

The background of the slide features a large, stylized Nokia logo. It consists of a large white circle centered on a dark orange background. Inside this white circle is a smaller orange circle. The text is placed within the orange circle.

Train-to-ground communications for urban and metro rail

A proven secure and resilient broadband
communications system to support safety-critical
and safety-related applications.

NOKIA

Enabling safe, on-time and connected journeys

Today's urban/metro railway operators are in the spotlight as governments look to reduce urban congestion, lower carbon emissions and increase the numbers of passengers served. Getting passengers to choose rail is about better in-station and on-board experiences, ensuring efficient on-time operations and 24/7 safety and security.



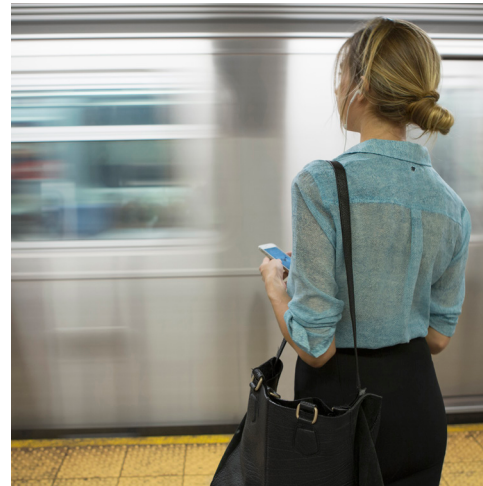
Better passenger experiences

Passengers expect enriched travel experiences with uninterrupted broadband connectivity and easy access to real-time travel information and announcements, both in-station and on-board.



Efficient, on-time operations

Digital, data-driven operations start with critical applications like SCADA and CBTC but can include everything from predictive maintenance to asset monitoring and renewal.



Around-the-clock safety and security

Keeping passengers safe and assets secure requires real-time CCTV video streaming and analytics, as well as mission-critical voice and video communications for operations personnel.

Mission-critical broadband connectivity is the foundation for digitally transforming today's railways.

The traditional Wi-Fi networks that most urban and metro rail operators rely on today weren't built for the demands of mission-critical rail. Simply put, Wi-Fi is not designed to support high speed mobility. Performance and quality of service cannot be guaranteed and the technology is susceptible to security compromises.

The Nokia Train-to-Ground solution

The Nokia Train-to-Ground solution supports multi-path wireless concurrent access backhaul and can be flexibly deployed over wireless networks such as private LTE, existing Wi-Fi networks or a hybrid network setup. Powered by a unique multi-path switching algorithm developed by Bell Labs, the solution addresses the need for 100 percent network availability to reliably support highly

automated rail operations. Urban/metro rail customers benefit from seamless network coverage, assured bandwidth through capacity aggregation, guaranteed QoS using LTE prioritization mechanisms, and end-to-end security.

Professional services expertise

Having successfully deployed and operated railway networks for over

a hundred operators across the globe, Nokia offers a full range of professional services to help urban and metro rail operators maximize operational value from their Train-to-Ground investments. Our digital delivery model speeds up time to market while our systems integration experts simplify and de-risk new technology introduction into existing brownfield railway environments.

A clear path to tomorrow's 5G networks

Nokia has designed all of its LTE-based train communications solutions with the future in mind. This includes the evolution from LTE to 5G in the coming years, ushering in a new era of automated rail operations and innovative applications.

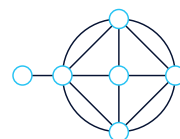
Mission-critical resilience, secure and reliable communications for the digital railway

Service **convergence** on a single broadband network

- Passenger experience
- Operational safety
- Train control/telemetry



Optimized TCO

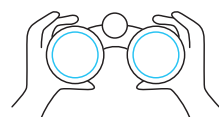


Mission-critical availability

Multi-path active **redundant** backhaul (patented)

- Enables **soft handovers**
- Minimize packet retransmissions

Manage train comms networks on fleet level in **real time** through Fleet Network Manager



Simplified management



Certified for railway environment



End-to-end security

Secure VPN tunnels from Onboard MARS to Operations Center through Tunnel Server

Grand Paris Express Lines 15, 16 and 17

Covering over 200 kilometers of new Paris metro lines, the Nokia Train-to-Ground solution will provide critical, high-speed wireless connectivity to meet all future Grand Paris Express operational and maintenance requirements. It will also provide emergency response and security services.

Grand Paris Express is the new automated metro of the Capital Region. With its 68 new stations and 200 kilometers of additional tracks, Grand Paris Express consists of a ring route around Paris (line 15) and lines connecting developing neighborhoods (lines 16, 17 and 18). Additionally, Grand Paris Express also involves the extension of existing metro lines. Its four new lines circle the capital and provide connections with Paris' three airports, business districts and

research clusters. It will service 165,000 companies and daily transport 2 million commuters.

The Nokia LTE private mobile radio solution will provide indoor/outdoor connectivity across all Grand Paris Express stations, lines and depots. These include voice, data (file transfer and multimedia support) and video services (transmission, on-board video surveillance) over a high availability private LTE network (B28 700 MHz / B38 2.6 GHz). Nokia will also supply mobile devices and on-board equipment (mobile access router) push to talk (PPT) server integration. Furthermore, Nokia will carry out the entire operation and maintenance of the network for a period of 12 years.



Why Nokia railway solutions?

Over one hundred railway customers rely on Nokia mission-critical networks, making Nokia a global leader in railway communications.

30+ years of railway experience with the most complete e2e portfolio and turnkey services

#1 in GSM-R with 110k+ of tracks in 22 countries and 80+ deployed railway networks

Best-in-class broadband solutions for passengers and train stations

Ready for future: Driving railway **standardization** from legacy to the next generation

Deep experience in **mission-critical network design, deployment, and operations**

Strong expertise in graceful **migration of legacy networks**

Leading **innovation with Bell Labs** to shape FRMCS/5G. Bell Labs **awarded with 9 Nobel prizes**

Nokia is committed to the **highest compliancy** standards and has best-in-class **cyber security** solutions

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Document code: (February) CID207719

NOKIA

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

As a B2B technology innovation leader, we are pioneering the future where networks meet cloud to realize the full potential of digital in every industry.

Through networks that sense, think and act, we work with our customers and partners to create the digital services and applications of the future.

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