

An aerial photograph of a complex highway interchange with multiple overpasses and ramps. The image is split vertically. The left half is a dark, blue-tinted version of the same scene, representing a digital twin or simulation. The right half is the original, brightly lit photograph, representing the real-world infrastructure. The glowing blue lines in the digital twin represent data flow or simulation parameters.

Digital Twins Generate Real-World ROI

Connect the Physical and
Virtual World to Better Plan,
Design, Construct, and Operate
Your Road Networks

Digital Twins Are Going Mainstream in the Transportation Industry

It's a common knowledge that road infrastructure is aging. Many bridges and roads around the world are in poor condition due to age, wear and tear, and environmental factors, requiring repair or even replacement.

To make our roads and bridge safer, federal, state, and local governments need to prioritize strategic investments that are dedicated to improving and preserving roadway conditions to increase public safety on the system in place, as well as plan for the future construction of new roadways.

To do their job better and faster, they need innovative technologies and processes. So, many of them are adopting digital twins. With digital delivery, projects are delivered using digital models, data, and supporting field tools for roadway design, structural design, and construction. Digital delivery incorporates streamlined processes to manage asset information

as it changes through project development. With this delivery method, it's easier to review the design intent and develop high-resolution 3D design visuals, providing improved design quality. It can make a significant impact on reducing project cost over-runs and the 3D design enables designers to test what-if scenarios to refine constructability and optimize project cost. Digital delivery improves design efficiency and enables contractors to benefit from a more complete representation of the design intent delivered in a more directly usable format. Therefore, it enables enhanced construction planning and less time to extract information. Lastly, digital delivery improves as-built records, saving valuable time. Instead of marking up PDF plans, contractors will collect digital as-built records.



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 can be continuously updated from multiple sources, including sensors and continuous surveying, to represent its near real-time status, working condition, or position.

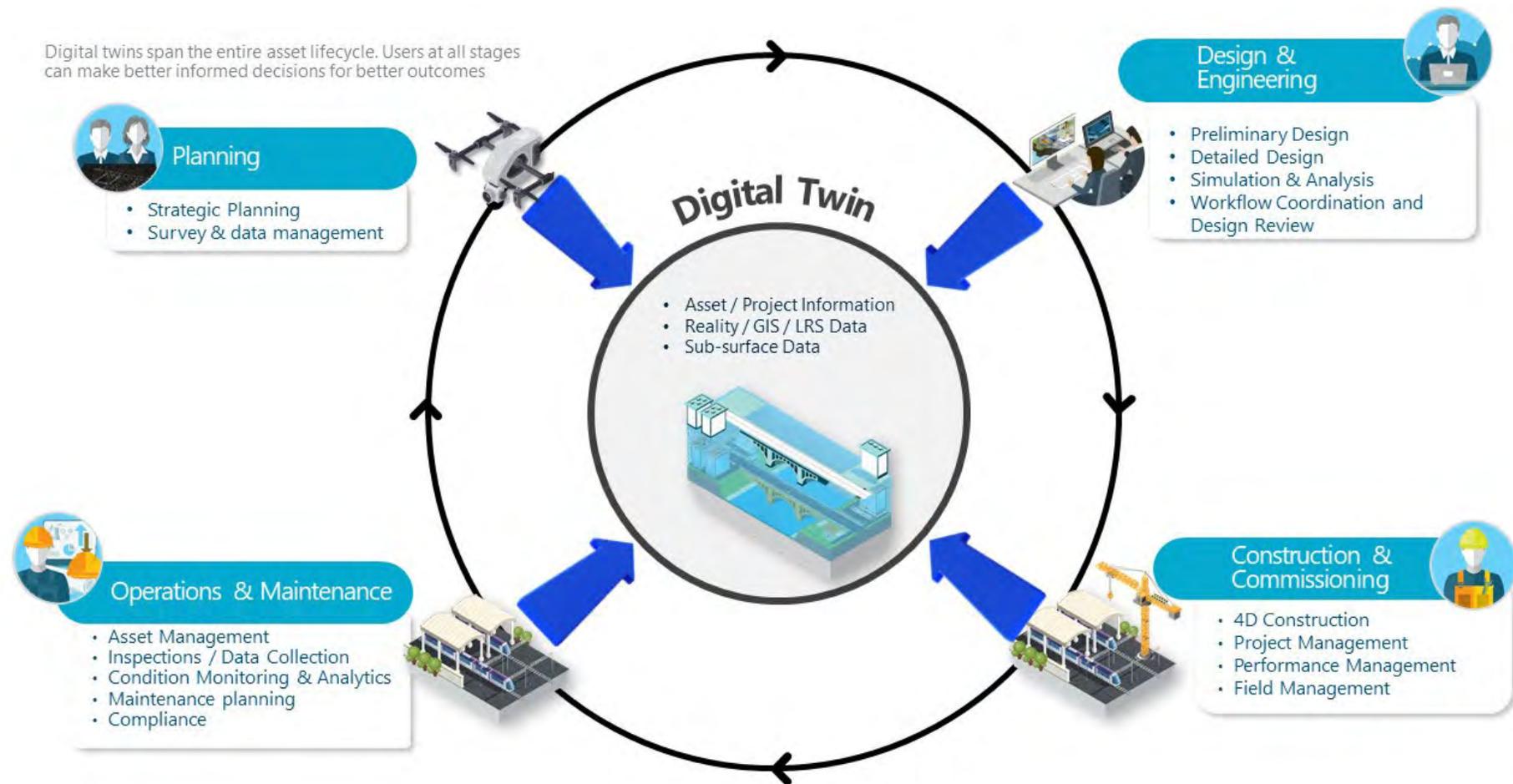
Throughout the lifecycle of an asset, a digital twin helps:

- ◆ 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 span the entire asset lifecycle so users can make better informed decisions for better outcomes.



What are the Benefits of using Digital Twins?

In Planning

- ◆ Assess and understand existing conditions (above- and below-ground)
- ◆ Identify asset needs
- ◆ Identify project requirements
- ◆ Manage and mitigate risk
- ◆ Manage asset performance
- ◆ Optimize collaboration and coordination with stakeholders and citizens
- ◆ Understand financial impact early

In Design and Engineering

- ◆ Accelerate project delivery
- ◆ Evaluate project impact
- ◆ Optimize collaboration and coordination with stakeholders and citizens
- ◆ Reduce risk, project costs and delays
- ◆ Simulate design options

In Construction and Commissioning

- ◆ Improve safety and enable right first-time construction
- ◆ Increase construction efficiency

- ◆ Manage project schedule vs performance
- ◆ Monitor and track progress
- ◆ Optimize collaboration and coordination with stakeholders and citizens
- ◆ Provide up-to-date documents
- ◆ Reduce on-site visits

In Operations and Maintenance

- ◆ Develop more repeatable assessment processes
- ◆ Ensure regulatory compliance
- ◆ Enhance worker safety
- ◆ Improved monitoring of asset performance
- ◆ Lower asset operational costs
- ◆ Optimize collaboration and coordination with stakeholders and citizens
- ◆ Reduce on-site visits and asset downtime
- ◆ Virtually assessment and document assets

The following use cases demonstrate how users around the world are leveraging digital twins to synchronize work, gain greater visibility, and make sense of the right data at the right time across the lifecycle of assets.

Planning

Founders' Honoree for Global Future-proofing
2021 Going Digital Awards in Infrastructure for
Roads and Highways

Modification of Surabaya-Gresik Toll Road Interchange

PT Hutama Karya (Persero)

Surabaya, East Java, Indonesia

PT Hutama Karya was retained to construct the Surabaya-Gresik toll road interchange in preparation for Indonesia to host the 2022 U20 Football World Cup. The project presented complex geological conditions and coordination challenges, compounded by requirements to minimize interference with traffic flow and a one-year construction timeline during a global pandemic. They tried implementing BIM software, but their initial technology lacked efficiency and visualization quality. Instead, they needed comprehensive, integrated 3D modeling and visualization applications.

