Digital Twins Drive Better Outcomes across the Rail Asset Lifecycle

Connect the physical and virtual worlds to plan, design, construct, and operate rail and transit networks

Digital Twins Are Going Mainstream in the Rail and Transit Industry

Rail networks will play an essential role in the future of mobility, but owner-operators and their supply chains face many challenges, including dealing with aging infrastructure, shorter deadlines, tighter budgets, and distributed teams. Yet, in an ever-evolving and connected world and economy, digital technology, including digital twins, has the potential to rewrite the rulebook.

Digital twins provide opportunities to deliver improved business outcomes across the entire rail and transit asset lifecycle, and can help reshape how infrastructure is planned, designed, built, and operated. However, the sheer volume and variety of data, as well as managing the constant and dynamic change in our industry, can be overwhelming for rail professionals, whether in project delivery or operations.

To help engineers, designers, asset managers, inspectors, and other specialists do their job better and faster, the rail industry is embracing digital workflows on existing and future networks.

As part of this transformation—made possible by advances in geotechnical engineering, 3D modeling, 4D planning and visualization, reality modeling, artificial intelligence, and machine learning—digital twins provide an immersive and holistic view of infrastructure assets aboveground and belowground.

For capital projects, a digital twin can help drive efficiency and increase quality within multidiscipline and digitized workflows, enabling streamlined collaboration, maximum productivity, and more informed decisions.

During operations, combining data from continuous surveys, photogrammetry, LiDAR, walked inspections and/or remote sensors, digital twins help optimize rail maintenance strategies to reduce costs and improve overall safety and reliability.

What Is a Digital Twin?

A digital twin is a digital representation of a physical asset, process, or system, as well as the engineering information that allows us to understand and model its performance.

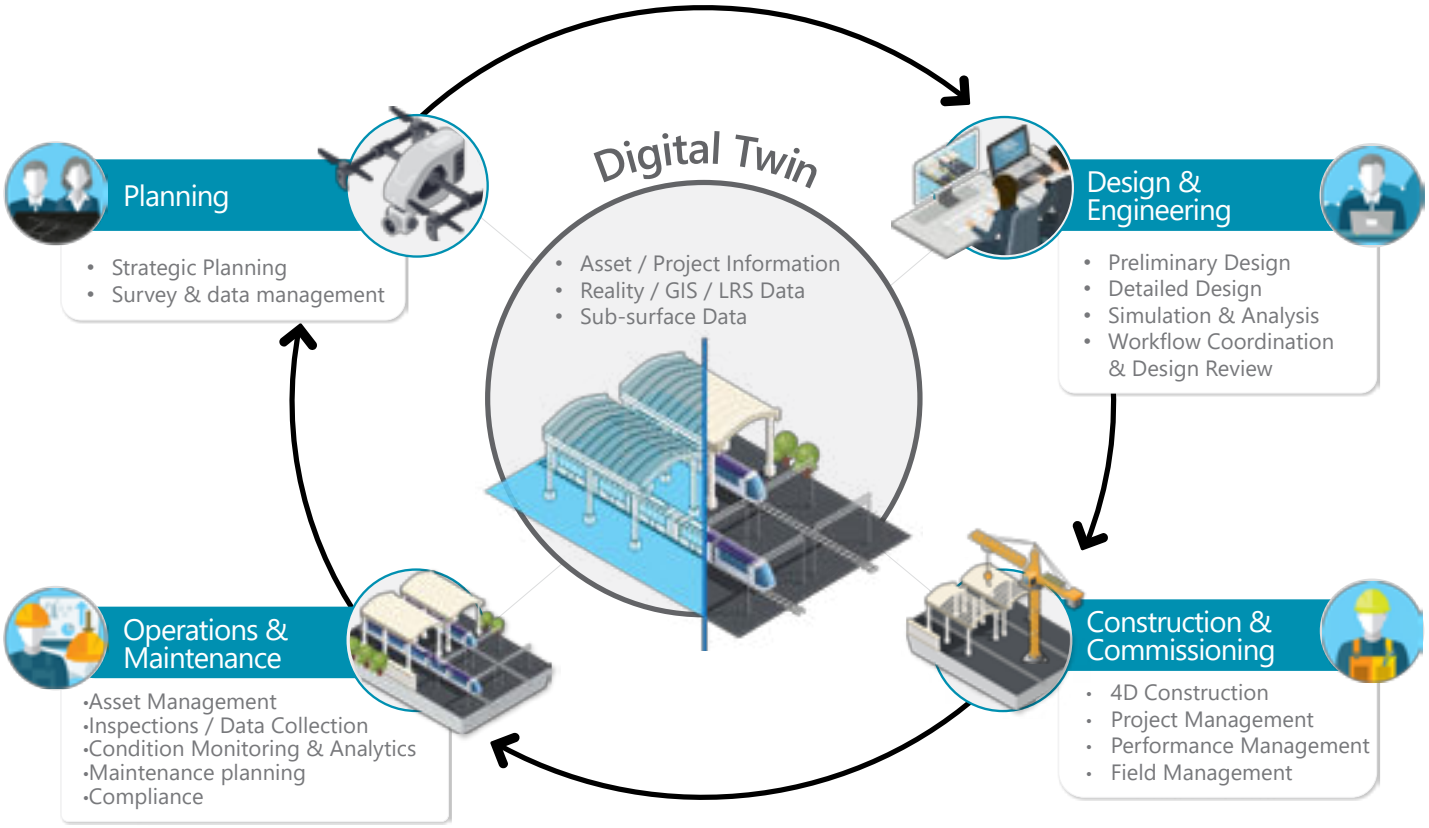
Typically, a digital twin is continuously updated from multiple sources, including sensors and surveying, to represent its near real-time status, working condition, or position. A digital twin enables users to visualize the asset, check its status, perform analysis, and generate insights to predict and optimize asset performance.

