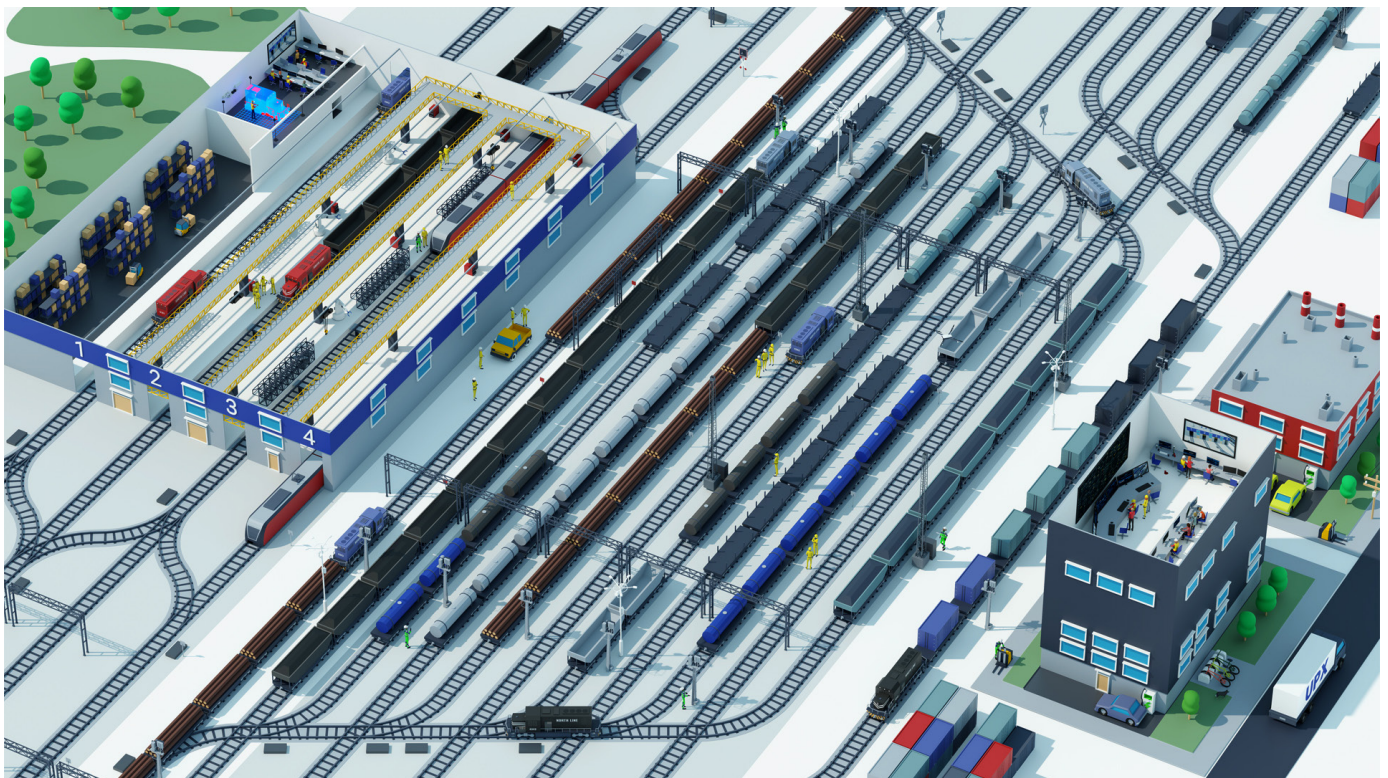


Nokia

Now Arriving at Track 4.0



Breakthroughs in automation and analytics are fuelling the new digital railway, but tomorrow's innovations can't run on today's connectivity: the railway of tomorrow is riding on private LTE and 5G wireless networks.

Shunting by camera and sensor, not workers. Wholly driverless parking of empty trains. Remote maintenance with expert consultation. And more insight-rich data uploaded in a day — relayed by everything from track and rolling-stock-placed sensors to CCTV cameras and drones — than what

could once be produced in a year.