PT Hutama Karya selected ContextCapture to generate a contour map of the existing site conditions 400% faster than manual methods. Using OpenRoads and OpenBridge for 3D modeling accelerated drawing production by 30 days and facilitated clash detection, avoiding potential errors to save USD 3 million. Working in an open, connected data environment saved two months amid COVID-19. They plan to use the 3D models as the foundation for creating digital twins to promote their digital strategies in the construction sector.

Project Playbook: ContextCapture, MicroStation®, OpenBridge Modeler®, OpenRoads™ Designer, PLAXIS®



Planning

Nominee

2021 Going Digital Awards in Infrastructure for Reality Modeling

East Selmon Expressway from North Morgan Street to Interstate 75

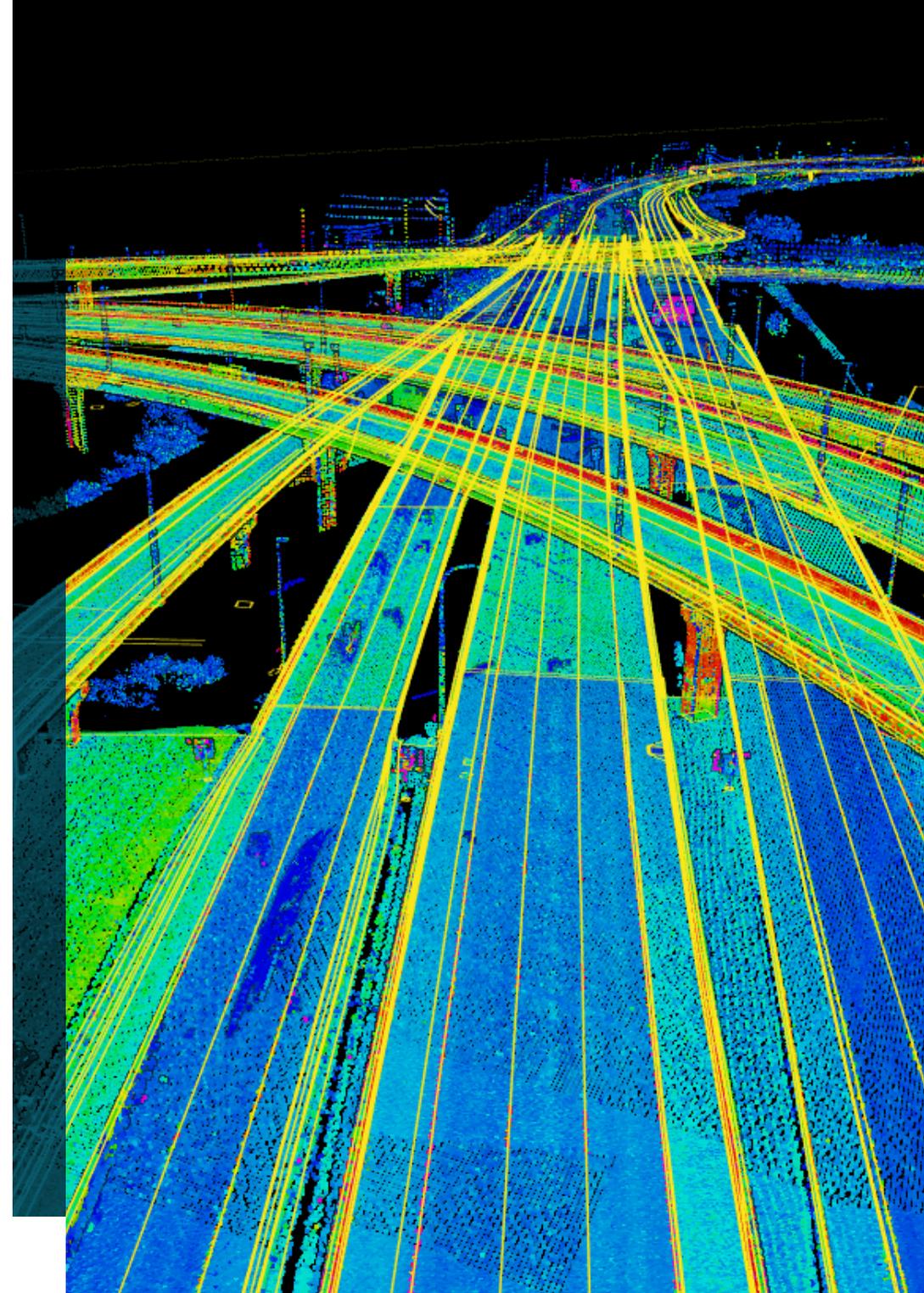
WGI

Tampa, Florida, United States

Part of the Tampa Hillsborough Expressway Authority's project development and environmental study of the East Selmon Expressway, WGI was tasked with performing a design survey for widening a nine-mile highway section. The complex roadway features a four-lane limited access highway and a three-lane raised toll expressway, 46 bridges, and 34 ramps, making it challenging to survey. WGI needed an integrated technology solution to survey and process multisourced captured data into a 3D digital model to share with the client.

They selected MicroStation and Orbit 3DM to integrate and merge the point clouds into a 3D model and create a digital database. Using Bentley's integrated applications provided a unified environment to combine feature extracted data from MicroStation with data from different LiDAR technology to generate a digital twin accessible to the client. The digital solution reduced staff survey time on site during COVID-19, improving safety and reducing labor costs associated with site visits.

Project Playbook: MicroStation, Orbit 3DM®, ProjectWise®



Planning

Nominee

2021 Going Digital Awards in Infrastructure for Reality Modeling

Jakarta - Cikampek II Paket 3 Selatan Toll Road

PT Waskita Karya (Persero) Tbk.

Karawang – Purwakarta, West Java, Indonesia

To accommodate rising urban population and to reduce traffic congestion between Jakarta and Bandung, the Indonesian government initiated the Jakarta-Cikampek II Selatan toll road project. The project is divided into three packages, and PT Waskita Karya is the main contractor for the third package spanning a total length of 29.55 kilometers. They faced topography and technical challenges calculating earthworks volume, and when they tried using conventional methods, they were unsuccessful. Instead, they needed an open modeling solution to generate a reality mesh and digital twin.

They selected ContextCapture to produce a 3D reality mesh of the 5.73-square-kilometer site in only four days, and integrated Bentley's open modeling applications to develop a digital twin. Using ContextCapture provided volume calculations that were 93% accurate, reducing earthworks volume by 16 cubic meters compared to manual methods. Using the digital twin improved collaboration and decision-making among the team and with the client to control project costs.