Throughout the lifecycle of an asset, a digital twin helps you to:

- Understand existing conditions
- Improve and accelerate design and construction workflows
- Increase asset reliability and performance
- Visually enhance collaboration

Asset Lifecycle and Digital Twin Information Exchange

Bentley Systems is a pioneer in offering a digital twin solution that spans the entire rail asset lifecycle, enabling users to make more informed decisions and deliver improved outcomes.



What Is a Digital Twin?

In Planning

- Assess and understand existing conditions (aboveground and belowground)
- Identify project requirements
- Manage and mitigate risk
- Optimize communication and coordination
- Understand financial impact early

In Design and Engineering

- Accelerate project delivery
- Evaluate project impact
- Streamline collaboration
- Reduce risk, project costs, and delays
- Optmize design alternatives

In Construction and Commissioning

- Enable right-first-time construction
- Increase safety and efficiency
- Monitor project schedule vs. performance
- Optimize communication and coordination
- Reduce site visits

In Operations and Maintenance

- Undertake virtual asset inspection and documentation
- Perform the right work, in the right place, at the right time
- Reduce operational costs and unplanned downtime
- Ensure regulatory compliance
- Reduce on-network time, increasing worker safety

The following use cases demonstrate how organizations around the world are leveraging digital twins to synchronize work, gain greater visibility, and make more informed decisions across the lifecycle of rail and transit networks.

Inspection of LRT Jakarta Phase 1 Using 3D Data Capture

PT. Wijaya Karya (Persero) Tbk | ***North Jakarta and East Jakarta, Jakarta, Indonesia***

LRT Jakarta Phase 1 is the first light rail train line in Indonesia's capital that aims to reduce traffic congestion. When the owner planned regular structural health monitoring, LRT Jakarta realized the need to accelerate information exchange among stakeholders to effectively manage asset performance and maintenance. PT Wijaya Karya (Persero) Tbk (WIKA) offered a digital inspection solution but faced challenges in safely surveying the rail line within a short timeframe in the dense urban area without interrupting service.

WIKA used ContextCapture to generate a 3D reality mesh of the as-built environment from aerial photos and terrestrial laser scanning. Integrating reality modeling with virtual and mixed reality technology, they established a digital twin for smart inspection. Bentley's dynamic, interoperable reality modeling solution saved up to 41% in costs and enabled WIKA to complete the inspection twice as fast as conventional methods. Stakeholders are extending the use of a digital twin beyond asset performance to help avoid design errors in Phase 2.

