Integrating IoT and analytics to support more efficient, safe and secure railways
The digital imperative

From smarter and safer stations to predictive maintenance of trackside and rolling stock maintenance, the modern railway has the potential to transform its operations from end to end by embracing IoT sensors, machine learning and AI-driven analytics. The Nokia railway solution helps operators to bring all of their data together in a secure way, using a single converged connectivity solution that integrates edge computing, IoT management and analytics in a powerful foundation for the digital transformation of their operations.

The digital transformation of your railway operations is an imperative not only to compete with other rail operators, but to grow freight and passenger traffic versus other modes of transportation. For many rail operators aging rolling stock, signalling systems and trackside infrastructure are long overdue for an overhaul, and this provides an ideal opportunity to integrate digital technologies, such as IoT sensors and software analytics, into your operations. For greenfield operators, digital will be built in from the very beginning. Integrating digital technologies will help you to lower the cost of operations, improve safety and enhance your passenger experience with smart stations and connected onboard services.

Digital railway applications 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 big challenge for rail operators is how to implement all of these promising applications while ensuring the data insights from one area are available to all other applications. The essence of digital transformation is hyper-connectivity — the joining together of multiple digital point solutions into a single digital view of the entire operation, rail ties to tickets.

Nokia is a world leader in providing industries, such as railways, with secure, reliable wired and wireless connectivity, which is the foundation for achieving digital transformation. We are also leading in building cloud, analytics, IoT device management and machine learning into our communications platform, tailored to the needs of railway operators. These capabilities, along with mission-critical communications, can be leveraged by your digital applications to help you operate more efficiently and safely, while offering services that satisfy and delight your passengers.
Digital technologies can be deployed for isolated point solutions, but they only become transformative when they are networked together to enable a fully digital understanding of your operations. This enables you to harness the power of big data using artificial intelligence and machine learning in order to draw out correlations and partially or fully automate aspects of your operations. Many use cases, such as preventive maintenance, gain in power with the depth and breadth of data they can access.

The Nokia rail solution joins two important technology shifts that intersect at the cloud edge. Wireless and wired networks are converging with 5G networks, which are software-defined, virtualized networks where much of the processing occurs at the network edge. At the same time, digital applications for railways, which harness IoT data and analytics, also need to process data at the cloud edge, because automation and autonomous operations are time-sensitive and need to be close to the local operation.

Autonomous and automated applications have very precise connectivity needs that require highly dynamic and adaptive connectivity. The Nokia solution starts with this dynamic connectivity and layers on edge-cloud-compute capabilities and software for managing IoT devices, analytics, machine learning and artificial intelligence. Being built into the connectivity solution ensures that not only is data shareable across applications, network connectivity can be tailored precisely to the needs of the application. We call this network architecture the Nokia Bell Labs Future X architecture for railways — the digital platform you will need for fully transforming your rail operations.
The Nokia railway solution:

**Benefits**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A single, converged approach to network connectivity that lets you manage all of your operational connectivity from a single pane of glass.</td>
<td>2</td>
<td>World-class optical, IP and wireless technologies create a pervasive, reliable and adaptive network that can be tuned to the needs of any application.</td>
</tr>
<tr>
<td>3</td>
<td>Wireless 4G/LTE solutions that can be deployed today with a clear upgrade path to 5G.</td>
<td>4</td>
<td>Multi-edge computing (MEC) capabilities are built into the architecture of the solution to support local and time-sensitive applications.</td>
</tr>
<tr>
<td>5</td>
<td>Provides a fully cloud-native, flexible approach across data centers, public, private and hybrid clouds.</td>
<td>6</td>
<td>Central management of any kind of IoT sensor or device for both onboarding and ongoing diagnostics and software upgrades.</td>
</tr>
<tr>
<td>7</td>
<td>Advanced analytics that break down data silos to enable better operational insights, asset lifecycle management and decision making.</td>
<td>8</td>
<td>Comprehensive, end-to-end security with the ability to mitigate large-scale DDoS attacks originating from, potentially, thousands of unsecured IoT devices.</td>
</tr>
</tbody>
</table>
SpaceTime flood risk prediction

Flooding is the most dominant weather event causing harmful impacts to railway operations. The new normal is for flooding to exceed historic norms in terms of volume, location, and time. Railroads need more precise and accurate patterning of flooding risk to make better in-time operational and long term planning decisions.

Nokia SpaceTime flood risk prediction provides a more actionable solution by leveraging advanced hydrologic process to model flooding while training models on client historic events. The result is a location and time specific view of operational flooding risk across many different types of flooding events. On a continually updating basis, real-time weather data is loaded and analytics are calculated to identify probability of risk.