Project Playbook: ContextCapture, OpenBridge Modeler, OpenRoads Designer



Planning

Nominee

Year in Infrastructure 2019 Awards for Bridges

Mobile River Bridge

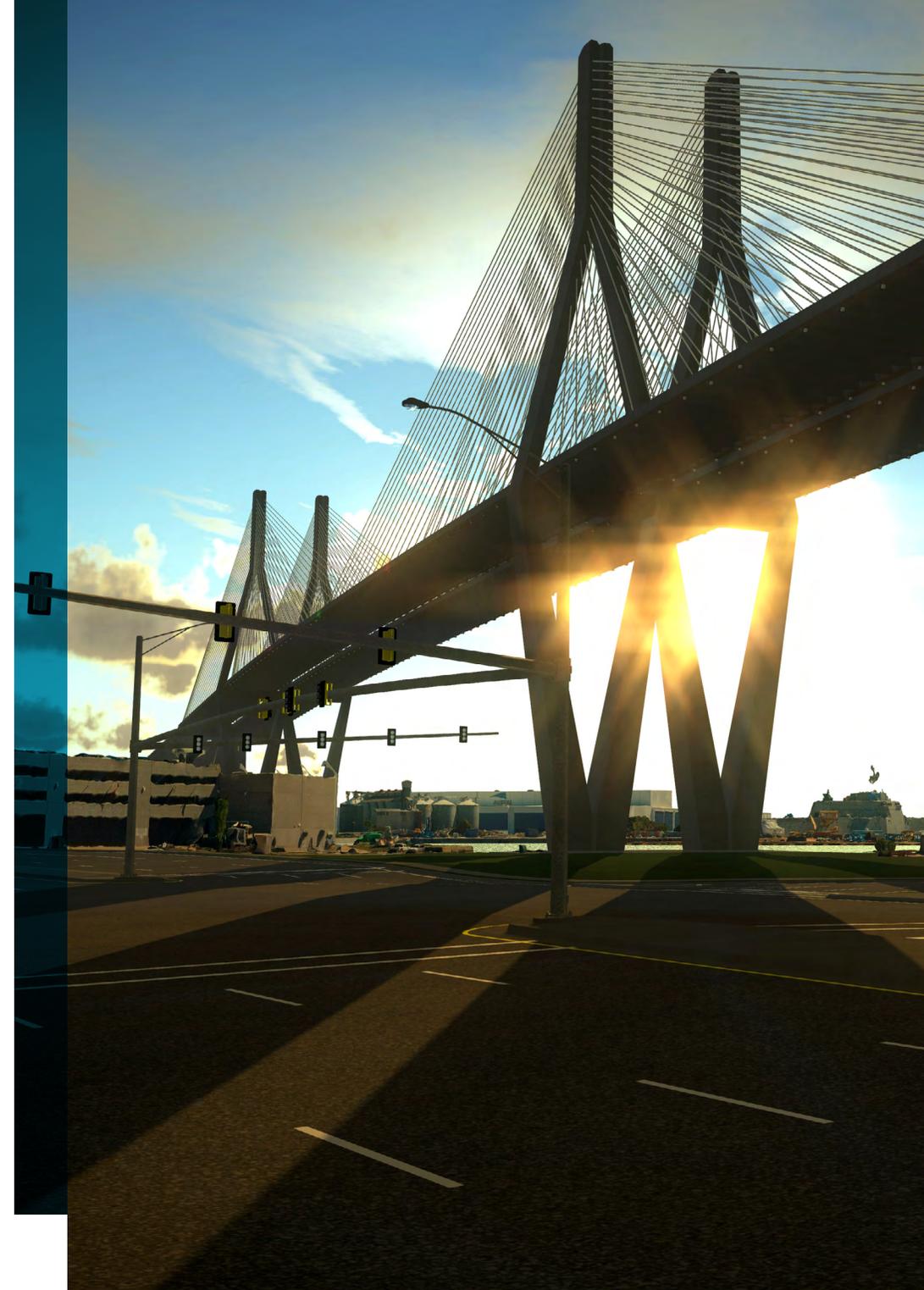
Alabama Department of Transportation

Mobile, Alabama, United States

The Alabama Department of Transportation (ALDOT) was tasked with increasing capacity on Interstate-10 between the existing Wallace Tunnels and the Eastern Shore, which is experiencing some of the worst congestion in the state. The estimated USD 2 billion project required ALDOT to use integrated 3D modeling and visualization applications to simply communicate its proposal to stakeholders and the public.

With Bentley applications, ALDOT could capture 3,075 photos and use them to create a digital twin of the bridge and surrounding area. ALDOT used OpenRoads to model the project, which increased project delivery by 30 days. It allowed the team to quickly and efficiently make changes to the 3D models, reducing resource hours and keeping the project on schedule. Using ContextCapture, ALDOT reduced visualization production time by 80%. Currently in the planning stage, ALDOT is expected to begin construction in late 2020 to early 2021 and complete the project in 2026.

Project Playbook: ContextCapture, LumenRT, MicroStation, OpenRoads





Design

Special Recognition for Advancing
Infrastructure Resilience through Digital Twins
*Year in Infrastructure 2019 Awards for
Bridges*

The New Polcevera Viaduct

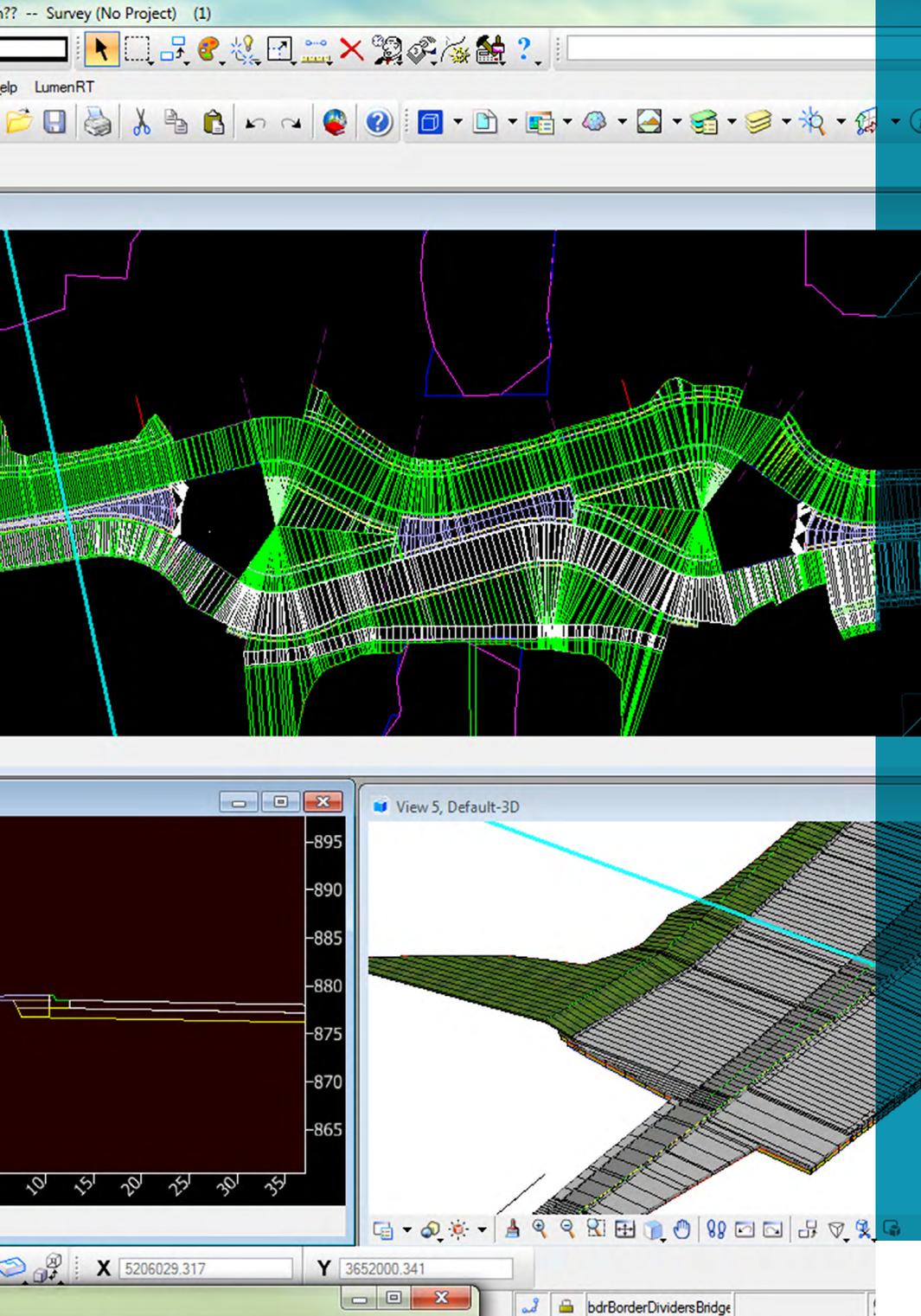
Italferr S.p.A.