Project Playbook: ContextCapture™, LumenRT™, Pointools™

Bristol Area Signaling Renewal Enhancements

Network Rail Wales and Western Region | ***Bristol, South Gloucestershire, United Kingdom***

Network Rail Wales and Western Region had to install new signaling apparatus at Bristol Temple Meads station. However, evaluating and designing new track signals is expensive and difficult to coordinate. They did not have much space to perform construction, and there were many overlapping schemes. They realized that, to showcase all the necessary renewals and predict the impact of the new signaling, they would need software to support an intelligent 3D model.

Network Rail chose MicroStation as their CAD platform, and used OpenRail Designer to recreate track geometry and place new signals, before developing fly-through animations that allowed designers to view the project from the train driver's perspective. They replicated multiple train approaches toward signals virtually to correct train signaling issues ahead of time, avoiding costly rework and the risk and expense of site visits, as well as optimizing design. Bentley's 3D collaborative modeling environment helped Network Rail reduce months of work into one single meeting.

Project Playbook: MicroStation®, OpenRail™, Pointools, ProjectWise®

Transpennine Route Upgrade

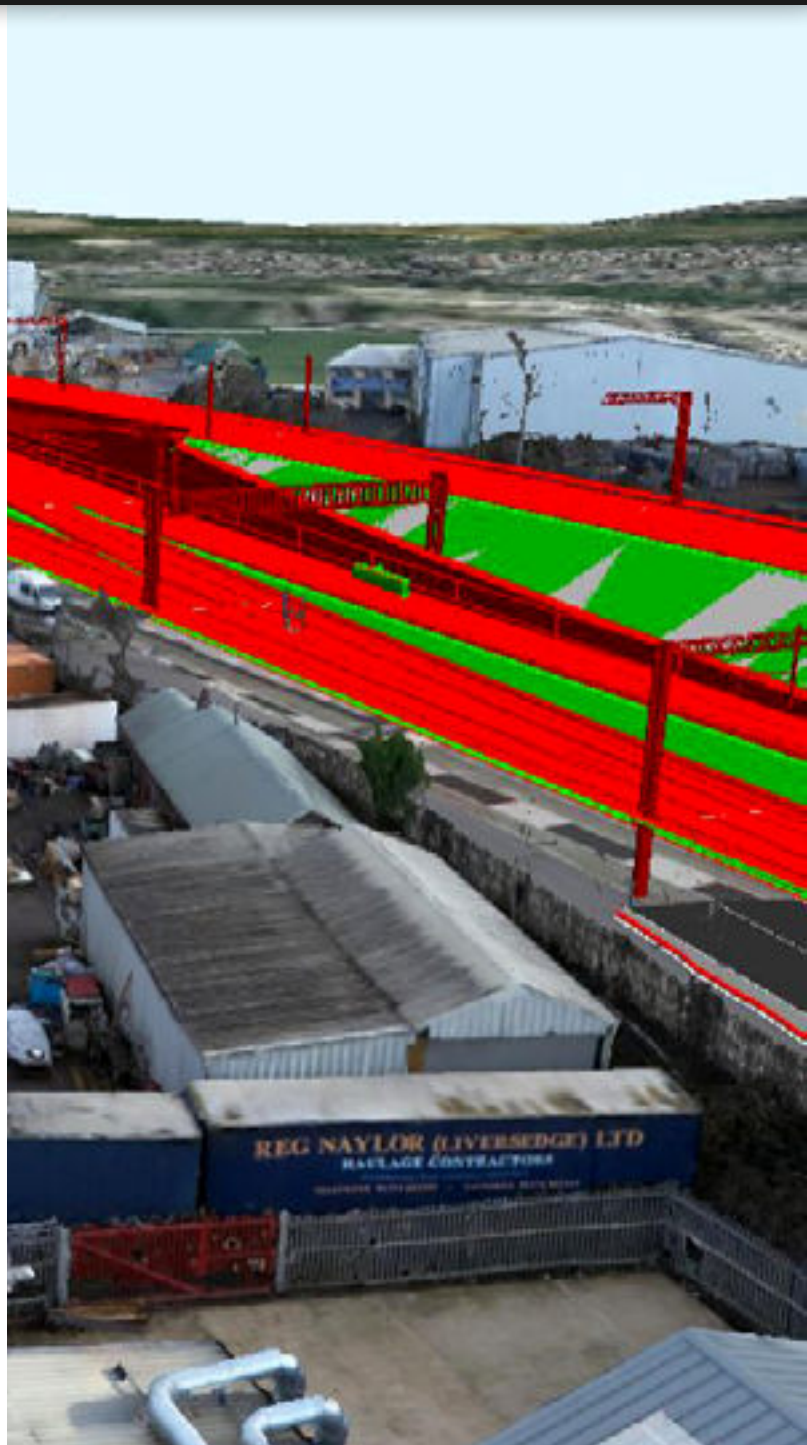
Network Rail + Jacobs | *Manchester, Leeds, and York, United Kingdom*

