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# Executive summary

Do you find that your current technical solutions, or those available in the market, are failing to meet your quality, productivity, and worker safety objectives? For many, this issue is linked to the challenge of integrating applications and facilitating real-time data exchange with dependable and consistent coverage. The culprit? It may very well be your choice of connectivity technology.

While connectivity might be taken for granted by some, it has proven to be a fundamental element in achieving the technical promise required to meet business goals. Enter 5G, the game-changer. It's the remedy for downtime, the stronghold of unwavering reliability, and the guardian of predictable coverage. Here are some industry examples:

- Hitachi has experienced firsthand the transformative power of 5G, enhancing product quality and eliminating bottlenecks by simultaneously inspecting the quality of 24 assembly components.
- A global car manufacturer is enabled to double output by implementing Ericsson's private 5G solution and transforming its work processes.

Manufacturers are recognizing the potential of private 5G to enhance product quality, boost production efficiency, and ensure worker safety. Market research firms such as OMDIA, Analysys Mason, and Technology Business Research predict a Compound Annual Growth Rate (CAGR) of over twenty percent.

We are excited about the opportunity to connect with you and explore how you can harness the benefits of reliable, predictable, and secure private 5G coverage. It's your ticket to improving product quality, supercharging production efficiency, and fortifying worker safety. Let's make it happen together.

Hitachi is simultaneously inspecting the quality of

24

components

5G has enabled a car manufacturer to

2X

the output

OMDIA forecasts a CAGR of

23%

for 2022-2027 – from 590 MUSD to 1.6 BUSD

# Manufacturing problems and needs

Do you find that your current technical solutions, or those available on the market, fall short of meeting your quality, productivity, and worker safety objectives? Have you, for instance, encountered:

- Instances where your equipment or tools, such as nutrunners, experience connectivity issues?
- Mobile devices like automated guided vehicles (AGVs), autonomous mobile robots (AMRs), cranes, and vehicles that lack seamless mobility or intermittently lose communication?
- Challenges where worker screens/devices struggle to connect or maintain a stable connection?
- Difficulty in integrating new connected sensors, devices, equipment, etc. into your existing setup?

Enterprise customers have experienced tangible benefits from Ericsson's Private 5G (EP5G) solution, enabling them to seamlessly adapt and optimize their production processes. This has resulted in enhanced product quality, improved production efficiency, and a safer work environment, all while maintaining operational flexibility. The image below provides examples of how EP5G has facilitated these improvements, and the following section contains real-life case studies of customer deployments and the successful achievement of their business objectives.

	Quality	Productivity	Worker Safety
Needs	<ul style="list-style-type: none"> <li>• Flexibly add wireless sensors and cameras for quality control inspections</li> <li>• Document product quality by collecting real - time data from tools and equipment</li> </ul>	<ul style="list-style-type: none"> <li>• Data driven production planning &amp; control of equipment &amp; tools</li> <li>• Autonomous/remote controlled vehicles, AGVs, AMRs, cranes</li> <li>• Connectivity for mobile screens and worker devices</li> <li>• Monitor and manage assets for predictive maintenance</li> <li>• Locate tool, equipment, device</li> </ul>	<ul style="list-style-type: none"> <li>• Wear the right safety gear</li> <li>• Training and safety alerts</li> <li>• Emergency communication and response</li> <li>• Realtime monitoring and equipment safety</li> <li>• Locate workers</li> </ul>
Ericsson's solution	<ul style="list-style-type: none"> <li>• Building flexibility with 4G/5G</li> <li>• Reliable communication for tools and equipment</li> <li>• Flexibly add devices</li> <li>• Leveraging an ecosystem of 4G/5G players for gateways, sensors, cameras, tools etc</li> </ul>	<ul style="list-style-type: none"> <li>• Flexibly add mobile devices, sensors, cameras, vehicles etc</li> <li>• Seamless and reliable mobile communication for equipment, tools, AGVs, AMRs, cranes with deterministic characteristics</li> <li>• Positioning of equipment, tools, devices</li> </ul>	<ul style="list-style-type: none"> <li>• Secure and reliable communication</li> <li>• Precise location of workforce/ workers</li> <li>• Augmented reality for local and remote training and support</li> </ul>

## Operational Flexibility in Manufacturing

Manufacturers face the challenge of enhancing product quality, productivity, and worker safety while navigating the complexities of new technology. In this paper, we demonstrate how to address these challenges and present examples of the successful outcomes achieved by manufacturers.

## Key Concerns

## Complication

## Resolution

### New technology

Private 5G is a new technology and I don't want to introduce it until use cases has been proven.

You can benefit from numerous use cases that have been proven in commercial production with a much better result than other technologies. Cellular technology, being based on 3GPP standardization and backward compatible, provides confidence in its future-proofing.

### 5G devices

I have a fear that the device ecosystem for enterprise use cases is not mature.

You have the flexibility to employ a variety of widely-used and versatile gateways utilized across multiple industries. These devices can be managed remotely for provisioning, configuration, and life cycle maintenance. And a sign of maturity of the technology is, for example, that Apple's iOS 17 supports private 5G networks.

### Cost

It is an additional cost to introduce a private 5G network.

Leverage private 5G for multiple use cases and benefit from a more cost-efficient network deployment and life cycle management as much less network tuning is needed and your facility can be covered with much fewer access points, that is, five to ten times fewer compared to Wi-Fi. It's probable that private 5G and Wi-Fi will coexist, offering the potential to reduce the quantity of Wi-Fi access points, generations, and other wireless technologies.

### Management

How will the private 5G network management fit into my existing operations?

You can seamlessly integrate the private 5G network into your current LAN structure, incorporating it into your existing manufacturing control systems. This integration empowers you with full control over a flexible and efficient solution, ensuring predictable, reliable, and deterministic operations, both indoors and outdoors.

### Cyber Security

The security threat is increasing. How secure is the private 5G solution?

Private 5G is securing high-performing operations. 5G was defined with end-to-end encryption, and adding enterprise-specific authentication and authorization by inserting custom SIM cards provides an additional layer of security. All industrial data will stay on site securing high-performing and secure operations.

# Ericsson Private 5G use cases and deployment examples

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To accelerate the journey toward Industry 4.0, manufacturers have identified several use cases to enhance their operational processes. These range from optimizing material handling to enhancing product quality and minimizing asset downtime. In this booklet, we provide examples of live customer cases and illustrate how they have achieved their business objectives.

## Hitachi Asterno Americas

The most significant bottleneck at the Hitachi factory in the USA was the laborious inspection of assembly component quality. In collaboration with Ericsson and Amazon Web Services (AWS), the company investigated the potential of several use cases to detect product defects more accurately and at an earlier stage in the production process using 5G technology. The team working on this devised a trial model that harnessed a cloud-based computer vision in conjunction with a fast and reliable private 5G wireless infrastructure, all aimed at alleviating the bottleneck.

### 5G enabled computer vision

The team defined several use cases for detecting quality flaws earlier and more precisely in the production process. Here are a couple of example use cases:

- mechanical defect detection
- simultaneous defect detection
- cycle time detection
- welding quality monitoring
- video evidence for analyzing failures

### The solution included:

- Edge network:
  - Hitachi-based video analytics platform with new algorithms to support machine vision use cases programmed for Asterno
  - Ericsson Private 5G Network Core
  - Hitachi cloud for future manufacturing use cases with integration into their platform
- Radio network: Ericsson indoor 5G mmWave and LTE radios providing coverage for the gateway-connected cameras
- Gateway Nodes: Inseego M100 gateways
- Sensors/cameras: AXIS 4K/HD cameras

### Product quality improved and bottleneck removed

The project at the Hitachi factory demonstrated a significant improvement in the quality inspection of assembly products, leading to the elimination of the bottleneck.

- The vision system with artificial intelligence (AI) and ML models could simultaneously inspect 24 assembly components for the defect detection use case, compared to the conventional one-by-one inspection approach.
- The factory achieved a quick return on investment (ROI) for other use cases, with four of them now in commercial production.

- 5G and the cloud are key to scaling use cases.
- Deploying new use cases with 5G was straightforward compared to the back-and-forth steps required with Wi-Fi, resulting in operational benefits and a 1/10 reduction in lead time for deploying new use cases in 5G. Please refer figure 1 and 2 below.
- The trial demonstrated that a 5G infrastructure with edge and cloud technologies could rapidly and cost-effectively scale integrated use cases across multiple global manufacturing sites while abstracting networking and compute infrastructure complexities from the end user.

