets in rural, maritime, and wilderness locations.

2G cellular networks, once the backbone of early IoT deployments, are in the process of being phased out and replaced by advanced 5G Low-Power Wide-Area Networks (LPWAN). These new networks are specifically designed to enable the cost-effective connection of billions of devices, paving the way for the creation of a global Massive IoT (MIoT) market. The 5G LPWAN technologies, such as NB-IoT and LTE-M, offer improved coverage, longer battery life, and reduced module costs compared to their 2G predecessors. NB-IoT and LTE-M were both standardized by 3GPP in Release 13 in June 2016 and first commercially deployed in 2017 and as of Release 15 are part of the 5G family of standards.
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This transition is expected to dramatically lower the barriers to entry for IoT deployments, allowing businesses to connect and monitor an unprecedented number of assets and devices across various industries, from smart cities and agriculture to logistics and manufacturing.

5G is now evolving with new 3GPP releases enabling the integration of 5G with satellite networks to enable develop cost effective, efficient and global asset tracking and other global IoT solutions.

The 5G mobile network, either using LTE-M or NB-IoT, underpins wide-area connectivity enabling maximum geographical coverage with reliable tracking performance. These networks are provided by licensed operators who manage these networks to deliver high quality levels of service and capacity.

Efficient mobile asset tracking requires the use of multiple local and wide area networks to deliver an optimum solution. The intelligent selection of these different networks by a smart, robust tracker is core to a high performance asset tracking.
The ability to switch between different available networks improves both connection reliability, location accuracy and optimum power efficiency.

Types of asset tracking networks

Wide Area Terrestrial

2G GSM still utilized by many asset tracking solutions offers wide coverage, relatively low power, however most countries are phasing out their 2G networks to refocus scarce spectrum on more capable cellular networks such as 4G and 5G.

3G: offers improved data transmission compared to 2G, however more power hungry and 3G networks are being phased out in favour of 4G and 5G.

4G: provides high-speed, reliable connectivity with good coverage, making it ideal for real-time tracking and data-rich applications. This capability comes at a cost of higher price modules, so limits the viability of this technology for many asset tracking applications.

4G LTE CAT1 BIS: an early power efficient 4G technology, specifically for IoT and a precursor to the more efficient 5G low-power technologies.

5G LTE-M: a 5G technology which offers a good balance of coverage, power efficiency, and data rates for IoT asset tracking, enabling real-time location updates and sensor data transmission while providing excellent battery life for mobile assets.

5G NB-IoT: a 5G technology which excels in deep indoor penetration and extremely low power consumption, making it ideal for tracking stationary assets or those with infrequent movement, especially in hard-to-reach locations like basements or dense urban environments.

LoRaWAN offers long-range, low-power communication for asset tracking, enabling battery-operated devices to transmit small amounts of data making it ideal for tracking less mobile assets across large areas with minimal infrastructure and low operating costs. LoRaWAN operates on unlicensed spectrum over largely unmanaged networks.

Local area connectivity – campus and indoor

Wi-Fi:

Wi-Fi is beneficial for asset tracking in indoor environments with existing Wi-Fi infrastructure, offering high-speed data transfer and the ability to provide precise indoor positioning through triangulation techniques or reference to the Wi-Fi Access Point Database.

BLE:

Bluetooth Low Energy 5.2 provides short-range, low-power communication ideal for asset tracking within facilities, offering features like direction finding and extended range, which enhance location accuracy and coverage in indoor settings.

Wide area connectivity beyond cellular networks

GPS:

GPS remains crucial for outdoor asset tracking, providing global coverage and accurate location data, essential for tracking vehicles, shipping containers, and other assets moving across large geographical areas. GPS requires a data transmission network to send tracking information back to the logistics platform.

Satellite connection:

Satellite connectivity ensures truly global asset tracking capabilities, vital for monitoring assets in remote areas, at sea, or in regions lacking terrestrial network coverage, albeit at higher costs and power consumption compared to other technologies.

Principle types of satellite utilized in asset tracking

- Low Earth Orbit (LEO): Satellites orbiting at altitudes between 160-2,000 km above Earth's surface.
- Medium Earth Orbit (MEO): Satellites in orbits between 2,000-35,786 km altitude.
- Geosynchronous Orbit (GSO): Satellites orbiting at about 35,786 km, with an orbital period matching Earth's rotation.

