Powering clients to a future shaped by growth

A Frost & Sullivan White Paper

An Open Platform for Infrastructure Digital Twins:

How Bentley Systems' iTwin Platform is enabling a digital twin ecosystem for the world's infrastructure

FROST & SULLIVAN

Table of Contents

State of the Market

One of the most important industry discussions regarding digital advancement is the use of digital twins. Digital twins, virtual models of real-world things and processes, offer users a holistic view to optimize the planning, design, construction, operations and maintenance of infrastructure assets. Organizations that want to create digital twin solutions must craft a roadmap that takes advantage of accessible opportunities today while providing space for adaptation in the face of future changes. This means that organizations must choose the right partners, technologies, and platforms to develop valuable and sustainable solutions for infrastructure digital twins. Even before considering industry partners, a fundamental requirement is an accurate understanding of what a digital twin is and what are the capabilities you should look for when selecting a digital twin software development platform.

This white paper, sponsored by Bentley Systems, aims to educate, and raise awareness in the infrastructure solution development community on the following topics:

- The definition of a digital twin and what it offers the infrastructure community;
- The scale of the opportunity for digital twin solutions more broadly;
- Key challenges facing technology developers creating digital twin solutions for the infrastructure industry;
- Bentley Systems' iTwin Platform's role as an enabling technology that addresses those challenges; and
- Key experiences and outcomes achieved with the iTwin Platform by technology developers.

"Digital twins offer a revolutionary means for the infrastructure community to adopt a new paradigm for optimization and efficiency throughout an asset's lifecycle."

What is a digital twin?

According to the **Digital Twin Consortium**, a digital twin is "a virtual representation of real-world entities and processes," where the representation is kept in-sync with the real world. Those entities and processes may form a real-world system or network. The virtual representation is a complex model consisting of multiple simpler models and simulations woven together with a digital thread. Digital twins can deliver critical insights into the outcomes that may result from various real-life decisions before they are taken. This provides the ability to improve decision-making by identifying the most beneficial action. The fidelity of a digital twin is tied to the accuracy and timeliness of observations of connected assets from the real-life system. Interventional mechanisms can react to changes in the virtual representation and make corresponding changes in the real world. These interventions can involve a human-in-the-loop by sending an alert to a worker, or they can be automated via IoT or traditional control systems. While this level of maturity is still the minority in digital twin use, it is anticipated to grow in the coming years.

The Digital Twin Consortium also emphasizes that that digital twins are implemented in digital twin systems. The virtual representation is only one part of those systems. A practical digital twin system also requires visualization, analytics, security, data integration, automation, and observational and interventional mechanisms that keep the virtual and real worlds in sync.

Further, digital twins are hosted in a digital twin system, which can be built in an ad hoc fashion, or built upon a purpose-built platform. A software development platform supplies important subsystems like persistence, visualization, analytics, IoT integration, digital thread, and security that are required for a robust digital twin system. It also facilitates updates and deployments. The ability of a digital twin to federate data and models from many sources enables it to be more accurate, comprehensive, multi-facetted, and deliver better predictive analysis. CAD, BIM, GIS, photos, LIDAR scans, business system data, IoT data feeds, etc. are examples of the data that are synchronized into the model and where iterations and updates can be tracked and recorded. A purpose-built software development platform for digital twins offers flexibility and openness to build solutions that address specific use-cases throughout an infrastructure asset's lifecycle.

How big is this opportunity and how can it be used in critical infrastructure?

Digital twins offer organizations, and specifically their strategic and operational decision-makers, a key tool to optimize planning, activity, investment, and ongoing management. Frost & Sullivan sees great potential for digital twins applied across a number of industries and geographies. While advanced activity in the 1990s onwards may have centered on CAD, with BIM capabilities expanding in the 2010s, Frost & Sullivan sees digital twin technology expanding over the 2020s as organizations leverage CAD and BIM within a federated digital twin to aid in decision-making throughout the lifecycle of assets. These efforts will continue to mature and advance towards real-time optimization, leveraging real-time feedback to make fast-paced decisions—and even automate decision-making via machine learning—to improve operations. Frost & Sullivan has conducted internal market research and analysis on digital twins applied to the built environment and construction (commercial, industrial, and residential) as well as the water industry. Solutions for digital twins in these markets are forecast to grow at a compound annual growth rate of 26.4% and 32.0%, respectively, through 2026. The pace of growth is reflective of the transformative opportunities digital twins bring to organizations, from c-level decision makers to plant operators, field crews, and project planners. Ultimately, these benefits represent multi-billion dollar per year opportunities, and have the potential to deliver even greater value to organizations in optimized spend, labor, and time management.