Genoa, Liguria, Italy

After a bridge collapse in northern Italy, Italferr S.p.A. was tasked with designing a new viaduct. The structure will be a pivotal point for the city, county, and country's transportation. The project team needed to use the same footprint as the original structure, measuring over 1,000 meters in length and consisting of 19 steel-concrete spans. The EUR 202 million project also needed to follow a tight schedule.

Italferr S.p.A. implemented a BIM model along with Bentley's connected data environment based on ProjectWise. The project team used Bentley applications to create digital models of the terrain, road, civil works, and mechanical and electrical systems. Bentley applications helped reduce design costs and improve collaboration due to faster decision-making, more accurate calculations, and better management of revisions. Currently in the construction phase, the project is on schedule for a June 2020 completion.

Project Playbook: Descartes, gINT®, iModel.js, LumenRT, MicroStation, Navigator, OpenBuildings® Designer, OpenRoads, ProjectWise, SYNCHRO™



Design

Winner

Year in Infrastructure 2019 Awards for Roads and Highways

Foth Transforms, Connects, and Revitalizes Cedar Falls, Iowa Corridor

Foth Infrastructure & Environment, LLC

Cedar Falls, Iowa, United States

Located in Cedar Falls, Iowa the University Avenue roadway, which serves over 20,000 vehicles per day, is over 60 years old and needs to be redeveloped to effectively serve the community. To improve roadway conditions and traffic flow, provide non-vehicular access, and support economic growth, Cedar Falls initiated a USD 38.9 million revitalization. Delivering the winning conceptual design, Foth then had to overcome technical, engineering, and coordination challenges, compounded by aggressive schedules and intense public involvement.

ProjectWise was used to store, manage, and share over 130 gigabytes of data, identifying and remediating design issues in hours rather than weeks. Using OpenRoads, STAAD, and OpenFlows, Foth modeled and analyzed several design alternatives. The modern, efficient transportation network is estimated to save USD 32 million over the next 25 years. LumenRT's animated renderings effectively presented the design intent, accelerating public approval. Bentley applications reduced the design phase by 50% with construction beginning a year and a half ahead of schedule.

Project Playbook: Descartes, glINT, Haestad, iModel.js, LEAP®, LumenRT, MicroStation, OpenFlow™ SewerGEMS®, OpenFlow™ WaterGEMS®, OpenRoads, ProjectWise, RAM®, STAAD®



Design

Nominee

2021 Going Digital Awards in Infrastructure for Roads and Highways

Serpong Balaraja Toll Road Project Section 1A STA 0 + 000 - 5 + 150

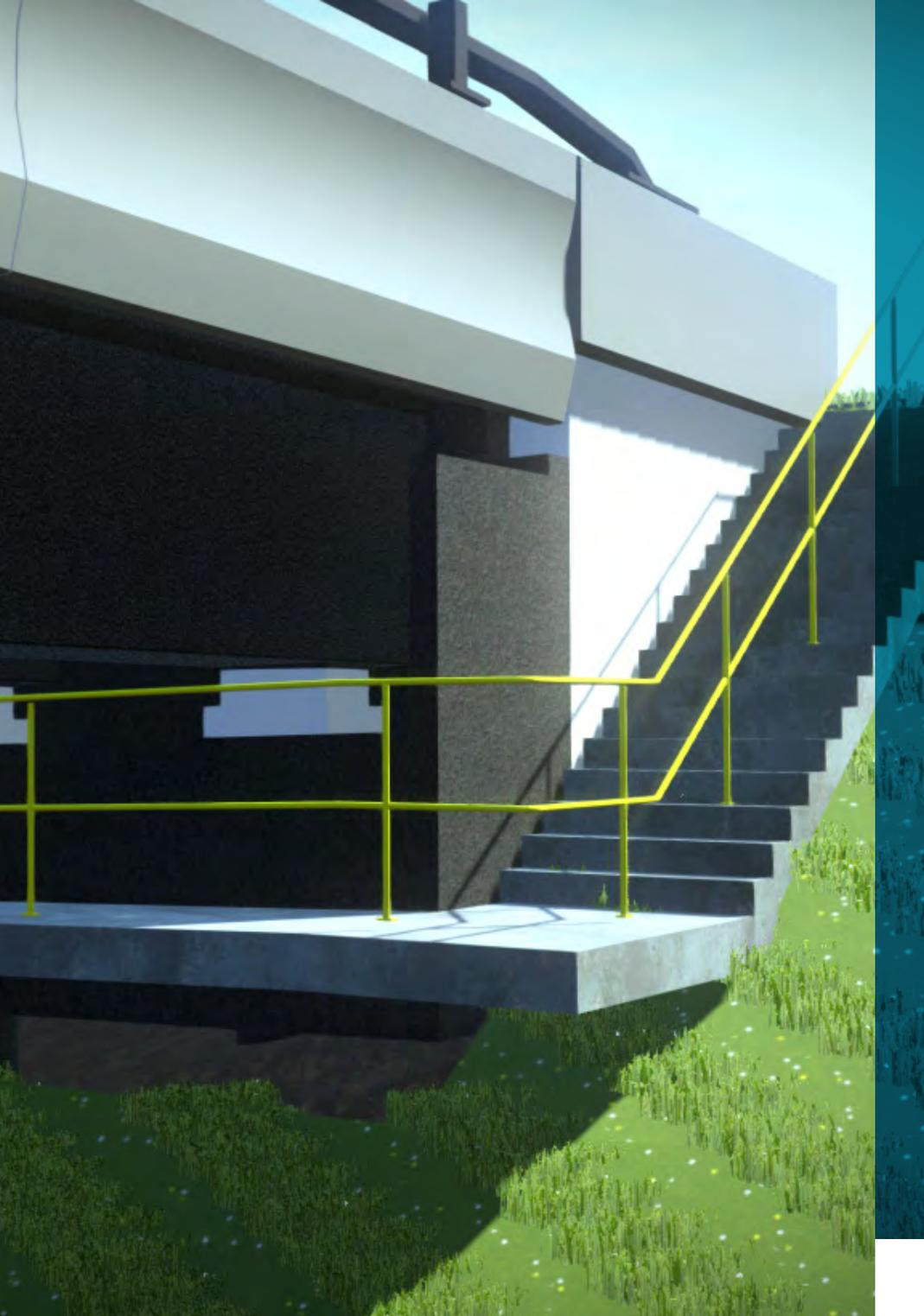
PT Wijaya Karya (Persero) Tbk.

Tangerang, Banten, Indonesia

The Serpong Balaraja toll road section 1A project is part of Indonesia's initiative to create integrated infrastructure supporting national economic growth. The project included earthworks, bridge, and embankment structures, which presented site challenges, coordination issues, and technical difficulties. PT Wijaya Karya wanted to implement BIM processes but faced strategic issues relating to the geometry transitions within the constrained land area, as well as managing the voluminous model data.