Intelligent wide-area asset tracking revolutionizes logistics through seamless network integration. Modern trackers dynamically switch between cellular, Wi-Fi, Bluetooth, and satellite networks, ensuring continuous connectivity and data transmission. This adaptability allows for uninterrupted tracking as assets move from warehouses (using Wi-Fi) to highways (via LTE-M) and remote areas (via satellite).

This intelligence extends beyond connectivity. Smart trackers adjust their reporting frequency based on available networks and specific asset management needs, striking an optimal balance between information richness and power conservation. This approach enables comprehensive monitoring of location, temperature, light exposure, and orientation across diverse environments.

As technology advances, satellite networks will further enhance this ecosystem, promising truly global, always-on asset visibility. This intelligent, adaptive tracking solution empowers businesses with real-time insights, optimizing supply chain efficiency and asset utilization across any terrain or distance.

5.0

Building Reliable and Scalable Wide-Area Asset Tracking Solutions

Designing and implementing a reliable wide-area asset tracking solution hinges on three critical factors:

1. **Intelligent hardware** - Appropriate selection and installation of trackers and sensors
2. **Network selection** - Optimized connectivity and power management solutions
3. **Smart logistics platforms** - Effective logistics management and condition reporting platforms

The unique requirements of different asset types significantly influence the optimal choices for trackers, installation methods, reporting frequencies, and connection technologies, as illustrated in Table 5.1.

By carefully considering these factors, organizations can create tailored tracking solutions that maximize efficiency and reliability across diverse asset portfolios.

> The unique requirements of different asset types significantly influence the optimal choices for trackers, installation methods, reporting frequencies, and connection technologies

| Table 5.1

PROFILES	POWER AVAILABILITY		ASSET MOBILITY		TRACKER MOUNTING		CONDITION		
Asset examples	**Unpowered**	**Powered**	**Often static**	**Often mobile**	**External**	**Internal**	**Temperature**	**State**	**Age**
Container	Yes	No	No	Yes	Yes	Option	For reefer containers	Load dependent	Time in transit
Trailer	Maybe	Maybe	No	Yes	Yes	Option	For reefer trailers	Load dependent	Maybe
Portable health scanner	Maybe	Maybe	Yes	No	Yes	No	No	Yes	Maybe
Forklift	Maybe	Maybe	No	Yes	Yes	No	No	No	No
Parcel	No	No	No	Yes	No	Yes	Maybe	Yes	Yes
Site Office	No	Maybe	Yes	No	No	Yes	Yes	No	No
Hire Bicycle	Yes	No	No	Yes	Yes	No	No	No	No
Temporary traffic lights	Yes	Maybe	Yes	No	Yes	No	No	No	No
Generator	Maybe	Yes	Yes	No	Yes	No	No	No	No
Road signage	Yes	Maybe	Yes	No	Yes	No	No	No	No
Shipping Pallet	Yes	No	No	Yes	Yes	No	No	No	Maybe
Pallet jack	Yes	No	No	Yes	Yes	No	No	No	No

Some examples of asset profiles likely to benefit from integrated 5G & satellite solutions:

Container: no available power, asset occasionally mobile and tracker fitted either outside and/or additional tracker inside.

Inventory management: no available power, asset occasionally mobile and the tracker needs to report additional data such as inventory condition or stock levels.

Trailer or truck: power available, the asset is very mobile so impacting the choice of connectivity and tracker maybe fitted both inside and outside the vehicle.

Refrigerated trailer/container: power is usually present and additional sensors are required inside for temperature reporting and control.

