Nokia Industrial-grade Private Wireless and Digitalization Solutions for Industry 4.0

Powering digital transformation in manufacturing and supply chain operations

Private wireless solutions for Industry 4.0

Enterprises across industries are embracing Industry 4.0 technologies to improve efficiency, flexibility and the ability to adapt and scale quickly to changing customer and market needs.

The key focus area for many manufacturing organizations is transforming operational technology (OT) environments. In OT environments, technology solutions monitor and control the many diverse physical processes, systems, devices and infrastructure used for production. To transform these environments, manufacturers need pervasive wireless connectivity that extends network reach to support mobile devices, sensors, autonomous vehicles and smart infrastructure everywhere.

To help you in the digitalization and automation of your OT environments, Nokia Industrial-grade Private Wireless solutions bring you the high-performance, low latency, secure and reliable connectivity that's essential to support business and mission-critical applications.

These solutions use field-proven 4.9G/LTE and 5G technologies, but are private networks that are tuned to meet the performance and reliability your industrial OT systems require. And they can be configured for any manufacturing and supply chain environment, from the simplest industrial sites, to the most complex regional smart infrastructure.

Our professional services team works closely with you to tailor your private wireless solutions to meet the exact requirements of every application.

Research confirms wireless networks underpin digital transformation

In a 2022 ABI Research study, 71% of manufacturing executives said their digital transformation initiatives will continue, or accelerate, and that wireless networks will become essential to digitally transform manufacturing operations.

Without highly reliable wireless networking infrastructure, many of the cloud, cybersecurity and Industrial IoT (IIoT) applications and capabilities manufacturers are investing in as part of their Industry 4.0 strategies are not possible. A secure, reliable and high-performance wireless infrastructure that connects all machines, people, and processes gives manufacturers the deep insights from the production line they need for more agile and proactive operations, including the ability to manage quality at any scale.

Source: ABI - Nokia 2022 white paper, Digital transformation in manufacturing - what's new and what's next for private 5G

Unleash the full potential of Industry 4.0

Focus on key digital transformation areas

In manufacturing – the very heart of Industry 4.0 – IoT technologies and higher levels of automation have already transformed operations. But now there's increasing pressure on manufacturers to further increase agility, flexibility and responsiveness to meet fast changing consumer demands. That means manufacturers must upgrade to reliable and resilient wireless connectivity that:

- Supports extreme automation and rapid reconfiguration of dynamic assembly lines
- Enables seamless collaboration between humans, robots and autonomous mobile robots (AMRs) to increase productivity and efficiency

The trouble is, Ethernet infrastructure is expensive and limits potential applications of Industry 4.0. And while Wi-Fi is more adaptable, it's limited in reliability, security and predictable performance, and will fail to meet future requirements.

Our private wireless solutions give you a dedicated, industrial-grade mobile network that delivers the flexibility needed to rapidly reconfigure and retool production lines and quickly respond to changing demands:

- A low-latency, high-reliability network supports remote control and context-aware collaborative robots and AMRs
- High-performance, resilient and secure connectivity helps to achieve the productivity increases and cost reductions promised by Industry 4.0 technologies
- 4.9G/LTE and 5G wireless technologies lets you prepare today for tomorrow's applications with minimal capital investment

