Banedanmark Creates a Digital Twin of Denmark's Railway System to Modernize Signaling and Reducing Delays

Bentley Applications Unified Teams and Visualized Real-world Conditions, Streamlining Development and Preventing Clashes

RUNNING TRAINS ON WWII TECHNOLOGY

Centuries after their creation, railways continue to provide reliable and convenient passenger and freight transportation across countries and continents. However, rail systems are locked into specific tracks shared by all trains. Without careful coordination, trains risk collisions, which lead to delays, damaged cargo, and even injuries or fatalities. Signaling systems keep railway operators aware of traffic flow and rail availability, which ensures trains can move safely and remain on schedule.

Denmark's railway system includes 2,633 kilometers of track with an annual ridership of more than 200 million, along with critical transportation of goods to and from Germany and Sweden. The country's rail operations rely on analog lights and signs along the tracks. Banedanmark is responsible for maintenance and traffic control on the state-owned railway network, including signaling system operations.

Though the current signaling system has served Denmark's rails well, it has aged. "Part of the signaling systems in use today are around 50 years old," said Farzad Aknooni, BIM specialist for Banedanmark. Many of the signals – some of which have been in use since 1912 – have degraded over the decades and are not compatible with digital solutions. Additionally, different countries use different signaling systems, which can lead to delays or schedule clashes when trains cross national borders. To fully incorporate innovative technologies and improve operations, Banedanmark needs to overhaul Denmark's signaling system.

DIGITAL SIGNALING WITHOUT SIGNS

Banedanmark determined that they should transition to the European Rail Traffic Management System (ERTMS). "The new signaling system is being rolled

out on the entire Danish railway," said Farzad. "It builds on common European standards and creates better conditions for rail transport across European borders, as the signaling system in trains and the infrastructure along the tracks will be uniform." The European system is radio-based and completely digital, drastically decreasing the need for optical signs and signals on the track. Instead, signals are coded into the rail operating system for operations management. In addition to improving rail operations within Denmark, the pan-European system will improve traffic between borders and make electrification efforts easier, which will lower carbon emissions. Various European countries are in the process of gradually replacing older signals and adopting ERTMS.

Though ERTMS is a unified standard, it must still be modified for each country's railways. The first step of implementing it in Denmark is to undertake a detailed review of the nation's rail lines. In the process, Banedanmark and the European Union Agency for Railways will determine how to adapt the system, and in some cases develop new system elements. After the organizations install new components in and around the tracks as well as inside the trains, these components must be tested individually and as a unified system before the new signaling wins approval and becomes the basis for transporting people and goods. Lastly, Denmark is the first European country to attempt a complete conversion of a national rail network to the system, making the project unprecedented. Though Banedanmark announced the EUR 3.3 billion effort in 2008, they faced numerous challenges – their analog design often could not predict issues discovered when workers visited the job site, or whether it was even possible to install a desired component at a specific location, causing a domino effect of revisions throughout the

PROJECT SUMMARY

ORGANIZATION
Banedanmark

SOLUTION
Rail and Transit

LOCATION
Denmark

PROJECT OBJECTIVES
- To develop a digital twin of the signaling system for Denmark's railway network.

- To establish digital signaling that would greatly improve the safety, reliability, and speed of Denmark's railways.

PROJECT PLAYBOOK
MicroStation®, OpenRail™, OpenRoads™, ProjectWise®

FAST FACTS
- Much of the signaling system on Denmark's railroad is outdated, some signals 50 years old.

- Banedanmark wanted to upgrade to the European Rail Traffic Management System standards, which would replace physical signals with digital information.

- Design proposals often clashed with real-world conditions, leading to rework and delays.

ROI
- The digital workflow reduces the design time by up to 30% by viewing data within the digital twin, rather than accessing PDF files.

- When the system is complete, signal-related delays are expected to decline between 50% to 80%, depending on the line.

> "Put simply, without Bentley applications it was impossible to successfully work on this project."
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> – *Farzad Aknooni, BIM Specialist, Banedanmark*

entire network. As a result, the project experienced many delays. To effectively manage, develop, implement, and test the groundbreaking and complex EUR 3.3 billion digitization project, Banedanmark needed to make their design process digital as well.

BRINGING REAL-WORLD CONDITIONS TO THE OFFICE

The design team soon realized that they could overcome their struggles by creating a digital twin of the rail system with Bentley applications. With clear, intuitive visualizations of real-world conditions available at the office, they can easily anticipate issues and ensure that components are installed in the desired locations without having to travel to the job site.

Banedanmark began by establishing a connected data environment with ProjectWise, helping all teams to collaborate and establish strict version control. Within that environment, designers used third-party applications to create a digital twin of the project. To ensure the digital twin accurately reflected real-world conditions, they used Bentley applications to review and approve all elements. They also used OpenRail to accurately create and align the track center line, serving as the backbone of the project. Once the team established geographical data in the main model, they can now import and incorporate material made by other applications or systems and automatically apply their geographical information to it without having to make manual adjustments or undertake additional field work.

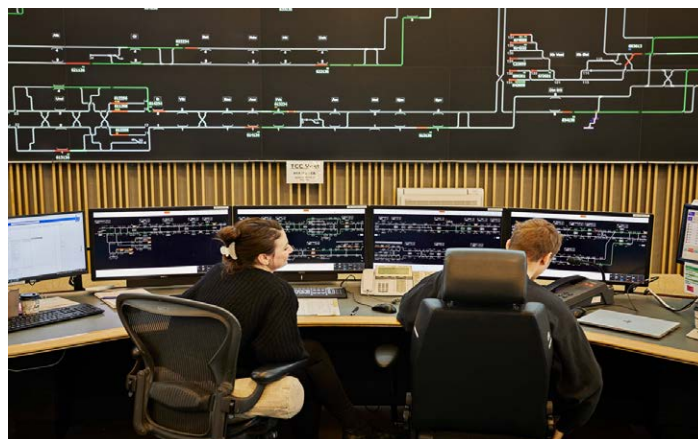### FASTER TRAVEL WITH ARTIFICIAL INTELLIGENCE

By establishing a connected data environment centered on a digital twin, Banedanmark streamlined the design process and enables all teams

to collaborate on this complex project without having to send information by email. The workflow reduces the design time by up to 30% by viewing data within the digital twin, rather than accessing PDF files. Using an exact replica of the project's geography greatly reduces the number of issues teams encounter on site, as designers in the office already know if component placement is physically possible or if it will create clashes. If a change in one element creates a cascade of other changes, designers can quickly determine the scope of adjustments that are needed and quickly make them without introducing errors.

The new signaling system will allow individual trains to be fully controlled by artificial intelligence and tracked by the system as they travel, eliminating human error and any possible clashes in train schedules. When the system is complete, signal-related delays are expected to decline between 50% to 80%, depending on the line. Not only will train operations become safer and more reliable, they will also result in frequent train travel. Continuous train location tracking will also help stations provide more accurate arrival and departure information to passengers. Since the same signaling system will be used throughout Europe, fast-moving trains will not need to check scheduling or slow down when they move into other countries. "Countrywide there will be a higher and more homogenous level of safety," said Farzad. "Future maintenance will be more economical, and the system will provide an unprecedented foundation for better centralized traffic control, energy optimization, and on-time passenger information." Additionally, the system will provide a foundation for continued electrification, further lowering carbon emissions generated by older trains.

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