Building a better railway experience
With rapid urbanization, increasing highway congestion and climate change, rail is a key, sustainable transportation. While there are many exciting new projects, especially in urban rail, much of the existing railway infrastructure is aging and in need of renewal. This presents a unique opportunity to transform the passenger’s experience, dramatically overhaul operational systems, and improve safety and efficiency by using sophisticated new digital technologies.

To realize these opportunities, railways around the world are looking for systematic approaches that both meet specific near-term challenges and provide a platform for future growth. No longer vertically integrated in many markets, they face new competitors, changing business models and more demanding compliance regulations around security, safety and the environment. Digital transformation will ensure their cost competitiveness, enable them to improve time to delivery for freight and deliver an improved customer experience for passengers.

Nokia is a global leader innovating the technologies at the heart of our connected world. We understand that smart, dynamic networks will be the foundation for the digital transformation of society, including our railways. The Nokia Bell Labs Future X architecture provides a connected, digital platform that supports and fosters new applications and services for greater productivity and innovation, richer experiences and enhanced quality of life.

As a leader in railway communications, we believe that building this dynamic, connected platform is the best starting point for achieving operational efficiencies and a customer-focused railway experience. We call this the Future X Architecture for the smart, safe and sustainable railway. We are committed to helping railways build this smart foundation and realize their goals for digitally transforming our railways.
Spurred by climate change and highway congestion, the EU’s goal is that 30 percent of road freight be shifted to rail or water by 2030 and 50 percent by 2050. Many Asian countries are putting a similar emphasis on building out rail capacity, with China being the most ambitious. If these targets are to be achieved, improving the efficiency of hybrid, multi-modal transportation networks is essential — oceans for long haul, rail for medium and trucking for local (less than 300 kilometers). Innovations will be required in the interconnection of transport management and collaborative logistics, including freight as a service, real-time cargo tracking and predictive analytics that reduce time to delivery.

In passenger service, governments around the world are targeting rail as part of their climate goals, with an emphasis on high-speed rail (HSR), which has grown steadily since 2005, mostly in Europe, Japan and, more recently, China. While HSR shows promise, non-HSR passenger services have seen their share of passenger traffic fall relative to other modes. This is putting pressure on railway operators to improve the passenger experience and grow their share of the transportation market to meet their governments’ commitments under the Paris Climate Accord.

As with most other consumer-facing services today, improving ridership starts with the passenger experience. Aligning the online experience with the in-station and on-board experience is critical. From online sales and marketing, to in-station alerts and signage, to on-board entertainment, meals and services, the railways need to create a rich, 360° passenger experience.

At the same time, railway operators are facing the overhaul of aging infrastructure. There is a level of urgency, as well as a golden opportunity to make a step change in railway technology. Emerging technologies include train control systems, asset monitoring, video surveillance, predictive maintenance, intelligent rail infrastructure and operations, freight and passenger information systems, safety systems, and cybersecurity.

The digital railway opportunity

<table>
<thead>
<tr>
<th>EU</th>
<th>Russia</th>
<th>USA</th>
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<tbody>
<tr>
<td>GDP</td>
<td>Rail T-km</td>
<td></td>
</tr>
<tr>
<td>2.7</td>
<td>1.5</td>
<td>2.3</td>
</tr>
<tr>
<td>6.4</td>
<td>5.3</td>
<td></td>
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By 2050 passenger mobility by rail will increase 200% - 300%*

* Statistics from the International Transport Forum of the OECD
The railways have always put a high emphasis on safety and security. As they increase freight and passenger miles on existing infrastructure, they will need to implement new signaling and control systems, such as the European Train Control System (ETCS) and Communications-based Train Control (CBTC), in order to support non-stop operations, decreasing time and safety margins. In mainline, this will require moving eventually from GSM-R to LTE or 5G for the Future Railway Mobile Communications System (FRMCS). More efficient and cost-effective trackside, rolling stock and station maintenance can be achieved using IoT paired with advanced analytics and machine-learning technologies. As railways increasingly employ digital technologies, they will also expand the attack surface, requiring a much higher emphasis on cybersecurity.

Railways are facing many challenges, and not only from other modes of transportation. In many markets, vertical separation and unbundling means that they are confronting changing business models and competition from other railway companies. With a falling share of miles in many markets for both freight and passenger, as well as more ambitious government targets, they are under significant pressure to respond, not only to comply with regulations around security, safety and the environment, but to new demands from digitally focused customers. Digital transformation is a critical piece in helping them to lower operational costs, improve time to delivery for freight and create an improved customer experience for their passengers.

