Advancing rail through infrastructure intelligence

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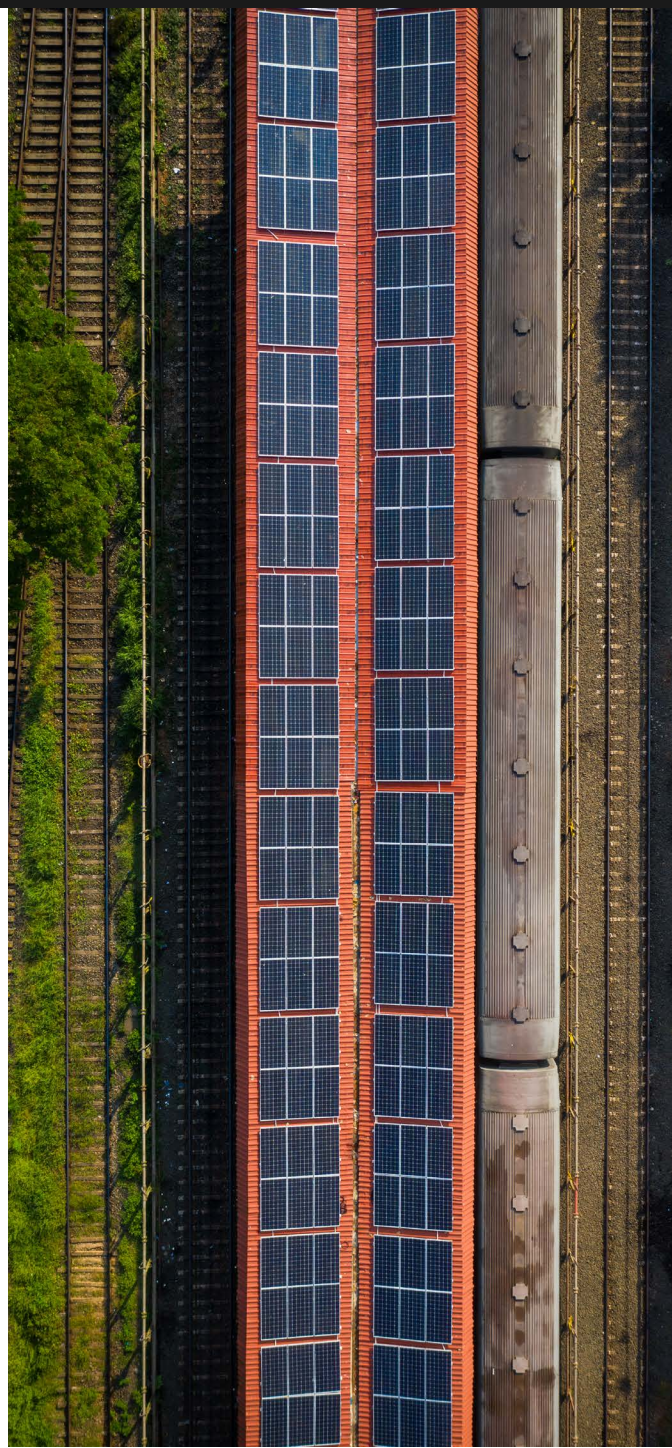