## 5G

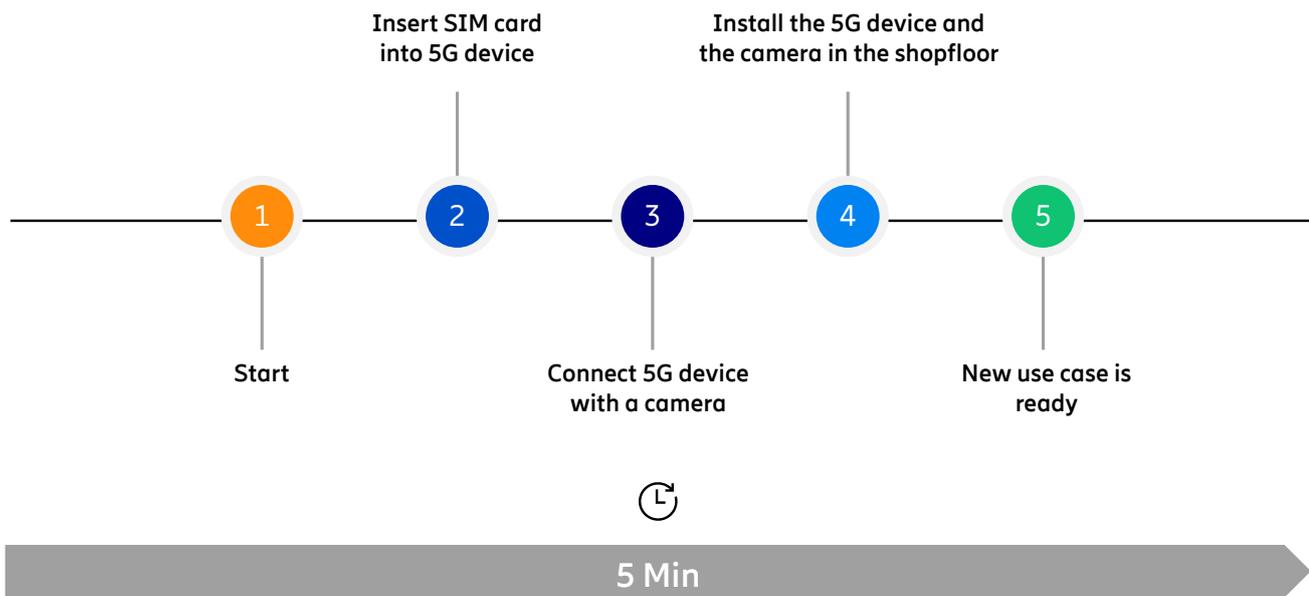


Figure 1: Enable use case on 5G

## Wi-Fi

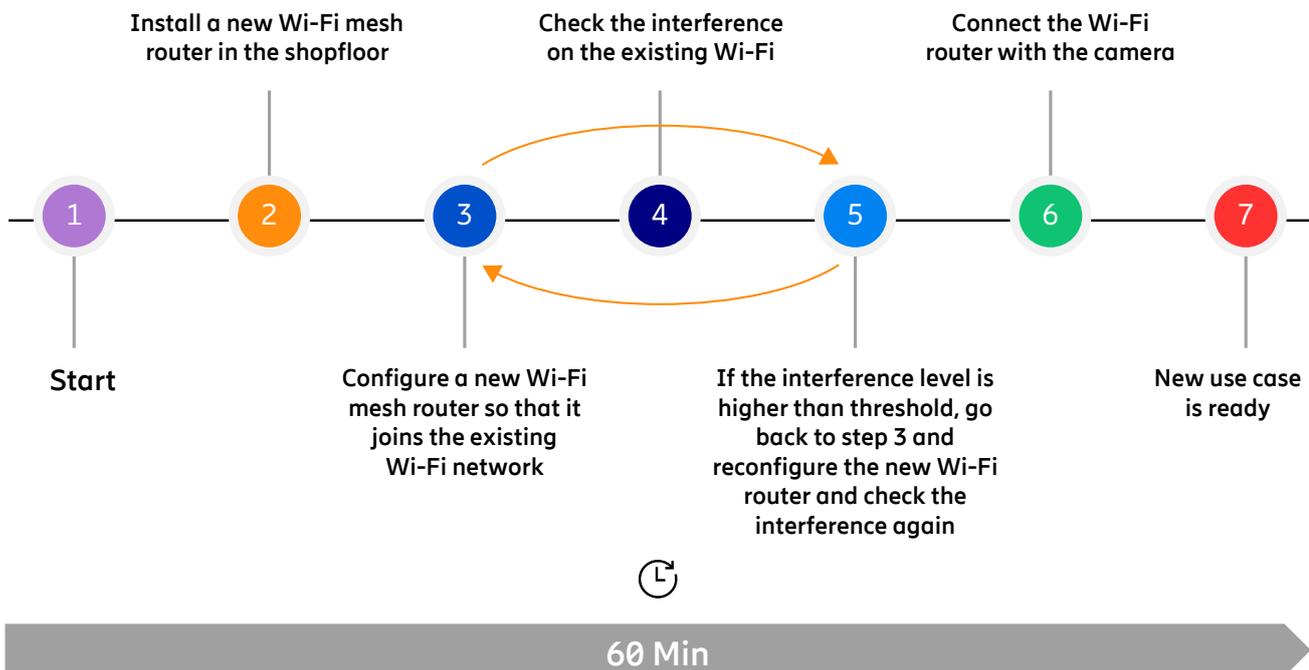


Figure 2: Enable use case on Wi-Fi

## Global car manufacturer

We're providing insights into a high-availability deployment within a European manufacturing environment, operational since the beginning of 2022 in a business-critical 5G rollout.

### Flexible and optimized general assembly increases output significantly

The car manufacturer employs Ericsson Private 5G to minimize downtime and optimize its general assembly line. This is achieved by connecting AGVs, battery-powered nutrunners, and mobile screens. This transition also introduces a more flexible way of working. These transformative use cases, detailed below, have enabled a doubling of car assembly output from the factory. Additionally, this solution proves more cost-effective, requiring eight to ten times fewer access points compared to Wi-Fi.

#### 24/7 performance by 5G-connected AGVs

Previously, the manufacturer faced unstable and unreliable connectivity in its general assembly processes, with AGVs connected by Wi-Fi. Due to Wi-Fi's inherent limitations, the AGVs occasionally lost connection, resulting in halted production lines. This issue led to severe productivity and business challenges, negatively impacting customer service and satisfaction.

Transitioning to 5G connectivity significantly improved the general assembly process, offering smoother, more reliable, and faster operations. This change drastically reduced production cycle times, allowing the AGVs to operate round the clock, ensuring superior reliability and coverage.



#### Enhanced product quality with 5G-Connected Atlas Copco Nutrunners

Connected nutrunners play a vital role in maintaining the quality of tightening bolts with precise torque and angle control. They also record and store data as documentation of the bolt-tightening process's quality.

Manufacturers previously encountered connectivity issues with existing battery-powered tools. These problems resulted from either inflexible setups requiring cables from the tool to the control box or erratic Wi-Fi connectivity. Wi-Fi-related challenges included varying load on access points and obstructions in the line of sight between the access point and the tool, often caused by people passing by. In response to

these issues, the tools would seek alternative access points, causing production interruptions.

Manufacturers sought a more reliable solution and experimented with connecting nutrunners through 5G. This change enabled the use of tools reliably around the clock, ensuring continuous and seamless production. As a result, customers began requesting Atlas Copco to connect their commercial nutrunners through 5G due to their superiority compared to other technologies.



Operator working with Atlas Copco nutrunner

#### Mobile screens support the mobile team

The manufacturer further optimized workflow by consolidating workstations in the general assembly, creating a mobile operator team. This shift in assembly methods utilized mobile screens to deliver work instructions based on the operator's location within the process.

### Key characteristics

The system operates within a 100 MHz industry spectrum (3.7 – 3.8 GHz) for which the customer obtained a license from the regulator.

The engagement commenced with a trial system, comprising an Ericsson Private 5G (EP5G) Network Controller with a 1x 8 Dot radio package and a macro radio for outdoor coverage. The initial system configuration was in mixed mode: 20 MHz of the 100 MHz industry spectrum was allocated for creating a long-term evolution (LTE) coverage, while the remaining 80 MHz was allocated to establish a 5G standalone (SA) coverage.

The customer opted for mixed mode (4G + 5G SA) initially due to the availability of specific devices that only supported 4G at that time.

## Trial phase

The overall project followed a standard project plan.

In this specific case, the customer took care of the initial radio planning.

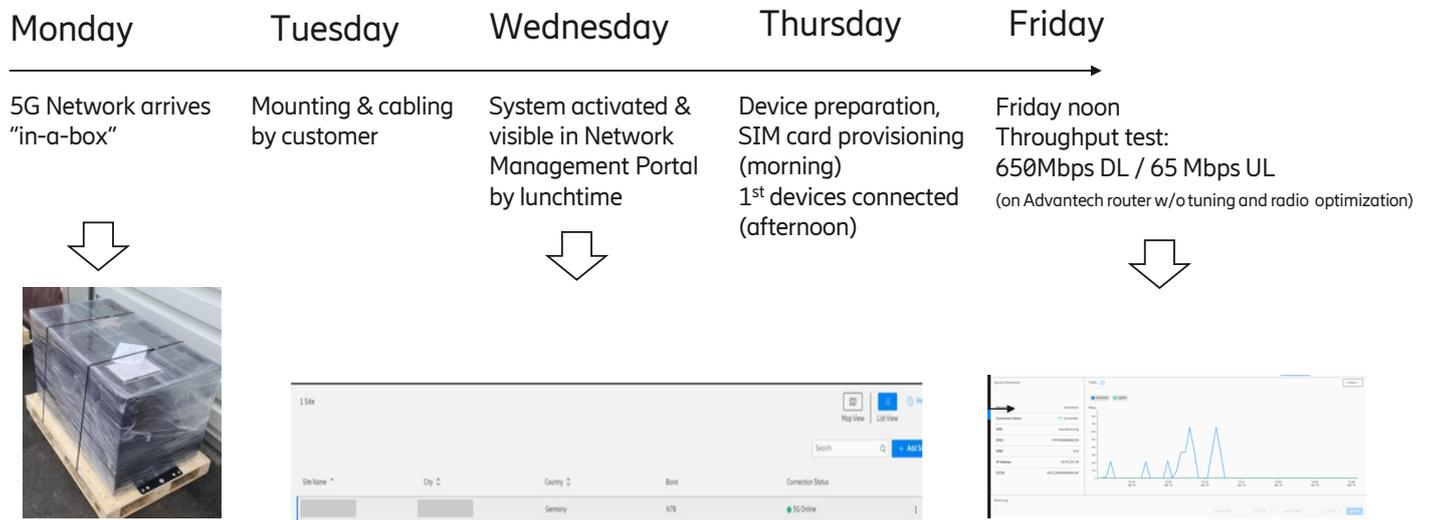


Figure 3: First week after the arrival of hardware

Figure 3 shows the activities during the first week after EP5G hardware arrived onsite. The customer spent 1.5 days installing the RAN and Compute hardware in the already prepared locations (that is, Main Distribution Frame (MDF) and Intermediate Distribution Frame (IDF), as well as the mounting brackets for Ericsson Radio Dots (indoor antennas)).

On day three at noon, the site went online and became visible in the EP5G Network Management Portal, and activation was started. During activation, the initial software is

downloaded and installed automatically on the core network servers and the baseband unit.

On day four, the first SIM cards were provisioned and tested with some devices. Those devices connected to the network and became visible in the EP5G Network Management Portal.

On day five, the acceptance test procedure was executed, and the system was accepted by the customer.

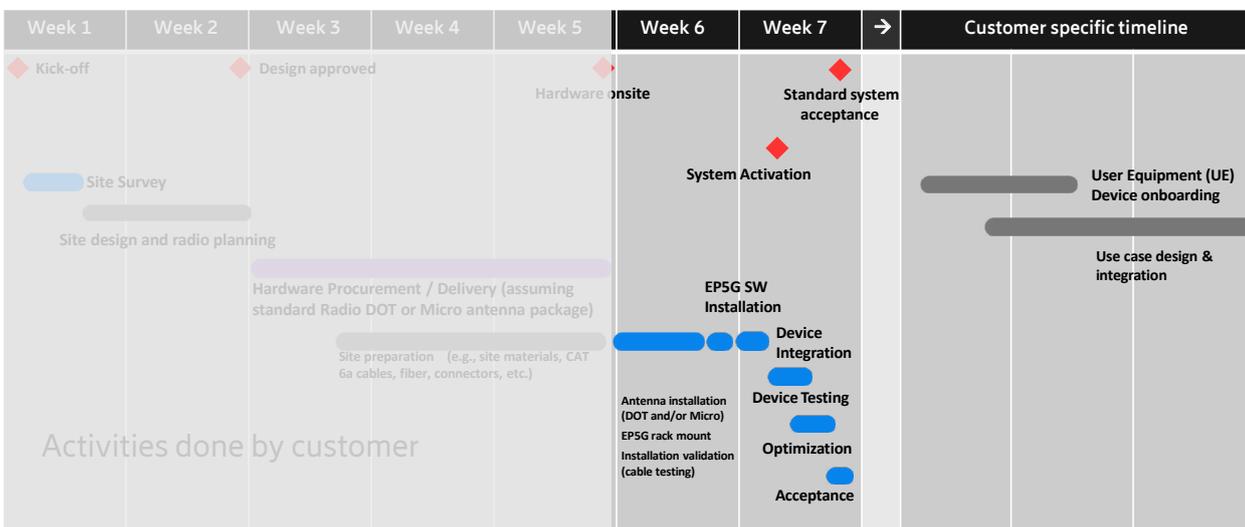


Figure 4: Customer took care of radio planning and pre-installation

During the first three months, the following use cases were tested:

- tunneling latency-sensitive layer 2 Profinet/Profisafe traffic through 5G.
- connecting wireless nutrunners over 4G/5G SA.
- connecting wireless outdoor video surveillance cameras for perimeter security.

