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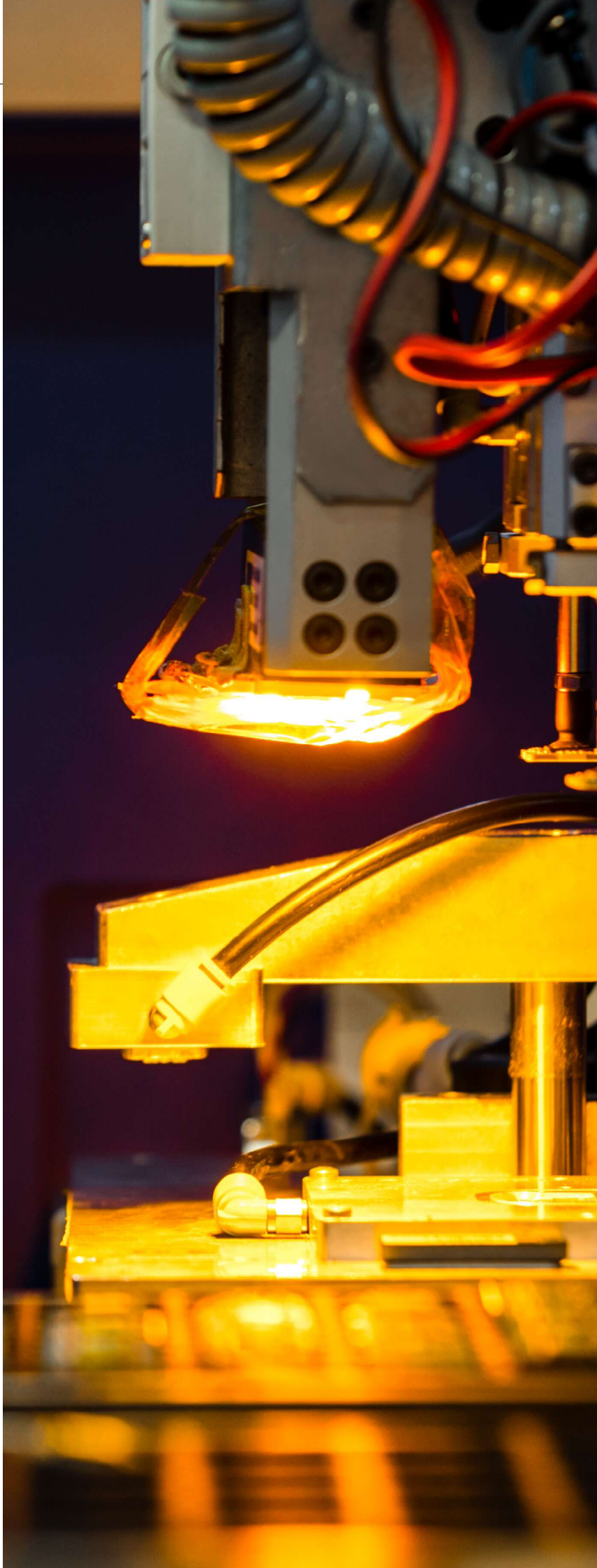


How to boost manufacturing efficiency with 5G indoor positioning

IndustryWeek.

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Executive summary

For modern manufacturing to achieve smarter, more agile operations, a critical challenge persists: the ability to precisely and reliably locate every device, tool, machine and person within their complex indoor environments. While various indoor location technologies exist, many face significant barriers to widespread adoption in industrial settings, including high costs, fragmented deployments and vendor lock-in, often struggling to meet the demanding conditions of these environments. However, private 5G cellular is emerging as the robust, long-term answer, unlocking high-precision visibility with inherent efficiency.

This paper explores how the rapid evolution of 5G precise indoor positioning is driving breakthrough advancements for smart manufacturing. By leveraging the inherent capabilities of a private 5G network, manufacturers can achieve meter-to-sub-meter accuracy for assets, equipment and personnel, without bespoke hardware or complex overlays. This approach offers remarkable flexibility because it can seamlessly complement existing infrastructure by enhancing specific areas or serve as the foundational backbone for entirely new, modernized industrial deployments.

From real-time asset tracking and improved worker safety to optimizing complex processes, powering predictive maintenance and feeding live data into digital twin models, 5G indoor precise positioning is a game-changer. It delivers the real-time insights and control needed to drive efficiency, reduce costs and elevate safety across operations. As a catalyst for digital transformation, private 5G networks provide a highly adaptable platform that positions the factory for continuous advancement.