Transpennine Route Upgrade (TRU) is a GBP multibillion railway program between York and Manchester, which will modernize the existing 100-kilometer rail line, doubling capacity and shortening journey times for passengers between rural and suburban stations and their nearest major urban centers.

Since the project needed to bring together the large volume of data and disciplines involved, Network Rail tasked Jacobs with implementing a route-wide digital twin to support the safest and most efficient design, construction, and handover ever completed on a U.K. railway upgrade.

Jacobs used the iTwin Platform with other Bentley applications. By federating the data from over 60 separate systems into the digital twin, over 1,300 staff could track, contribute, and analyze design data and asset information in real time. They then overlaid more than 600 GIS datasets, which improved decision-making. Rapid data access, 50% faster than previous methods, saved the team 20,000 hours in the first six months, worth an estimated GBP 1 million. Overall, the digital twin will save approximately GBP 15 million.

Project Playbook: ContextCapture, iTwin.js, iTwin®, MicroStation, OpenBuildings®, OpenRail, ProjectWise



Shaoxing Urban Rail Transit Line Design and Construction

POWERCHINA Huadong Engineering Corporation Limited
| *Shaoxing, Zhejiang, China*

POWERCHINA Huadong Engineering Corporation (HDEC) was entrusted to digitally engineer Shaoxing's new Urban Rail Transit Line 1, including project management, overall consultation, survey, design, construction, and handover to operations and maintenance. HDEC needed to overcome the challenges of limited underground space and complex environmental conditions, plus numerous technical interfaces between the disciplines involved. Facing tight deadlines and high complexity on the project, HDEC realized that they needed to adopt digital workflows.

The team independently developed 3D geology software based on Bentley applications, using their solution along with the subsurface utility engineering functionality of OpenRoads, to create an integrated BIM model of the railway's route. The ability to manage urban spatial and planning data in a single unified environment helped the team optimize design quality, reduce rework, cut time, and reduce the impact of subway construction on the citizens of Shaoxing.

Project Playbook: ContextCapture, iModel.js, MicroStation, OpenBuildings, OpenRoads™, ProjectWise, ProStructures™