Alerts exceeding defined thresholds of flood probability combined with Infrastructure vulnerability are pushed to the user interface and then sent by email, text or other systems to operational staff who analyze the best course of action to mitigate the risk to assets. An operational decision is determined and resulting action is taken, averting or minimizing the impact of flooding.
**Trackside maintenance**

Rail maintenance and trackside asset health are high on the list of rail operator priorities. Unplanned trackside maintenance issues affect service, incur penalties and thousands of people can be inconvenienced by delays. To ensure the best service and greatest safety possible, it is essential to predict when maintenance is required and for timely scheduling of trackside resources.

The goal of predictive maintenance is to identify the various fault characteristics of the asset and model custom maintenance activities. The modeling is done using data from historical sources such as rail traffic, rolling-stock flows, maintenance logs, and planning and control activities. Eighty percent of actual track issues resulting in derailsment are caused by vertical displacement of the track. IoT sensors installed on trackside assets can detect vertical displacement and temperature changes. They can also monitor the motions of actuators on the trains and catenary tension swings. Anomalies captured by video analytics, rail-related occurrences and traffic events are all additional data that enable more accurate prediction of maintenance cycles, reducing operations costs and maintenance-related delays, while increasing overall safety.

---

**Manual (time-based maintenance)**

- Measuring irregularity
  - By inspection car (every 3 months)

- Inspection for travel material
  - By visual inspection (annually)

**Warning in real time**

Planned maintenance based on projection

---

**Predictive maintenance with IoT and analytics**

- Real time remote inspection through IoT devices installed on trackside assets

- Condition monitoring

- Decision-making support system
Rolling stock maintenance

The maintenance and repair of rolling stock poses challenges in planning the use of repair equipment and teams. Breakdowns and unscheduled maintenance of aging rolling stock can wreak havoc with even the best maintenance and repair planning. Optimizing rolling stock performance requires an understanding of each asset’s likelihood of failure and the consequences should failure occur.

The Nokia SpaceTime asset lifecycle optimization solution uses condition-based asset assessment and predictive analytics with machine learning to identify failure times and optimize maintenance options. It reduces costs, increases utilization, enhances safety, and minimizes delays and revenue loss. Advanced analytics can also break down data silos, correlating data from IoT sensors, environmental information and historical trends to provide operations intelligence, solve specific operational and maintenance pain points, and optimize asset lifecycle.

Nokia’s industry-leading visualizations display analytics in a wide range of intuitive visual formats to provide unique contextual understanding to users.

The comprehensive, real-time view enables operators to align their risk tolerances, business objectives and processes, asset management strategies, and capital investment planning for optimum performance.
Smart station applications

Analytics and IoT applications can also help to provide a safe and efficient rail station with a better experience for the end user. Smart station applications include smart lighting, smart waste, flood detection, platform ice detection, e-paper display and video analytics for station safety.

Linking these applications to share their data improves their overall efficiency. A waste bin collection application, for instance, could be correlated to train schedules, passenger traffic volumes or ambient temperatures to predict and trigger early pickup in anticipation of greater volumes or faster spoilage.

Video analytics trained to look for anomalous behavior can also be correlated to platform use schedules, personnel badging sensors or audio sensors to help refine the filtering for improved identification of safety or security incidents.
The Nokia difference

Nokia has a full range of connectivity solutions that span from optical to 5G wireless. We are a long-standing leader in providing railways with GSM-R solutions and are working with the industry to evolve towards FRMCS with 5G. We also provide many of our customers with IP/MPLS routing solutions, on-board and in-station Wi-Fi, as well as support for signalling and other trackside requirements.

The Nokia Bell Labs Future X architecture for railways is unique in the industry because it integrates IoT and analytics into the network and leverages the compute and communications resources at the network edge. This not only ensures support for time-sensitive applications, such as autonomous and automated operations, but makes it possible to correlate data from multiple local applications to draw deeper insights and trigger more precise responses.

Nokia network technology has all of the requirements to support business- and mission-critical digital applications of virtually any description. Full security is built into all our technology, which was originally designed for global carrier networks. Even analytics and machine learning are essential characteristics of the network. From secure wireless, wireline and IoT connectivity to the edge cloud, datacenter and video and IoT analytics, Nokia is well placed to build the essential fabric of the digital railway.

Let us help you

At Nokia, we’re defining the fabric of the digital railway with solutions that provide the communications foundation for more reliable, efficient operational processes. Our unique offering of end-to-end, critical communications solutions for the railway industry is built on deep, many-year relationships with the rail industry around the world.

Complementing our full portfolio of railway solutions, Nokia also offers professional and managed services. Bell Labs Consulting will help with planning for the future and for understanding the business case benefits of new technologies using a structured methodology that establishes quantifiable outcomes for rail operators.