

An aerial photograph of a port area. In the foreground, a large container ship is docked at a pier, its deck covered with stacks of colorful shipping containers. Several white gantry cranes are positioned along the pier, ready for loading or unloading. In the background, another container ship is docked, and the water is filled with more ships and cranes. The sky is clear and blue.

No more trade-offs: Combining Wi-Fi and private wireless for business continuity

Digitalization Guide for port operators

NOKIA

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Achieve operational excellence by combining Wi-Fi and private wireless

The acceleration of Industry 4.0 digitalization and the growing demand for high-performance, highly reliable data processing is prompting a reevaluation of whether existing Wi-Fi networks are sufficient. Moreover, the need for a flexible network foundation that can accommodate a complex and constantly changing site environment, coupled with the requirement for highly reliable, low-latency communications to operate critical machinery in near real-time, underscores the limitations of Wi-Fi-only networks in adapting to these changes.

This guide explores how innovative multi-layer connectivity, supported by a mission-critical industrial edge, can deliver the failsafe operational continuity you need. Read on to see how you can combine the power of Wi-Fi and 4.9G/5G private wireless in a single wireless solution, and leverage the best attributes of both technologies across your port terminal. Keep your assets connected and applications performing at expected thresholds to reliably deliver the efficiency, productivity and safety improvements digitalization brings.



Disruption, delay and downtime

In the increasingly digitalized Industry 4.0 era the challenges of poor connectivity are growing:

- Interrupted processes and workflows
- Unnecessary operational delays
- Unplanned downtime
- Poor customer experience
- Reduced productivity and efficiency
- An inflated risk of worker safety incidents
- Hampered digitalization efforts and dependence on manual workflows

“Connectivity downtime
stopped everything” ¹

“The down the line consequences
of connectivity interruptions
are catastrophic” ¹

1: GlobalData and Nokia, 2024 Industrial digitalization report

Underperforming machines slow operations

In a modern port environment, you're only as productive as your connectivity allows. In Port 4.0, video-based applications, autonomous vehicles and remote machine control become increasingly important. Whether deploying fleets of AGVs (Automated Guided Vehicles) or remote control for port cranes, without sufficient network capacity, reliability, latency and mobility, planning seamless and agile operations for Port 4.0 is impossible.

Even if your existing network typically satisfies your operational needs, any sudden degradation or complete failure can disrupt critical workflows and the functioning of autonomous or remote-controlled vehicles. This can result in frequent delays and unplanned downtime. With no backup network in place, these issues could escalate, potentially halting your systems entirely and causing mission-critical failures.

Unplanned downtime and substandard productivity are big problems for port operators. A solid connectivity foundation can make all the difference.

Wireless remote control for semi-automated operations in port terminals drives significant performance gains:

7%

yard productivity
increase ²

95%

fewer emergency
stops ²

112,219

additional container moves
per year ²

² Nokia port terminal business case

Unreliable operations inflate worker safety risk

Port terminals are often dangerous workspaces with automated vehicles, heavy machinery, and workers operating in hazardous and out-of-sight locations. Poor connectivity and interruption to remote-controlled and autonomous machines increase the risk of safety incidents with machinery performing unpredictably. Substandard network performance can also delay instant machine shutdown in case of near-collision incidents and stop your control center from receiving life-critical worker safety data in real time and, therefore, from dispatching a timely emergency response.

Worker safety is a top priority for any port operator. But an insufficient connectivity foundation can aggravate the challenge.

5.7 million

non-fatal incidents occurred in the EU and US in 2021 alone

512,000

of those were in transportation and warehousing ^{3 4}

At

31.2%

industrial sites have the highest share of non-fatal accidents in the EU ³

³ Eurostat, European Union ⁴ National Safety Council

Wireless network capabilities need to evolve to serve mission-critical OT operations

As new Industry 4.0 use cases emerge and more digitalization applications come online, your network is experiencing unprecedented demand, and the pressure on your connectivity capabilities will continue to grow.

Digitalization is becoming the key competitive differentiator of our era – making high-capacity, ultra-reliable and secure wireless connectivity vital to addressing these major challenges and realizing your growth ambitions.

Combine Wi-Fi and private wireless for improved **machine control, safety** and **uptime**

Powerful video-based machine operations

Ensure remote-controlled and video-assisted machines run smoothly and without interruption by combining Wi-Fi with 4.9G/5G Private Wireless, boosting the data capacity, reliability and latency of your network.

Five-nines life-critical worker safety

Improve machine perimeter fencing and other life-critical applications by combining Wi-Fi with 4.9G/5G Private Wireless to considerably improve network reliability and latency, and in the future reach five-nines reliability and beyond.