Table 5.2

Types of wide-area asset trackers and sensors

TRACKER TYPE	TYPICAL SIZE	POWER SOURCE	CONNECTIVITY	SENSORS MEASURES	INSTALLATION
Compact Self-Powered	Less than 60x40x20mm	Battery	Wi-Fi, BLE2, GPS, GSM, 5G LTE-M or NB-IoT	Location, Movement, Temp, Air Pressure, Humidity & Status	Indoor & outdoor limited space
Midsize Self-Powered	80x60x30mm	Battery	Wi-Fi, BLE2, GPS, GSM, 5G LTE-M or NB-IoT	Location, Movement, Temp, Air Pressure, Humidity & Status	Indoor & outdoor
Midsize Wired	80x60x30mm	Wired	Wi-Fi, BLE2, GPS, GSM, 5G LTE-M or NB-IoT	Location, Movement, Temp, Air Pressure, Humidity & Status	Indoor & outdoor
Midsize Solar	100x60x30mm	Solar +	Wi-Fi, BLE2, GPS, GSM, 5G LTE-M or NB-IoT	Location, Movement, Temp, Air Pressure, Humidity & Status	Outdoor
Compact Satellite	90x50x30mm	Wired & Battery	GPS, Satellite LEO/ GEO	Location, Temp, Movement, Status	Outdoor
Midsize Satellite	100x90x30mm	Wired & Battery	GPS, Satellite LEO/ GEO	Location, Temp, Air Pressure, Humidity	Outdoor

Optimum tracker installation

GPS antenna needs to face upwards towards the sky and away from metal surfaces. For optimal performance, a wide-area asset tracker should be installed with careful consideration of several key factors. The device should have a clear line of sight to the sky to ensure the best GPS signal reception and cellular connectivity, avoiding placement under metal roofs or in enclosed metal containers.

Mounting it as high as possible on the asset reduces signal obstruction and improves cellular reception. It's crucial to position the tracker away from other electronic devices to minimize potential interference, while also providing protection from the elements to extend its lifespan, even if the tracker is weatherproof.

Secure mounting prevents false motion alerts and ensures consistent orientation for accelerometer-based features. The tracker should be placed near the asset's exterior - for vehicles, this might be near windows or on the dashboard, while for shipping containers, it's often near the top corner.

Correct antenna orientation is essential, as some trackers have specific requirements for optimal performance. The installation should allow for easy accessibility for maintenance and battery replacement when needed, while also considering concealment if theft prevention is a concern.

Compliance with relevant regulations is crucial, especially for vehicles and in certain industries.

For satellite-based trackers, the installation considerations are similar, but with an even greater emphasis on an unobstructed view of the sky to maintain consistent communication with satellites. The exact placement can vary depending on the specific asset type and the particular model of tracker being used, so it's always advisable to consult the manufacturer's guidelines for the best results.

Power management is essential to the success of tracking solutions

Optimizing power usage is crucial for wide area asset tracking devices to ensure long-term operation and reduce maintenance costs. These devices typically rely on battery power, making energy efficiency a top priority.

To maximize battery life, manufacturers employ various strategies such as using low-power components, implementing sophisticated power management algorithms, and utilizing energy-efficient communication protocols. The device's firmware is designed to minimize power consumption during idle periods by entering sleep modes when not actively tracking or transmitting data.

The choice of communication technology also plays a vital role; for instance, using low-power wide-area networks LTE-M and NB-IoT can be made more energy-efficient than keeping constant connections. Adding satellite to the choice of communication technology will increase the use of power and further work is required to measure the exact difference and implement appropriate solutions. Clearly reducing polling rates, how often the device communicates with the platform, during satellite connectivity will be part of the solution.
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Additionally, the use of energy-harvesting technologies, such as solar panels or kinetic energy converters, can help supplement battery power in certain applications. Balancing the frequency of location updates with power consumption is critical and more frequent updates provide better tracking resolution, but drain the battery faster. To address this, many modern tracking devices incorporate adaptive algorithms that adjust their behaviour based on movement detection, geofencing, or other contextual factors.

Changing polling rates dynamically based on the asset's activity level or location can significantly improve power usage, allowing for more frequent

updates when necessary and conserving energy during periods of inactivity. By carefully optimizing these factors, wide area asset tracking devices can achieve operational lifespans of several years on a single battery charge, greatly enhancing their practicality and cost-effectiveness in long-term tracking scenarios. This is especially necessary for integrated 5G and satellite solutions.