Predictive maintenance

Real-time data and advanced analytics to minimize downtime

Digital twins

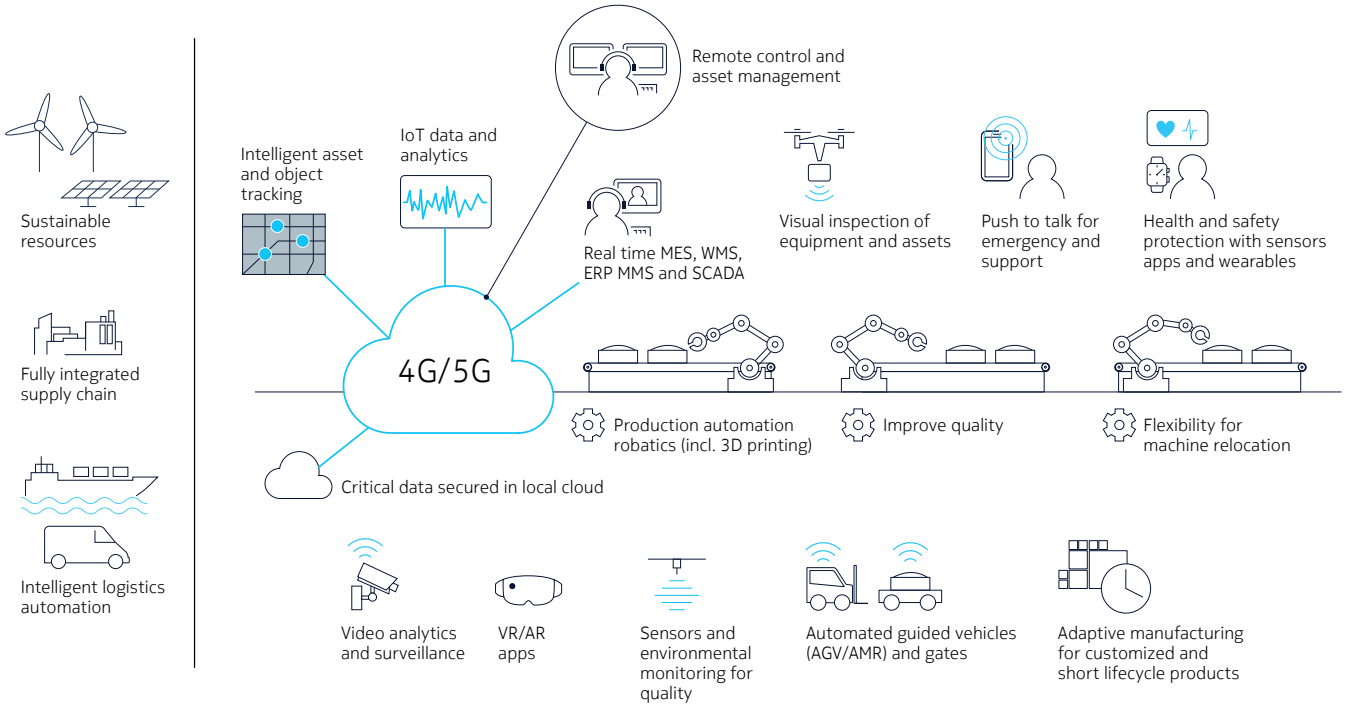
Increased insight and mobility to support dynamic, flexible production lines

Machine connectivity

Secure, resilient 4.9G/LTE and 5G to connect machines, robots, devices and people

Intelligent AMRs

High-performance, low-latency connectivity to increase AMR autonomy



Rely on an end-to-end solution to manage your digital transformation

Secure, reliable and predictable connectivity is essential for industrial applications. You can't afford downtime, spotty coverage or intrusion into your networks. Your mission-critical processes require redundant protection, no single points of failure and fail-over — even from complete system failures.

Our end-to-end approach, including services, meets all of these requirements to keep you in control at all times, across industrial sites, field area or region-wide network applications. Traffic prioritization and scheduling ensure reliable and predictable connectivity that's appropriate for the application, from mission-critical push-to-talk and push-to-video services, to low-powered IoT sensor communications.

Our industrial-grade private wireless network is offered in two varities: the plug-and-play, as-a service subscription based Nokia Digital Automation Cloud (Nokia DAC); or a Modular Private Wireless (MPW) network that is custom designed and built for your industrial complex with your complete management and control.

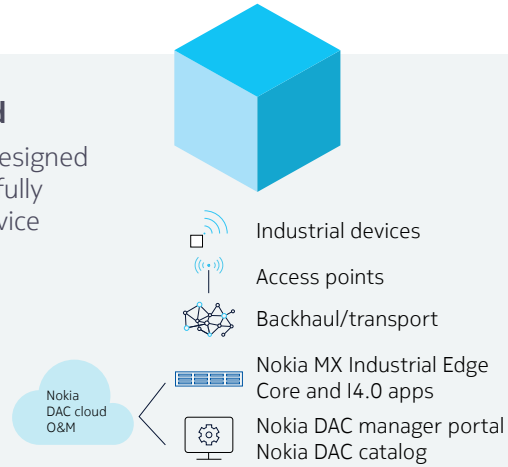
Our Nokia DAC and MPW solutions leverage the same technologies and innovations to:

- Overcome the limitations of legacy wireless networking solutions
- Untether equipment and machines from expensive and hard-to-modify cabled infrastructure

In most cases, our solutions offer superior wireless coverage at lower costs compared to IT-grade wireless technologies, such as Wi-Fi, while adding mobility, mission-critical reliability, deterministic performance, true security and the capacity to handle tens of thousands of users and devices.