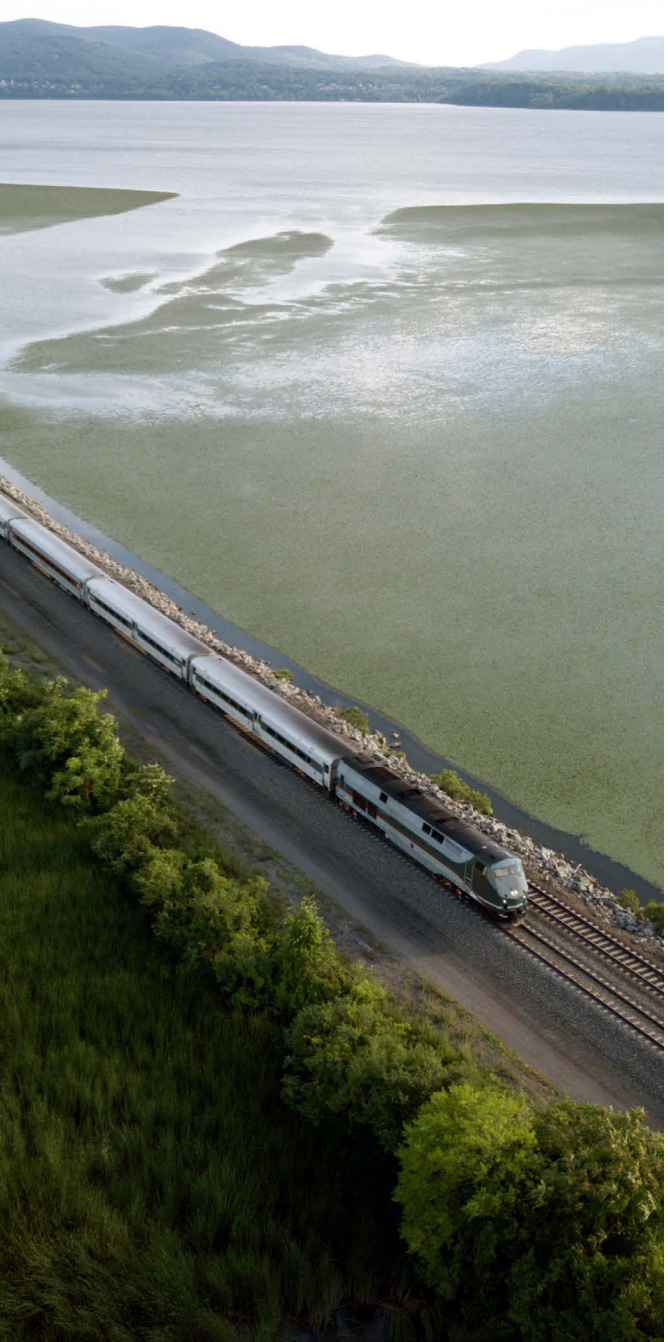
Connected, intelligent, resilient: The new era of rail infrastructure

The rail infrastructure sector is under mounting pressure to modernize in the face of growing urban populations, aging assets, and ambitious climate goals. Global rail demand is expected to increase by over 50% by 2050, yet many networks are already operating at or near capacity. Infrastructure managers must now deliver safer, more efficient, and more sustainable systems without the luxury of expanding physical footprints.

Digital transformation is emerging as the key to meeting these demands across the entire infrastructure lifecycle. In the planning phase, digital twins and data-driven simulations enable smarter network design and scenario testing. During design and construction, building information modeling (BIM) and integrated project delivery improve collaboration, reduce rework, and accelerate timelines. In operation, real-time monitoring and automation enhance safety and efficiency, while predictive maintenance powered by AI and the Internet of Things (IoT) reduces downtime and extends asset life.

Bentley offers a comprehensive digital approach specifically tailored for the rail and transit industry. Our solutions support the full infrastructure lifecycle, helping owner-operators, engineers, and contractors accelerate delivery and create safer, more efficient, and resilient rail systems.

This e-book explores how digital innovation is reshaping each stage of the rail infrastructure lifecycle, empowering leaders to make informed decisions, optimize performance, and build resilient systems for the future of mobility.



Chapter 1: The digital shift in rail and transit

The need for smarter, data-driven infrastructure

With urban populations rising and sustainability targets tightening, traditional methods of planning and managing infrastructure are no longer sufficient. Data is now a strategic asset enabling real-time decision-making, predictive maintenance, and optimized performance across the entire asset lifecycle. Digital tools empower stakeholders to simulate scenarios, assess risks, and make informed choices that improve safety, efficiency, and long-term value.

Despite the promise of digital transformation, many owner-operators and engineering firms face significant hurdles. Fragmented data, siloed workflows, and legacy systems often hinder collaboration and slow project delivery. Budget constraints and regulatory complexity add further pressure, especially when managing aging infrastructure alongside new capital projects. Additionally, the lack of interoperability between tools and platforms can lead to costly rework, delays, and missed opportunities for innovation.