Introduction—The foundational network for digital transformation

The manufacturing sector is amid a profound transformation, driven by the imperatives of Industry 4.0. To remain competitive and meet evolving demands, factories must become more efficient, agile and safe. This requires unprecedented levels of connectivity and real-time data, enabling sophisticated automation, intelligent decision-making and seamless operational flows. At the heart of this digital evolution lies the ability to know precisely where everything is, all the time.

While the Global Positioning System (GPS) has revolutionized outdoor navigation and logistics, its capabilities diminish significantly indoors, leaving a critical "localization challenge" within the sprawling, complex environments of modern factories. Traditional indoor positioning solutions, such as Wi-Fi, Bluetooth beacons or Ultra-Wideband (UWB) systems, often come with their own set of limitations, including fragmented coverage,

high deployment and maintenance costs and susceptibility to interference from industrial machinery. These shortcomings have historically hindered the widespread adoption of truly precise indoor positioning.

Enter 5G cellular technology

Designed from the ground up for industrial applications, private 5G networks offer a robust, reliable and secure foundation for advanced industrial capabilities. Unlike public cellular networks, private 5G provides dedicated resources, ensuring consistent performance and enhanced security crucial for business-critical operations. This paper will focus on how 5G indoor precise positioning, leveraging the power of these private networks, is emerging as a transformative enabler, fundamentally changing how smart factories operate and unlock their full potential.



Understanding precise indoor positioning and the private 5G advantage

Precise indoor positioning is the ability to pinpoint the exact location of assets, people, and equipment within indoor environments with a high degree of accuracy, ranging from meters down to sub-meter precision (see Figure 1). This goes far beyond simple zone detection, providing granular, real-time spatial awareness that is vital for advanced automation and operational intelligence.

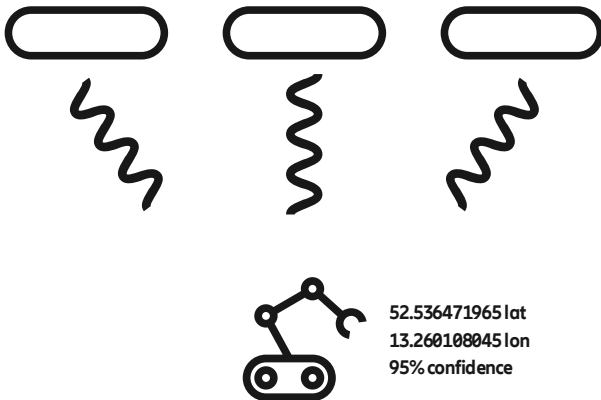


Figure 1: Precise indoor positioning with 5G

GPS's reliance on line-of-sight to satellite signals makes it largely ineffective inside buildings. The dense structures, metallic surfaces and constant movement within a factory create a complex radio environment where GPS signals are blocked, reflected or attenuated, leading to inaccurate or non-existent positioning data.



Limitations of conventional approaches

Numerous technologies have been explored in attempts to solve the indoor positioning—each with its own limitations:

- **Wi-Fi**—While ubiquitous for connectivity, Wi-Fi often falls short for industrial-grade, precise positioning. Its accuracy is inconsistent—typically 5-15 meters, even with advanced techniques like Wi-Fi RTT, which can achieve 1-3 meters under ideal conditions but requires compatible hardware. Wi-Fi networks are primarily designed for data communication, not precise location and can suffer from interference in electrically noisy factory environments. Overlaying Wi-Fi for high-precision location often involves significant additional cost and complexity for calibration and specialized software. It simply does not meet all the demanding needs of a smart factory.
- **Other RTLS (real-time location system) technologies**—Technologies like Bluetooth Low Energy (BLE) beacons, UWB and Radio Frequency Identification (RFID) each offer advantages. UWB, for instance, can offer centimeter-level accuracy. However, these systems typically require separate, dedicated infrastructures—often involving thousands of beacons or UWB anchors. This often leads to fragmentation, high maintenance costs and complex integration with existing IT and operational technology (OT) systems.

Why private 5G is the strategic choice

Private 5G is purpose-built to meet the demands of industrial environments, making it the strategic choice for precise indoor positioning. It offers:

- **Dedicated spectrum**—Private 5G operates on dedicated or licensed spectrum, minimizing interference and ensuring consistent, predictable performance crucial for business-critical applications.
- **Enhanced security**—With network isolation and robust encryption, private 5G offers a level of security unmatched by shared wireless networks, protecting sensitive operational data and intellectual property.
- **High capacity and low latency**—Designed to support a large number of connected devices and deliver ultra-low latency (down to milliseconds), private 5G can handle the immense data volumes and real-time control requirements of a fully automated factory.