For the infrastructure industry, digital twins can be used throughout an asset's lifecycle:

- Planning: site surveys and reality capture or 3D mesh;
- Design: stakeholder engagement, planning and visualization, quality review, and change tracking;
- Analysis: pedestrian, flood, and other simulations;
- Construction: logistics simulation, project progress, status review, and 4D modeling, and;
- Operations and Maintenance: health, safety, social, and environmental (HSSE) training, operators training, maintenance planning, shutdowns, action verification, remote inspection, leak detection, and corrosion detection.

Digital twins can be applied to a wide variety of infrastructure assets across industry sectors and verticals. These include transportation systems, communications infrastructure, energy and natural resources infrastructure, healthcare, and defense and security, among others. The success of developing digital twin solutions for infrastructure, however, is not simply based on the merit of potential use-cases and benefits. Success will be heavily influenced by the level of engagement from infrastructure organizations and asset owner-operators, and the creation of a robust ecosystem of technology developers serving the infrastructure community. The wider industry needs to move towards the adoption of open standards for digital twins and an open development platform. The agreement on standards, and the compounded benefit of using an open development platform, will make the development of digital twin solutions more efficient and effective and further digital twin adoption. However, there are key considerations that software developers should take into account when choosing a development platform to build their digital twin solutions for infrastructure.

Considerations for Selecting a Software Development Platform for Digital Twins

A key challenge in any nascent market or growth opportunity is a lack of developed or accessible standards and enabling technologies; this adds risk to an investment and delays organizational buy-in from strategic decision-makers. Concerning the development of digital twin solutions, software developers must choose between building their own enabling technology from scratch or identifying an existing platform that will support and expedite their development goals. Both of these options come with degrees of risk and investment. For an organization to create its own enabling technology from scratch, however, it takes a great deal of time and resources, as well as upskilling. Using an existing, purpose-built platform that includes key enabling technologies can reduce development cost and time to market, but there are still risks involved if the platform lacks certain underlying capabilities or the flexibility to add them. Early development decisions have long-term implications in software development, as it can be costly to deconstruct and rebuild fundamental aspects of an existing solution.

> **For an ecosystem of digital twin solution providers to grow and serve the needs of the infrastructure industry, there must be enabling technologies that address key software development challenges.**

If you are an independent software vendor (ISV) supplying software and services to those owners and engineering, procurement, and construction (EPC) companies, you don't want to re-invent the wheel. You want to be able to build your solutions and get them to market quickly. If you are an owner or EPC with an in-house development staff, you also don't want them reinventing the basics—you want them to start with a robust digital twin platform so you can focus on adding capabilities to meet your specific use-cases or differentiate the value of your digital twin solutions. You want that platform to be "open" so that it can easily work with existing sources of data and adjacent systems. It is essential that the platform provide you with a way to avoid vendor lock-in and develop your digital twin solution without having a dependency on the original platform vendor. Imagine having to start from scratch if you decided to terminate your relationship with the original platform vendor. It is essential to work with a vendor that provides open source technology, available for use without a license, so your data and business processed are not at risk of vendor-specific data lock-in. An open platform promotes an ecosystem of choice and flexibility.

What has been missing in the market are well-developed, open platforms for creating digital twins and digital twin applications for infrastructure. There is a compelling need for a software development platform that allows users to select pre-developed components to form the foundation for digital twins and the creation of digital twin applications to satisfy specific needs and use-cases. This type of platform can limit the risk for developers as they will have reduced investment in the development of the underlying enabling technology, and they can focus their resources on core competencies in delivering digital twin applications and solutions according to requirements and client demand. Openness is a prerequisite, to enable interoperability and longevity and ensure that various systems, such as engineering design data (CAD, BIM, and GIS), business systems data, IoT data, asset data etc. can be used together seamlessly over the life of an asset. Without openness, development is slowed down by the need to develop new data integration capabilities from scratch to achieve interoperability within the digital twin ecosystem. The critical role of openness is acknowledged in the **Gemini Principles**, published by the Centre for Digital Built Britain, as a measure that improves trustworthiness in digital twin development. This is an openness that creates shared ownership, accountability, and common goals while at the same time embracing security and resiliency.

Digital twins are meant to be live representations of the real world they model. In addition to the foundational needs for openness—being able to incorporate different types of data, potentially in different locations—developers need a platform that facilitates timely synchronization of the digital twin with the observed reality. It needs automated integration of engineering data from CAD, BIM, GIS and other sources, and it needs the integration of data from leading IoT solutions. Much of this work has been manual, which slows down the efficiency of the digital twin. The integration and synchronization of asset and system data allow the querying of

databases. This querying is central to the ability to deliver analytics and reporting capabilities.