Key technologies for all use cases

- MX Boost: multi-layer connectivity
- DAC Private Wireless 4.9G/5G
- Existing/legacy Wi-Fi
- MX Industrial Edge (MXIE)



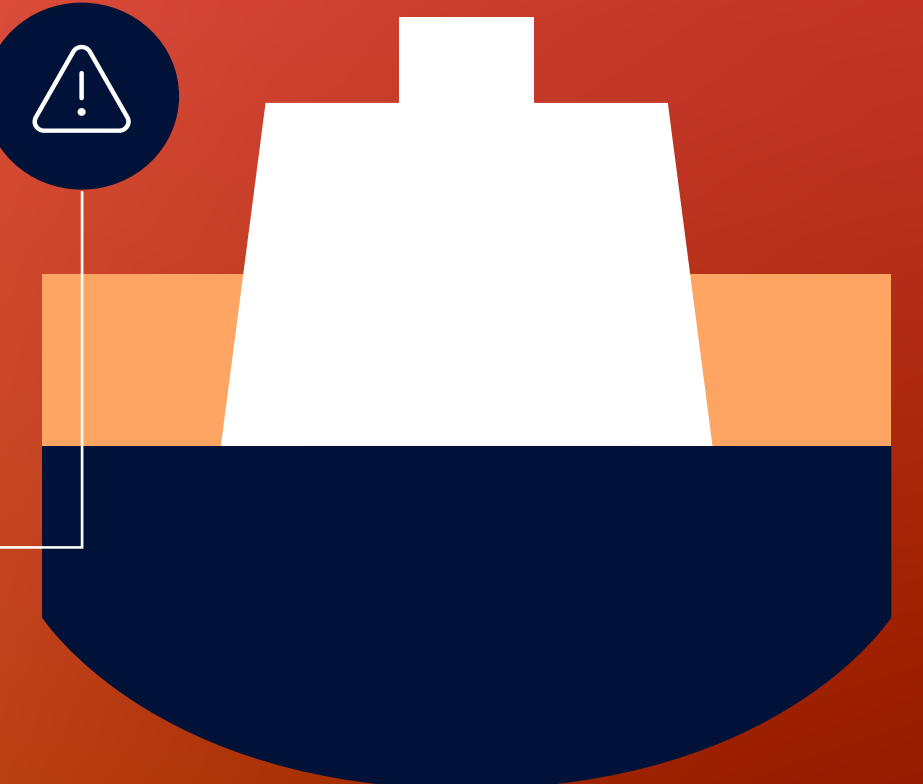
Seamless vehicle operations across coverage areas

Ensure operational continuity as vehicles move across different connectivity footprints by enabling frictionless handovers between your Wi-Fi and 4.9G/5G Private Wireless networks.



Ultra-reliable machine control

Increase machine uptime, productivity and worker safety: keep remote-controlled and autonomous machines running to plan and without interruption by combining Wi-Fi with 4.9G/5G Private Wireless for ultra-high reliability.



Private wireless fills the gaps Wi-Fi can't address

A mission-critical 4.9G/5G private wireless network is a stand-alone network dedicated to connecting your critical operational assets and is owned and controlled by you. Private wireless is designed to reliably connect devices on the move and in challenging environments. It has excellent capacity, extensive indoor and outdoor coverage, and better signal penetration, making it immune to interference from harsh industrial environments. It also provides predictable low latency, which is essential for Industry 4.0 applications, such as robotics and machine control, where there can be little delay variation from instruction to reaction.

By putting in place a robust, high-performance private wireless network for your business- and mission-critical OT operations – with all the reliability, coverage and scalability you need – you can connect many more machines and devices than with Wi-Fi, with low latency, high mobility and built-in security. This puts you on track to become a Port 4.0, enabling digitalization and advanced automation to drive business agility, productivity and safety.

“Private wireless is enabling the next stage of our transformation process.” ⁶

“The machine operators have advocated for the use of private wireless connectivity.” ⁶

6: GlobalData and Nokia, 2024 Industrial digitalization report

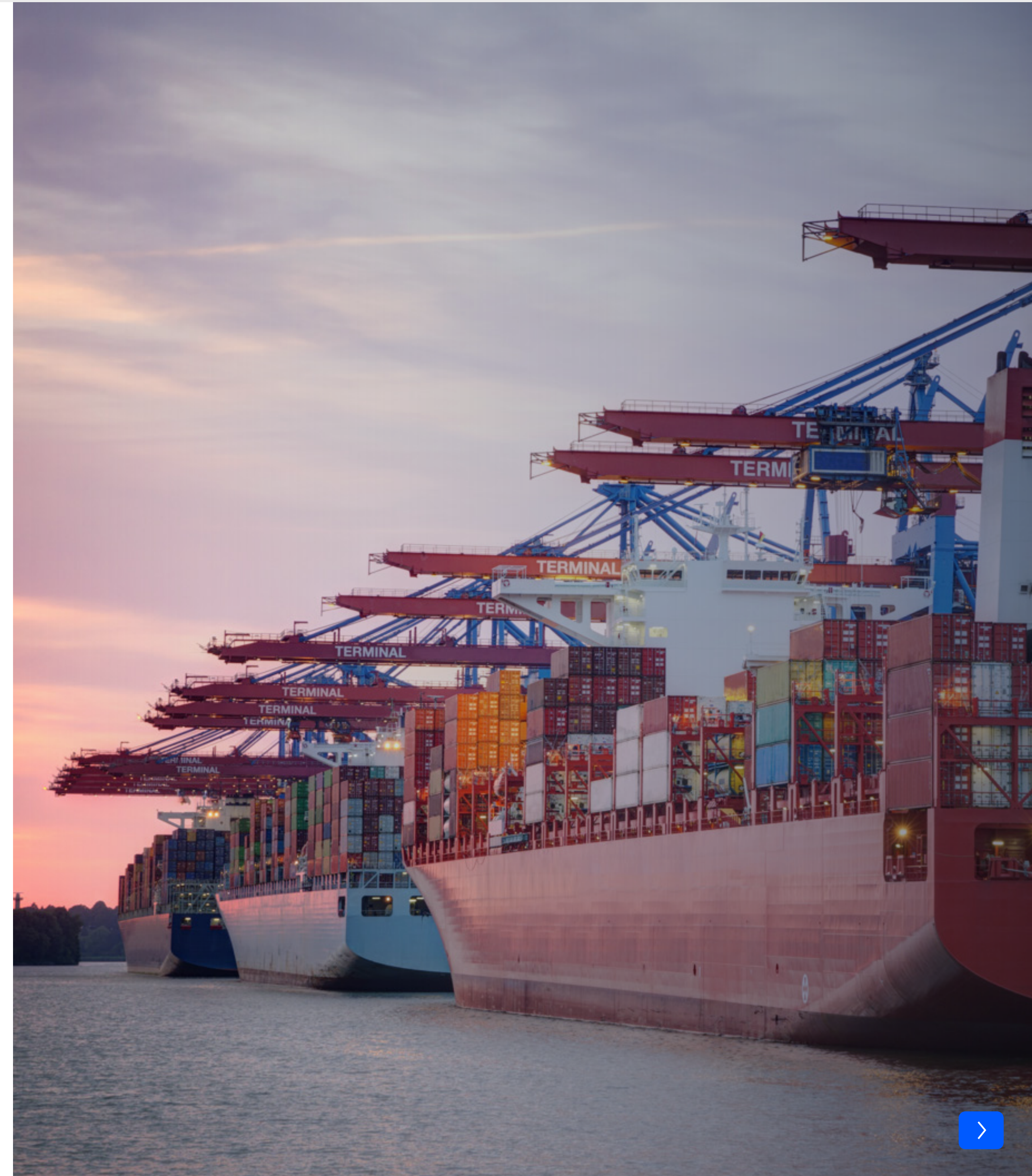
Combine the power of private wireless and Wi-Fi