“Trains completing inspections are said to remain inactive in terminals for nearly 1 million hours per year. Technologies such as machine vision and prognostics can identify issues early, decrease time to identify, and allow parts to be ordered and available at the right location, thus maximizing uptime.”

Susan Beardslee, principal analyst ABI Research, QTR 1 2018.

### Energy efficiency of shipping methods

Number of miles one ton can be carried per gallon of fuel. (Adapted from US DOT Maritime Administration)

<table>
<thead>
<tr>
<th>Mode of transportation</th>
<th>Number of miles/gallon carrying one ton of cargo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean</td>
<td>514 miles/gallon</td>
</tr>
<tr>
<td>Rail</td>
<td>202 miles/gallon</td>
</tr>
<tr>
<td>Truck</td>
<td>59 miles/gallon</td>
</tr>
</tbody>
</table>

* Source: ABI Research, “Rail Freight Digitization and Innovation,” Susan Beardslee, Senior Analyst – April 2018

Automation reduces time between trains by 66%

Rail freight cheaper than air 70%

Accidents caused by human error 40%
The Nokia Bell Labs Future X architecture for railways

Railways are complex with multiple sub-systems connected to trackside and train operations, as well as stations and online retail information and transactions. All of these diverse applications have requirements for connectivity, data storage and processing, as well as analytics and machine learning. The Nokia Bell Labs Future X architecture for railways provides an intelligent, dynamic communications and cloud-based platform to support all of the individual systems, processes and activities of the railway. It will enable better interaction between many existing systems and provide a launch pad for innovative new applications and services.

At the deepest level of the Future X architecture lies dedicated universal broadband connectivity, both wireless and wired, making every kind of communication and information exchange possible. Built with a dynamic mesh fabric around a high-performing IP/optical/microwave core, it uses wired or wireless access to connect with people, sensors, trains, video monitors and automated train control, all securely and with the highest reliability.
Cloud technology is essential to the Future X architecture, ensuring the flexibility, scalability and universal availability of both data and intelligence. Placed throughout the network fabric, local and distributed edge clouds ensure the ultra-low latencies required for video analytics and other processes. Cloud-native, software-defined networks dynamically allocate capacity when and wherever it’s needed — whether to support in-station passenger surges, rush hour congestion, or popular sporting events being watched by passengers onboard.

Built into the Future X architecture are data processing capabilities and analytics, including machine learning and artificial intelligence systems. These ensure that, out of the ocean of data about assets, processes, environment and people, relevant and actionable insights can enable greater efficiencies and new services. Analytics, operational systems and automation provide open, digital value platforms that can be harnessed by any kind of rail application.

The Nokia Bell Labs Future X architecture will help railways to launch their digital transformation. They will be able to create new levels of intelligence, responsiveness and efficiency. With it, they will be better able to address their many challenges and help rail to realize its new role in a more sustainable world.
Use cases for the new railway:

**Train control**
As the global standard for mobile railway communications, GSM-R is used internationally for mission-critical voice and train control data. Nokia was a pioneer in GSM-R and, since its first project in 1998, has installed 21 GSM-R networks worldwide. Looking to the future, new requirements, such as automatic train operation (ATO), will require broadband to support video streams to and from the train. With the planned phase-out of GSM-R in 2030, this will require migration to LTE and, eventually, 5G. These technologies have the potential to support broadband services and high-speed mobility, and also to consolidate all communications needs onto one single, highly flexible but secure and resilient Future X architecture.

**Predictive maintenance and operations intelligence**
The maintenance and repair of rolling stock, track components, depots and stations, often across large geographies, pose challenges in planning the use of repair equipment and teams. Predictive maintenance applications, leveraging IoT asset management and advanced data analytics, are designed to improve on today’s preventive and conditions-based maintenance. They promise to reduce costs, increase asset utilization, enhance safety, and minimize delays and revenue loss. Advanced analytics can also break down data silos, correlating data from IoT sensors, environmental information and historical trends to provide intelligence, solve specific operational and maintenance pain points, and optimize asset lifecycle.

**Video surveillance**
Video surveillance is key for railway operators to monitor critical assets and ensure the safety of personnel and passengers. A typical railway operation has multiple, high-quality closed-circuit television (CCTV) systems generating many multicast IP video streams. This requires a cost-effective and reliable high-capacity communications network able to handle traffic of several Mb/s per camera and thousands of multicast streams. Video analytics can automatically call out anomalies in captured behavior, alerting safety and security personnel in real time.