Just a handful of snapshots from the railway digital transformation scrapbook being composed right now by the networks powering Industry 4.0: industrial-grade private wireless networks based on LTE and 5G.

When Wifi Goes Off the Rails

The importance of robust, resilient and virtually impenetrable private wireless networking to the digitalisation-driven possibilities of Industry 4.0, from driving

automation, to streamlining processes, to finding staggering efficiencies, can't be understated. And in the world of rail operations, where connecting IIoT sensors on engines, workers and rolling stock across vast rail yards, and the radio interference from metallic surfaces and insufficient mobility support, make wifi problematic, a self-contained private wireless network's deterministic performance makes it the perfect solution for mission-critical operations, especially when worker and passenger safety are just as critical.

With their high capacity, low-latency performance, and support for the low bandwidth/low power communications required by IIoT sensors, private LTE and 5G wireless networks are being installed worldwide to support

the voice, video, data and other communications needs of the rail industry. Improving efficiency, increasing productivity, enabling automation, and transforming the safety and quality of working conditions.

Hands-Off, Efficiency-On

As the world continues its cautious recovery from the pandemic and qualified staff are historically hard to find, one promising use case being explored is the autonomous and remote operation of shunters in the yard, enabled by engine-mounted cameras and sensors monitored from central offices, tablets and more: a single remote driver can handle numerous trains at once. In Hamburg, the Nokia 5G network is being used to transmit

train control information as part of Deutsche Bahn's automated trains trials, which are testing driverless parking near the Bergedorf station.

Many other operators are looking into remote solutions, including a shunting yard system that combines vision sensors with AI/ML to automatically detect and classify objects: private wireless connects workers via tablet to the video feed, eliminating the need for a shunter driver.

Beyond Automation

Other examples incorporate the technologies that we hear about every day in relevant new ways. Video analytics are being explored to reduce incidents and survey anomalies in rail yards — everything





from intruders to objects on the track — and at level crossings to boost safety. The limitless span of drones is providing otherwise impossible-to-achieve imagery of tracks, bridges and trains, identifying repair issues before they elevate, and bringing even the largest areas within focus.

Nokia private wireless networks are also powering exciting explorations in the aviation industry that can make the leap to the rail yard, such as Lufthansa Technik's virtual engine inspection with remote client, now part of normal operations. There's also augmented reality (AR) for passenger compartment reconfigurations. And yet another global leader in passenger mobility is testing AR for remote expert observation of train and equipment repairs.

Of course, all of this isn't happening in a bubble.

Pressure on all transportation providers is accelerating from inside and out, from reducing emissions to improving efficiency

and productivity. Rail is poised to claim more truck miles in the name of environmental sustainability. And passengers and operators alike are acutely aware of the digital transformation happening everywhere, which plays out in the rail yard in countless ways: from new passenger information systems, to smart stations, smart rail maintenance and smart infrastructure.

With countless railway communications networks already in use, best-in-class GSM-R, and broadband solutions for operations, passengers and train stations, Nokia has the track record — pun very much intended — to meet every destination that transformation-minded operators know they need to arrive at. And those they can't even imagine.

30 Years Rolling: Nokia At-a-Glance

- 30+ yrs railway experience: network design, deployment, operations
- Most comprehensive portfolio & turnkey services
- #1 in GSM-R: 110k+ tracks, 22 countries
- Legendary Bell Labs innovations shaping FRMCS/5G
- Countless deployed railway networks
- Best-in-class broadband for operations, passengers, stations
- Leaders in legacy network migration
- 420+ private wireless deployments worldwide
- Unparalleled cyber security solutions

Scan the QR code to discover our solutions for the railway industry



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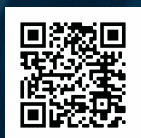
Trains have brakes. Digitalization doesn't.

There's not enough words in this publication to describe the benefits of digitalization. But you only need one. Nokia. As the leader in GSM-R and game-changing private wireless networking, with great stops at some of the world's top railways, we're more equipped than anyone to transport you into the FRMCS/5G era, one of unheard-of safety, security, automation and efficiency. But this trip isn't optional, so there's one more word you need to know.

And that's now.

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