All use cases were tested successfully, and the customer was satisfied with the reliability and stability of EP5G.

During the trial phase, the customer switched from mixed-mode to single-mode 5G SA in the full 100 MHz industry spectrum since, in the meantime, 5G SA prototypes of the wireless nutrunners became available from Atlas Copco. Here, Ericsson's device ecosystem expertise played a key role in testing the first 5G SA prototypes from Atlas Copco and helped to fix initial issues caused by an outdated modem firmware.

## Commercial operation

After successfully testing the use case on a system that was running stably for four months since installation, the customer decided to upgrade to a commercial system to further extend the coverage and add RAN resiliency for business-critical operations.

Wi-Fi was ruled out by the customer since it was not able to provide the required reliability and performance.

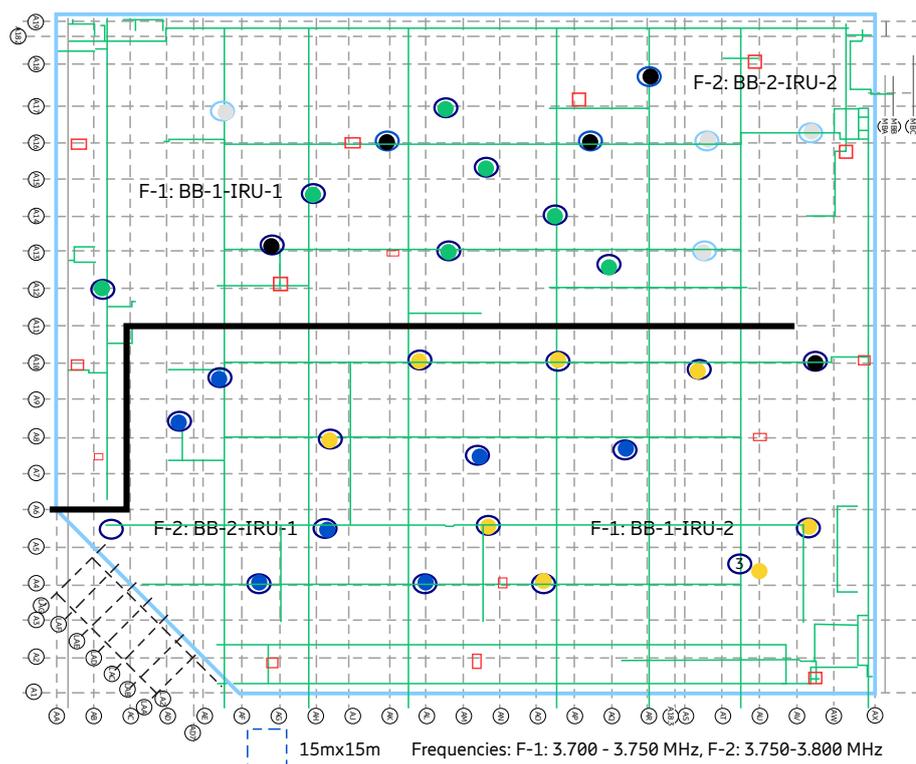
EP5G is now providing reliable 5G coverage for a business-critical step in the overall manufacturing process.

## High-level design of the deployed commercial system

Key requirements for the commercial system were:

- providing reliable coverage for two shop floors, each about 10,000 m<sup>2</sup>, with particularly good coverage within about 8,000 m<sup>2</sup> with Reference Signal Received Power (RSRP) in the -70 to -90 dBm range
- additional outdoor coverage for connecting wireless video surveillance cameras and for backhauling traffic from ad-hoc Wi-Fi access points for remote construction sites

## Redundancy



The figure on the left shows a floor plan of the two shop floors (north and south, separated by a firewall) and the locations of radio dots, marked by coloured dots.

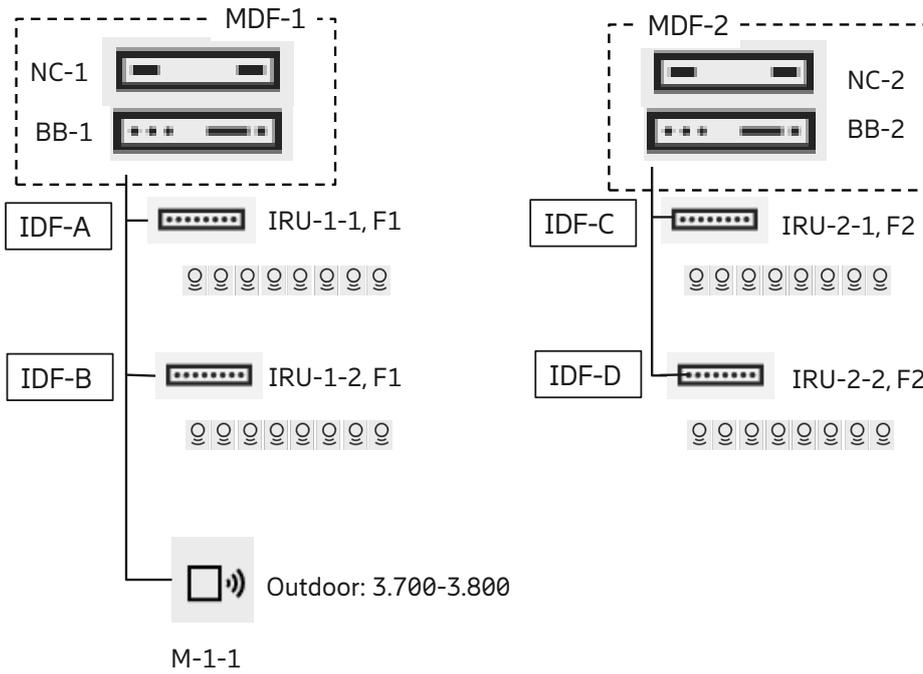


Figure 5: RAN Resilient deployment

In the deployment shown in Figure 5, one core network server plus one baseband is installed in two separate MDFs (see right-hand side). Each of the two MDFs is in a different fire protection zone, and each MDF gets electricity from a different electricity provider. The equipment is deployed in a high availability configuration. In this way, the risk of core

network server failure due to fire and power outage is mitigated.

The network is using an Ericsson EP5G system in a large configuration with a fully redundant core network component (active-active mode).

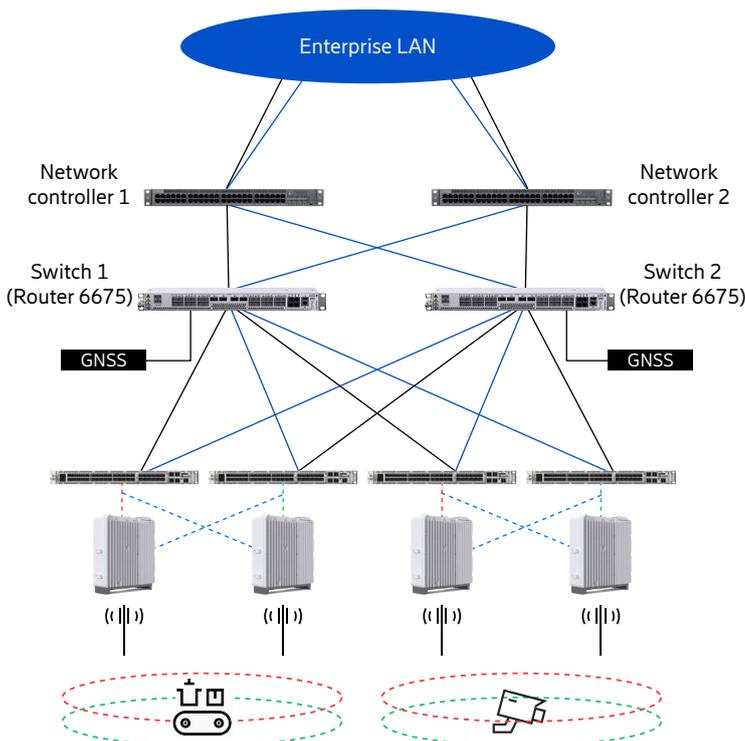


Figure 6: Deployment architecture

To ensure seamless connectivity in case of a radio component failure, the available spectrum has been split across two 50 MHz blocks (3700-3750 and 3750-3800), each served by a separate baseband and radio unit.

The time division duplex (TDD) pattern used is DDDSU, a transmission pattern describing 75 percent downlink and 25 percent uplink (S=10:2:2).

Also, the radio coverage was designed for high availability. The RAN coverage is provided by two overlapping 50 MHz cells. Figure 6 above shows the positions of the Ericsson Radio Dots and which cell (blue, yellow, black, green) they are broadcasting.

If one of the MDFs is hit by either fire or a power outage, the equipment in the other MDF still provides Coce and radio services. For example, if MDF-1 is hit by a disaster, Network Controller 1 (NC-1) and Baseband 1 (BB-1) will fail. However, Network Controller 2 (NC-2) and Baseband 2 (BB-2) will still

be up and running. This means that in the southern part, the blue cell will still provide coverage. In the northern part, the black cell will still provide coverage.

This setup allows the use of the full capacity during normal operation where user equipment (UE) can attach to either frequency or at the same time offers redundancy over two cells in case one part of the radio equipment fails. All critical traffic (AGVs) is served by one cell.

The figure 7 below shows the configuration of two basebands. Baseband 1 has two channels defined: one 50 MHz channel and one 100 MHz channel, both configured for 5G new radio (NR) in Band n78.

Channel 1 uses the lower part of the industry spectrum (that is, 3.700 – 3.750 GHz), whereas channel 2 uses the full 100 MHz (that is, 3.700 – 3.800 GHz). Channel 2 is used for 100 MHz outdoor coverage, whereas Channel 1 is used for creating resilient indoor coverage.