They selected ContextCapture to generate a reality mesh in one day, compared to four it would have taken using manual survey methods. Using Bentley's open applications, they integrated data and workflows, quickly identified clashes, and automated volume calculations to optimize design and meet the limited budget. The digital solution improved design efficiency by 75%, saving 91 days and improving cost efficiency by 2.93%, saving INR 24 billion. They achieved better design and construction coordination, improved decision-making, and provided digital deliverables to the client.

Project Playbook: ContextCapture, OpenBridge® Designer, OpenBridge® Modeler, OpenBuildings®, OpenRoads Designer, OpenRoads™ SignCAD®, PLAXIS, ProjectWise, STAAD



Design

Finalist

2021 Going Digital Awards in Infrastructure for Bridges

Lathams Road Bridge

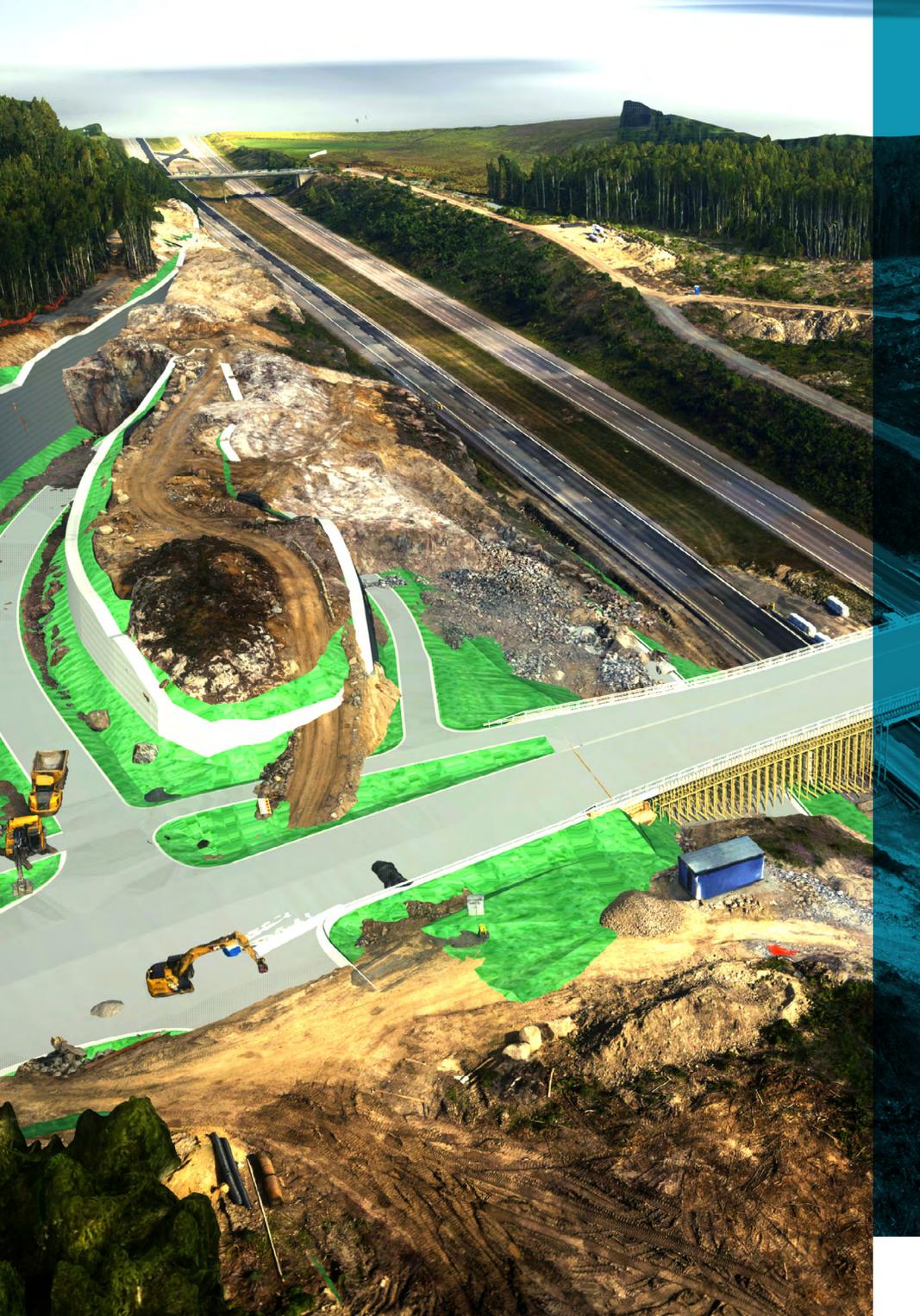
Hatch

Carrum Downs, Victoria, Australia

Lathams Road Bridge is a new two-span continuous bridge that is part of an urban brownfield road duplication project to provide connectivity to the Carrum Industrial Estate in Victoria. Engineering consultant Hatch looked for an integrated BIM solution to streamline workflows between the bridge and civil design teams. Prior traditional processes would require hours of manual modeling, so they needed to establish an open connected data environment to facilitate a fully digital project context.

They selected OpenRoads Designer and OpenBridge Modeler, merging their functionality for the first time in the region. Using Bentley's software, the civil and bridge design teams shared and leveraged real-time data in a coordinated model that they published to iTwin for web-based project reviews. The integrated, 100% digital solution avoided data conversion, providing transparency between the two teams and eliminating the risk of costly design mistakes. The digital twin meets the client's downstream asset management requirements.

Project Playbook: MicroStation, OpenBridge Modeler, OpenRoads Designer, ProjectWise



Design

Nominee

Year in Infrastructure 2020 Awards for Roads and Highways

Klaukkala Bypass Road

Finnmap Infra Oy

Nurmijärvi, Uusimaa, Finland

During construction of the Klaukkala bypass in Finland, Finnmap Infra Oy realized that their original design included rock masses that could not be used as initially intended. Since their goal was to economically design the estimated EUR 34 million forest corridor, the project contractor could not incur the heavy expense of transporting the surplus rock masses out of the project area. To evaluate cost effective alternatives, Finnmap decided to use Bentley technology and digital twins.

With digital twins, Finnmap visualized the progress of the project for the client and public. Using OpenRoads and Descartes, they optimized the rock cuts and elevated the road level so the masses could be used as fills. This solution eliminated expensive, long-distance transfers to reduce construction costs by 20%. Finnmap opened the road for traffic nearly 12 months ahead of schedule by reusing the supplementary rock loads to the client's satisfaction.