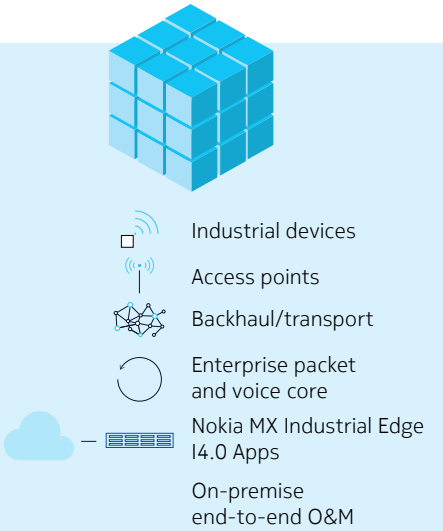
Nokia Digital Automation Cloud

Nokia Digital Automation Cloud is designed with simplicity in mind, providing a fully integrated plug-and- play, as-a-service private wireless solution.



Nokia Modular Private Wireless

If you want complete control over the way you build and operate your private wireless network, our Modular Private Wireless solution supports end-to-end customization that meets your most demanding requirements and tightly integrates into your current IT network. The solution includes separate 4G/5G packet and voice core functionality designed for enterprise deployments.



Choose from our leading portfolio of wireless access

Nokia AirScale 4.9G/LTE & 5G

AirScale outdoor macro RRH

AirScale mmWave radio

AirScale outdoor micro RRH

AirScale indoor pico RRH

AirScale Baseband Unit

RRH - remote radio head

Nokia DAC Wi-Fi

Indoor Wi-Fi 6/6E AP

Outdoor Wi-Fi 6/6E AP

AP - access point

Benefit from a wide variety of wireless access solutions to support almost any Industry 4.0 application in manufacturing.

We offer our Nokia Digital Automation Cloud Wi-Fi (Nokia DAC Wi-Fi) - a cost-effective choice for less complex and demanding sites and applications where Wi-Fi 6/6E sufficiently fulfills the non-business critical use case requirements.

In manufacturing sites where low latency, high capacity and reliability are required or radio propagation conditions are challenging, our best-in-class carrier-grade cellular Nokia AirScale radio access solution is ideal. It supports 4.9G/LTE and 5G radio technologies, including industrial NB-IoT and LTE-M.

Nokia AirScale radios support an extremely broad spectrum range spanning from low- and mid-band frequencies to millimeter wave.

Both DAC Wi-Fi and Nokia AirScale radio access solutions can be easily integrated into the existing LAN environment at manufacturing sites using flexible backhaul, fronthaul and power supply options.

Accelerate OT digitalization with the MX Industrial Edge

The Nokia MX Industrial Edge, MXIE, is a future-ready on-premises edge solution that accelerates digital transformation of industrial OT environments.