<b>Baseband 1</b>	
Baseband Model	6631
<b>Channel 1</b>	
Communication standard	5G
Band	n78
Bandwidth	50 Mhz
Frequency Assignment	3700.01-3750.01
NR-ARFCN	648334
TDD Mode	3 - DDDSU
TDD Sub Mode	3:8:3
Indoor Radio Units	2 - 88Rb
Radio Dots	44Ar B78L
<b>Channel 2</b>	
Communication standard	5G
Band	n78
Bandwidth	100 Mhz
Frequency Assignment	3700-3800
NR-ARFCN	650000
TDD Mode	3 - DDDSU
TDD Sub Mode	3:8:3
Radio Dots	1 - 4422 B43

<b>Baseband 2</b>	
Baseband Model	6631
<b>Channel 1</b>	
Communication standard	5G
Band	n78
Bandwidth	50 Mhz
Frequency Assignment	3749.99-3799.99
NR-ARFCN	651666
TDD Mode	3 - DDDSU
TDD Sub Mode	3:8:3
Indoor Radio Units	2 - 88Rb
Radio Dots	44Ar B78L

Baseband 2 has only one channel, which is also a 50 MHz channel but in the upper part of the industry spectrum.

Figure 7: Baseband configuration

## Tunnelling Layer 2 PROFINET/PROFISAFE traffic over 5G

The main use case for the deployment in the southern part is tunneling of Profinet/Profisafe layer traffic over 5G is supporting about 50 Profinet/Profisafe endpoints and connecting about 50 human machine interface (HMI) screens wirelessly.

Profinet/Profisafe tunneling is achieved using products from the Siemens Scalance family. The HMI screen connectivity is established with devices from Tangent, which are connected to a Cradlepoint (a company, which has been acquired by Ericsson) wireless 5G router.

The primary users of this connectivity are AGVs of varying sizes, both large and small, each assigned different tasks (for example, small AGVs are used for material and parts supply) and connected to a Siemens Simatic (S7) control and safety environment.

The large AGVs each employ three UES, one for critical ProfiNet control traffic (User Datagram Protocol [UDP]), and two for HMI operation. ProfiNet traffic operates at 330 bytes per packet, with data transmitted every 128 ms on both uplink and downlink. HMI transmission control protocol (TCP) traffic is generated upon interaction, with typical observed values of approximately 360 kbps (uplink) and 290 kbps (downlink).

The larger number of small AGVs utilizes only one UE, carrying ProfiNet control traffic (UDP) with the same metrics as the control traffic on the large AGVs.

Additionally, the manufacturer has deployed surveillance cameras along the outdoor perimeter, connected to the network through a Cradlepoint R1900 5G router.

Logs consistently indicated an average roundtrip time of approximately 25ms, which meets the Profinet/Profisafe configuration requirements for this use case (that is, 128 ms cycle time with three cycles without IO data).

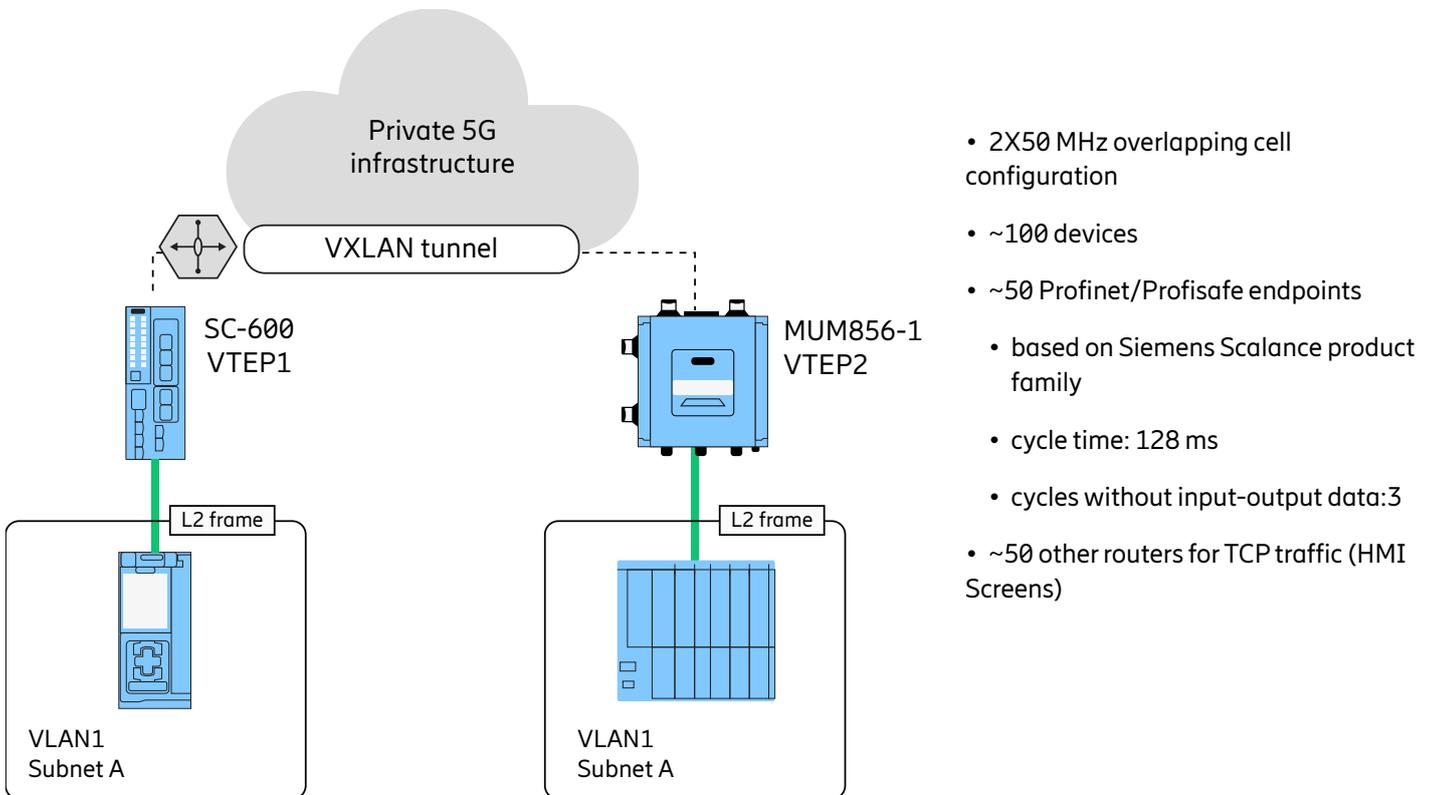


Figure 8: Use case: Tunneling Layer 2 Profinet/Profisafe traffic through 5G

## Advanced connectivity at greenfield gigafactory

Decision makers investing in a greenfield gigafactory explored ways to leverage the latest technology to enhance the working environment for employees, from the shop floor to the offices. It was concluded that advanced connectivity is key to realizing a digital IT/OT architecture. 5G and edge computing are essential enablers of future-ready advanced connectivity to meet business and sustainability goals.

### Transform the way we work and meet business goals

The decision-makers wanted to explore how different personas could benefit from the private 5G solution for their different responsibilities. Ericsson has suggested use cases and technology for an extensive set of roles within the factory, and below we outline a couple of examples.

- The production operator's role involves monitoring equipment for production and product quality. This is achieved by utilizing 5G-connected sensors and cameras. The more data points that can be monitored and analyzed, the better equipment uptime and product quality can be ensured. Analyzing the received data will require AI analytics, and for camera data, vision solutions can be employed. Upon receiving the analyzed results, such as detected faults or issues, the operator can take action. For instance, they can adjust parameters using a 5G-connected, ruggedized tablet and communicate with colleagues through a 5G-connected cellphone to coordinate new updated instructions.
- The maintenance operator uses the output from the sensors and devices attached to the production equipment to predict when maintenance should be performed on their assets. The operator can utilize 5G-connected augmented reality (AR) glasses, complete with a repair manual, and access remote guidance from vendor experts.
- An external maintenance worker, upon arrival at the plant, can install an eSIM and gain access to specific areas using a QR code and pin code. They can inspect equipment using 5G-connected cellphones or tablets and take action on identified issues. The external maintenance worker can also connect with remote experts to analyze problems.
- The office worker can access the company's internal production data through 5G-connected laptops. With the 5G-enabled Manufacturing Execution System (MES), this individual can remotely monitor the production process and, based on real-time data, manage inventories, handle customer inquiries, and more.

## Creating an advanced connectivity blueprint for Industry 4.0 with 5G and edge technologies

Advanced connectivity plays a crucial role in achieving a digital IT/OT architecture, and 5G and edge technologies are vital facilitators for future-ready advanced connectivity, aligning with business and sustainability objectives.

Accelerating Industry 4.0 is attainable through rapid deployment of use cases aimed at process monitoring and control capabilities. The integration of wireless 5G sensors, cameras, devices, and gateways, coupled with data exposure through application program interfaces (APIs), along with analytical solutions, enhances visibility into key performance indicators, enables remote diagnosis, and facilitates recommendations for improvements.

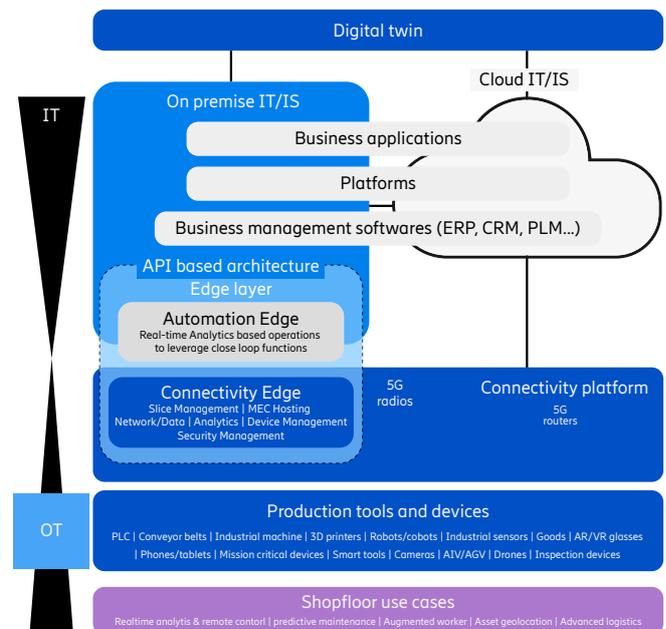
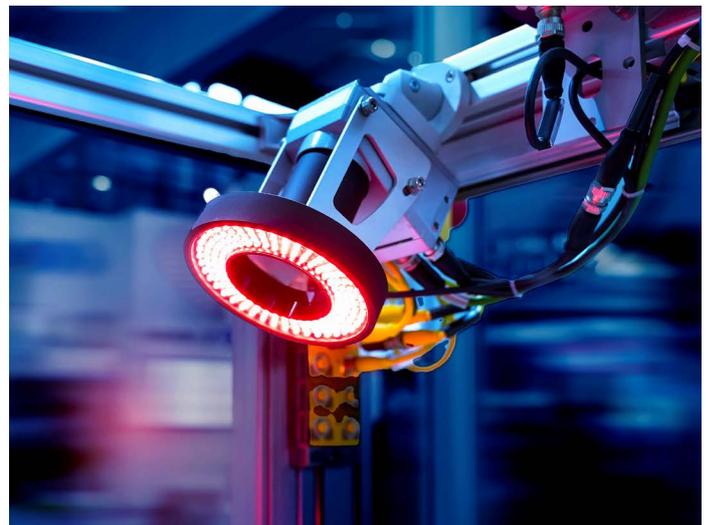


Figure 9: Industry 4.0 blueprint for 5G and edge



# Nestlé

## Imparting knowledge and safety through immersive learning and collaboration

Nestlé has been exploring immersive learning and collaboration using AR and virtual reality (VR) applications for training and employee onboarding. This solution enhances awareness of potentially hazardous areas on the factory floor, offers a 360-degree tour of the company premises, and provides interactive scenarios for assessing employee behavior. Their Immersive Learning & Collaboration application demonstrates how extended reality can bring several advantages to the factory floor, including accelerated learning, cost-effective training, reduced machine downtime, and an improved safety environment.