Project Playbook: ContextCapture, LumenRT, MicroStation, OpenRoads

Construction

Winner

2021 Going Digital Awards in Infrastructure for Bridges

East 138th St. over the Major Deegan Expressway

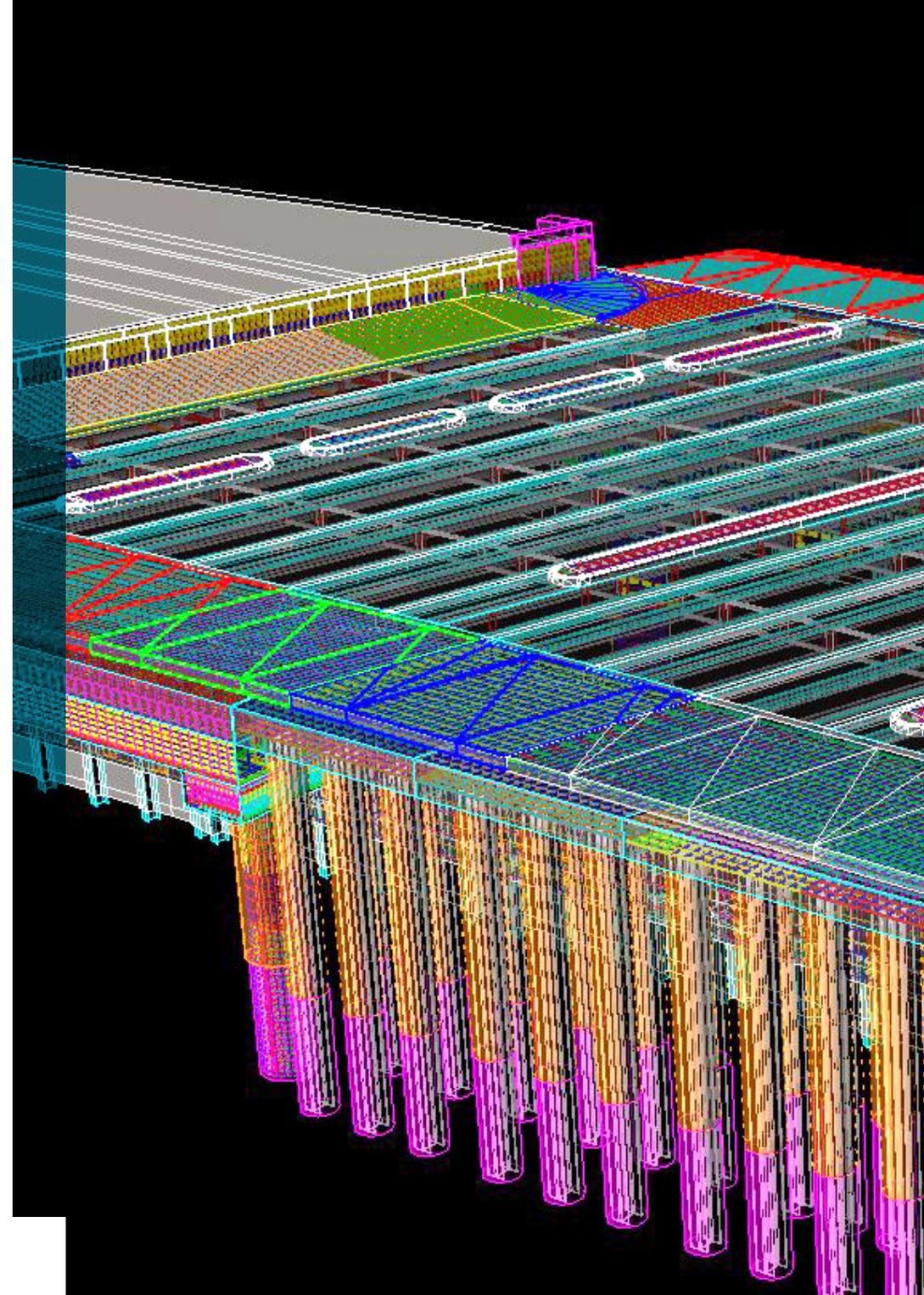
NYSDOT

New York, New York, United States

Replacing East 138th Street Bridge will eliminate vertical clearance issues and optimize traffic demands. Although the bridge seemed uncomplicated at first glance, NYSDOT had to overcome many complex design challenges. Located in the heavily congested area outside Yankee Stadium, the team needed to create the construction sequencing plan and accommodate existing utilities during COVID-19. They sought to generate a digital twin of the superstructure and pedestrian components as part of a legal contract.

NYSDOT used Bentley applications to generate an accurate 3D model. iTwin Design Review provided a central platform for over 180 reviewers, providing options not available in 2D. Bentley's technology helped identify and resolve costly issues prior to construction. Instead of participants reviewing hundreds of paper documents, SYNCHRO 4D helped facilitate visual and dynamic sequencing and traffic control planning for better project coordination. This project is one of the most sophisticated transportation projects to be delivered with model-based contracting in the United States, and the digital twin is important for future asset management and bridge inspection.

Project Playbook: MicroStation, OpenBridge Designer, OpenBridge Modeler, OpenRoads Designer, ProjectWise, ProSteel, ProStructures, SYNCHRO 4D



Construction

Nominee

2021 Going Digital Awards in Infrastructure for Digital Construction

Forder Valley Link Road - New Junction Construction and Improvements

Balfour Beatty

Plymouth, United Kingdom

The Forder Valley Link Road is a new link between the A38 highway and the area north of Plymouth. The roadway serves as a key infrastructure project, unlocking growth and accommodating new residential, leisure, retail, and health facilities planned over the next 15 years. Balfour Beatty is the main contractor and faced challenges managing diversions and maintaining the flow of traffic throughout construction while avoiding public impact. They realized that it was imperative to simulate the construction sequence based on a 3D BIM model, and needed advanced construction modeling and simulation technology.

They selected ProjectWise to share information among all stakeholders and SYNCHRO 4D to establish a 4D model and digital workflows, determining an optimal construction scenario that would minimize impact on the public and improve traffic flows. Using Bentley software, they generated a high-quality animation close to real-world textures and digitally presented their solution, effectively optimizing stakeholder review.

Project Playbook: MicroStation, ProjectWise, SYNCHRO 4D



Construction

Founders' Honoree for Pandemic-proof Execution
2021 Going Digital Awards in Infrastructure for
Roads and Highways