Connecting the physical and digital worlds

Bridging the gap between the physical and digital worlds is essential to overcoming these challenges. Technologies like digital twins, IoT sensors, and cloud-based collaboration platforms allow infrastructure to be visualized, analyzed, and managed in real time. By creating a living digital representation of physical assets, stakeholders can monitor performance, anticipate failures, and coordinate across disciplines more effectively. This convergence of the physical and digital realms is not just a technological shift; it's a strategic imperative for building resilient, future-ready rail systems.

Our industry-specific software and expertise help infrastructure professionals meet each sector's unique demands, offering solutions for today's challenges while ensuring a sustainable and resilient future.

Drive better outcomes across the entire asset lifecycle with:

- Dynamic and comprehensive planning that sets the foundation for successful design.
- Safe, efficient, and streamlined construction from simulation in advance and connected field activities when shovels move.
- Well-built infrastructure that facilitates smooth consistent operations.
- Integrated and predictive analytics that ensure longevity and reliability.

Let's explore how these solutions for each phase of the asset lifecycle contributes to building smarter, more resilient rail systems.

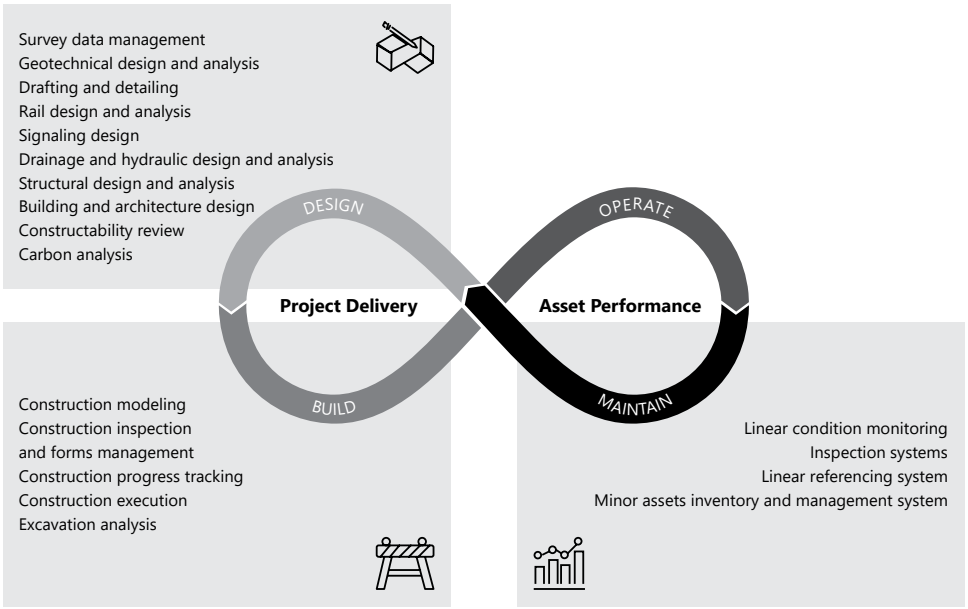
Rail and transit solutions

Full lifecycle

Document management system
Connected data environment
Geographic information systems (GIS)
Engineering geological modelling

Mobility simulation
Geotechnical data management
Requirements/compliance management
Condition monitoring system (IoT)

Enterprise data management
Reporting and dashboarding system
Imagery and field data collection management



Chapter 2: Design excellence with digital workflows

Modern rail infrastructure planning is being transformed by digital tools that enable more precise, informed decision-making from the outset.

Through dynamic simulations and conceptual layouts, planners can visualize how stations and networks will perform under various conditions, reducing redesigns and ensuring future-ready infrastructure.

Reality modeling techniques, such as 3D models generated from photographs and point clouds, offer accurate representations of existing environments, helping teams assess constraints and plan confidently.

3D reality meshes provide photorealistic, contextual visualizations that enhance stakeholder communication and accelerate approvals. Together, these technologies empower rail and transit organizations to plan smarter, mitigate risks, and build more resilient systems.