Importantly, while a digital twin is an advanced software system, it needs to be accessible to a wide range of stakeholders in an organization. The output needs to be communicable and easily visualized anytime and anywhere, which makes visualization a very important platform capability. Engineering language can be complex and unique to engineers, but a digital twin should not only be used by engineers. The platform should be able to merge data from public mapping and satellite services, private GIS databases, point clouds and photogrammetry, BIM, CAD, various business systems, and IoT into a single seamless pane of glass. Visualization of all the federated models and data is a powerful driver of the insights that digital twins can enable. It is also important that this play out across devices, whether viewed in fixed or mobile devices and through a web browser on an app. Many digital twins have shortfalls concerning 3D and 4D visualization, particularly with complex and large-scale models, but fast and scalable visualization is critical for bringing together different individuals, teams, and perspectives within a holistic point of reference.

A final barrier to developing robust digital twin solutions is security, especially in an environment that promotes connectivity between data, assets, organizations, and people. A digital twin is a powerful tool for understanding the state of an organization, its facilities, its processes, and even its people. It can even be used to intervene and affect them in the real world. With great power comes great responsibility to secure the digital twin to prevent its access for unauthorized purposes. Security is another area in which you don't want to reinvent the wheel. You want a development platform with built-in security capabilities that are strong and flexible enough to satisfy a variety of use-cases and owners' requirements. This position helps to ensure optimal security for today's known needs, but incorporates the foresight in knowing that needs and threats are evolving. Critically, this flexibility supports the multiple actors, systems, and data that are involved in digital twin development and maintenance.

For ISVs looking for a development platform or developers looking to build their own solution, these are challenges that must be factored into calculations on how to best proceed. These challenges reflect the scale of the demand and the need to get it right, as well as the costs in getting it wrong. Bentley has approached this as an opportunity that leverages its DNA in infrastructure engineering software and the industry's evolutions towards digital twins to create the iTwin Platform, which facilitates a larger ecosystem of developers to address market needs.

Bentley Systems Delivers a Robust Answer to Industry Needs Through the iTwin Platform

Bentley Systems has approached the digital twin industry with wide eyes as to what must be done to deliver a solution that is attractive to ISVs looking to select the most suitable platform and to win over developers that may be otherwise inclined to create their own independent solution. The iTwin Platform is guided by central principles that influence how the Platform was created and what benefits it offers These principles include: openness; cloud integration; scalability; security, and; as a service solutions.

Openness

Bentley Systems' position as a founding member of the Digital Twin Consortium displays its commitment to openness and interoperability for digital twin development. To Bentley, an open platform is one that supports a broad range of data formats, including proprietary engineering design formats, and must be vendor neutral in regards to format support. The platform must be able to extract data in a native format and make it available in an open standard that can be queried, interrogated, and integrated. To facilitate this approach, Bentley Systems supports a broad range of internal and third-party design tools and file interchange formats. This includes Industry Foundation Class IFC 2X3 and 4.3 and the new SMART Civil schema additions. In addition, Bentley Systems delivers a comprehensive repository of JavaScript packages that use open and flexible standards for digital twin development. These packages help developers and partners build and connect disparate digital components with the digital twin. This approach aims not to dictate how an organization realizes a digital twin, but to create building blocks that speed digital twin development and improve compatibility between digital components.

> **"Bentley Systems, through its iTwin Platform, has adopted central principles that translate into key capabilities, such as data federation, workflow digitalization, and 2D, 3D, and 4D visualizations."**

Cloud Integration and Scalability

In order to maximize benefit and opportunity in digital twins, cloud services are central in achieving advanced capabilities. If a digital twin was hosted and managed at a single facility there would be challenges regarding scalability and agility, remote access, collaboration, and higher costs. Further, cloud integration helps ease the management of regular maintenance and updates, and project deployments. The benefits of cloud integration will only grow as the industry continues to mature. Bentley Systems understands the implications of digitalization and the need for cloud integration. Cloud integration saves costs, enhances flexibility and collaboration, speeds access to updates and new services, and improves mobility. Importantly cloud integration and services facilitate and support scalability, whether increasing or decreasing in need. This is important as digital twin needs evolve and change in priority over time. Scalability through cloud integration delivers the agility and support needed. In delivering cloud integration,

Bentley Systems works with Microsoft's Azure cloud platform. As recently as October 2020, Bentley Systems has reinforced this approach through a strategic partnership with Microsoft as the COVID-19 global pandemic reaffirmed the need for digital access and operations enabled by cloud computing. New capabilities will improve the ability and reliability of digital twins to access IoT data and for themselves to be accessed through a number of different devices and locations.