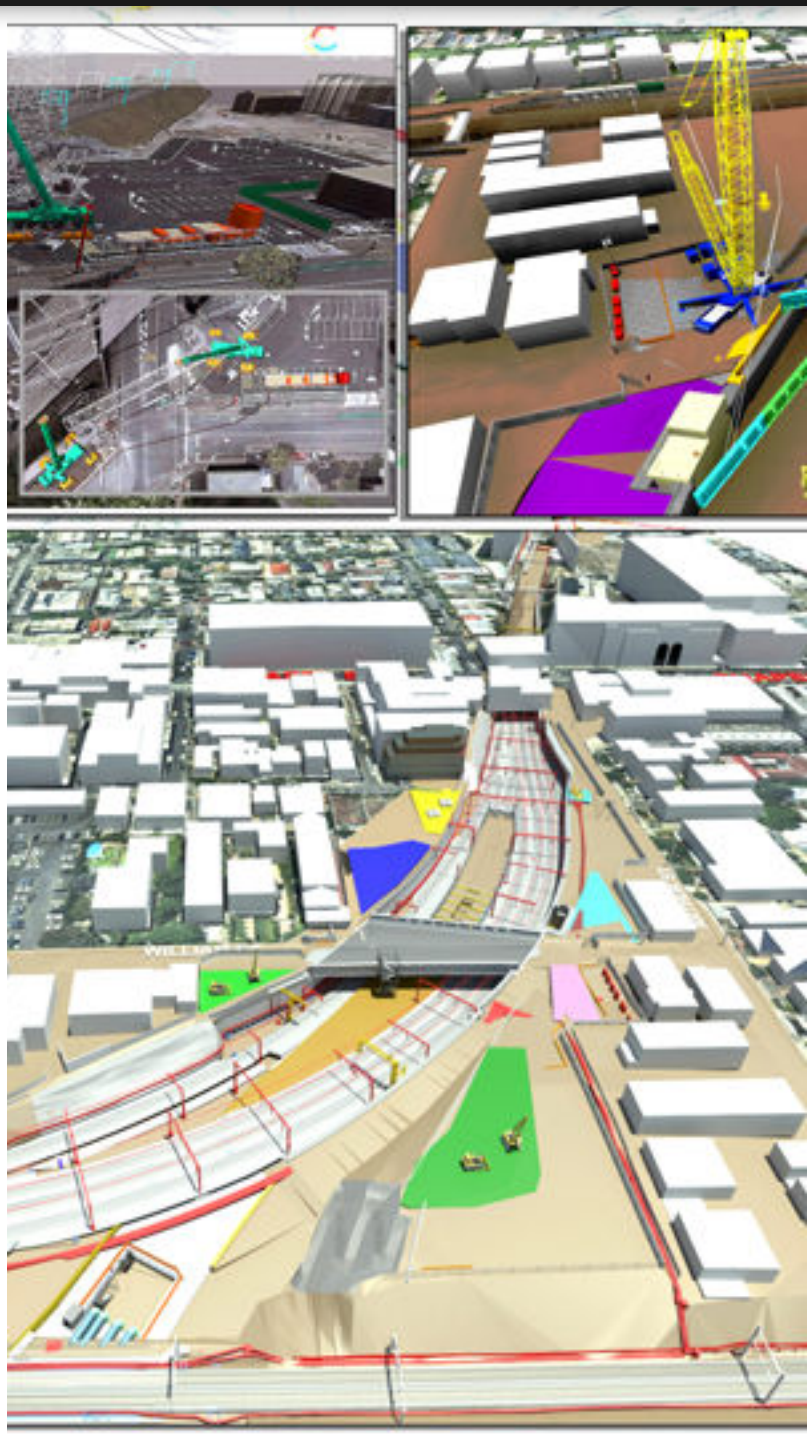
Metrotunnel RIA

Rail Infrastructure Alliance | *Melbourne, Victoria, Australia*

To ease congestion in Melbourne's Metro Tunnel, the Rail Infrastructure Alliance sought to create a new line that would reroute three of its busiest lines. The AUD 1 billion project included 9 kilometers of twin tunnels, two new entrances, and five underground stations. Because they had to minimize disruption to ongoing rail traffic, careful planning was vital. Conventional 3D models, while useful for previous rail designs, did not provide the required level of coordination.

The alliance discovered 4D construction planning and a digital twin created with Bentley applications could help them overcome all challenges. Each 3D model was coordinated through ProjectWise's open data environment. SYNCHRO 4D consolidated these models and external logistics information into a federated 4D model and automatically assigned resources to tasks. The finished 4D construction schedule eliminated potential clashes, improved safety, reduced costs, and inspired other infrastructure organizations in the region to leverage 4D design.

Project Playbook: iModel.js, MicroStation, OpenBuildings, ProjectWise, SYNCHRO™



Railway Facility for Manggarai to Jatinegara

PT. WASKITA Karya (Persero) Tbk | *South Jakarta, Jakarta, Indonesia*

Indonesia's Ministry of Transportation is revitalizing Jakarta's Manggarai Station, converting it from a commuter transit station to a terminus for long-distance trains. With the existing station incapable of accommodating a daily flow of 100,000 commuters, PT. WASKITA Karya (Persero) Tbk was retained to construct a new bridge connecting the first-floor mainline track to a new, second-floor mainline. Additionally, they were required to ensure they adhered to current industry standards, maintained train operations during construction, and controlled cost on prestressed concrete bridge segments accounting for 30% of the project budget.