Effective logistics management and condition reporting platforms

A comprehensive asset tracking logistics platform is essential to optimize supply chain operations, improve efficiency, and reduce costs. The key elements of a robust platform include:

Real-time Tracking: The cornerstone of any asset tracking system is its ability to provide real-time and near real-time location data. This feature should utilize a combination of GPS, cellular, local and satellite technologies to ensure continuous visibility across various environments.

Multi-sensor Integration: Beyond location, the platform should integrate data from various sensors monitoring temperature, humidity, shock, power, state and other relevant parameters. This provides a holistic view of asset conditions throughout the supply chain.

Geofencing and Alerts: The system should allow for the creation of virtual geographic boundaries, triggering notifications when assets enter or leave designated areas. This feature enhances security and enables proactive management of logistics processes.

Analytics and Reporting: Advanced analytics capabilities are crucial for deriving actionable insights from the vast amount of data collected. The platform should offer customizable dashboards and reports to help businesses make data-driven decisions.

Battery Management: Efficient power usage is critical for long-term tracking. The platform should include intelligent battery management features, such as adaptive polling rates that adjust based on asset movement and network availability. This might involve increasing data transmission frequency when an asset is in motion or in high-risk areas, and reducing it during periods of inactivity or when in secure locations.

Interoperability: The ability to easily integrate with other enterprise systems such as enterprise resource planning, warehouse management systems, or transportation management systems is essential for seamless data flow and process automation.

User-friendly Interface: An intuitive, easy-to-use interface ensures that all stakeholders, from logistics managers to drivers, can effectively utilize the system.

Scalability: The platform should be able to handle a growing number of assets and increasing data volumes without compromising performance.

Security: Robust data encryption and access controls are necessary to protect sensitive information about asset locations and movements.

Customization and Flexibility: Every business has unique needs, so the platform should offer customization options to adapt to specific industry requirements or company processes.

Mobile Accessibility: A mobile app component allows for on-the-go access to tracking information and alerts, essential for field operations.

Predictive Maintenance: By analyzing historical data and asset conditions, the platform should be able to predict maintenance needs, reducing downtime and extending asset life.

By incorporating these elements, a logistics asset tracking platform can provide comprehensive visibility, enhance operational efficiency, and drive significant improvements in supply chain management.

Successful ongoing management of asset tracking logistics solutions

A logistics platform requires continuous monitoring, adaptability, and proactive maintenance. Key factors include regular system updates, robust data analytics for performance optimization, responsive customer support, and ongoing staff training. Emphasizing cybersecurity, scalability, and integration capabilities ensures the platform remains effective and competitive in the evolving logistics landscape. Regular stakeholder feedback and agile problem-solving are crucial for addressing emerging challenges and capitalizing on new opportunities.

> Emphasizing cybersecurity, scalability, and integration capabilities ensures the platform remains effective and competitive in the evolving logistics landscape

6.0

Enhancing asset tracking with integrated 5G and satellite solutions

All of the principles of building reliable and scalable wide-area asset tracking described in earlier chapters apply to developing successful integrated 5G and satellite solutions. 5G networks interworking with satellite will impact many key aspects offering both benefits and challenges to tracker manufacturers, solution designers, network operators and customers. The goal is to create reliable, cost effective asset tracking solutions which deliver global coverage and are simple to integrate with current logistics platforms.

An example of an integrated 5G and satellite configuration is a proof of concept asset tracker being developed by BeWhere which features a new satellite compatible module, the Telit ME910G10WW-NTN, based on the QUALCOMM 9205S chipset. This tracker is based on the BeWhere BeSol+ multi-network terrestrial unit which is widely deployed in North America.

The BeSol+NTN has dimensions of 165 x 70 x 39.5 mm and includes a solar panel for battery recharging. This tracker is designed to connect to the best available network smartly checking Bluetooth 5.2, Wi-Fi, LTE-M, NB-IoT, GPS and using Skylo to connect to a 3GPP NTN NB-IoTsatellite.

The least-cost routing configuration within the platform detects the absence of LTE-M and NB-IoT coverage within a specified period (default is 24 hours) and then switches to satellite to update the device's current position based on the fallback interval. Each attempt will first try to establish an M1 link before switching to satellite as a fallback, keeping power consumption and cost to a minimum.