Engineering excellence starts below the surface

Unforeseen site conditions are the second leading cause of claims on transportation projects. The solution lies in a clearer understanding of what's below the surface. If unforeseen site conditions, changes in scope, or environmental events do occur, how can you add new data and easily model scenarios to make better-informed decisions quickly?

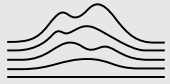
Seequent®, the Bentley Subsurface Company, is the global leader in subsurface software. Understanding what lies beneath isn't just part of what they do—it's their sole focus and deepest expertise. Together, Seequent's trusted subsurface tools and Bentley's proven civil design software work together to provide a clear, connected view of what's happening above and below ground. This enables users to identify and mitigate risks early, minimize errors and rework, and deliver projects more quickly, cost-effectively, and with greater resilience.

Ensure projects are built on a solid foundation

Provide reliable geotechnical assessments to ensure designs are stable, meet standards, and reduce risk.

Proactively identify and mitigate risks

Identify and manage subsurface and environmental risks early to prevent delays and cost overruns during construction. Use the 3D geological model during operations and maintenance to inform ongoing risk management.

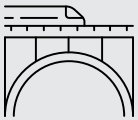


Full insight above ground and below ground

See the full picture with integrated subsurface and infrastructure data, so nothing gets missed. Ensure ground investigation data remains reliable and accessible for ongoing operations and maintenance, supporting long-term project success.

Smarter workflows for smarter design

Gone are the days of static 2D plans as the sole source of truth. Today's digital workflows support model-based design that spans 2D documentation, 3D visualization, and 4D construction sequencing. These models not only enhance design accuracy but also improve communication between design and construction teams.



Integrating multidiscipline design

Integrating multidiscipline design in rail and transit projects ensures seamless collaboration across engineering domains like track, bridge, tunnel, and signaling. Digital workflows unify teams in a shared environment, enabling real-time coordination. This approach eliminates silos, reduces rework, and enhances overall design quality. The result is a more efficient, cohesive, and future-ready infrastructure.

Design for 2D, 3D, and 4D deliverables

Model-centric workflows support model-based design that spans 2D documentation, 3D visualization, and 4D construction sequencing, enhancing accuracy, communication, and construction planning. This shift to model-based deliverables ensures that design intent is preserved throughout the project lifecycle.

Ensure compliance with local and global standards

By embedding compliance checks into the design process, teams can meet local and global standards while reducing manual errors and focusing on innovation. This integrated, standards-aligned approach empowers rail and transit organizations to deliver higher-quality infrastructure faster and with greater confidence.

Digital workflows in the rail design phase enhance cross-discipline collaboration, reducing design conflicts and rework, ultimately driving significant cost savings and accelerating project timelines.

Why choose Bentley for rail and transit design?
Our design solutions are based on decades of industry knowledge combined with advanced digital tools and data-driven strategies to maximize project value.

Purpose-built Accelerate design and documentation with rail and transit-specific modeling capabilities and automated plan production.

Scalable Improve performance with the ability to easily consume, process, and analyze large data files.

Collaborative Work from field to finish with multidiscipline teams using one dataset.

Our solutions

- Survey data management
- Geotechnical design and analysis
- Drafting and detailing
- Rail design and analysis
- Signaling design
- Drainage and hydraulic design and analysis
- Structural design and analysis
- Building and architecture design
- Constructability review
- Carbon analysis

Chapter 3: Enhancing construction with 4D modeling

The handover from design to construction is critical, ensuring that the vision and technical intent of the design are accurately translated into physical execution. Traditionally this meant relying on PDFs and disconnected schedules. Today, that paradigm is shifting.

From static documents to dynamic models

4D modeling is revolutionizing rail infrastructure construction by replacing static documents and disconnected schedules with dynamic, time linked digital models that enhance planning, communication, and predictability.

Real-time visualization and progress tracking

Empower teams to visualize construction progress in real time, both in the office and on-site. By integrating real-time field data, teams can visualize progress, track productivity, and proactively manage risks. Simulate construction sequences, identify potential clashes, and adjust plans before issues arise.

Bridging the gap between design and construction

Foster collaboration between design and construction teams and reduce rework. By working from a shared digital model, stakeholders can validate constructability, coordinate logistics, and ensure that design intent is preserved throughout execution.