Port operations need both

While private wireless is and will remain the solution of choice for business- and mission-critical OT use cases, both Wi-Fi and private wireless are essential to your operation. As a port terminal operator, you have various critical and non-critical use cases that need enabling, so you need both Wi-Fi and private wireless in your operation. Both connectivity technologies can harmoniously co-exist and complement each other, delivering seamless performance and improved productivity, efficiency and worker safety across your operation.

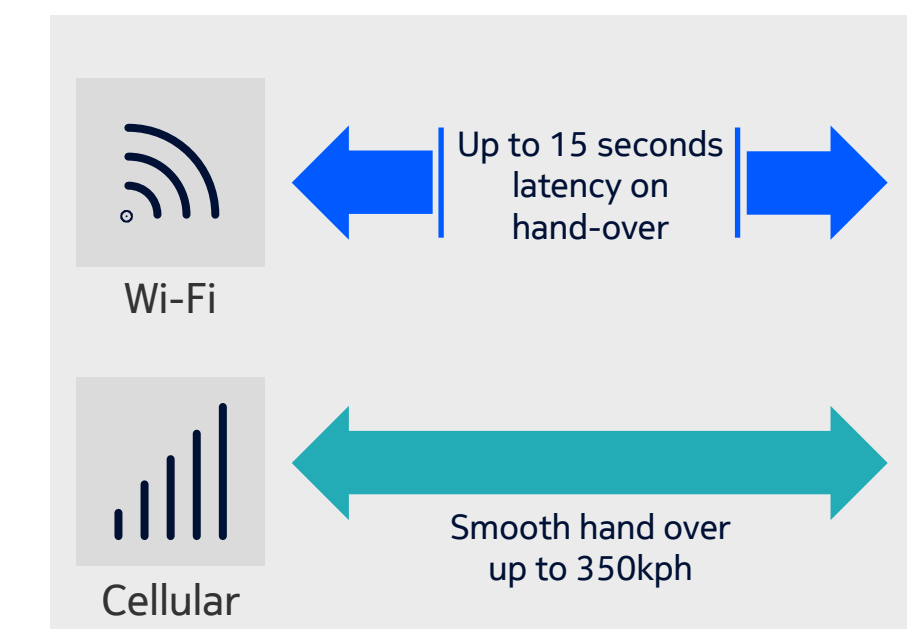
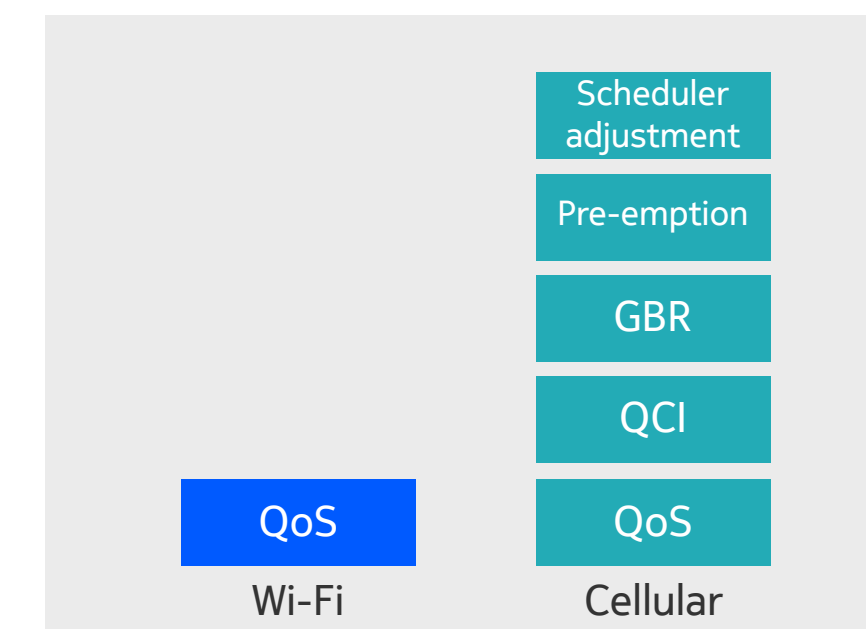
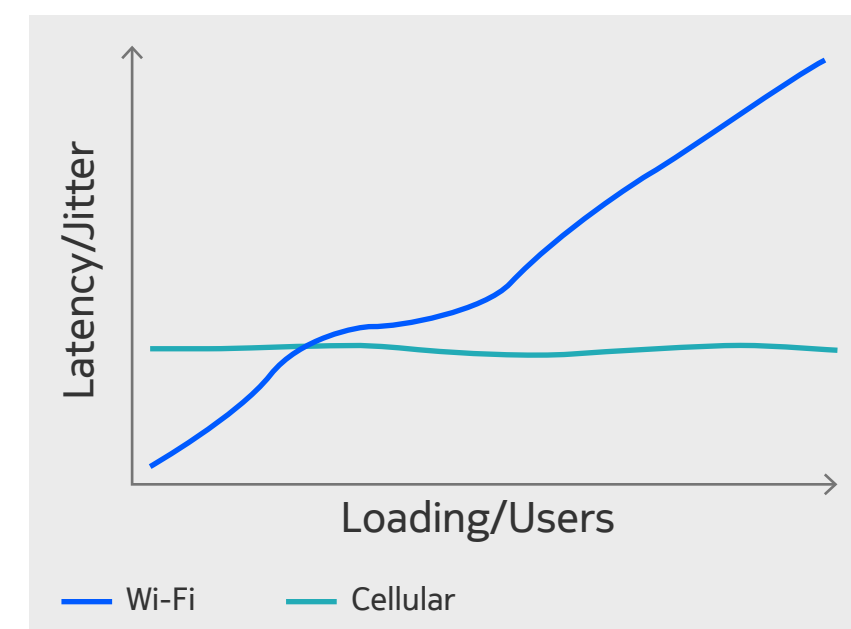
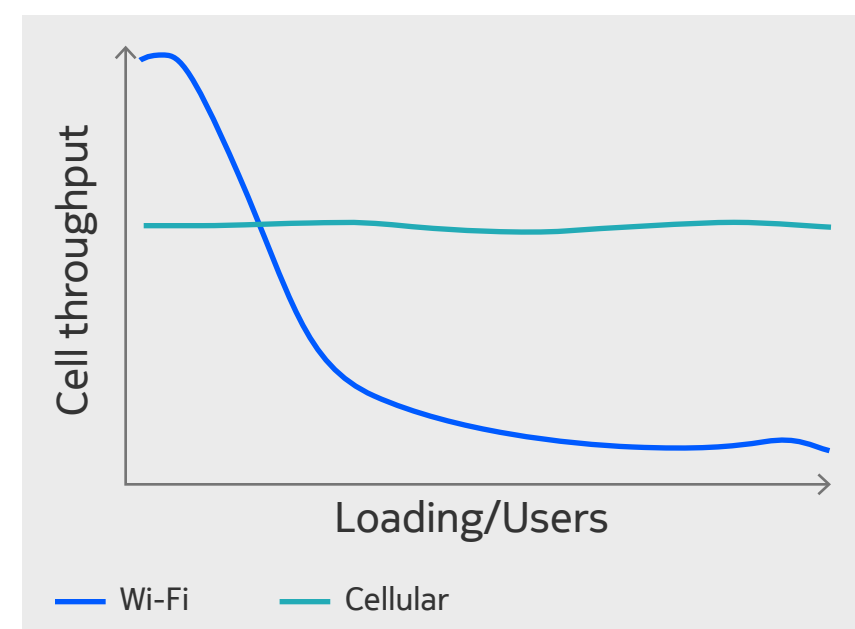
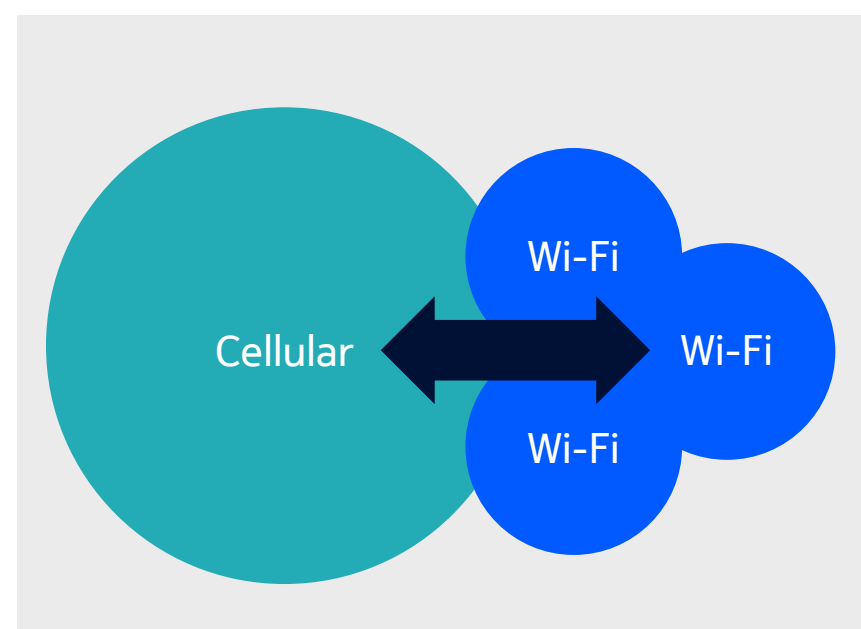
Combined network power for every need