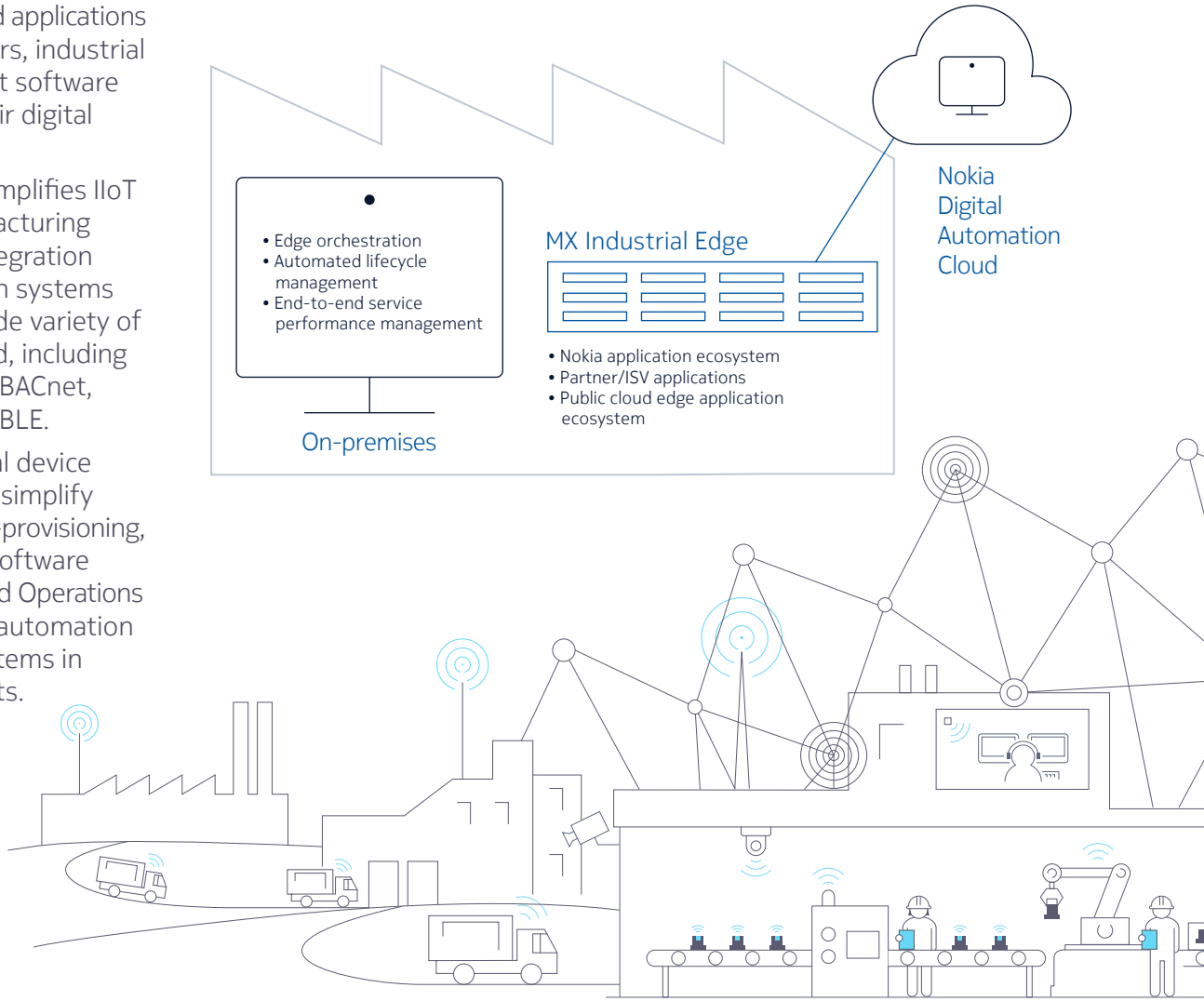
It combines the agility and simplicity of an edge-as-a-service model with a high performance, resilient and secure edge architecture to meet the mission-critical needs of asset-intensive industrial environments and complex industrial application workloads.

MXIE is designed and built to meet the strictest requirements for high availability providing full system and geo-graphical redundancy. Security is assured with app-to-app isolation, transport layer security, and role- and attribute- based access permissions.

MXIE comes with a portfolio of ready-to-use industrial applications and provides an ecosystem-neutral platform that allows manufacturers to swiftly adopt edge cloud applications from public cloud providers, industrial partners and independent software vendors to accelerate their digital transformation.

The MX Industrial Edge simplifies IIoT complexity on the manufacturing floor by enabling easy integration with industrial automation systems using connectors for a wide variety of for north and southbound, including Profinet, Sigfox, Modbus, BACnet, ODBC, OPC-UA, CAN and BLE.

Integrated Nokia Industrial device management capabilities simplify device discovery and auto-provisioning, and enable over-the-air software updates. And the Integrated Operations Center enables workflow automation across cyber-physical systems in industrial OT environments.