The satellite connection is enabled with an AT command AT+COPS=,,,14. The AT+COPS set to default, module starts to scan for short range networks then LTE-M, NB-IoT and then NTN NB-IoT. This means that when the cellular connection fails, the schedule fallback to satellite the application will initiate the satellite call. In the worst environmental conditions the search time is roughly from 20 to 80 seconds, and the attach time is around 46 seconds. This is quite a long time compared to cellular which is typically less than 10 seconds.

Once the Skylo network is detected, as the only available option, a daily only polling rate is implemented to reduce battery consumption and cost, until other networks are available. Reduced polling rates and enhanced tracker solar capability keeps the power overhead in check and overall power performance within existing terrestrial levels.

The results of the data speeds are especially interesting, again using the worst environmental conditions, such a dense cloud cover it was possible to send 150bytes, all data required, in around 5 seconds.

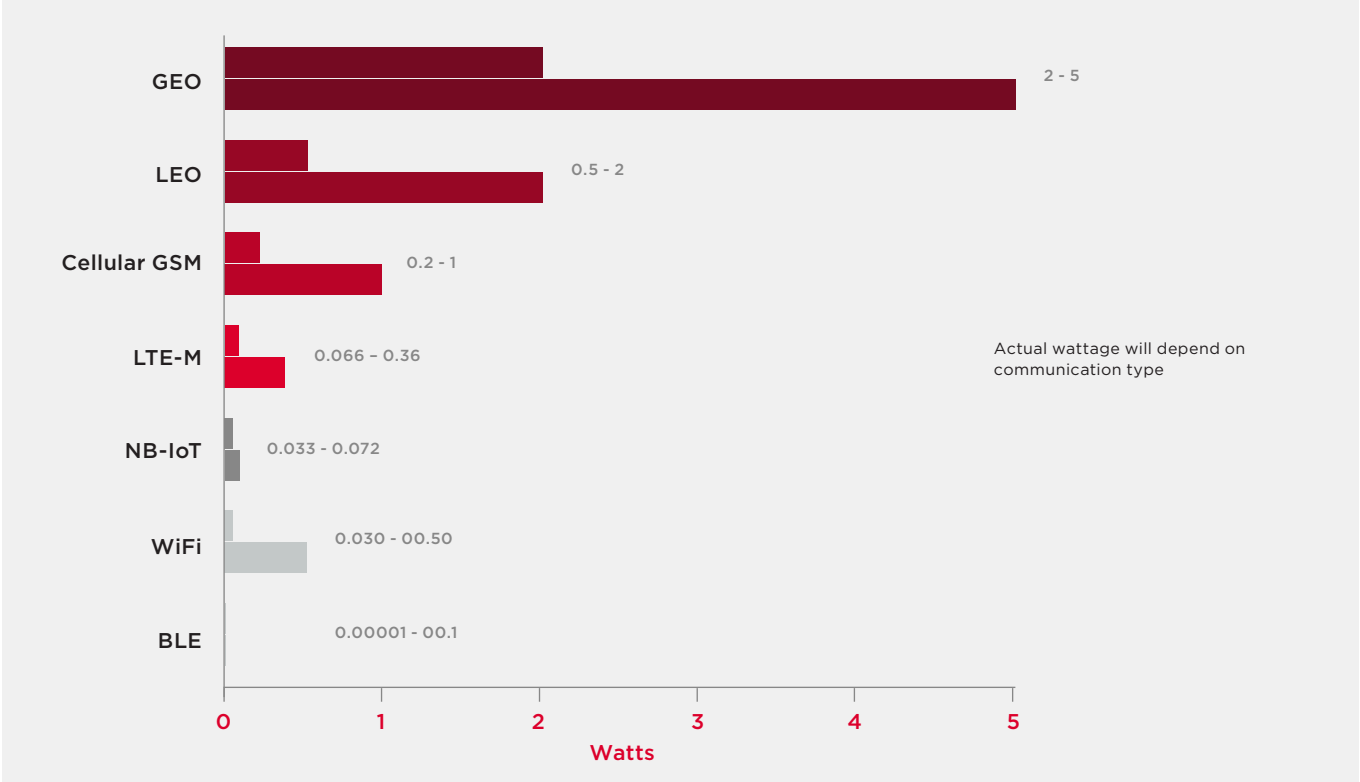
An increase in power draw was expected when switching from 5G to satellite, especially during the signal search phase. However, this is not be a major concern, as the BeSol+NTN has a high-power capacity of 7000 mAh and is rechargeable when exposed to sunlight. This shows that a modern solar powered trackers and intelligent asset management platforms are able to deal effectively with power and more complex network switching.