The proliferation of Industry 4.0 is increasingly creating more demanding use case requirements. An innovative new one-stop wireless approach lets you use Wi-Fi and private wireless simultaneously to address the connectivity requirements **of extreme deployment scenarios** and maximize operational uptime, productivity and efficiency. Creating a single, multi-layer connectivity solution that leverages the best attributes of both technologies helps you ensure seamless performance and boosts productivity, efficiency and worker safety across your operation.



Wi-Fi and private wireless: a perfect match

Combining both networks creates a powerful industrial multi-layer connectivity solution that lets you benefit from the best of both technologies: the mission-critical capabilities of private wireless and the extra capacity boost of Wi-Fi.



Coverage: a single private wireless access point provides pervasive coverage over a considerable area and is resistant to interference from other sources or the surrounding environment. Many Wi-Fi access points would be required to achieve similar coverage, and the network would be highly susceptible to interference from harsh port environments, such as extreme temperatures, structural elements and highly dynamic, constantly changing site layouts.

Data capacity: 4.9G/5G private wireless spectrum is abundant, but the bandwidth of private wireless spectrum bands is relatively narrow. This means private wireless provides highly stable data throughput, but the total capacity available within a spectrum band can be limiting. Wi-Fi, on the other hand, provides very high data capacity, but only in controlled circumstances. If the Wi-Fi network gets overloaded with too many devices, it quickly becomes unstable and data throughput drops rapidly and significantly.

Latency: 4.9G/5G private wireless networks provide the highly reliable and robust low-latency connectivity that is needed for critical OT applications, free from interference from other devices or network load. Wi-Fi can provide low latency, too, but only in a strictly managed manner; as the network becomes congested with more users and data loads, latency rapidly declines, rendering it useless for critical OT applications.

Reliability: Private wireless technology provides centrally controlled radio resource management, built-in system resiliency inherited from large-scale mobile network deployments, high Quality of Service, and deterministic performance for your business and mission-critical applications that can't be matched by Wi-Fi.

Mobility: Wi-Fi provides very slow handovers between access points, which risks signal drops for connected machines, vehicles and devices and leads to prolonged periods of reconnection, often requiring manual intervention. This makes Wi-Fi entirely unsuitable for critical OT applications that involve moving assets, such as AMRs or forklifts. Private wireless, on the other hand, is proven to deliver fast, seamless and entirely unnoticeable handovers between access points.

Wi-Fi + private wireless: improved capacity, reliability and mobility

In brief, with an innovative multi-layer connectivity approach, you always have the right connectivity solution in place. Combining Wi-Fi and private wireless into a single, powerful, optimized wireless system gives you pervasive coverage and flexible connectivity options across your connected operation. Finally, all the capacity, reliability, latency and mobility you need to keep your systems up and running nonstop is at your fingertips.

MX Boost, our powerful multi-layer connectivity solution, lets you choose how that connectivity is delivered, optimizing network performance to suit your different use case needs.

Exponential capacity MX Boost aggregation

Boost data capacity to make sketchy and unstable video-based operations a thing of the past. Ideal for voracious applications such as video-assisted and remote-controlled machine operations that eat up vast amounts of capacity.

Ultra-high reliability MX Boost replication

Deliver the improved reliability and latency you need for life-critical safety use cases such as machine perimeter fencing. Ultra-high reliability is also perfect for keeping your critical machines up and running, such as remote-controlled and autonomous vehicles.

Seamless mobility MX Boost mobility

Ensure smooth network handovers that increase uptime. Frictionless handovers are essential for autonomous vehicles and remote-controlled machines and tools, giving you the assurance of uninterrupted communication.

A multi-layer, one-stop wireless approach lets you flex and cater to all of today's Industry 4.0 use case connectivity needs and future-proof your approach for new use cases coming down the line.

- Ensure business continuity and seamless operations
- Maximize operational uptime
- Increase productivity and efficiency
- Bolster life-critical worker safety
- Maximize the value and investment of your Industry 4.0 deployments
- Lay the foundation for future Industry 4.0 use cases

MX Boost: powerful multi-layer connectivity at a glance

- Uses Wi-Fi and private wireless technologies simultaneously to maximize network performance
- Compatible with any brownfield Wi-Fi
- MX Boost-capable fieldrouters provide dual-mode connectivity to any asset
- Application traffic is routed on MX Boost, not your connected assets, to maintain full application performance
- Three modes in a single solution to support different operational needs:
 - MX Boost Aggregation for exponential data capacity
 - MX Boost Replication for ultra-high reliability and low latency
 - MX Boost Mobility for seamless network handovers
- Always chooses the best connectivity layer
- Meets the most demanding network requirements
- Ensures seamless operations for maximum business continuity.