Why choose Bentley for rail and transit construction?
Our rail construction solutions offer integrated digital workflows that span preconstruction planning to execution and beyond.

Simplify construction planning and collaboration Use model-based workflows and cloud technology to create a secure, single source of truth that aligns design and construction for better outcomes.

Plan, model, visualize, and simulate in 4D Turn linear design models into construction models to improve the use of data and to better optimize project plans, schedules, and resources.

Manage cost projections and automated quantity takeoffs Leverage 4D workflows to break horizontal projects into constructible components with auto-calculated quantity takeoffs (QTO) for more accurate cost projections.

Our solutions

- Construction modeling
- Construction inspection and forms management
- Construction progress tracking
- Construction execution
- Excavation analysis

Chapter 4: Empower operational efficiency with connected data

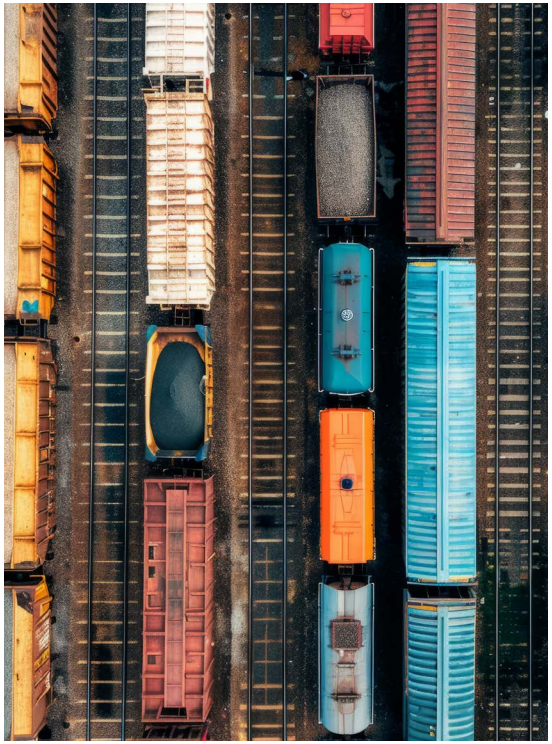
With over 95% of the infrastructure needed for 2030 already in place, the focus must shift to modernizing, maintaining, and optimizing existing assets while continuing to build for the future.

Unlocking the power of connected data
In today's complex rail and transit environments, data is only valuable when it's accessible, accurate, and actionable. Digital platforms that unify engineering, operational, and inspection data across the asset lifecycle are transforming infrastructure management. By breaking down silos and enabling a holistic view of networks, connected data environments empower smarter, faster decisions.

Digital twins: Real-time view of infrastructure
Digital twins are dynamic, continuously updated digital representations of physical assets. In rail and transit, they integrate sensor, inspection, and engineering data to provide a real-time, immersive view of infrastructure, both above and below ground. It enables stakeholders to visualize conditions, anticipate issues, and simulate performance to optimize operations.

Driving safety, reliability, and proactive management
As digital twins evolve with incoming data, they offer a living model that supports proactive asset management. Real-time analytics provide continuous visibility into asset health, helping teams detect anomalies, assess risks, and respond before issues escalate. Whether it's tracking the health of bridges, monitoring track geometry, or optimizing rolling stock availability, these insights enhance safety, reliability, and regulatory compliance.

Reducing rework and maximizing resources
With accurate, up-to-date information, teams can prioritize maintenance, streamline inspections, and allocate budgets more effectively. Predictive analytics further reduce downtime by forecasting degradation and enabling just-in-time interventions extending asset life and reducing costs.



By embracing digital intelligence, rail and transit organizations can move from reactive operations to proactive asset management, delivering better service, reducing costs, and building a more resilient future.

Why choose Bentley for rail and transit operation and maintenance?
Bentley's asset performance solutions provide a set of applications for optimizing operational rail and transit networks and related infrastructure. Our solutions leverage the data organizations own to mitigate risk, increase operational efficiency, improve performance, and ensure regulatory compliance.