In essence, private 5G offers a robust, long-term foundation, specifically built for industrial operations. It provides a unified and reliable platform for connectivity that also adds a powerful new dimension of precise location intelligence, complementing and often surpassing the capabilities of traditional wireless and fragmented RTLS approaches for demanding industrial environments.

How private 5G networks enable precision location

What sets 5G indoor positioning apart is its core innovation—the network doesn't just connect devices; it actively determines their location. Instead of relying on external, separate systems or tags that communicate with an overlay, the very infrastructure providing connectivity is intelligently leveraged to determine location.

This creates a unified infrastructure where the same private 5G network components—including radio units (like small cells or "dots"), compute resources and core network functions—provide both high-performance communication and precise location services (see Figure 2). This significantly simplifies deployment and management, reducing the need for redundant hardware and complex lifecycle management (LCM) across different systems.

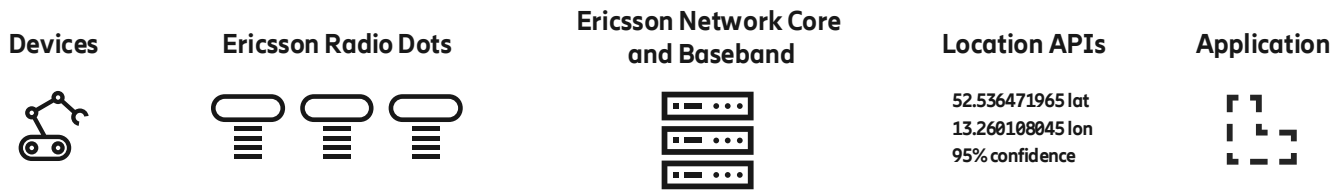


Figure 2: Realizing precise indoor positioning using Ericsson Private 5G

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A key advantage of this approach is device agnosticism. Any standard 5G-enabled device can be located without requiring specialized tags, additional hardware or custom software. As long as the device has a cellular connection, such as a SIM card or eSIM, it can be seamlessly detected and located by the network. This dramatically streamlines implementation and reduces costs associated with outfitting every asset with a proprietary tag.

The precision is achieved through advanced 5G capabilities (see Figure 3):

- **Time-based methods**—The network measures the minute differences in the time it takes for signals to travel between the 5G device and multiple network radio units ("dots"). By precisely calculating these Time Differences of Arrival (TDoA), the system can triangulate the device's exact position.
- **Angle-based methods**—Advanced 5G antenna technologies can also determine the Angle of Arrival (AoA) of signals, further refining positional accuracy.
- **Wider bandwidth and dedicated signals**—5G's larger available bandwidth and dedicated Positioning Reference Signals (PRS) provide richer, more robust data for these measurements, leading to significantly higher accuracy compared to previous cellular generations.

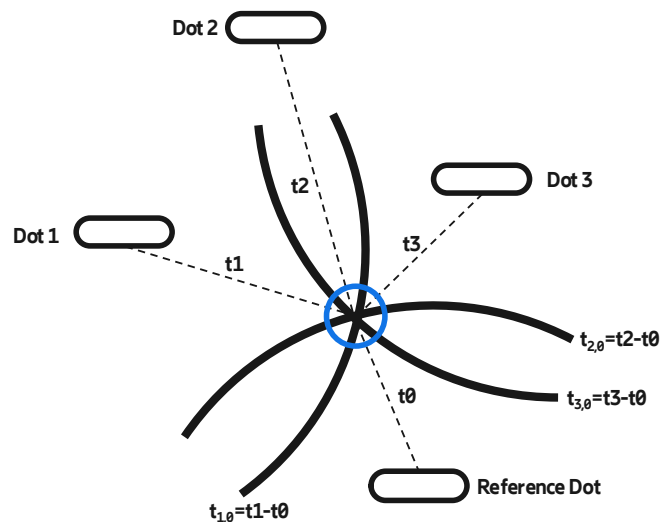


Figure 3: Multilateration positioning using Ericsson Radio Dots

One of the key advantages of 5G precise indoor positioning is the flexibility it brings to deployment strategies:

- **Complementary**—A private 5G network can seamlessly integrate with and enhance existing legacy infrastructure. For instance, it can provide superior precise positioning in specific high-value zones or areas where existing Wi-Fi or other RTLS solutions struggle, feeding its high-fidelity location data into broader factory management systems.
- **Foundational**—For factories with outdated, unreliable or insufficient existing infrastructure, a private 5G instance serves as a powerful, future-ready foundational solution. It provides a comprehensive, robust and future-ready platform for all connectivity and positioning needs, simplifying the network architecture and reducing long-term operational overhead. This eliminates the need for multiple, disparate systems while also providing a single, powerful backbone for digital transformation.