Security

The iTwin Platform is designed to keep user data secure with enterprise grade security. The Platform has received a SOC2 Type I and a Type II report by a certified AICPA auditing body and is audited annually against the SOC reporting framework by qualified independent computer-security auditors. The iTwin Platform also supports industry standard OAuth 2.0 and role-based access control providing a secure way to ensure data tenancy.

Through its partnership with Microsoft and its Azure cloud system, Bentley Systems and the iTwin Platform gain access to a leading global partner in cyber security. Microsoft Azure leverages a team of 3,500 cyber security experts and has integrated security controls in hardware and firmware. Additional layers of security are embedded to combat DDOS attacks and other threats, and data is encrypted in transit and at rest.

Most importantly for those developing upon with the iTwin Platform, is that the security attributes will enable users to experience products and services uninterrupted and with assurance that their data and systems are protected. As users of the iTwin Platform adopt stringent cyber security standards in their own systems and solutions, they can be assured of industry leading protection and security.

As-a-Service Experience

Bentley Systems delivers the iTwin Platform through an as-a-service solution. This method of delivery upholds and reinforces the iTwin Platform's ability to provide partners with agility, ease of use, and delivers partners access only when they want it. As-a-service solutions offers customers the ability to review their partnerships at sensible intervals to further tailor the services and how they use it and to scale up and down as needed. Further, as-a-service solutions offer partners a lower risk option to test new services and capabilities; should they test and experiment new capabilities but not find enough value, only a limited investment was made to obtain important knowledge that averts a greater financial loss. Should the experience be beneficial, partners may easily continue the service. Bentley Systems has taken decisions that prioritize the needs of partners, developers, and customers as they explore and grow their activity in digital twins.

Bentley Systems' Principled Approach Realizes Strengths in iTwin Platform

These principles have guided Bentley Systems in the creation and development of the iTwin Platform and they were chosen because of the importance and value of outcomes they deliver. Specifically, the iTwin Platform excels at the federation of data

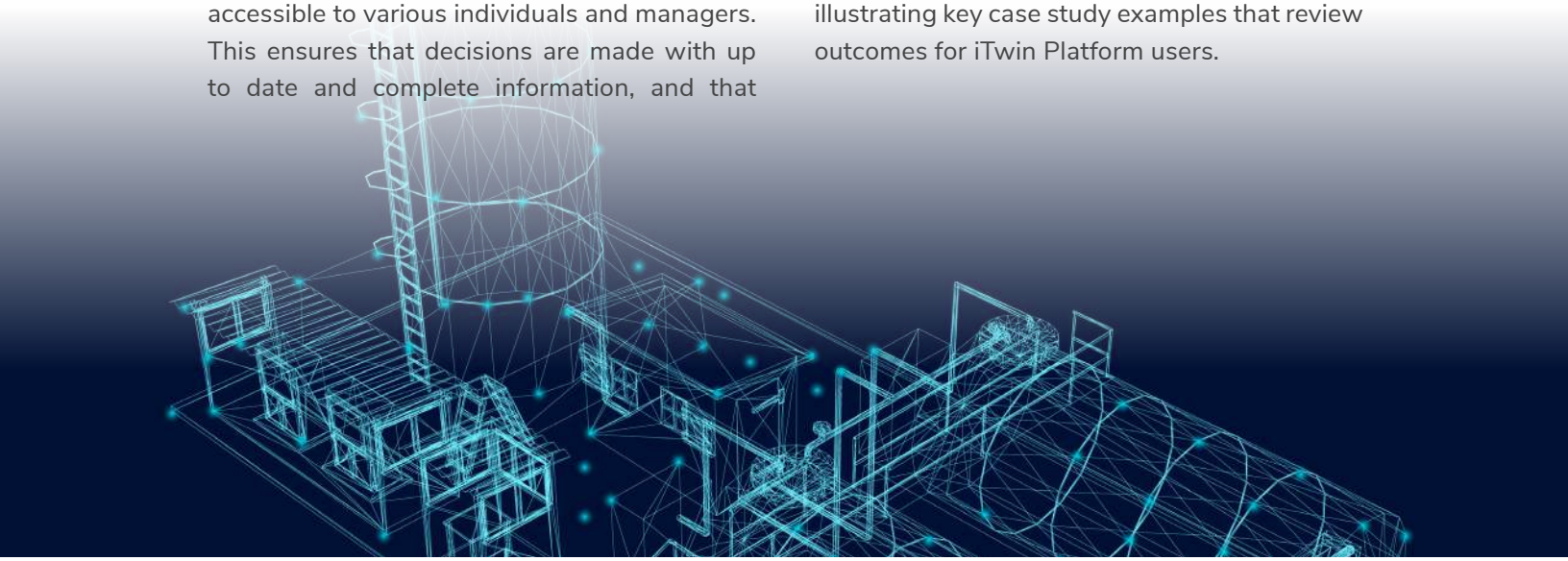
and the subsequent analysis, querying, and reporting, the digitization of workflows, achieving realistic visualizations, and delivering an ecosystem of developers.