**The digital passenger**
The modern passenger expects to be connected all the time. They expect the companies they do business with to understand their needs and respond with personal, bespoke communications and services. Making sure that the passenger has full broadband access in-station and on-board is only the beginning. Their smartphone and wearables, such as a watch, should be giving them in-station directions, alerts and information updates. Online planning and ticketing should be closely linked to their in-journey experience. Railway personnel should be equipped with handheld devices that can immediately identify the passenger and provide them with key contextual information. Railways need to provide the seamless connectivity, cloudified data and analytics engines that enable them to partner with others to develop these innovative applications and services.
Customer case story:

Laying the foundation for Swiss Federal Railways’ interconnected and digitized future

Owned by the Swiss Confederation, SBB has 32,000 employees, more than 790 stations and 3,100 kilometers of track. It annually transports more than 430 million passengers and 53 million tons of freight. Facing unprecedented growth, new demands from passengers for broadband connectivity, and the need to support CCTV monitoring systems, SBB decided to also consolidate its existing networks for train control, signaling and GSM-R. According to Yves Zischek, Head of SBB Telecom, “This new nationwide next-generation network will increase our data capacity significantly and at the same time provide an enhanced availability. We’re laying the foundation for an increasingly interconnected and digitized future.”

Nokia is providing SBB with two integrated IP/optical networks. The first is a fully redundant network for all mission-critical applications, including train control and signaling, GSM-R, CCTV and emergency services. The second network will provide passenger, employee and rail applications and services, such as information, announcements, ticketing and passenger broadband. Once operational (2020), this new ultra-broadband network will streamline operations, manage traffic demands more efficiently and introduce new customer-focused services.
Customer case story:

Supporting advanced services for Régie Autonome des Transports Parisiens (RATP)

When the Régie Autonome des Transports Parisiens (RATP), which operates most of the public transport in Paris and its surrounding Île-de-France region, decided to upgrade its transmission and IP routing infrastructure, it turned to Nokia. The project migrated the telecommunications services for 360 of its stations (and a large number of other sites) to a Nokia converged all-IP ultra-broadband network. The network will support new-generation services, including an advanced video surveillance system comprising 15,000 cameras, with unlimited scalability for the foreseeable future.

Line 14 of the Paris Metro, linking the railway station St. Lazare in the 8th arrondissement and Olympiades in the 13th, was already the most advanced RATP metro service when it launched in 1998. Fully automated, it was the first driverless line and, by 2009, it was handling 80 million passengers per year. Nokia helped RATP take Line 14 one step further, demonstrating the first world-test trial of 4G/LTE. During the test, LTE replaced station and in-train Wi-Fi, as well as handling the CBTC train control (simulated), the in-train and on-platform video surveillance systems and passenger information systems.
Solutions for a smarter, safer, customer-focused railway.

As a leader in railway communications, we believe that the Nokia Bell Labs Future X architecture is the best starting point for achieving a smarter, safer and customer-focused railway. Nokia is well placed to support operators with more than 30 years of experience in the sector and the most complete portfolio of products and services to support train control, trackside and rolling stock maintenance, station management, cyber and physical security and customer experience.

Nokia is the market leader in GSM-R with 21 networks and more than 80 mission-critical railway IP/optical networks deployed. As a principal driver of the industry’s standardization work in GSM-R and the evolution to LTE/FRMCS, Nokia knows the complexities and requirements of migrating from legacy to IP-based networks.

As a leader in SD-WAN 2.0 with a unified platform for data centers, public clouds, and branches, Nokia has a range of virtual network and cloud offerings for harnessing the flexibility of the cloud. We also offer solutions for IoT management, operations center, and analytics solutions such as scene analytics, water events prediction and asset lifecycle optimization.

Complementing our full portfolio of railway solutions, Nokia also contributes its professional railway services, such as integration for predictive maintenance and station management, as well as helping with migration of legacy railway systems to the next generation of network and cloud-based technologies. Bell Labs Consulting will help you with planning for the future and understanding the business case benefits of new technologies using a structured methodology for establishing quantifiable outcomes for railways.

networks.nokia.com/industries/railways
About Nokia

We create the technology to connect the world. Powered by the research and innovation of Nokia Bell Labs, we serve communications service providers, governments, large enterprises and consumers, with the industry’s most complete, end-to-end portfolio of products, services and licensing.

From the enabling infrastructure for 5G and the Internet of Things, to emerging applications in virtual reality and digital health, we are shaping the future of technology to transform the human experience.

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