Using OpenRail Designer, OpenBridge Designer, and iTwin Capture, PT. WASKITA Karya established a digital twin that incorporated existing site conditions and a federated BIM model of the designed structure, boosting productivity and enabling more timely and accurate decision-making. Using OpenBridge Designer they provided accurate geometry and coordinated information for each bridge segment, avoiding miscalculations and reducing the chance that segments would be incorrectly ordered. Simulating construction sequences in SYNCHRO 4D helped them optimize resources and coordinate delivery of the project while railway operations continued.

Project Playbook: iTwin Capture, LumenRT, OpenBridge®, OpenRail, OpenRoads, SYNCHRO

Predictive Decision Support System (PDSS)

SMRT Trains Ltd | *Singapore*

SMRT Trains operates and maintains over 282 kilometers of rail track in Singapore. With an average daily ridership of over 2 million people in 2019, SMRT needs to keep the tracks in good condition to avoid delays. Previously, however, they had used intensive, time-consuming, and manual maintenance planning using millions of data points per year across multiple systems and separate data silos. SMRT realized that they needed to upgrade their inefficient processes.

To optimize the engineers' decisions using all relevant data, SMRT used Bentley's AssetWise Linear Analytics as the basis of their predictive decision support system (PDSS). The PDSS enables them to overlay multiple data sources within seconds rather than hours. The design allows for easy access to data, significantly streamlining multiple analyses. Now, SMRT can optimize the efficiency of a work crew's maximum work capacity during one shift, ensuring the reliability of the rail network.

Project Playbook: AssetWise®

Stone Arch Bridge Rehabilitation

Collins Engineers, Inc. | *Minneapolis, Minnesota, United States*

Collins Engineers was tasked with rehabilitating the iconic Stone Arch Bridge in Minneapolis. The 22-span, 2,100-foot-long masonry arch bridge became a pedestrian bridge in the 1980s and is the most historically significant bridge in Minnesota. With its age and size, the team faced challenges when developing repair plans. The bridge is in a busy urban environment that makes access difficult. They previously used reality modeling, but it lacked the quality required for inspecting and modeling complex structures. To collect sufficient data and accurately model the bridge, they needed an integrated survey, modeling, and inspection solution.

Collins Engineers selected iTwin Capture to generate a high-fidelity 3D model from over 13,000 images, improving the quantity and quality of data. By creating a digital twin, the team could record field inspection notes directly in the model. Using iTwin applications facilitated real-time model access, saving 20% of field time. The solution is expected to save 10% to 15% in construction costs due to improved project and bid data. Because of the digital twin's high level of detail, they will use it throughout the bridge's lifecycle for planning and maintenance decisions.

Project Playbook: AssetWise, iTwin, iTwin Capture, MicroStation, ProjectWise

Southern Program Alliance

WSP Australia Pty Ltd. | *Melbourne, Victoria, Australia*

The Parkdale level crossing removal project is part of the Victorian government's initiative to remove 110 level crossings across Melbourne by 2030 to improve community safety, reduce traffic congestion, and support sustainable transport. Involving rail and road removals, and constructing a viaduct and new station along the Frankston line, the project presented a narrow rail corridor near heritage sites. Faced with managing project data among a multidiscipline team, lead design consultant WSP needed an integrated digital solution.

Leveraging Bentley's open modeling applications and ProjectWise, WSP established a digital twin, streamlining workflows to meet project objectives. Working in an interoperable, web-based platform minimized rework and improved decision-making, which helped to reduce modeling time by 60% and save 15% in resource hours during the design delivery process. The solution optimized material usage, reducing bridge materials by 7% and the carbon footprint by 30%, and enabled WSP to reuse digital bridge components for future projects.

Project Playbook: iTwin, iTwin Capture, LumenRT, MicroStation, OpenBridge, OpenBuildings, OpenRail, OpenRoads, ProjectWise, ProStructures, SYNCHRO

Johor Bahru–Singapore Rapid Transit System

AECOM Perunding Sdn Bhd | *Malaysia and Singapore*

The Johor Bahru–Singapore Rapid Transit System (RTS) is a cross-border project that will connect Johor Bahru in Malaysia with Woodlands, Singapore. Featuring stations in both countries, each featuring customs, immigration, and quarantine facilities, the RTS will ease traffic congestion by reducing the number of cars using the Johor-Singapore Causeway, providing greener transportation for around 10,000 passengers per hour. AECOM is delivering the project and faced several challenges on the rail project spanning two countries. To facilitate collaborative workflows and establish optimal project delivery, AECOM wanted to adopt a digital twins approach.