Initially, Nestlé ran the VR application locally on the VR headset without a 5G connection, leading to issues like lagging and image distortion, which adversely affected the overall VR user experience. Consequently, there was a need to enhance the user experience further by utilizing higher-resolution images, enabling more dynamic interactions among avatars in the virtual environment, and providing the convenience of using wireless and lighter devices. Ericsson Private 5G played a crucial role in achieving these objectives, allowing Nestlé to fully leverage the benefits of the solution for these high-network-demanding XR use cases.

As a result, their cloud XR server, powered by Ericsson Private 5G, flawlessly rendered VR content, delivering high-quality visuals that matched the user's perspective with realism and without any lag or latency, ensuring an exceptional quality of experience.

## General requirements and system implementation

The overall objective was to experience how 5G can uniquely offer low-latency and dependable communication for demanding immersive learning and collaboration scenarios. Furthermore, the aim was to assess the performance of running a VR remote rendering application on a cloud XR server through an Ericsson Private 5G network, comparing it with local VR rendering applications on VR headsets.

It was crucial that the technology could be transmitted remotely by the 5G signal. This could be achieved using VR glasses or a tablet. This approach ensures that application processing occurs remotely, and the network is tested with a substantial volume of data originating from:

### 1. XR application features:

- 3D digital representation of Nestlé production line (molding machine)
- immersive interactivity in real-time
- synchronized VR multilayers

### 2. Network features

- compute offloading, that is, low latency and high throughput to enable XR devices to offload VR rendering to the XR cloud server
- XR multiplayer, that is, low latency and reliable communication to secure synchronization and interaction between XR multi-user's

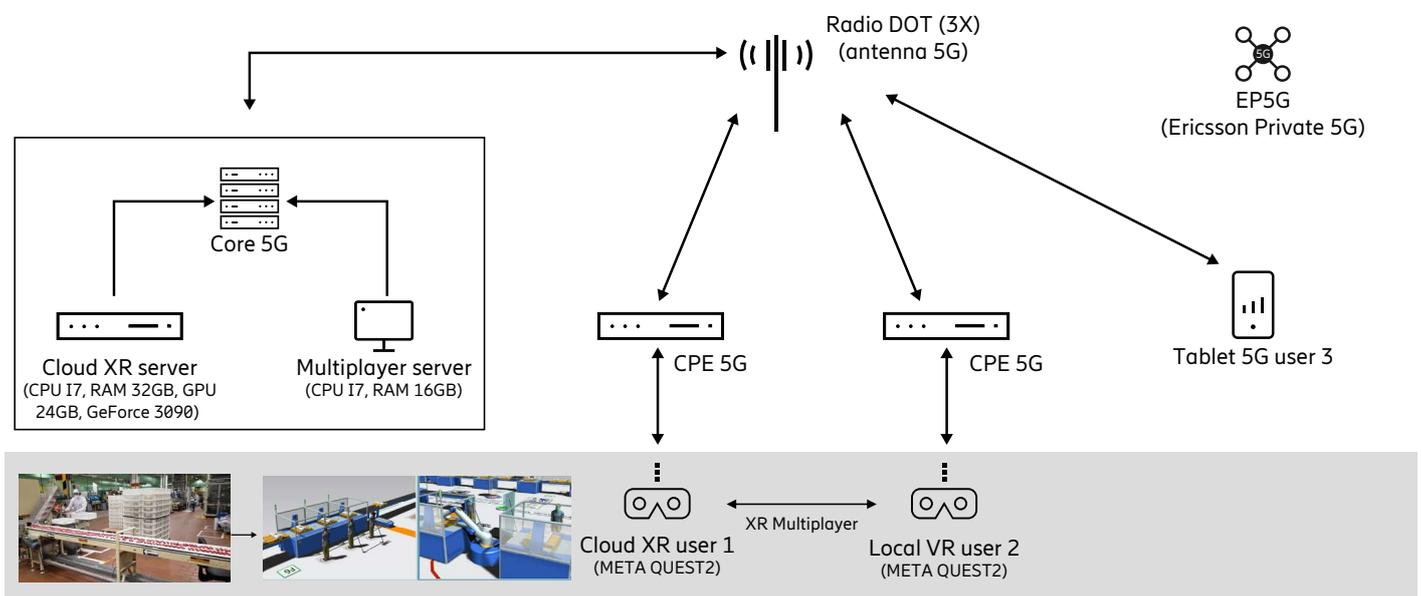


Figure 10: The architecture for the Nestlé immersive case

## Ericsson USA 5G Smart Factory

### 5G connects AMRs improve productivity

AMRs are evolving from single AMRs with static paths and tasks to more intelligent ones equipped with advanced onboard capabilities and additional resources. The goal is to implement a central AI-powered computing system that utilizes real-time information from AMRs and external sensors to autonomously manage the fleet, enabling a flexible production flow.

At the Ericsson USA 5G Smart Factory, AMRs are employed in the production line to enhance material flow efficiency. The factory has identified several requirements that are addressed through the introduction of AMRs:

- the ability to plan batch production in a more flexible way
- separation of the final assembly line
- the possibility to make changes to the production line in a seamless manner
- minimized downtime of machines and processes
- addressing workforce shortages in material handling

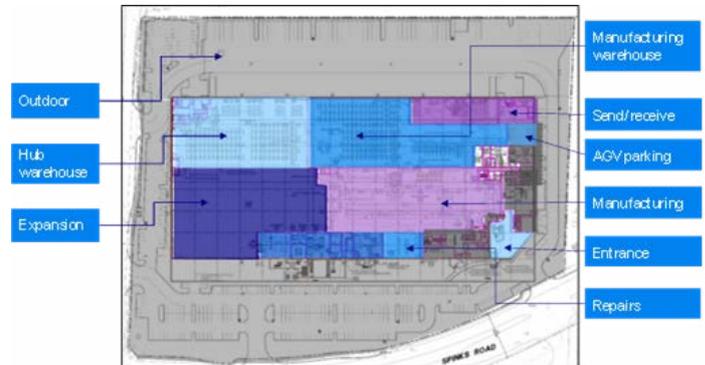
To select the proper AMR, the factory initially defined the specific tasks the AMR needed to perform, identified the materials it would handle, and determined the area it would cover. An analysis was then conducted of various AMR types and connectivity options explored, including Wi-Fi, LTE, and 5G. After careful evaluation, it was concluded that opting for 5G would only require two 5G radios, a significant reduction compared to the 20 Wi-Fi access points, while still meeting latency and jitter requirements.

The 5G network offered several advantages, including fewer handovers, a reduced number of trouble spots, and less need for manual intervention due to its stable connectivity. AMRs connected through 5G demonstrated improved efficiency in material handling, achieving higher throughput and speed while maintaining safety standards. The benefits were reliable connectivity, increased bandwidth, lower latency, and the utilization of real-time data to update maps for optimal performance.

### Lewisville deployment

The Ericsson USA 5G Smart Factory, located in Lewisville, Texas, specializes in producing 5G and advanced antenna system radios designed to enhance network capacity. This cutting-edge facility boasts robust and secure cellular connectivity, with the goal of connecting all critical production systems through cellular technologies.

The highly automated factory serves as a model for leveraging smart manufacturing techniques to enhance efficiency and boost production through automation and Industry 4.0 principles.



Picture: Different areas of the factory covered by the 5G private network

To further enhance and expedite automation and efficiency initiatives, the smart factory employs two different spectrum types tailored to specific use cases and areas.

The first 5G private network employs 5G mmWave licensed spectrum obtained from a communications service provider. This mmWave deployment operates in non-standalone (NSA) mode, necessitating an LTE anchor for initial connectivity signaling. The 28 GHz mmWave private network coverage is facilitated by Ericsson's proprietary Streetmacro radios manufactured within the factory, along with Ericsson Radio Dots handling the LTE anchor band.



Picture: Streetmacro and Ericsson Radio Dots in the production area, constituting the mmWave NSA network.

The second private network is an LTE CBRS network that utilizes Ericsson Radio Dots, catering to lower bandwidth-intensive use cases such as the building management system (energy/environmental monitoring) and other sensors. CBRS, a USA-specific frequency band known as B48, enables LTE and 5G private networks without the need for mobile operator services. This band is regulated by the Federal Communications Commission (FCC).

AMRs represent an evolution from automatic guided vehicles (AGVs) and have become increasingly vital in modern manufacturing. The AMR fleet manages material movement, transporting parts and components to assembly lines, and also plays a role in the production process by transferring products between stations. This decouples various aspects

of production, assembly, and testing, enhancing production efficiency and line balancing.

Ericsson collaborated with the AMR vendor to retrofit 5G technology, enhancing the speed and efficiency of the AMR fleet. The initial sizing of the AMR fleet involved digital simulations to simulate production capacity. To enhance efficiency further, 5G mmWave Inseego gateways enabled the AMRs to utilize the stable radio frequency (RF) connection and ample bandwidth of 5G. This, in turn, facilitated software improvements for optimizing AMR path routing through sensor sharing and real-time map updates.

The Ericsson USA 5G Smart Factory serves as a testament to how 5G in a manufacturing environment can function as an innovation platform, driving smarter automation.



# Ericsson Private 5G



## The solution you need

Across industry segments the main questions, when looking for a private network, are often similar:

- How can it be integrated in existing production/systems?
- Is quality good enough for industrial protocols?
- Will it scale?
- Will I get coverage in my specific scenario?
- Are private networks secure?
- What will it cost initially and over the long-term?
- How can I optimize my network?

## Integration and fit

EP5G is tailored to align with industries' progression, from initial Proof of Concepts (PoC) to comprehensive full-scale implementations (learn more [here](#)).