Single view of the truth Seamlessly combine engineering data from diverse design tools into a federated environment without disrupting existing workflows, while aligning that data with real-world conditions using geospatial, IoT, and other operational inputs.

Visualize, simulate, and monitor Combine disparate data into a federated environment that reflects current and predicted conditions for inspections, reporting, and insights. Track real-world changes through IoT-connected devices, use immersive visualization, and gain deeper understanding with analytics powered by artificial intelligence (AI) and machine learning (ML).

Improve decisions, get results By reducing project costs and risks, enhancing service quality, and supporting sustainability goals, you can deliver greater value, improve operational efficiency, and strengthen long-term asset performance.

Our solutions

- Linear condition monitoring
- Inspection systems
- Linear referencing system
- Minor assets inventory and management system

Chapter 5: Real-world success stories

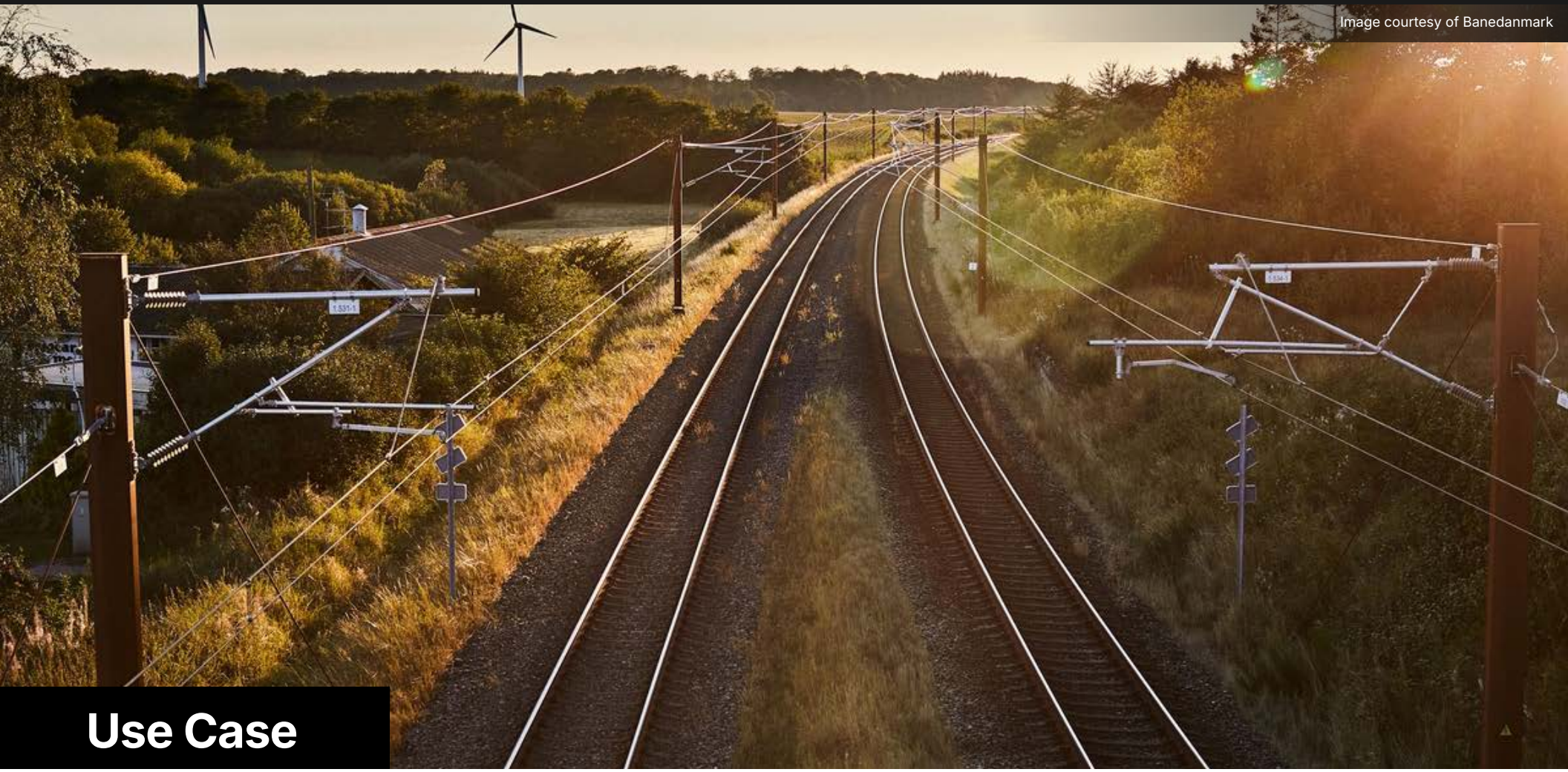
The benefits of digital transformation are not just theoretical they're measurable. These efficiencies are driven by the ability to visualize infrastructure in context, simulate construction sequences, and proactively manage asset health.