Combine the power of your networks with MX Boost: Innovative, robust and proven in harsh industrial settings

One solution, three modes

With MX Boost, you get a powerful multi-layer connectivity system that combines Wi-Fi and 4.9G/5G private wireless. It supports the most extreme connectivity requirements and ensures frictionless, future-proofed performance across all your applications. The solution comes in three modes – aggregation, replication and mobility – delivering different operational advantages.

MX Boost-capable devices

Your machines and vehicles don't need to support either Wi-Fi or 4.9G/5G. Our MX Boost-capable devices, the Nokia Industrial 5G fieldrouters, bring dual-mode connectivity to any of your assets. And as a fully automated and software-defined network overlay, the heavy lifting happens on MX Boost, not your connected assets. MX Boost actively steers the application traffic to ensure the aggregation/replication/handover of the two radio links.

Maximize your current investment

MX Boost is technology-, vendor- and spectrum-agnostic, giving you maximum flexibility and protecting your current technology investments. There's no need to rip and replace: MX Boost works with your existing, legacy Wi-Fi network.

Unique and proven

MX Boost is a unique one-stop wireless connectivity solution offering three modes at superior performance. It's based on a patented design by award-winning research house Bell Labs and has already been deployed around the world in our mission-critical Train-to-Ground solution. We are combining this proven capability with our experience in providing over 890 port operators, manufacturers, mines and other industrial enterprises with mission-critical private wireless connectivity.

Bring exponential
capacity to your
network today



Deliver exponential data capacity with MX Boost in aggregation mode

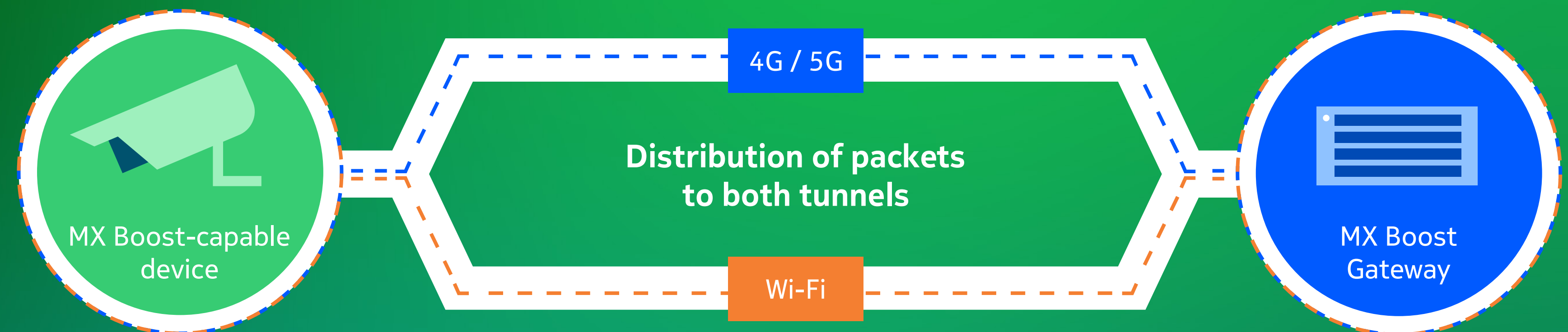
The problem

Your video-based machine operations, such as remote-controlled port cranes or drone-powered inventory management, are sketchy and unstable, leading to inefficiencies, lowered productivity and unnecessary reworks.

The solution

MX Boost in aggregation mode combines the capacity of your Wi-Fi and private wireless network for exponential data capacity and chooses the best of either network for best latency, coverage and mobility performance. The result is robust, video-based machine operations, with port cranes loading/unloading and stacking containers seamlessly and at maximum efficiency, and drones reliably capturing inventory status without fail.

Aggregation mode delivers increased radio capacity to support your most data-hungry applications



Would you trust
your network
with your life?

Deliver ultra-high reliability and low-latency connectivity with MX Boost in replication mode

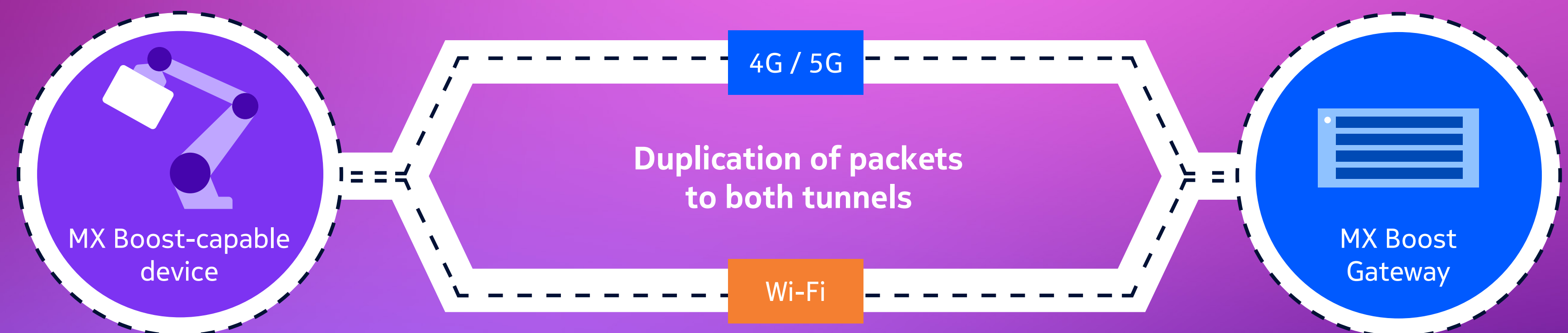
The problem

Your critical machine control capabilities are exposed and suffer from unreliable performance. For example, automated straddle carriers intended to optimize container handling efficiency experience frequent disruptions, with a serious impact on port productivity. And your life-critical worker safety applications are not as reliable as they could be, experiencing delays in data transmissions, because your network becomes congested or simply does not provide top network speed.