The operation and management can be conducted through the provided Network Management Portal. The system's management is designed for OT/IT operations and can also be achieved by integrating APIs into existing operational control solutions. The API capabilities are continually expanded to align with users' needs under the Advanced Management Initiative.

The Network Management Portal simplifies the complexity of a cellular network as per 3GPP standards. Operating the

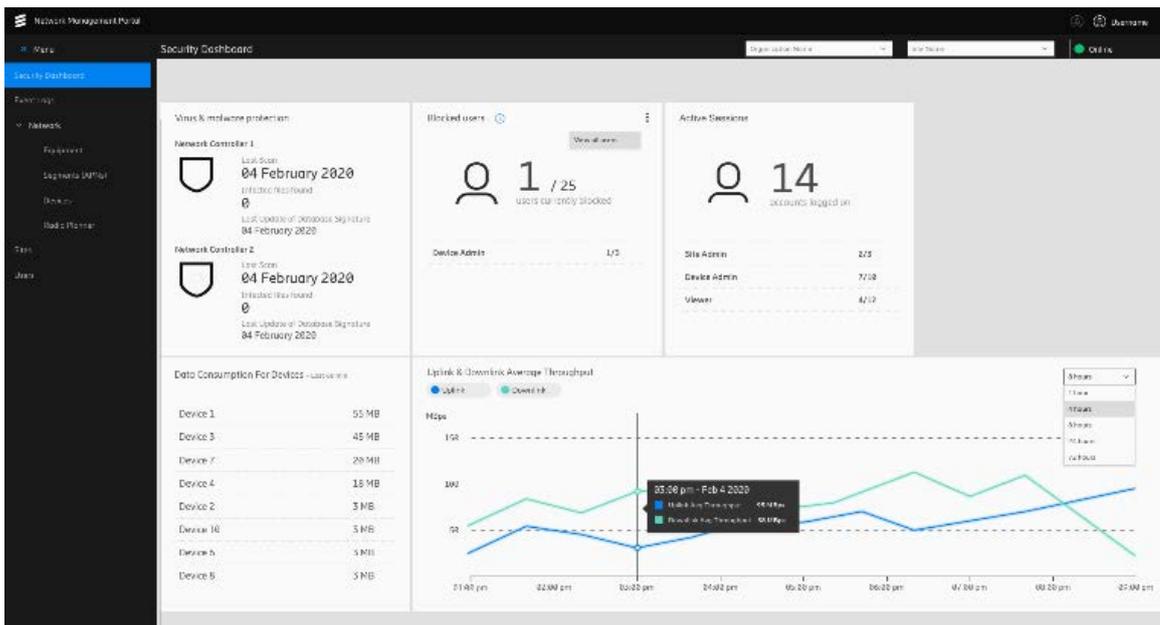


Figure 11: Network management portal

network, defining devices, and adjusting quality settings becomes straightforward, requiring no specific cellular knowledge or expertise.

Since EP5G supports 4G, 5G SA, and both in dual mode, it can address current limitations on cellular devices. This means that 4G devices can be used concurrently with 5G devices.

## Quality of service and industrial protocols

The use cases for a private network extend beyond those of other wireless technologies. A common question often asked is whether the network is compatible with industrial protocols.

EP5G is demonstrating in operational use with our customers that the provided quality meets the requirements for Profinet/ Profisafe and similar industrial protocols. EP5G is therefore suitable for a wide variety of high-demand use cases.

The built-in quality management allows for the separation of critical traffic and the protection of the required latency and capacity to ensure stable quality for high-demanding applications.

This quality management also enables the operation of multiple use cases with various quality requirements in parallel. Incumbent wireless technologies often cannot provide the required quality for different use cases.

## Scaling

EP5G is designed to scale with your demand, from a simple PoC installation to a full-scale utilization in a multi-site production environment.

The RAN installation can expand as needed, and even distributed setups across multiple sites are possible. The network controller hardware, which hosts the core, comes in different sizes to accommodate installations of various sizes. Each size offers substantial capacity to accommodate future expansion.

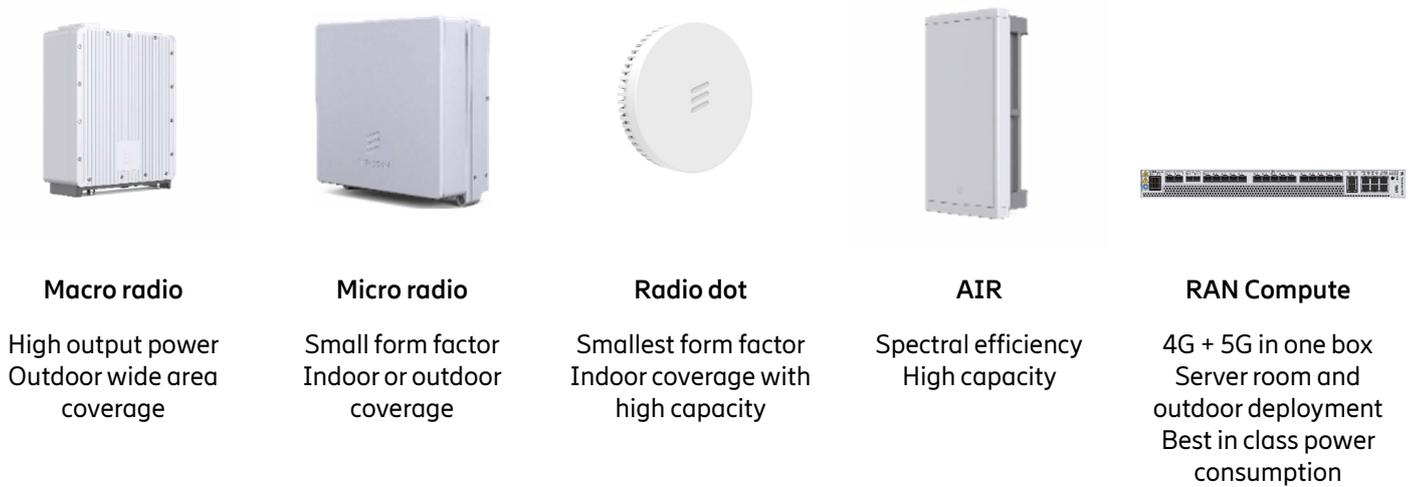
The management solution enables quality protection, allowing the parallel deployment of many use cases and services while reserving capacity and bandwidth for critical and high-demanding use cases.

## Coverage

Compared to non-cellular wireless solutions, private networks offer multiple advantages. Due to varying regulations on transmission power and available radio bands, cellular solutions function effectively in complex environments. EP5G is utilized in complex process industries characterized by a high density of metal, machinery, and obstacles. It is also deployed in small, winding tunnels in mining operations and in high-ceiling open-floor factories.

With Ericsson's RAN portfolio, EP5G provides the ideal solution tailored to site requirements, usage scenarios, radio bands, required bandwidth, indoor or outdoor settings, and

## Overview of Ericsson EP5G Radio indoor and outdoor portfolio



the country of operation. Ericsson’s radio portfolio is globally recognized and covers all relevant aspects for your specific operational site.

Any limitations in the radio portfolio can restrict placement options and achievable coverage. Often, to compensate for such limitations, numerous access points need to be deployed. Ericsson’s world-class radio portfolio eliminates these restrictions, offering the right radio option for each unique purpose.

## Security



Figure 12: Main security areas

A private network empowers a company to independently manage critical elements such as quality settings, device and service prioritization, and access control. No new device can gain entry without the necessary access, which is managed through SIM cards. Access can be precisely tailored for each device, not only granting general access but also limiting it to specific other devices, device groupings, and services.

Based on the priority of the device and its services, network resources will be allocated accordingly. Particularly in multiuse case scenarios, this ensures that critical operations are never compromised by less important network activities.

This capability enables the attainment of critical quality levels required for automated processes, industrial protocols, or remote control of machinery. It safeguards critical business operations while allowing for a shared network accommodating multiple use cases and devices. Unlike alternative technologies that demand strict exclusion of any other use case to ensure minimal quality assurances, Private Networks can support a wide range of use cases, users, and devices without compromising quality levels for critical applications.

With access control both to and within the network, as well as control over outgoing network activities, operational data is protected and secured. Security features continuously monitor for breaches and facilitate the prevention of malicious access and activities.

Given the paramount importance of operational security, EP5G provides a suite of security features to monitor the system and the integrity of connected devices. Intrusion detection and malicious activity detection are fundamental components. Mechanisms to prevent cyberattacks are reinforced by services that monitor global 3GPP security, offering updates and information.

Device authentication is ensured through SIM/eSIM, offering greater security than most competing technologies.

The solution itself is inherently robust, rigorously tested for vulnerabilities, and subjected to penetration tests. Strong encryption is integrated, even in the over-the-air interface. This guarantees the end-to-end security essential for integrating this system into critical production processes.

## Future-proof investment

In comparison to existing non-cellular wireless technologies, the limitations on emitted energy lead to a high density of access points (APs) required for area coverage. Each AP demands cabling for data and power, resulting in additional installation, operation, and maintenance costs that scale with the number of APs.

Cellular radios operate under different regulations, granting them increased flexibility in configuring and transmitting signals within the cell. Therefore, significantly fewer radios are needed, reducing costs during both installation and operation.

When considering investments in new technologies, ensuring future-proofing is a key consideration. Cellular solutions are highly standardized through 3GPP to ensure high-quality communications with a wide variety of devices and vendor equipment. This standardization mitigates any risk of vendor lock-in, whether on the network or device side. Application development remains independent; applications can be developed regardless of the networking solution used for signal transmission. While different technologies offer varying transmission quality, application development is not constrained by a private network.

As the adoption of 5G in industry segments is still in its early stages, skepticism surrounds its widespread acceptance in various industries. However, because communication technology is independent of the devices used and the application layer, this question can be generalized across all industries. There is a strong demand for and adoption of private networks in various sectors.

For existing machinery and brownfield adaptation, industrial routers provide the capability to connect to cellular networks. Some tool and machine vendors have started integrating 4G and 5G chipsets directly into their solutions. Especially when you can utilize both 4G and 5G in parallel, as you can with an EP5G, you won't face a shortage of available devices for your application scenarios.

Will cellular networks persist in industries over the next 5, 10, or 25 years? Given that cellular solutions are designed for the long term, they are operationally robust over extended periods. They can support both extreme operational cases without necessitating frequent updates, as well as updates to newer technology, and any moderate approach in between these extremes. New technologies, such as new

cellular standards like 6G or the addition of other radio bands if regulators open new bands for industrial use, can be integrated into cellular solutions to ensure their longevity.

## Optimizing for the industry



The 3GPP standard, developed by the European Telecommunications Standards Institute (ETSI), is a project established in December 1998 that creates specifications for advanced mobile communications, including 5G. 3GPP defines not only the air interface but also all the protocols and network interfaces that enable the entire mobile system, including session control, mobility management, and service provisioning.