Game-changing use cases in smart manufacturing

Precise indoor positioning, powered by private 5G networks, is not merely a technological upgrade; it's a catalyst for fundamental operational transformation in smart manufacturing. It drives unparalleled value by enabling real-time visibility and control across the entire factory floor.

Asset tracking



- Gain real-time visibility into the exact location of high-value tools, raw materials, work-in-progress and mobile equipment such as automated guided vehicles (AGVs), autonomous mobile robots (AMRs) or forklifts.
- Prevent costly loss, misplacement or theft of critical items.
- Automate continuous inventory audits, to improve accuracy and reduce manual effort.
- Optimize material flow, ensuring components are precisely where they need to be, when they need to be there.

Worker safety and compliance



- Monitor personnel in hazardous zones and trigger automated alerts for unauthorized access or proximity risks to machinery.
- Accelerate emergency response and evacuation management by quickly locating personnel in incidents, minimizing response times.
- Enable lone-worker protection with automated distress signaling based on precise location, ensuring help arrives swiftly.

Process optimization



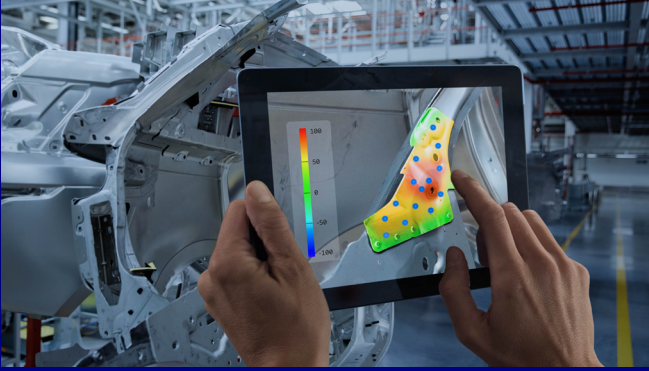
- Analyze real-time movement patterns of assets, materials and personnel to identify and eliminate idle time, bottlenecks and inefficient routes.
- Optimize workflows and synchronize logistics directly with dynamic production schedules, leading to leaner, more agile manufacturing processes.
- Enable adaptive routing for AGVs and AMRs based on real-time factory floor conditions, reducing delays and collisions.

Predictive maintenance



- Track usage patterns, routes and specific locations of machinery and mobile equipment to enable highly optimized, proactive maintenance cycles.
- Correlate precise movement data with machine wear and operational context to predict and prevent unplanned downtime, maximizing asset lifespan and overall equipment effectiveness (OEE).

Digital twin integration



- Feed high-fidelity, real-time location data directly into digital twin models of the factory.
- Enable live process simulation, virtual commissioning and continuous efficiency analysis, closing the loop between the physical and virtual factory.
- Unlock advanced applications, such as augmented reality (AR), for maintenance, assembly or training, where the precise location of the worker and equipment is crucial for overlaying digital information.

Smart building integration



Extend the benefits of precise positioning beyond the factory floor to the entire smart building ecosystem.

- **Optimize energy consumption**—Lights and air conditioning can be adjusted automatically based on occupants' real-time locations, significantly reducing waste.
- **Enhance productivity**—Building layouts can be dynamically reconfigured based on team and individual behavior, optimizing seating arrangements and collaborative spaces. "Smart" elevators can anticipate demand and move to floors where people are gathering.
- **Streamline operational efficiency**—Package deliveries, IT support and general maintenance services can be dispatched precisely to where they are needed, reducing response times and improving service delivery.
- **Improve emergency scenarios**—In emergencies like evacuations, it becomes critical to confirm that everyone has left the building. First responders can be quickly directed to the exact locations where people are, accelerating response and improving outcomes.

Use of RedCap devices for cost efficiency and scalability

The evolution of 5G also includes the introduction of Reduced Capability (RedCap) devices—streamlined, cost-efficient 5G devices designed for simpler, high-scale deployment, thanks to reduced bandwidth and fewer antennas. This makes them ideal for:

- **Lower cost**—RedCap devices reduce modem complexity by approximately 65% for low- or mid-band (FR1) devices and by approximately 50% for high-band (FR2) devices, resulting in significant cost savings.
- **Scalability**—Their lower cost and complexity make it feasible to deploy them in massive numbers for industrial wireless sensor networks, video surveillance and wearables.
- **Optimized for positioning**—While having lower bandwidth than full 5G devices, 5G Release 18 enhancements specifically address positioning for RedCap devices. This ensures they can still achieve decent positioning accuracy, making them highly suitable for use cases that benefit from location tracking but don't require the full capabilities of regular 5G devices. This expands the range of trackable assets and personnel, making comprehensive visibility more attainable and economical.