The solution

MX Boost in replication mode sends critical operational data over both your Wi-Fi and your private wireless radio link to offer ultra-high reliability and low latency. This means mission-critical machine operations run without delay and interruption, and your fleet of automated straddle carriers operates at its expected threshold with maximum machine uptime and productivity. And life-critical data from worker safety applications such as machine perimeter fencing is sent in an instant, triggering immediate machine shutdown and emergency responses with your control center.

Replication mode delivers improved reliability and latency support for your most critical applications



Never miss a beat with perfect wireless handovers



Achieve seamless network handovers with MX Boost in mobility mode

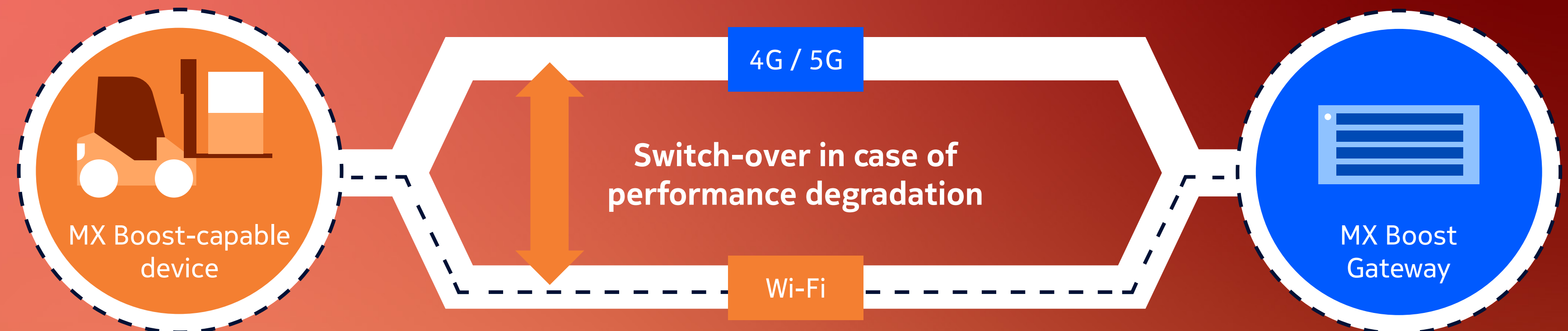
The problem

You need to deliver uninterrupted communication for mobile assets, but your straddle carriers, forklifts, worker tools and other specialist equipment are moving across different connectivity footprints. On top of that, you risk operational disruption and mission-critical breakdown if your network fails, with no backup solution. That leaves you with challenges such as out-of-touch vehicles and machines.