Leveraging Bentley's integrated digital modeling and analysis applications, AECOM established a connected data environment through ProjectWise to optimize planning, design, and construction. They developed a reality mesh from drone-captured images, accelerating survey and processing fivefold. Applying Bentley software automated workflows, ensured structural integrity, and saved 50% in drafting time. The digital twin solution provided an accurate, holistic view of the cross-border rail project, meeting technical requirements for both countries while reducing rework.

Project Playbook: ComplyPro, iTwin Capture, Leapfrog®, MicroStation, OpenBridge, OpenRail, PLAXIS®, ProjectWise, ProStructures, STAAD®

Safely Removing Dangerous Level Crossings through Digital Construction

ACCIONA | *Melbourne, Victoria, Australia*

As part of Melbourne's level crossing removal initiative, an AUD 744 million project was deployed to remove 20 level crossings and construct 13 new stations along the Frankston Line. Given the project scope, the team needed to ensure efficient design and timely delivery of the project. However, they faced several construction planning challenges when working in congested areas among a large stakeholder group. They also needed to upgrade their digital approach to a more seamless integrated solution, as their previous strategy lacked context and connectedness, and did not visually communicate the construction sequence.

By leveraging SYNCHRO Control and SYNCHRO 4D, Bentley's collaborative project management and 4D modeling solutions, the team established a connected data environment and created a digital twin to streamline workflows and provide unparalleled insight into constructability and construction monitoring. Implementing SYNCHRO allowed the team to reduce staging time by 67% and drafting requests by approximately 88%. SYNCHRO helped deliver the project on time with minimal disruption to passengers and the public. It provided a digital asset that can now unlock new opportunities for the realization of an intelligent digital Victoria.

Project Playbook: ContextCapture, iTwin, LumenRT, MicroStation, OpenBridge, OpenRail, OpenRoads, ProjectWise, SYNCHRO

Learn more about this project >

Port of Melbourne – Port Rail Transformation Project

WSP | *Melbourne, Victoria, Australia*

The Port of Melbourne Rail Transformation project aims to reduce truck movements across Victoria by providing new on-dock rail terminal capacity, new road and rail infrastructure, and improved rail terminal operations. WSP was responsible for completing the final design within 12 weeks, including a preliminary design submission at the six-week mark. The limited time between these key milestones presented information management and collaboration challenges. WSP realized that their traditional approach using multiple platforms would be insufficient and that they needed to establish a connected data environment.

They selected Bentley applications to create a cloud-based platform, providing a single source of truth for all users to access, visualize, and share key project information in real time. Their implementation reduced 2D drawings, automated 3D model coordination, reduced rework, and streamlined stakeholder communications, saving 475 hours and realizing a total return on investment of 67.31%, or AUD 43,500.

Project Playbook: MicroStation, OpenBuildings, OpenRail, OpenRoads ConceptStation, OpenRoads, ProjectWise, SYNCHRO

Digital Twins for Rail and Transit

Discover More

About Bentley Systems

Bentley Systems (Nasdaq: BSY) is the *infrastructure engineering software* company. We provide innovative software to advance the world's infrastructure – sustaining both the global economy and environment. Our industry-leading software solutions are used by professionals, and organizations of every size, for the design, construction, and operations of roads and bridges, rail and transit, water and wastewater, public works and utilities, buildings and campuses, mining, and industrial facilities. Our offerings, powered by the *iTwin* Platform for infrastructure digital twins, include *MicroStation* and *Bentley Open* applications for modeling and simulation, *Seequent*'s software for geoprofessionals, and *Bentley Infrastructure Cloud* encompassing *ProjectWise* for project delivery, *SYNCHRO* for construction management, and *AssetWise* for asset operations. Bentley Systems' 5,000 colleagues generate annual revenues of more than $1 billion in 194 countries.

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