To learn more, visit

<https://www.ericsson.com/en/blog/2024/11/5g-advanced-positioning-in-3gpp-release-18>.

Key considerations for a successful deployment

Unlocking the full potential of 5G indoor precise positioning requires thoughtful planning to maximize its transformative potential.

- **Strategic alignment**—Begin by clearly defining your business objectives and the specific operational challenges you aim to solve. A clear understanding of desired outcomes and expected return on investment (ROI) will guide the entire deployment.
- **Network design**—Proper radio planning and network design are paramount for optimal accuracy and coverage. This involves understanding the unique propagation characteristics of 5G signals within your specific factory environment, including obstacles, machinery and desired precision levels.
- **Integration**—Ensure seamless interoperability with your existing IT and OT organizations. This includes manufacturing execution systems (MES), enterprise resource planning (ERP) and industrial systems, like SCADA and PLCs. Solutions should offer open APIs to facilitate data exchange and ensure location intelligence can be leveraged across your entire operational ecosystem.
- **Scalability and future-proofing**—Choose a solution that can grow with your evolving needs. A 5G-native approach inherently offers scalability, allowing you to expand coverage and connect more devices as your factory's digital transformation progresses, supporting future 5G advancements without costly "rip and replace" upgrades.
- **Security and compliance**—With sensitive location data and critical operations at stake, leverage the inherent security advantages of a private cellular network, including dedicated spectrum and robust authentication, to ensure data privacy and compliance with industry regulations.

Getting started—Your path to a smarter factory

Embarking on the journey to a smarter factory with 5G indoor precise positioning can be approached systematically:

- **Assessment and pilot**—Conduct a thorough needs analysis to identify specific challenges and high-impact use cases within your factory. Consider launching a targeted pilot program in a defined area to demonstrate tangible value, refine the solution and build internal confidence before a broader rollout (see Figure 4).

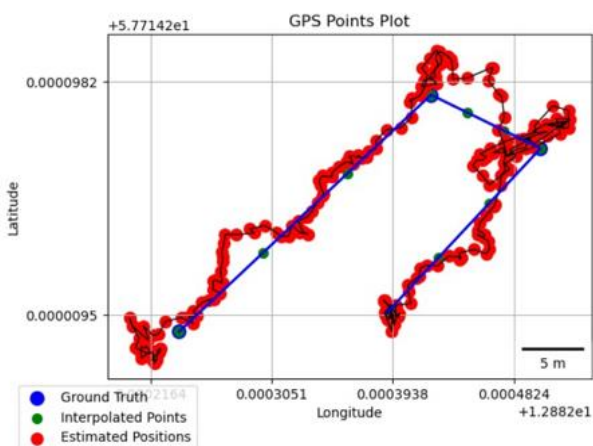


Figure 4: Example test results in a harsh RF industrial environment



- **Strategic partnership**—Collaborate with experienced technology partners who possess deep expertise in both 5G private networks and manufacturing operational challenges. A knowledgeable partner can guide you through planning, deployment, integration and ongoing optimization, ensuring a smooth transition and maximizing the benefits of your investment.

Conclusion—The precise advantage for Industry 4.0

The era of truly smart manufacturing is here, and 5G indoor precise positioning is proving to be a fundamental enabler. Powered by robust private 5G networks, this technology transcends the limitations of traditional indoor location systems, offering unparalleled operational efficiency, enhanced worker safety and optimized asset utilization.

By providing real-time, granular location intelligence, 5G unlocks advanced Industry 4.0 applications, from dynamic digital twins to adaptive automation. The technology is rapidly maturing, offering flexible deployment models that can either complement existing infrastructure or form the resilient foundation of a modern industrial

environment. Embracing 5G indoor precise positioning is not just an investment in technology; it's a strategic move that positions the factory for continuous advancement and enduring competitive advantage in the digital age.

To explore how 5G private networks and precise indoor positioning can transform your operations and initiate your journey towards a truly smart factory, please visit www.ericsson.com/manufacturing for further resources on private networks, Industrial IoT and autonomous systems.



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