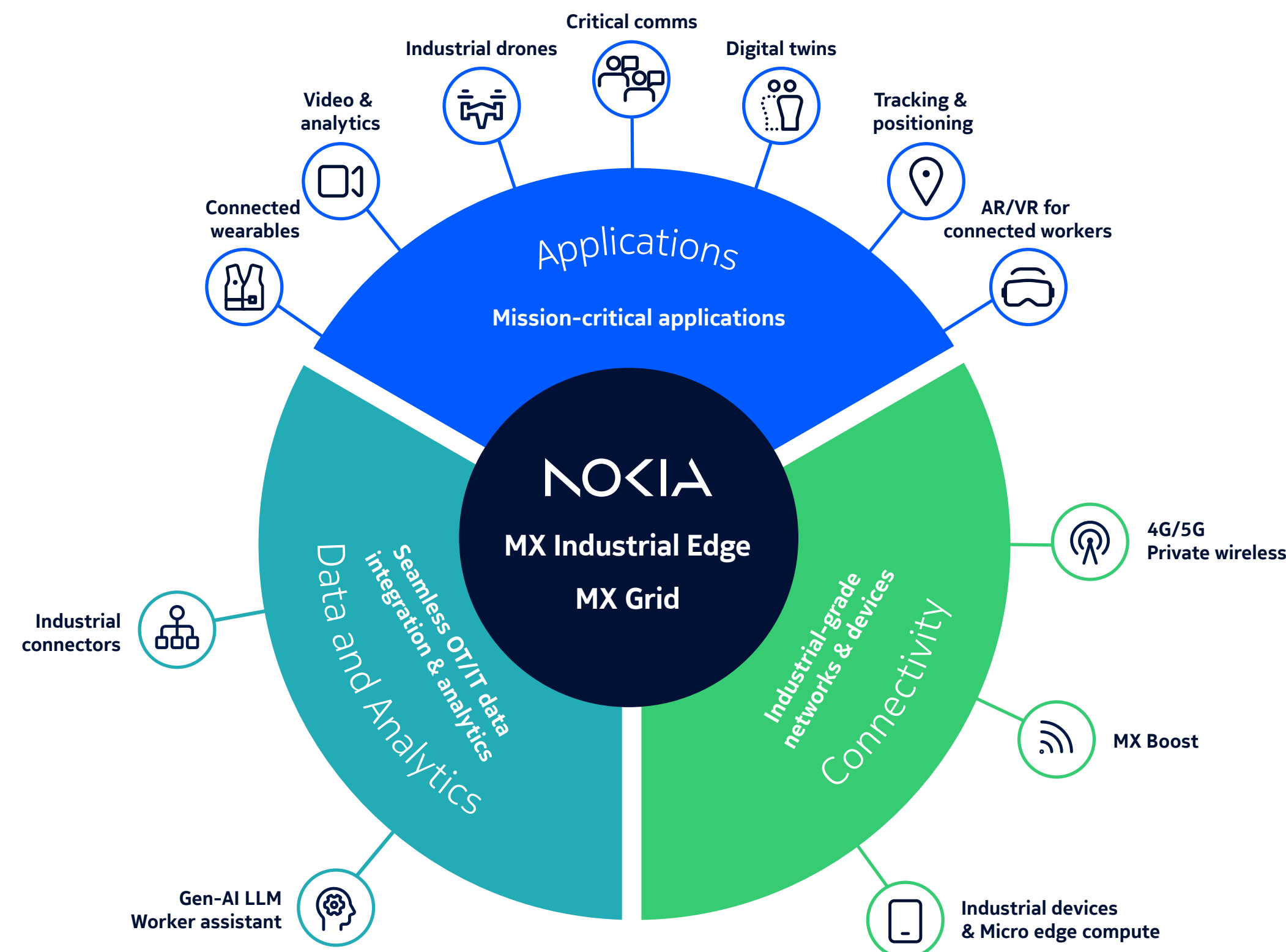
The solution

MX Boost in mobility mode enables seamless network handovers between your Wi-Fi and private wireless network, ensuring exceptional application uptime and uninterrupted communications delivered via backup connectivity paths. This means mobile assets moving across your plant and different coverage areas can operate without interruption. Mobility mode also lets you create a fast network fallback 'safety net' to ensure business continuity in the event that your network degrades or fails – ensuring smooth network handovers between your primary and backup network technologies.

Mobility mode gives you seamless network handovers and a fallback scenario if your primary network fails.



Beyond connectivity: our edge compute and AI platform



On-premises industrial edge:

Nokia MX Industrial Edge (MXIE) is at the heart of industrial digitalization. It powers your wireless networks even if the internet is down, keeps critical Industry 4.0 applications running at their expected thresholds, and guarantees data security and sovereignty alongside high-speed, high-reliability data processing. Nokia MX Grid, a network of micro-edges, brings compute power and AI processing even closer to machines, sensors and other connected devices, to enable use cases such as AI-based video analytics and very low latency automation for critical industrial applications.

Real-world AI use cases:

With an on-premises edge, you have a unified real-time data hub where all OT data is centralized, giving AI applications access to the data they need, when they need it. This facilitates the deployment and scaling of real-life AI use cases, enabling comprehensive data visibility, actionable insights, advanced automation and improved situational awareness.

Wireless Connectivity:

Pervasive and deterministic wireless solutions keep your machines, sensors and workers connected across your entire operation. Our innovative, secure and reliable wireless connectivity solutions, including 4.9G/5G private wireless, are designed for easy deployment, eliminating complexity so you can focus on your core operations.

Marketplace for industrial devices and applications:

DAC Marketplace offers convenient access to a wide portfolio of industrial devices and applications, for greater flexibility, reduced deployment complexity and faster time-to-value. This empowers you to easily deploy and scale Industry 4.0 use cases, and add new devices and applications as needed – from Nokia and trusted ecosystem companies – with speed, ease and cost efficiency.

Partner Nokia: Continuous innovation to take you further, faster

Delivering pervasive, always-on wireless connectivity across your port terminal is just one of the many ways we help industrial enterprises accelerate their digital transformation to create more efficient, productive, safe and sustainable operations.

We've helped more than 890* enterprises around the world to achieve their Industry 4.0 goals, from leveraging digital twins for simulations to deploying driverless ground vehicles and using drones for remote inspections. With Bell Labs, our renowned research powerhouse, we are always at the forefront of innovation, developing cutting-edge technologies for enterprise digitalization and pushing the boundaries of what's possible – from AI and 6G to the industrial metaverse and Industry 5.0. So you're not just ready for today's opportunities but also for what's possible tomorrow.

* As of March 2025



Combine the power of your networks for fail-safe operational uptime

Let us help you boost operational continuity by combining Wi-Fi and 5G private wireless in one solution.

We're ready to deliver pervasive connectivity that creates productive, efficient, and safe operations. Contact us today to start benefiting from multi-layer connectivity.

Talk to one of our experts
for a free, expert consultation



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About Nokia

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

As a B2B technology innovation leader, we are pioneering networks that sense, think and act by leveraging our work across mobile, fixed and cloud networks. In addition, we create value with intellectual property and long-term research, led by the award-winning Nokia Bell Labs.

Service providers, enterprises and partners worldwide trust Nokia to deliver secure, reliable and sustainable networks today – and work with us to create the digital services and applications of the future.

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