TH 169: Redefine Elk River

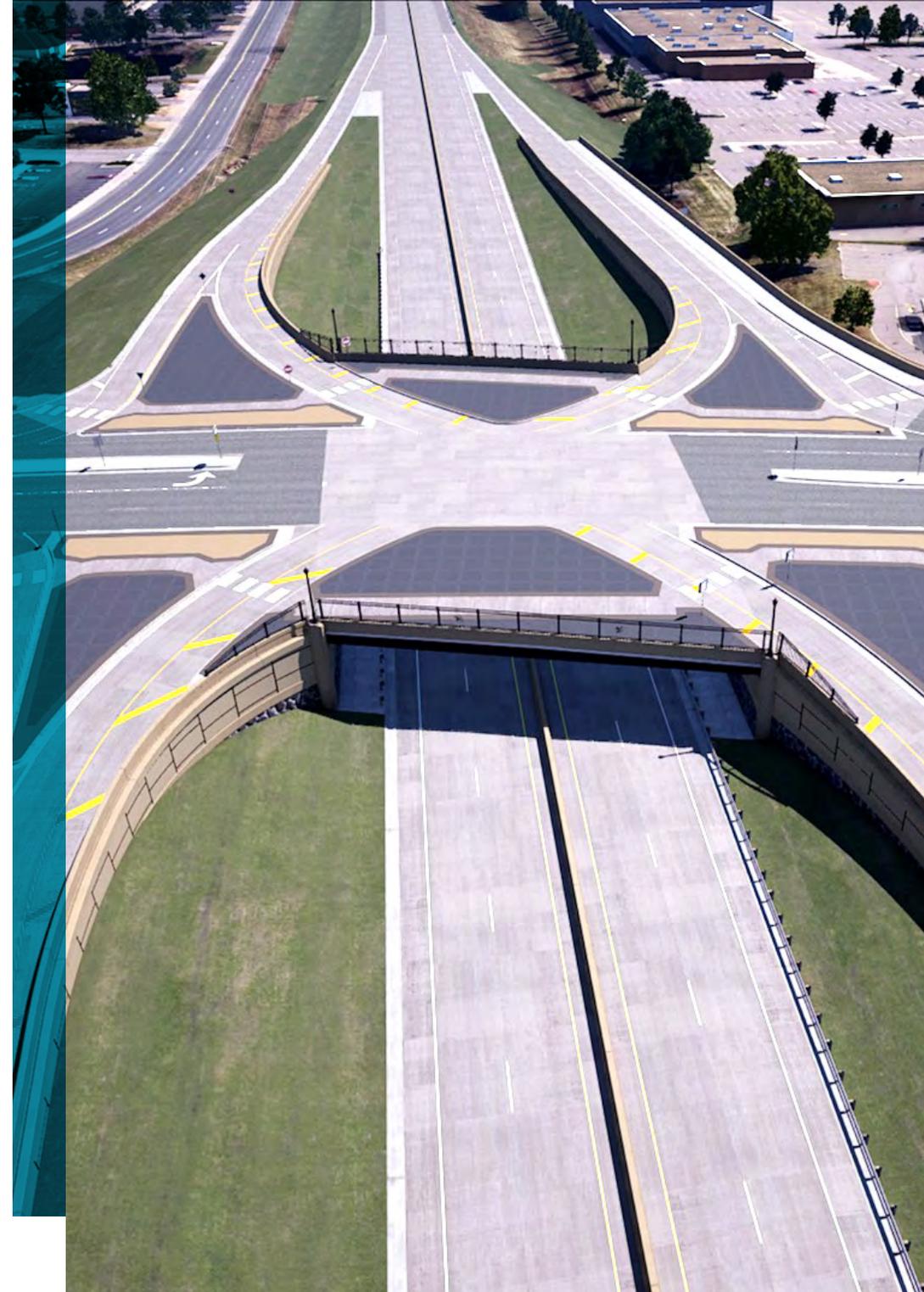
WSB

Elk River, Minnesota, United States

When the Minnesota Department of Transportation received funding to transform TH 169 into a freeway system, they retained WSB to oversee the final design. The project included converting four traffic intersections into interchanges, relocating utilities, and designing roadway, drainage, and bridge elements. With complicated earthworks and construction costs capped at USD 130 million, WSB needed a flexible, iterative design process and accurate material quantity takeoffs.

WSB selected Bentley's open modeling, visualization, and construction simulation applications to help save the client over USD 12 million. Performing clash detection saved 18 months in relocating utilities, while synchronizing the 3D model with 4D construction scheduling identified potential conflicts, accelerating construction activities by three months to save USD 485,569. Using the Bentley iTwin platform to create digital twins early in the engineering process facilitated collaboration that supported seamless data and model integration throughout construction and operations.

Project Playbook: ContextCapture, iTwin.js, iTwin® Design Insights, iTwin Design Review, iTwin Design Validation, MicroStation, OpenBridge Designer, OpenBridge Modeler, OpenBuildings, OpenRoads Designer, ProjectWise, ProjectWise 365, SYNCHRO 4D, SYNCHRO Control





Operations

Winner

*Year in Infrastructure 2019 Awards for
Road and Rail Asset Performance*

Pan Borneo Highway

Lebuhraya Borneo Utara Sdn. Bhd.

Sarawak, Malaysia

Malaysia's Pan Borneo Highway is a 1,060-kilometer, four-lane dual carriageway running along undulating terrain and through existing communities and protected reserves in Sarawak. The project serves as a benchmark for expanding the use of BIM to develop a complete asset management system for highways. With the first 32.77-kilometer stretch fully completed, project delivery partner Lebuhraya Borneo Utara is now responsible for integrating the construction data with asset performance technology to manage operations and maintenance.

During construction, the team used a connected data environment to facilitate seamless integration of construction data, plus planning and implementation of asset performance and reliability strategies. Bentley applications helped digitize construction information, linking data with asset tags and GIS applications to develop an efficient asset management system that delivers real-time reliable information for operations, maintenance, and engineering. The system mitigates risk, increases operational efficiency, improves decision-making, and ensures regulatory compliance.

Project Playbook: AssetWise®, ProjectWise



Operations

Finalist

Year in Infrastructure 2020 Awards for Road and Rail Asset Performance

Maryland State Highway

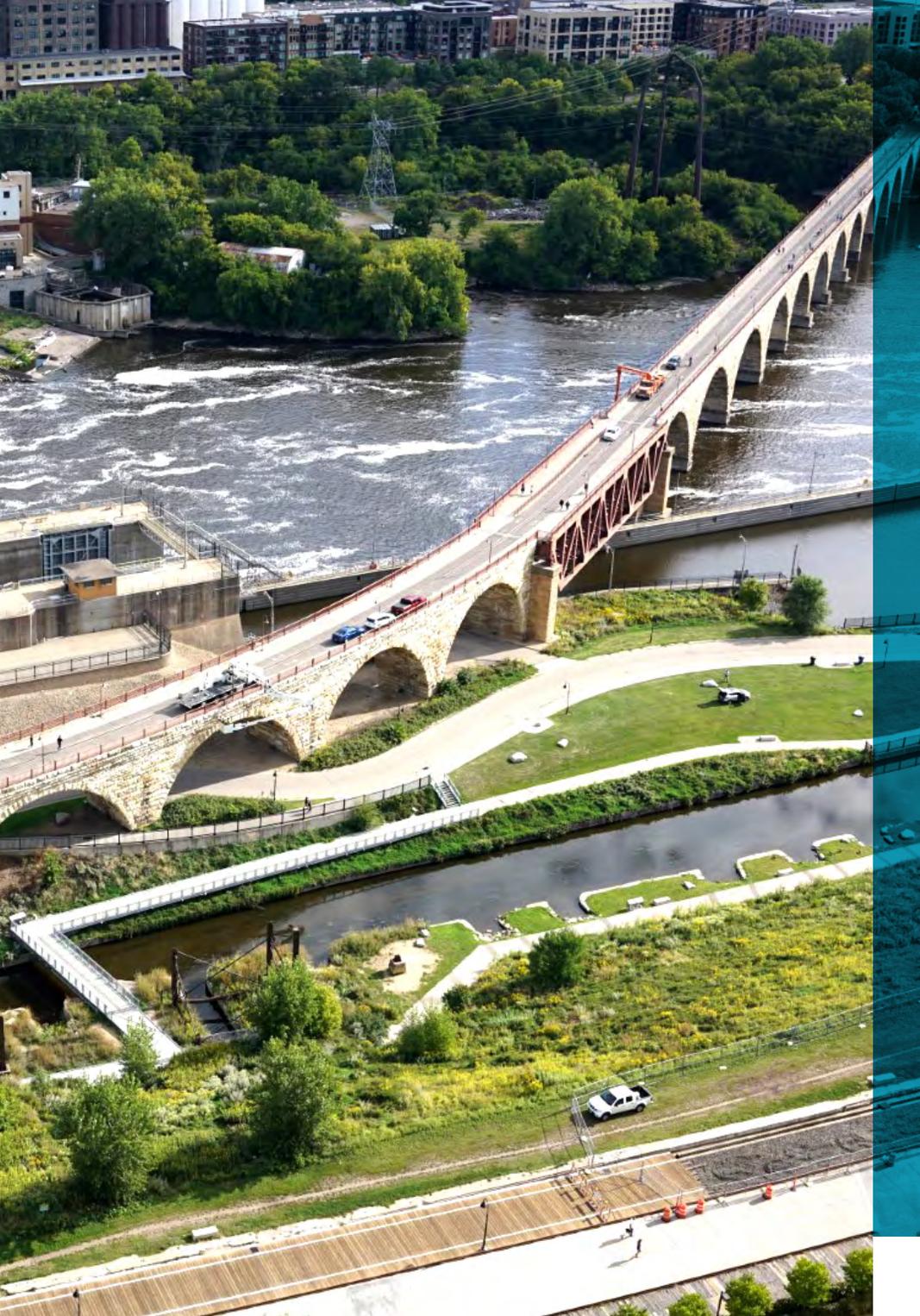
Maryland One (SUPERLOAD) Violation Tracking & Asset Insight

Hanover, Maryland, United States

Maryland State Highway (MDSHA) wanted to connect disparate systems and develop baseline metrics to monitor system performance and ROI. They needed to aggregate information about infrastructure performance, permitting operations, and hauler violations. This information needed to be in a secure portal available for key stakeholders and allied partners. MDSHA recognized a solution could be built with Bentley's AssetWise software to create the Violation Tracking and Infrastructure Insight Portal.