Image courtesy of PT Wijaya Karya

Use Case

Integrated high speed rail and station Jakarta

- By improving design efficiency and quality, PT Wijaya Karya saved USD 185 million in construction costs and shortened the schedule by six months.
- Bentley's OpenRail™ facilitated contractor involvement and increased productivity and design quality assurance by 40%.
- Using a connected data environment, WIKA expects to save 20% in construction time, cut labor costs by 10%, and reduce the frequency of meetings by 35%.
- By integrating location intelligence and real-time data into digital twins, teams can reduce the time spent searching for information and instead focus on high-value tasks that drive project success.



Use Case

Upgrading Denmark’s railway system to modernize signaling

- The digital workflow reduces the design time by up to 30% by viewing data within the digital twin, rather than accessing PDFs.
- 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.
- When the system is complete, signal-related delays are expected to decline between 50% to 80%, depending on the line.

Image courtesy of ACCIONIA

Use Case

Removing dangerous level crossings and constructing new stations in Melbourne Australia

- With the iTwin® Platform, ACCIONA developed a digital twin of the project that they could adjust in real-time, allowing the team to visualize construction workflows and decide how they could reduce construction time.
- ACCIONA reduced staging time by 67% and drafting requests by approximately 88%.
- Using SYNCHRO™ helped the team ensure that workers were always a safe distance from live rail lines for secure operation of the rail network.

Voices from the field

Engineering firms and operators consistently highlight the value of Bentley's solutions in enabling smarter, more collaborative project delivery.

> "The adoption of [Bentley's] digital technologies improves project performance and seamless collaboration among project stakeholders while maintaining the quality of deliverables."

Imam Detriana, Head of Project Management Office Division, PT MRT Jakarta

> "The adoption Bentley's software and support, coupled with our domain knowledge of infrastructure, the environment, and social value, has enabled us to bring this [project] together and use digital engineering processes from start to finish to manage and deliver the work program in record time, despite facing global challenges, such as the pandemic, like never before."

Alex Gilbert, Managing Director, Amey Consulting

> "Bentley's [digital] applications translate into inevitable efficiency in the design phase, as well as significant savings in time for review and coordination between discliplines."

Daniela Aprea, BIM Manager, Italferr S.p.A.

These voices underscore a powerful truth: when rail and transit organizations embrace digital transformation, they unlock new levels of performance, resilience, and return on investment.

Smarter, safer, more sustainable: The digital advantage

As the rail and transit sector faces increasing complexity, digital transformation is no longer optional it's essential. For owner-operators, the benefits are clear: improved asset performance, reduced lifecycle costs, and enhanced safety. For engineering firms, digital workflows enable faster delivery, better collaboration, and higher quality outcomes.

Bentley stands at the forefront of this transformation, empowering organizations to connect data, disciplines, and decisions across the entire infrastructure lifecycle. From planning and design to construction, operations, and maintenance, Bentley's solutions help turn vision into reality efficiently, sustainably, and at scale.

The future of rail and transit is digital, and it's already underway. By embracing open, interoperable technologies and investing in digital capabilities today, industry leaders can build smarter, more resilient infrastructure for generations to come.

Now is the time to act. Start your digital journey with Bentley and lead the way in shaping the future of mobility.

Learn more