Choose from a rich set of applications for Industry 4.0

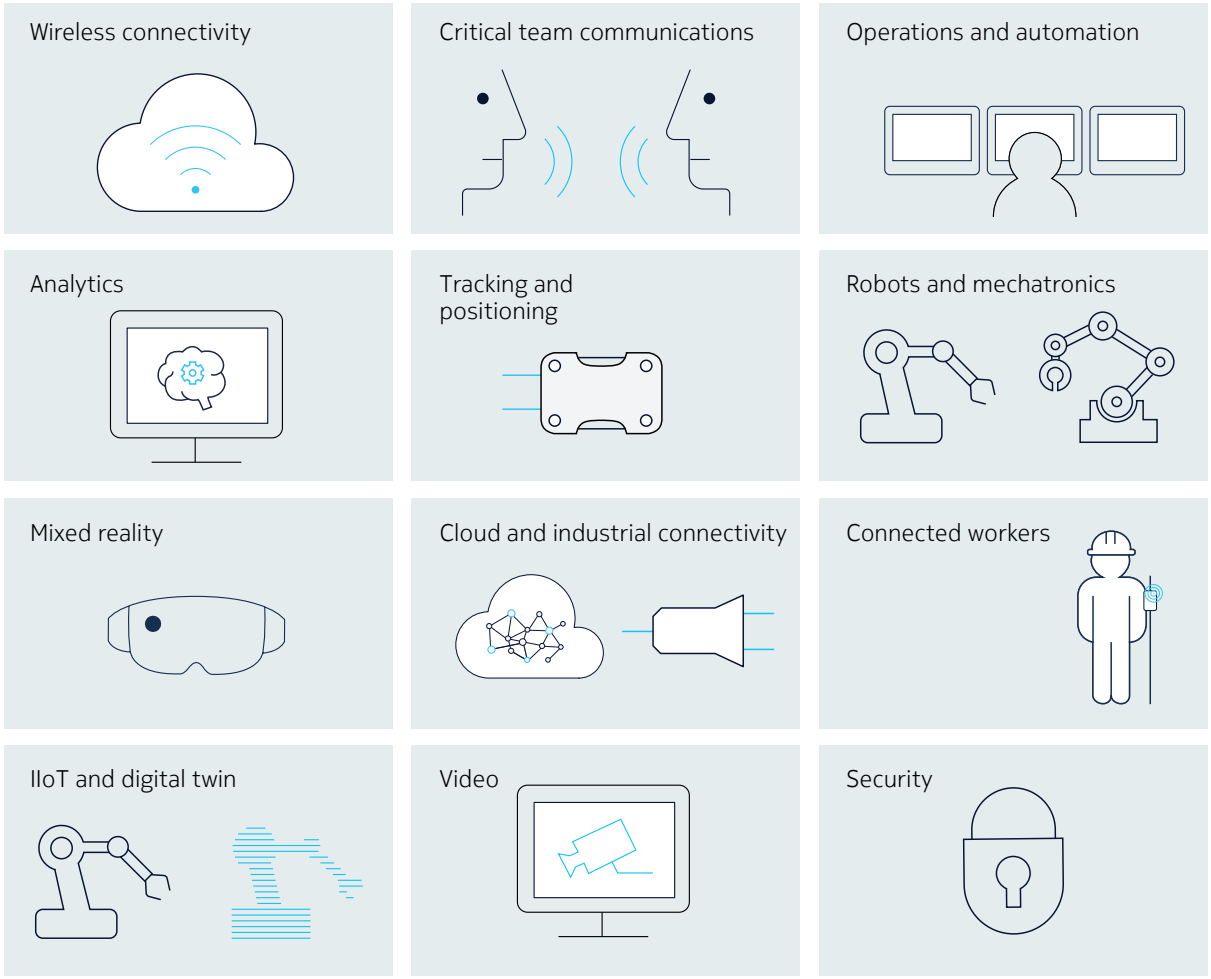
We provide a variety of applications that cut through IoT complexity to accelerate digital transformation in manufacturing. You can benefit from our ecosystem-neutral approach by choosing among our applications as well as applications from other ecosystems and independent software vendors.

Because these applications are deployed on our MX Industrial Edge, they're delivered with the high compute and networking performance, security and resilience Industry 4.0 use cases require.

You can simply click-and-deploy a variety of applications from the Nokia Digital Automation Cloud application catalog to the on-premises MX Industrial Edge. Connectivity, mixed reality, automation, data aggregation, real-time location services and video analytics are just some of the capabilities to choose from.

You can also use the application management portal to easily onboard partner applications, including a sandbox and a developer toolkit. Orchestration tools to automate application life-cycle management ensure that new security, stability and feature updates are always available on the edge.

Nokia DAC application categories running on MX Industrial Edge



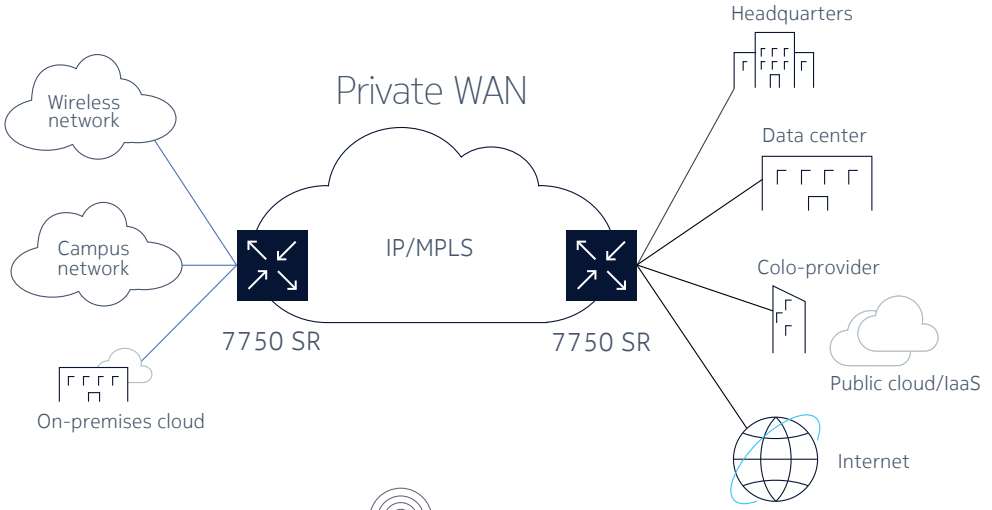
Add high-performance backhaul with a private IP/MPLS WAN