Integrated tracking devices and modules

Trackers are powered by mobile modules which is the core component of a cellular asset tracking device, serving as its communication hub. This module enables the device to connect to available networks, transmitting location data and other sensor information while also receiving commands and updates, thus forming the critical link between the tracked asset and the central monitoring system. Integrated 5G and satellite asset tracking requires dual-mode or hybrid modules which are able to connect via multiple local and wide area networks including Wi-Fi, BLE2, GPS, Cellular, 5G LTE-M or 5G NB-IoT, LEO and/or GEO satellites. Currently there a very few suppliers of dual-mode or hybrid modules, which are able to connect with and to seamlessly switch between cellular and satellite networks. In 2025 it is likely that major manufacturers will follow the market leaders and supply hybrid modules aided by global device and network standards allowing the market to scale. It is thought that integrated trackers are unlikely to be larger than existing models as hybrid capable chipsets and modules will not impact the device design. The size of these trackers may be impacted by power requirements, such as larger batteries and solar components.

Figure 6.1

Illustrative Power Comparison During Transmission



Integrated solution power management

Integrated trackers will use more power when switching and connecting to satellite networks and typically use more power than cellular and low power wide area networks such as LTE-M and NB-IoT. Therefore good power management is a vital feature of these devices. The device software will monitor device behaviours such as motion and time schedules and only attempt to update when it knows it has changed its position and or has adequate power. A smart hybrid tracker will use the satellite networks as infrequently as possible sharing the minimum amount of data. For example, polling rates will be adjusted when connected by satellite, probably reducing data connection to once a day or even less until the device connects again to a more power efficient network

These figures based on multiple sources for general comparison and actual wattage will depend on the amount of data transmitted.

Further information on the exact impact of the switching from terrestrial networks and sending small amounts of data to satellite networks is being investigated as part of active industry prototyping.

Use of trackers for cargo and shipping containers

Several common placement options exist for integrated trackers on shipping containers. The top corner is one of the most popular locations, offering good sky visibility and reduced obstruction when containers are stacked.

Some containers feature built-in protective housings for tracking devices, providing both security and functionality. Placing the tracker behind ventilation slats can offer concealment while maintaining signal transmission, though care must be taken not to interfere with ventilation. The container door frame can be suitable for monitoring openings, but may be more susceptible to damage during loading and unloading.

Ultimately, the ideal location depends on the container type, tracker capabilities, and shipping routes, requiring a balance between optimal signal reception and device protection.

Networks

Integrated asset tracking devices employ a sophisticated system to maintain connectivity by seamlessly transitioning between local, cellular, and satellite networks. The device typically prioritizes these networks in order of efficiency and cost-effectiveness: BLE or Wi-Fi first, followed by cellular, and finally satellite as a last choice. This prioritisation ensures optimal use of resources while maintaining consistent communication. The device scans for available networks, attempting to connect to preconfigured Wi-Fi networks in indoor locations or areas with reliable coverage. When Wi-Fi is unavailable or the connection is lost, it swiftly switches to cellular networks, utilizing various technologies such as 5G LTE-M and NB-IoT depending on availability. Smart software filters also ensure efficient use of networks by checking 4 or more GNSS satellites available for location accuracy, there is no alternative terrestrial network available, tracker out of coverage for a set number of hours or at set periods when stationary. When these conditions are met the satellite service is engaged.

In scenarios where both local and cellular connections are unavailable, the device activates its satellite modem. This failsafe option guarantees connectivity even in remote areas, albeit with higher power consumption and lower data rates. Throughout these transitions, the device employs data buffering techniques, storing information locally when no network is available and transmitting it once a connection is re-established. This ensures no critical data is lost during network changes or temporary disconnections.

