



Norwegian railways
deploys advanced
nationwide
communications
network to enhance
safety and efficiency

NOKIA

Jernbaneverket is Norway's national railway administration, responsible for maintaining and operating rail infrastructure for the Ministry of Transport and Communication. Its system runs from Oslo in the south to the Arctic Circle, encompassing 4,230 km of track, 357 stations, over 700 tunnels and four data centers for transporting 61 million passengers and 30 million tons of cargo annually. Jernbaneverket relies heavily on its mission-critical communications network to safely manage traffic and timetables, operate railway stations and terminals, conduct studies and planning, and support business operations. In recent years, the agency faced increasing traffic and the need to deploy new-generation services that met international ERTMS and GSM-R standards. It also wanted to boost operational efficiency and reduce Total Cost of Ownership (TCO). Working with Nokia, Jernbaneverket is deploying a future-ready, GSM-R ground-to-Train infrastructure, and an ultra-broadband IP/MPLS-based optical and microwave network, transforming its communications infrastructure to enable more reliable, efficient and secure services throughout its national system.



Challenge:

- Enhance mission-critical ground-to-train radio network to meet the operational requirements of train operators, dispatchers and on-board personnel.
- Address a continuous increase in passenger and freight traffic.
- Meet international standards for ERTMS, ETCS L2 and GSM-R.
- Deploy CCTV application that requires high-bandwidth transmission capacity.
- Cope with long-distance fiber spans and critical communications in cold, harsh climates and hundreds of tunnels.
- Provision new business applications requiring Ethernet services.
- Reduce TCO by converging all legacy communication networks into a single network.
- Achieve more flexibility in the deployment of new operational and passenger services.

Solution:

- A geo-redundant GSM-R nationwide network carrying ERTMS signaling data for operational communication to the train driver.
- Microwave packet radio solution to backhaul the GSM-R base stations in hilly relief.
- DWDM optical network for high capacity transmission network supporting CCTV in stations.
- Multi-service IP/MPLS network supporting all mission-critical services (signaling, GSM-R), operational applications (CCTV, SCADA), business applications (LAN, telephony) and passenger services (PIDS, PAGA).
- Single management platform for microwave, optical and IP/MPLS components.
- IP address and DHCP management platform Vital QIP to simplify and unify the planning and administration of IP addresses and domain names (DNS).

Benefits:

- Future-proof, flexible networking solution for operations, business and passenger services.
- Simplified management of all transmission and network elements, with a central service portal for easy provisioning of new applications.
- Smooth migration of legacy applications to the new network.
- Ultra-high reliability and redundancy.
- Native integration of the microwave ODU control card in the 7705 router to reduce the number of active elements.
- Enhanced efficiency and safety, with reduced TCO.



“ Jernbaneverket has achieved a major step in modernizing Norwegian railways to meet the increased requirements for security and reliability expected by our passengers.”

Per Magne Olsen, Department Manager, Signal & Tele, Tele Jernbaneverket



Jernbaneverket

“ Nokia proposed the best solution, from edge to core, for all the key elements of our communication infrastructure: GSM-R, microwave, optic, IP/MPLS, management and services.”

Per Magne Olsen, Department Manager, Signal & Tele, Tele Jernbaneverket

The challenges

The Norwegian National Rail Administration, Jernbaneverket, owns and operates one of the world's most scenic railway networks. A large portion of its 4,230 kilometers of track traverses dramatic landscapes of fjords and mountains, with over 700 tunnels. It spans a large area stretching from the capital city, Oslo, in the south, to the town of Bodø, just north of the Arctic Circle. Efficiently and safely transporting 61 million passengers and 30 million tons of cargo each year through remote areas and harsh climates presents an ongoing mission-critical communications challenge.

For years, Jernbaneverket relied on multiple dedicated networks using various technologies supplied by different equipment vendors, making operations complex and costly. None of those networks was capable of supporting projected increases in passenger and freight traffic, nor the

latest generation of advanced applications, such as video protection through closed-circuit television (CCTV), passenger information and business applications (voice and data).

In addition, Jernbaneverket faced the imperative of enhancing safety, efficiency and cross-border interoperability through European Rail Traffic Management System (ERTMS) standards, including European Rail Traffic Management System Level 2 (ETCS L2) for in-cab train control, and the Global System for Mobile Communications – Railway (GSM-R), a proven digital platform that is now the standard for railway-specific voice and data operational services on five continents that is vastly improving the safety and speed of operational services.

All of this required a robust, unified and future-proof networking infrastructure that would

support both mission critical applications such as switching and train control, as well as all operational and business services. The new networking infrastructure also would need to seamlessly run existing legacy applications, with a smooth migration to advanced services going forward. To reduce the total cost of ownership (TCO) of the solution, Jernbaneverket also was seeking comprehensive management tools.