A private IP/MPLS wide area network (WAN) plays a fundamental role in your private wireless network. With pervasive wireless connectivity, machines and workers can send and receive critical operations and business data from everywhere. But data still needs to be transported over a backhaul network to servers and applications in data centers, offices and the cloud.

The Nokia private IP/MPLS WAN takes full advantage of IP/MPLS capabilities to provide:

- Service-aware Layer 2 Ethernet and Layer 3 IP services to enable network segmentation based on different needs
- Scalable, flexible and reliable bandwidth as data volumes continue to grow
- Flexible service level agreements (SLAs) to support increasing numbers of use cases with different latency and response speed requirements
- Multi-layer security to safeguard the confidentiality, integrity and availability of sensitive operational and business data
- Real-time analytics and reporting for 24x7 network supervision and performance management

In addition to wireless backhaul, the WAN also connects to data centers and the cloud to support adoption of Industry 4.0 technologies.



Empower staff and machines with ruggedized Nokia Industrial user equipment for Industry 4.0

Our portfolio of ruggedized, plug-and-play user devices deliver significant value in demanding industrial environments.

The devices feature hardened enclosures and industrial-grade components, high IP ratings and an anti-vibration design and are on-boarded and maintained with Nokia Industrial device management.

With these devices, combined with our private wireless networking solutions and value-added applications and services, you have one vendor to deliver on your end-to-end vision for Industry 4.0.

Ensure seamless communications in tough conditions

Our industrial devices connect machines, sensors and people over 4.9G/LTE or 5G private wireless networks and perform impeccably indoors, outdoors and in vehicles.

- **Handhelds and smartphones** give your workforce push-to-talk and push-to-video capabilities, as well as access to real-time data.
- **Workpads** provide a larger interface to manage operations, run applications, and can be mounted in vehicles.
- **Field routers** bring connectivity to complex systems and support industrial protocols like Profinet, OPC-UA, EtherCAT and Modbus. If your private wireless network operates in unlicensed spectrum, our MulteFire routers are the ideal solution.
- **Dongles** provide small-form-factor connectivity options for vehicles, automated mobile robots and PC-based solutions.
- **Hotspots** are a popular option for connecting Wi-Fi equipment to private networks.
- **Accessories and cameras** improve usability and enable new use cases

Nokia Industrial Private Wireless solutions accelerate Industry 4.0 transformation

Nokia is a proven leader in digital transformation and has spent decades building some of the world's largest and most advanced mission- and business-critical IP, optical and wireless networks. Our 400+ LTE mobile operator customers serve more than three of every four cellular subscribers worldwide.

With more than 2,200 mission-critical networks deployed, including more than 480 private wireless customers around the world, our industrial customers trust us to provide the connectivity they need.

In addition to our strong heritage in networking, we're also home to Nokia Bell Labs, which has pursued cutting-edge research for decades. Our researchers' current focus areas include cloud, machine learning and analytics, as well as the software platforms needed to support networking solutions for Industry 4.0.

We take a services-based approach to every network we build because we understand your requirements are unique. We have a rich portfolio of technologies and tools to draw from, and an extensive ecosystem of partners including mobile operators, cloud providers, industrial suppliers, systems integrators and consultants that can be engaged to help with any aspect of your network evolution.

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About Nokia

At Nokia, we create technology that helps the world act together.

As a trusted partner for critical networks, we are committed to innovation and technology leadership across mobile, fixed and cloud networks. We create value with intellectual property and long-term research, led by the award-winning Nokia Bell Labs.

Adhering to the highest standards of integrity and security, we help build the capabilities needed for a more productive, sustainable and inclusive world.

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