The entire process is underpinned by intelligent power management and adaptive transmission strategies. The solution adjusts its power consumption and data transmission intervals based on the active network type, often implementing

more aggressive power-saving measures when using satellite communication. In cases where all networks fail, the device may enter a low-power mode, preserving critical data until connectivity is restored. This comprehensive approach ensures that asset tracking devices maintain the best possible connectivity while optimizing for power consumption, data costs, and transmission reliability, adapting to various environmental conditions and network availabilities.

Figure 6.2

The BeSol+ a 4th generation solar powered a multi-network 5G low-power smart asset tracker used as the basis for the BeSol+NTN proof of concept.

7.0

Conclusion – Opportunities for the future

The rapid development of the 5G and satellite interworking market is forecast to grow strongly due to the increase in demand for efficient global asset tracking and the availability of lower cost hardware and networks. Recent developments have reinforced the view that multiple 5G satellite solutions will come to market in 2025. The increasing costs of transportation and movement of containers is also a major driver.

Global communication is being enhanced with more terrestrial and non-terrestrial networks offering more geographical coverage and the ability to support many more connections. As of 2024, there were approximately 7,800 active satellites in orbit, according to the Union of Concerned Scientists satellite database. This figure is forecast to grow to around 20,000 in orbit by 2030 according to Quilty 2023. Analysis Mason estimated (2023) that by 2032, 68% of the 57.7million in-service satellite IoT units will be connected via 5G or other standards protocols.

The 5G Mobile IoT network is rapidly rolling out across the world with over 252 LTE-M and NB-IoT networks being deployed by mobile operators, according to the GSMA May 2023. The number of installed cellular IoT devices is forecast to grow from around 2bn in 2024 to 5bn by 2030 according to Transforma Insights 2024.

Mobile operators are increasingly working with the satellite industry to offer non-terrestrial services. In May 2024 91 mobile operators were either offering live or testing satellite services. Most importantly

Active Satellites
in orbit

2024 **7,800** | 2030 **20,000** ↑↑↑

Cellular IoT Devices
Installed

2024 **2bn** | 2030 **5bn** ↑↑

this market is set to scale, 'Of the 38 billion IoT devices we expect to be operable by 2030, 2-3 billion (10-15%) are addressable for satellite. This equates to a potential revenue uplift of $10 billion per year, approximately 25% of the current IoT revenues that come from connectivity' according GSMA Intelligence, NTN Tracker Report, June 2024.

Remote inventory and asset management beyond location tracking:

The market for remote inventory and asset management solutions that go beyond simple location tracking is experiencing rapid growth and diversification. As businesses seek to optimise their operations and reduce costs, there's an increasing demand for comprehensive systems that provide real-time insights into asset conditions, usage patterns, and inventory levels. These advanced solutions leverage IoT sensors, AI-driven analytics, and cloud computing to offer functionalities such as predictive maintenance, automated reordering, and environmental monitoring.

By providing detailed data on factors like temperature, humidity, shock, and utilisation rates, these systems enable companies to prevent spoilage, reduce downtime, optimise stock levels, and improve overall operational efficiency. Industries ranging from manufacturing and healthcare to agriculture and logistics are recognising the value of these enhanced management capabilities, driving a market expected to dramatically grow globally in the coming years. This growth is further fueled by the integration of 5G and satellite technologies, which promise to extend these capabilities to even the most remote or challenging environments.

Powering the sharing economy

Asset tracking technology is unlocking significant market opportunities in the sharing economy, particularly for hire and rental schemes. By providing real-time location data, usage metrics, and condition monitoring, asset tracking enables businesses to efficiently manage and maintain distributed fleets of shareable assets, from bicycles and e-scooters to construction equipment and medical devices. This technology reduces operational costs, minimises theft and loss, and improves user experiences through features like easy location and reservation of available assets. As a result, new business models are emerging, allowing companies to monetise under utilised assets and consumers to access a wider range of products without the burden of ownership. The market for such asset sharing platforms, underpinned by robust tracking systems, is projected to grow rapidly, driven by increasing urbanisation, sustainability concerns, and the desire for on-demand access to various equipment and vehicles.