“The key driver was the need to support many different services,” says Per Magne Olsen. “We built this big GSM-R network, and we needed to merge everything into one network that also can support the legacy services and those of the future. All of these are demanding more bandwidth and Ethernet. We have a slogan, ‘IP all over, all over IP.’”

Why Nokia?

Nokia offered Jernbaneverket superior expertise in designing and deploying mission-critical communication networks for railways. It leads the global GSM-R market, and has implemented major rail communications projects in Sweden, United Kingdom, Spain, Turkey, China and throughout Europe, including for Switzerland's Gotthard Base Tunnel. It also was one of a very few suppliers that was able to provide an end-to-end-solution, from the GSM-R radio network, to IP address and a domain name system (DNS) management platform, including dense wavelength division multiplexing (DWDM) for maximizing bandwidth over optical fiber networks, packet microwave and internet protocol / multi-protocol label switching (IP/MPLS) routers and switches. By supplying the entire solution, Nokia would be able to meet all the safety and security requirements by optimizing the implementation of all fail-over, back-up and redundancy mechanisms along the end-to-end network.

"This is a major step in modernizing the Norwegian railways, and necessary to meet the increased requirements for security and reliability expected by our customers," says Per Magne Olsen. "Nokia proposed the best solution, from edge to core, for all the key elements of our fixed and radio communication infrastructure."

The solution

In 2010, Jernbaneverket engaged Nokia to roll out a national GSM-R network that would cover all aspects of the system, including its hundreds of tunnels. Nokia upgraded the existing R99 core platform with its R4 core platform at the primary site in Trondheim, including the subscriber data management and dispatcher system; and deployed an additional, fully geo-redundant core network platform at a distant location to carry the full traffic in case of any disaster or during maintenance activities at the primary site.

"We put a lot of time and effort into getting the design right, so that we don't have to change it later," says Per Magne Olsen. "We rolled out the regional nodes, followed by the access nodes. The first line up and running was between Oslo and Bergen and it's really working well."

The solution includes eight base station controllers (BSCs), 700 base transceiver stations (BTS) covering all 4,230 km of railroads. The solution also includes cab radios for all locomotives, probe solutions for analyzing data traffic, voice recorders and the OSS system for efficiently managing all services.

The geo-redundant GSM-R nationwide network carries ERTMS signaling data and operational communication to train drivers. In addition to the base station controllers (BSC/ FlexiBSC), the base transceiver stations (BTS/ FlexiEDGE), the solution also includes an intelligent network (IN) platform, a general packet radio service (GPRS) packet core, a short message service center (SMS-C), subscriber data management (SDM), dispatcher, voice recorder and an operational support system (OSS). The single management platform for microwave, optical and IP/MPLS components runs with Nokia's 5620 SAM

(service aware manager) and 5650 CPAM (control plane aware manager). It provides an intuitive graphical user interface to deliver end-to-end network service planning, provisioning, monitoring and troubleshooting.



To backhaul the GSM-R network and support all mission critical and operational applications along the rail tracks and stations, as well as interconnect the control centers at data centers, Nokia deployed DWDM optical network infrastructure, a packet microwave system (9500 MPR with packet microwave card and power injector card integrated in 7705 SAR-8) and an IP/MPLS network to reliably transport all converged services with maximum reliability, efficiency and security.

A DWDM optical network supplies high-capacity transmission for CCTV in stations utilizing a tunable, reconfigurable optical add drop multiplexer (TROADM), the 1830 PSS-32 and PSS-16, 10G Ethernet cards, and a tracker to manage wavelengths anywhere in the network.

This provides the necessary data capacity to deploy bandwidth-hungry applications such as CCTV, as well as extra capacity that will allow the potential resale of excess bandwidth to third parties.

The microwave packet radio solution is used both in the aggregation network and to connect GSM-R base stations. MPR and power injector cards are integrated in the IP/MPLS 7705 SAR-8) service access router to connect the outdoor unit (ODU) in a single element configuration. Microwave is a cost-effective backhauling solution, especially in Norway's mountainous environments.

An end-to-end IP/MPLS network, made of more than 1,000 service routers and switches, runs on top of the fiber, microwave and even copper to support both new and legacy services and applications, including train control, CCTV, passenger information and SCADA, as well as operational voice, business telephony, LAN, interconnection with data centers and control center operations. The Nokia IP/MPLS network also provides synchronization for all services

requiring accurate time and phase information. Utilizing 7750 SR-7 service routers for the core network, 7450 ESS and 7750 service routers for the aggregation layer, and 7705 SAR-8 service aggregation routers for the access and distribution layer, the system handles all of the services that previously required multiple separate networks, simplifying operations and increasing operational efficiency, with lower overall total cost of ownership (TCO).