The solution will aggregate data—such as asset inspections, maintenance records, safety performance, permitting operations and hauler enforcement tracking—to enhance agency coordination and improve operational efficiency. MDSHA identified the baseline assets, their performance monitoring metrics, and the key violation patterns to be tracked within the solution. MDSHA anticipates optimizing permitting operations, increasing voluntary hauler compliance, law enforcement coordination, and timely access to key information with a goal towards enhancing infrastructure preservation. The solution will enable more targeted and proactive enforcement based on violation patterns.

Project Playbook: AssetWise Asset Reliability, LARS, ProjectWise, SUPERLOAD®



Operations

Winner

2021 Going Digital Awards in Infrastructure for Road and Rail Asset Performance

Stone Arch Bridge Rehabilitation

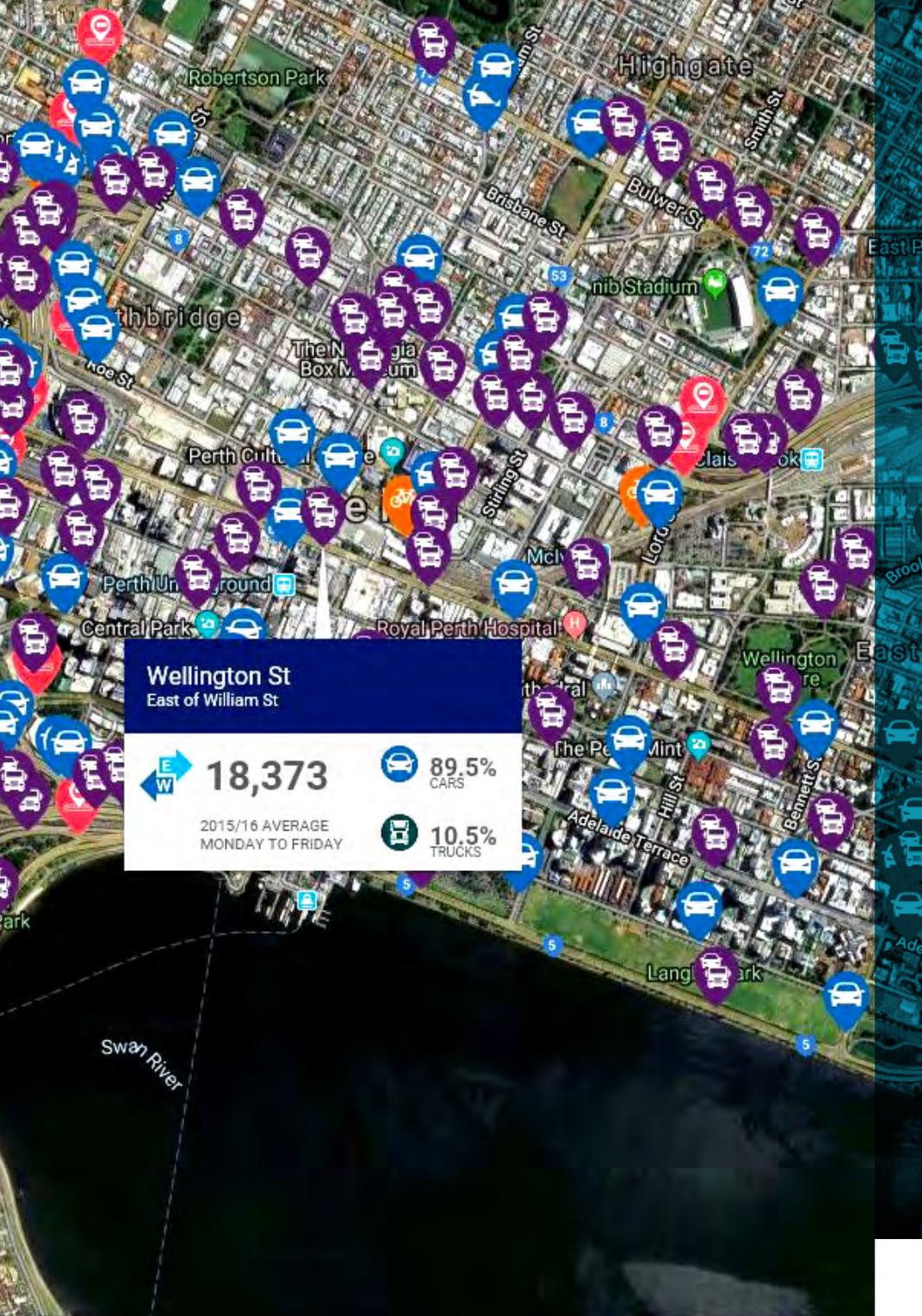
Collins Engineers, Inc.

Minneapolis, Minnesota, United States

Collins Engineers was tasked with inspecting and designing the rehabilitation of the iconic Stone Arch Bridge in Minneapolis. The 22-span masonry arch bridge is 2,100 feet long and is the most historically significant bridge in Minnesota. However, the team faced challenges when developing repair plans that traditional data collection could not accommodate. The bridge is in a busy urban environment, making access difficult. They used reality modeling previously, 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 solution.

Collins Engineers selected ContextCapture to generate a high-fidelity 3D model from over 13,000 images. By creating a digital twin, the team could record field inspection notes directly in the model, improving accuracy. 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. They will use the digital twin throughout the bridge's lifecycle for future planning and maintenance decisions. It was so accurate that Microsoft used it as part of their keynote address at their Ignite conference.

Project Playbook: AssetWise Inspections, AssetWise Digital Twin Services, ContextCapture, ContextCapture Insights, iTwin Immersive Asset Service, MicroStation, ProjectWise



Operations

Finalist

Year in Infrastructure 2019 Awards for Road and Rail Asset Performance

Trafficmap Release Two

Main Roads Western Australia

Perth, Western Australia, Australia

Main Roads Western Australia (MRWA) is responsible for managing one of the world's most expansive state road networks. Committed to improving data collection and sharing for road network management, MRWA needed to display and present accurate traffic data to stakeholders and the public. The organization developed Trafficmap to provide external users with open access to traffic data and to enable better asset management decisions by MRWA employees.

MRWA used AssetWise ALIM as the foundation for Trafficmap. Bentley's asset information management application saved significant time collecting, analyzing, and using the data for its mapping and information dissemination efforts while optimizing decision-making regarding roadway infrastructure. Publishing this data through a web-based interface provides clarity and transparency in road asset management decisions and allows stakeholders to make better investments. Trafficmap has realized an ROI of AUD 150,000 annually and saved users 25% to 30% in time accessing appropriate information.

Project Playbook: AssetWise

About Bentley's Road and Bridges Solution

Bentley Systems offers a comprehensive software portfolio for your road and bridge projects to cover the entire lifecycle of your asset, from planning to operations.

Learn more: www.bentley.com/en/goingdigital/roads/going-digital-in-roads

Discover more about the main software applied across each stage of the asset lifecycle:

Planning

Design and Engineering

Construction

Operations

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 include *MicroStation*-based applications for modeling and simulation, *ProjectWise* for project delivery, *AssetWise* for asset and network performance, Seequent's leading geoprofessional software portfolio, and the *iTwin* platform for infrastructure digital twins. Bentley Systems employs more than 4,500 colleagues and generates annual revenues of approximately \$1 billion in 186 countries.

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