IoT connections fuel AI powered logistics

The convergence of AI, IoT, 5G, and satellite technologies is creating a transformative opportunity in the logistics management sector. As the number of IoT devices proliferates, powered by the expanded coverage and enhanced capabilities of integrated 5G and satellite networks, logistics companies gain access to an unprecedented wealth of real-time data from across the supply chain.

AI-powered platforms can harness this data to optimise routes, predict maintenance needs, automate inventory management, and even anticipate market demands. These platforms offer the potential to significantly reduce operational costs, minimise delays, and improve overall supply chain resilience. Many analysts are forecasting that the market for such AI-driven

Glossary

No.	
1	5G: The fifth generation of GSM cellular network technology, offering higher speeds, lower latency, and greater capacity than previous generations.
2	LTE-M (Long Term Evolution Mobile): A low-power wide-area network (LPWAN) 5G technology designed for IoT devices, providing improved indoor coverage and longer battery life.
3	NB-IoT (Narrowband Internet of Things): A narrow-band radio 5G technology designed for IoT devices, offering low power consumption and improved coverage.
4	IoT (Internet of Things): A network of interconnected devices that can collect and exchange data without human intervention.
5	GPS (Global Positioning System): A satellite-based navigation system that provides location and time information anywhere on Earth.
6	2G (Global System for Mobile Communications): A second-generation (2G) digital cellular network standard used for mobile communications.
7	LTE CAT1 BIS (Long Term Evolution Category 1) is an enhanced version of LTE Cat 1 technology designed for IoT devices, offering improved coverage, longer battery life, and moderate data speeds on 4G networks.
8	Wi-Fi: a local wireless networking technology that allows devices to connect to the internet or communicate with each other wirelessly.
9	BLE (Bluetooth Low Energy): A wireless personal area network technology designed for short-range communication with reduced power consumption.
10	LEO (Low Earth Orbit): satellites orbiting close to Earth's surface, typically at altitudes between 160-2,000 km.
11	MEO (Medium Earth Orbit): satellites orbiting at altitudes between 2,000-35,786 km above Earth's surface.
12	GEO (Geosynchronous Orbit): satellites orbiting at about 35,786 km altitude, with an orbital period matching Earth's rotation.
13	LPWAN (Low-Power Wide-Area Network): type of wireless telecommunication network designed for long-range communications at a low bit rate among connected objects.
14	LoRaWAN: low-power, wide-area networking protocol designed for wirelessly connecting battery-operated devices to the internet.
15	Non-Terrestrial Networks (NTN): communication networks that involve non-terrestrial components such as satellites or high-altitude platform stations.

No.	
16	Geofencing: location-based service that triggers an action when a device enters or exits a virtual boundary set up around a geographical location.
17	UMTS (Universal Mobile Telecommunications System): third-generation (3G) mobile cellular system for networks based on the GSM standard.
18	Massive IoT (MIoT): the deployment of a very large number of low-cost, low-power IoT devices in a global network.
19	Hybrid modules: communication modules capable of connecting to both cellular and satellite networks, providing seamless global coverage.

Acknowledgements

The whitepaper was co-authored by BeWhere, with the GSMA Foundry. It is released by the GSMA as a whitepaper to the industry to highlight the potential for future industry initiatives in the integration of 5G and satellite asset tracking. The GSMA Foundry project is designed to demonstrate the market opportunity and to develop live solutions to push the boundaries of communications technology.

BeWhere are pioneers in low-power 5G IoT wide-area tracking technology, creating remote monitoring solutions that address cost, power, and environmental challenges. In just 6 years, the company has experienced rapid growth, collaborating with top resellers and installers to deploy hundreds of thousands of trackers across numerous sectors, including transportation, construction, logistics, utilities, health, and government.

BeWhere's tracking solutions are designed to be both cost-effective and simple to implement, significantly expanding the scope of assets that can be connected. These connected devices generate data that powers intelligent AI management platforms. By increasing the number of connected devices, BeWhere enhances the capabilities and growth potential of AI solutions.
https://bewhere.com/

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GSMA HEAD OFFICE
1 Angel Lane
London
EC4R 3AB
UK
Email: info@gsma.com

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