An important specification introduced in release number five at the beginning of 2002 is known as IP Multimedia Subsystem (IMS). IMS is a technological architecture for incorporating and providing standardized IP-based services in mobile telephone systems. Its purpose is to link fixed and mobile networks and enable end users to use services regardless of the terminal they use. Ericsson played a significant role in driving the standardization process for IMS.

Today, we benefit from the well-defined specifications of this standard. In Ericsson Private 5G (EP5G), we can seamlessly integrate multiple devices while differentiating their quality of service (QoS) using a range of customizable parameters. Network administrators can tailor connectivity to precise specifications.

A notable feature is the ability to easily add devices to the network infrastructure and categorize them into classes based on QoS requirements, a concept called segmentation in EP5G. This optimization of network resources ensures that each device receives the level of service it demands.

Cellular technology excels at efficiently managing numerous devices concurrently, primarily through various scheduling techniques. Cyclic recurring resources can be preassigned for a device, while devices with dynamic data flows can be assigned different techniques. Multiple scheduling configurations are also supported in parallel to serve multiple traffic flows. For example, an industrial robot with sensors

and a camera must transmit both time-critical sensor data and less critical information, such as video or updates, allowing for precise resource allocation.

Another example is adjusting the allocated size for data transmissions per segment. In 5G, it is possible to efficiently allocate bandwidth resources, especially if the size of time-critical packets is already known. Manipulating the grant size from the cellular scheduler ensures that critical data streams receive the necessary throughput while accommodating lower-priority traffic.

Additionally, the choice between radio link control (RLC) Acknowledge and Unacknowledge modes adds flexibility to the network. RLC Acknowledge mode guarantees data delivery confirmation for enhanced reliability in sensitive applications, while Unacknowledge mode is more suitable for real-time delivery where retransmission can be avoided to minimize latency.

Furthermore, the capacity to set up different mobility parameters for handover situations increases network adaptability. Handover, involving a device transitioning from one cell to another, requires precise management to ensure service continuity. By configuring mobility parameters like handover thresholds and priorities, network administrators can plan seamless transitions while maintaining QoS.

In conclusion, the ability to incorporate multiple devices into a network, classify them based on QoS requirements, and fine-tune their parameters for data transmissions represents a significant advancement in wireless technology compared to our competitors in the industry. This level of customization empowers 5G owners to effectively cater to diverse user requirements, ensuring a robust, reliable, and adaptable communication infrastructure for the future.

## Ericsson Private 5G services

Ericsson, in collaboration with our partners, offers professional services to assist you through every stage of your private network's lifecycle, encompassing planning, delivery, deployment, operations, and value-added services.

### Planning

Effective planning is crucial for the success of your private network. The planning phase begins with conducting surveys to assess your network requirements and identify the detailed bill of materials to ensure accurate cost estimation and resource planning.

With our partners, we have experienced radio planning professionals who use advanced tools and methodologies to design and optimize network coverage and capacity.

We take into consideration your specific environment, including terrain and building structures, to deliver optimal

network performance to ensure that your private network meets the capacity and performance requirements for emerging technologies, enabling you to leverage the full potential of digitalization.

### Delivery and deployment:

Ericsson's global supply hub facilitates short lead times, ensuring timely delivery and installation of your private network, enabling you to capitalize on its benefits sooner.

Ericsson and our partners have experienced technicians who manage the installation of network equipment, ensuring proper setup and configuration. Technicians conduct acceptance testing to validate network performance and functionality. Ericsson and our partners will also support integration activities to ensure smooth interoperability with your infrastructure.

### Operation

Ericsson provides managed network operations for your private network, allowing you to focus on your core business operations. Our team of experts takes care of network monitoring, maintenance, and rapid incident response.

Ericsson's automated tools proactively identify and address issues before they impact your operations, ensuring maximum uptime with guaranteed service level agreement (SLA) and providing you peace of mind.

Ericsson also provides software upgrade and update services to keep your network current with the latest technologies, features, and security patches.

### Value-add services

**Demo services:** Ericsson offers demo services to help you experience our solutions firsthand, giving you the opportunity to explore different use cases. This allows you to gain confidence in the capabilities and benefits of private networks, evaluate the fit of our solutions within your organization and make informed decisions before committing.

**Training:** Ericsson and our partners provide training programs to equip your team with the necessary knowledge and skills for network management and operation. Our expert trainers deliver programs that cover various aspects of private network planning, deployment, operation, and optimization.

**Radio optimization:** If the coverage or capacity requirements of the network change, radio optimization ensures optimal performance of the network.

By leveraging our expertise and specialized tools, we can identify and resolve issues such as coverage gaps, signal interference, and capacity constraints, ultimately optimizing network performance and enhancing user experience.

# Ecosystem and Partners



By partnering with Ericsson, you gain access to our extensive knowledge in telecommunications for industrial applications, enabling seamless integration with legacy and new systems.

Partners within the ecosystem are leaders in their respective industries. From operations technology partners to cloud providers, Ericsson partnerships work to reduce complexity, collaborating with hardware, software, and professional services partners to ensure end-to-end solutions for your manufacturing operation.

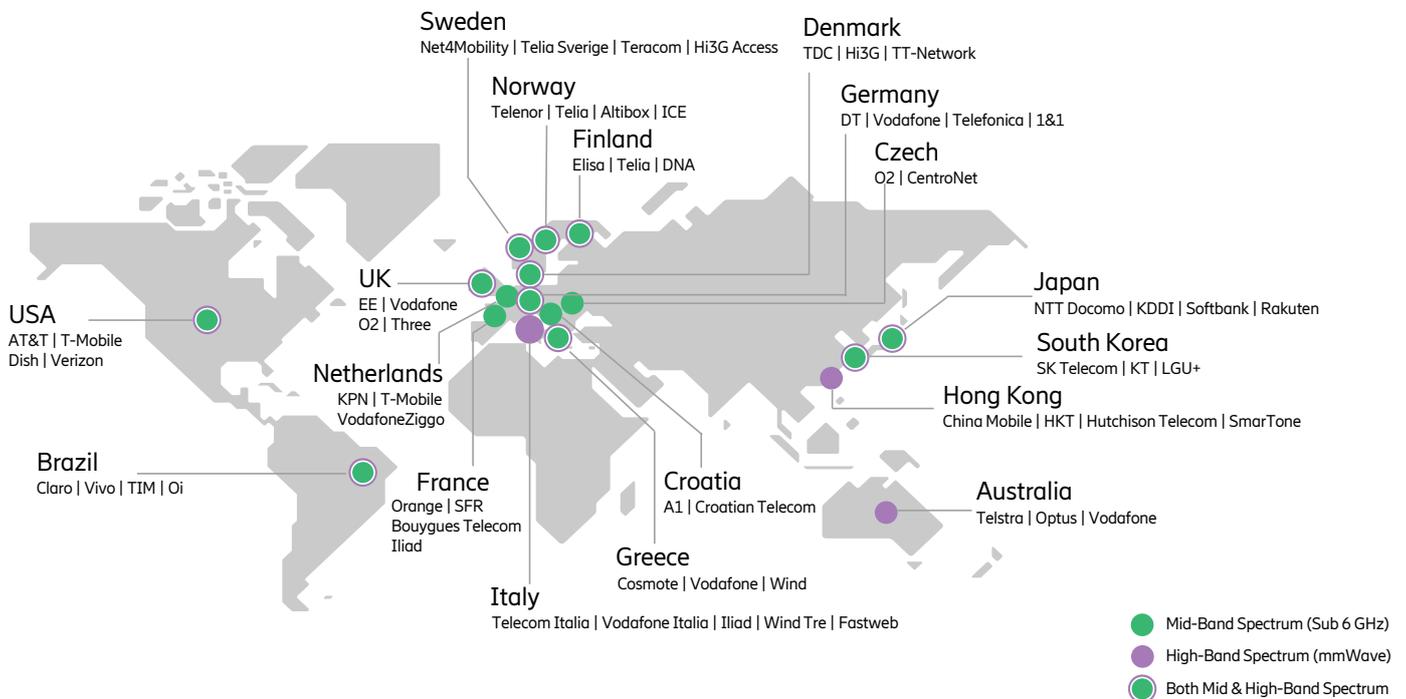
Through integration with each partner, Ericsson reduces complexity and time-to-market, while ensuring reliability and robustness with our industrial-grade, certified solutions, allowing you to tap into new opportunities and drive digital transformation.

Explore solutions from the Ericsson Industry 4.0 partner ecosystem on [Ericsson Partner Marketplace](#).

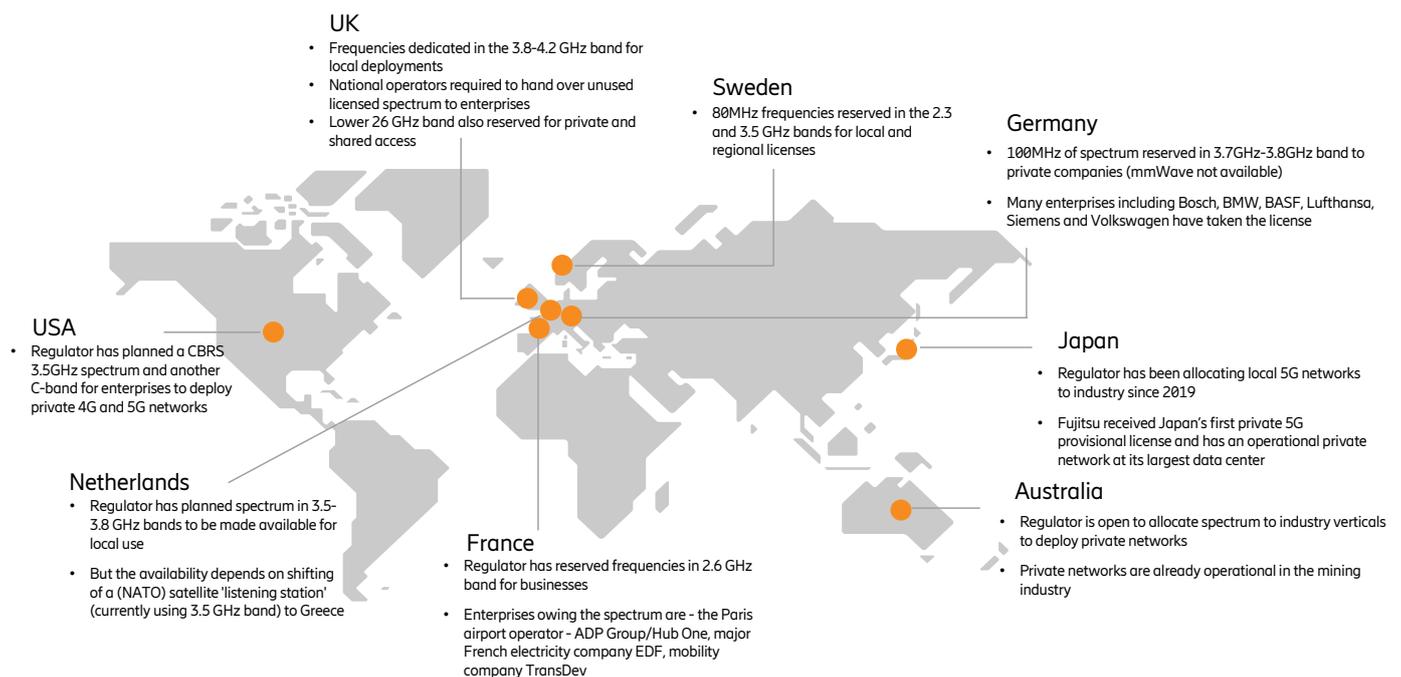
# How to get started

In this chapter, we will explore the initial steps necessary to embark on your private 5G journey. Discover how to acquire spectrum, establish contact with a reseller, and delve into the essential aspects of radio planning.