This unified network is highly reliable and redundant. Its fast re-routing and re-convergence capabilities guarantee that all critical applications are always running, ensuring 99.99 percent reliability, with fast switchover of the GSM-R base stations.

The GSM-R solution is able to evolve with geo-redundant and GPRS cores. DWDM optical transport reduces OPEX with multi-degree tunable and reconfigurable optical add/drop multiplexing (T/ROADM) design. This allows full networking flexibility, so that any client service can be transported over any wavelength in any direction. T/ROADM capabilities ease the deployment of new services and reduce CAPEX by avoid installing signal regenerators along long-distance spans.

A packet microwave solution is natively integrated within the IP/MPLS routers to reduce the number of boxes to manage. The IP/MPLS solution offered was superior with its synchronous Ethernet, (key for GSM-R), fast re-route and traffic engineering capabilities. A single and unified management platform manages the entire transmission networking infrastructure.



Next steps

Jernbaneverket's new future-proof network will allow it to further deploy new applications, services and communications platforms such as LTE in the years ahead. Its multi-tenancy capability also opens the way for the agency to resell any network capacity for generating additional revenues, should it choose to do so. Jernbaneverket and Nokia also have a 20-year support agreement for the complete maintenance of the network, including hardware services, spare-parts management, software support and upgrades that will provide Norway's rail system with a high-performance, always-on communications system.

The benefits

Jernbaneverket now has a highly reliable geo-redundant GSM-R network to support the mission-critical signaling and operational voice services. The fixed networks is a future-proof, flexible IP/MPLS ultra-broadband networking solution for operations, business and passenger services, providing ultra-high reliability, redundancy and security. This IP network support legacy applications, and will allow a smooth migration to next-generation IP-based services and applications as they become available and are deployed.

"We wanted to further improve the quality of our railway communications by ensuring high availability of the GSM-R network. This will enhance efficiency of our railway operations, minimize train delays and improve safety of our passengers," says Per Magne Olsen.

Thanks to its single infrastructure for all applications (critical and non critical), which

previously ran on separate networks, and native integration of the microwave ODU control card and 7705 SAR-8 service aggregation routers, the new network reduced number of active elements, simplifying daily operations with a lower potential for errors.

The new network provides Jernbaneverket with reduced TCO, a single management platform for all transmission network elements and a TROADM for optical multiplexing, allowing dynamic assignment of bandwidth.

Summary

Nokia provided Jernbaneverket a highly reliable GSM-R network with an integrated, ultra-broadband solution that has transformed its communications infrastructure into a next-generation network, enabling more reliable and secure services throughout Norway's national rail system. A unified IP/MPLS network with WDM infrastructure, and microwave backhauling of GSM-R stations, provides a nationwide backbone to support deployment of ERTMS, ETCS L2, GSM-R, CCTV and SCADA while converging several legacy infrastructures into one, reducing costs. This allows Jernbaneverket to take its operations to the next level of efficiency and safety while adapting international safety standards, resulting in an overall lower TCO.

Says Per Magne Olsen, "There now is consistency in our product line; we have one management solution, and we also have the service portal, so it's easier for us to provision the network and minimize the number of people working in network operations. We now have one platform, a one-stop solution, and one vendor, with access to technical expertise – these are all advantages."



Glossary

BSC:	Base Station Controller
BTS:	Base Transceiver Station
CCTV:	Closed Circuit TeleVision
DNS:	Domain Name Server
DWDM:	Dense Wavelength Division Multiplexing
ETCS L2:	European Train Control System Level 2
ERTMS:	European Rail Traffic Management
GPRS:	General Packet Radio Service
ICT:	Information Communication Technology
IP:	Internet Protocol
IP/MPLS:	Internet Protocol / Multi Protocol Label Switching
LAN:	Local Area Network
LTE:	Lont Term Evolution
MPR:	Microwave Parcket Radio

ODU:	Outdoor Unit
OSS:	Operational Support System
PAGA:	Passenger Announcement General Annoucement
PIDS:	Passenger Information Duisplay System
PSS:	Photonic Service Switch
SAM:	Service Aware Management
SAR:	Service Access Router
SCADA:	Supervisory Control And Data Acquisition
SDM:	Subscriber Data Management
SMS-C:	Short Message Service Center
TCO:	Total Cost of Ownership
T/ROADM:	Tunable/Reconfigurable Optical Add Drop Multiplexing

Nokia OYJ
Karakaari 7
02610 Espoo
Finland

Tel. +358 (0) 10 44 88 000

CID 200530

© 2023 Nokia

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.