## Spectrum



Countries with CSPs having option or obligation to lease local spectrum



## Countries with local spectrum licensing option directly to Enterprises

Spectrum refers to the range of frequencies used for transmitting and receiving data wirelessly.

5G and Wi-Fi utilize different portions of the electromagnetic spectrum for wireless data transmission. Wi-Fi operates within the 2.4 GHz and 5 GHz frequency bands, while 4G and 5G offer various frequency options based on geographical regions. Your selection, along with the spectrum availability in your locality, has consequences for site-specific radio planning. It is advisable to research the local spectrum situation early in the project's planning phase.

### Benefits of licensed vs unlicensed spectrum

You will often hear comparisons about the benefits and drawbacks of each radio technology regarding whether they operate in a licensed spectrum.

- high power output – wider coverage
- nobody else is allowed to transmit – no traffic congestion
- on cellular 4G/5G, traffic can be scheduled – deploy thousands of devices on the same network

### Benefits of cellular technology

The benefit of transitioning from unscheduled technologies like Wi-Fi to scheduled technologies such as 4G and 5G is that it allows you to deploy a larger number of devices on the network while maintaining predictable low latency.

Unscheduled wireless technologies typically require each device to listen before transmitting. As the number of deployed devices on the network increases, this results in more frequent high latency spikes or lag. In contrast, scheduled technologies coordinate traffic centrally, ensuring that each device knows when it should transmit. This leads to predictable and stable low latency, even with a large number of devices connected to the network. This forms the core of the 5G value proposition, enabling extensive wireless usage of industrial traffic protocols.

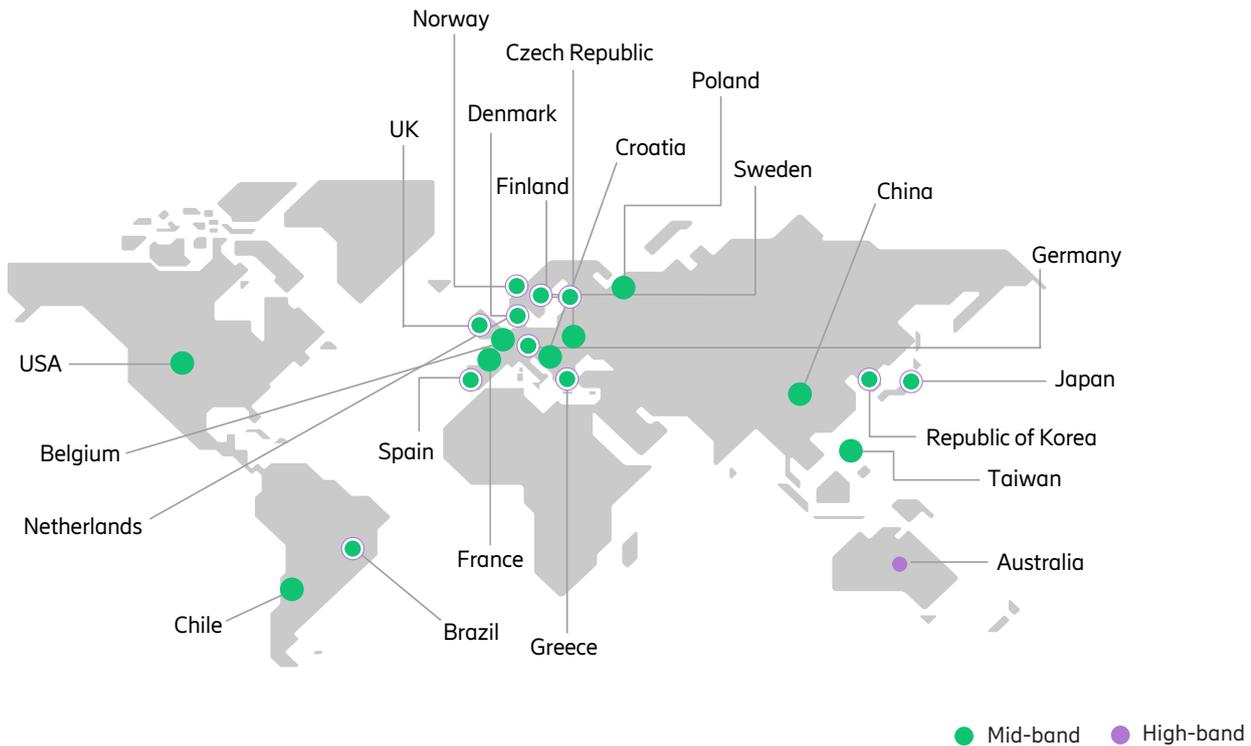
By transitioning to a wireless infrastructure for key use cases, you gain greater flexibility in production. The concept of devices selecting the next access point, accompanied by a temporary loss of connection, is eliminated. In a cellular network, the closest equivalent to a Wi-Fi access point would be the radio dot. Since all radio dots belong to a single cell, any moving asset, such as an AGV, experiences seamless connectivity without handovers as it moves through the factory. This significantly enhances performance and enables more advanced applications and use cases to be supported.

[Learn more](#)

## Spectrum and band recommendations

The current spectrum availability is rapidly improving with new spectrum for industry being added every quarter. The

availability of devices in the high band is increasing, but for industrial applications, Ericsson currently recommends the mid-band spectrum to start with as the device ecosystem has a higher maturity.



Availability of industry spectrum is taking up!

## How to acquire spectrum for your deployment site

Two options exist for acquiring spectrum. The standard approach is to work with spectrum owners such as communications service providers (CSPs). These entities have a spectrum available to lease for enterprises. The second option is to utilize a dedicated industry spectrum, which is an option in some countries.

### Option 1 – Local spectrum from a CSP

Case: Atlas Copco

Atlas Copco in Benelux required spectrum for their manufacturing facility. A CSP owning local spectrum was approached. Mid-band frequencies were selected for the deployment.

### Option 2 – Industry spectrum

Case: Arcelor Mittal

In countries where dedicated industry spectrum is available, enterprises can acquire this from a central authority by applying for the spectrum needed for each site. Arcelor Mittal in France is one company that has acquired its own spectrum.

## Reselling partners

Ericsson maintains a global network of resellers, including CSPs and value-added resellers. Our reselling partners possess the expertise and resources to deliver Ericsson Private 5G solutions tailored to your specific needs.

Contact Ericsson [here](#) to learn which reseller can unlock the transformative potential of private 5G technology for your manufacturing operations and accelerate your digital transformation journey.



## Requirement specification

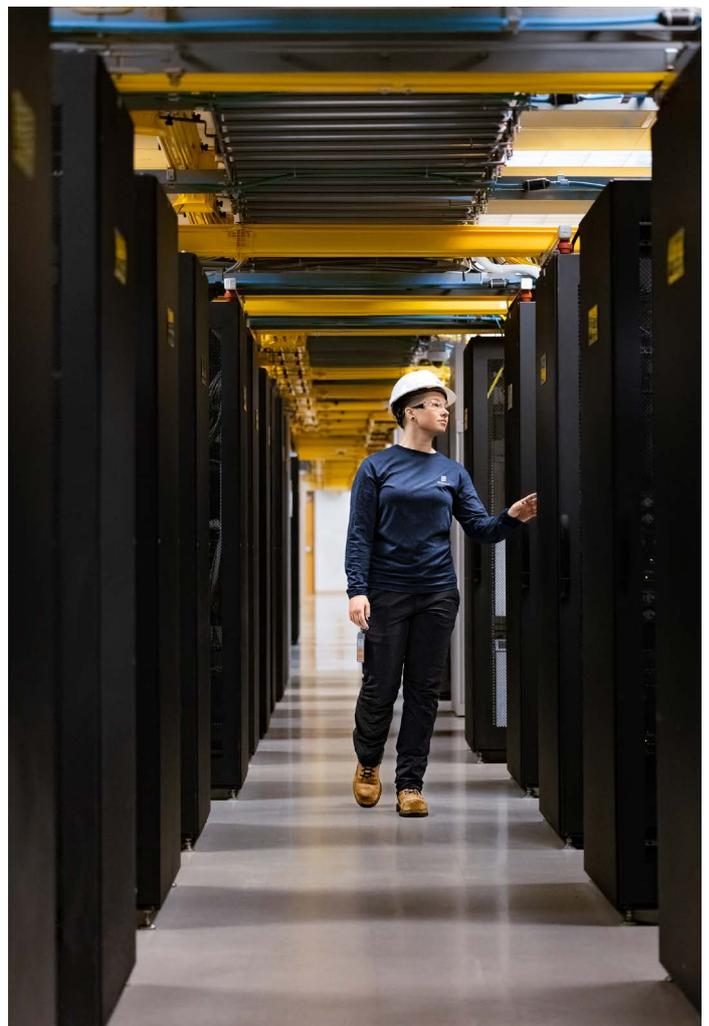
Try to understand how your network will support your business. Answering the questions below will help you decide what capacity, solution, and services are most suitable for your operations.

- What are your coverage requirements? Are they indoor, outdoor, or both?
- Do you have an understanding of what applications you would like to run over the network and the traffic model?

### Some examples:

- surveillance
- automated guided vehicles
- connected tools
- Are there other services that you intend to run over the network such as over-the-top applications?
- What kind of support level is expected, 8/5 or 24/7?
- How many users (that is, people or devices) do you expect on the network?

Share this information with your local sales representative. If you're looking for a local reseller, contact [Ericsson](#) for further details.



Ericsson enables communications service providers, enterprises and the public sector to capture the full value of connectivity. The company's portfolio spans the following business areas: Networks, Cloud Software and Services, Enterprise Wireless Solutions, Global Communications Platform, and Technologies and New Businesses. It is designed to help our customers go digital, increase efficiency and find new revenue streams. Ericsson's innovation investments have delivered the benefits of mobility and mobile broadband to billions of people globally. Ericsson stock is listed on Nasdaq Stockholm and on Nasdaq New York.