One of the greatest challenges to the success and impact of digital twins is the incompatibility of data between systems and software. Whether due to silos, legacy systems, or a lack of early foresight in developing a comprehensive digital strategy, most organizations face difficulties in data compatibility. Engineering data can reside in multiple file formats, which complicates the process of federating data for a digital twin. CAD, BIM, and GIS are crucial systems to integrate into a digital twin, but can present compatibility challenges. Bentley Systems, through open source code and architecture efforts, helps to streamline and federate disparate data formats and sources. The organization aims to ensure engineering technology, information technology, and operational technology are brought together through the digital twin to provide holistic insights. This simplifies and speeds the creation of digital twins for users, allowing developers to skip the basics and focus on added value. Further, it enables specific data to be selected, queried, and analyzed for trends, alerts, and scheduled reporting.

Critically, Bentley Systems' iTwin Platform excels at the digitization of workflows. What used to be manually managed between teams and locations, often resulting in time delays and incomplete data capture, is now centralized and accessible to various individuals and managers. This ensures that decisions are made with up to date and complete information, and that co-collaborators are kept abreast of ongoing changes that impact their work. This increases productivity and quality of work through a project's lifecycle.

To ensure that all relevant individuals, whether familiar with engineering models and language or not, can derive benefit from the digital twin, the iTwin Platform excels at offering accurate visualizations through 3D models. Further, through the iTwin Platform a 4D experience can also be gained when 3D visualization is paired with data over time. Using a 4D digital twin reinforces the importance of data synchronization and change management. As projects progress or new decisions are enacted, the data in the digital twin needs to be updated to ensure accuracy and timeliness. Offering multiple ways to use a digital twin and to obtain data held within it is critical when the objective is to engage various teams, function levels, and individual learning preferences.

The ultimate output of the iTwin Platform is a secure, collaborative developer ecosystem. Bentley Systems' work on the Platform has been guided the knowledge that no single company will provide a holistic solution, but that organizations need to collaborate on an equal platform of shared standards. In this way, digital twins and those using them will get to access a combination of best of breed solutions. This approach has delivered real outcomes for industry partners. In order to best understand these benefits, the white paper will conclude by illustrating key case study examples that review outcomes for iTwin Platform users.



iTwin Platform Users have Realized Strategic Gains through Project Lifecycles

SafetIbase

Is a system created by a consortium of companies to manage health and safety risks within construction projects in a repeatable and effective manner. It had been apparent to these organizations that there were challenges with existing options in managing construction industry health and safety risks. These organizations typically had two choices, either they could purchase proprietary technology and software to help centrally track risks and hazards or they could use spreadsheets to manually track these risks. Concerning proprietary software, while generally fit for purpose there were drawbacks when using a closed system that could at times be slower and that were often deemed expensive. This reality left organizations typically looking at using Excel spreadsheets to track health and safety risks. A new set of challenges, however, arose through this approach. The spreadsheets were not easily transferred and shared between project participants and the use of spreadsheets often resulted in customizations between projects creating inconsistencies and low transferability. SafetIbase felt that these options presented solutions that were unstructured, disconnected, and complicated. To overcome these limitations, SafetIbase created a SharePoint database. The consortium found it affordable, flexible, mobile friendly, and built around a common database structure, which aided connections to other technologies and data sources. The database was also hosted in the cloud and could then be transferred easily between projects.

> **“iTwin Platform partners have found numerous capabilities on the Platform to deliver superior customer benefits by leveraging the power of digital twins.”**

The database, however, needed to be linked to the 3D model environment in order to realize its greatest potential. This is where the iTwin Platform helped SafetIbase deliver on its mandate. The SafetIbase consortium used the iTwin Platform to develop the first and only PAS 1192-5 implementation of SafetIbase, which can link to the 3D model that enables control and traceability of the database. A two-way edit capability was enabled so that users could edit, add, and mitigate risks in the model. Model reviews could be run, and project partners could access and understand the database in a visual and data-centric manner.

FutureOn

A provider of visual engineering software for the oil and gas industry, is integrating with Bentley Systems' iTwin Platform to visualize and interrogate design data from their FieldTwin application, which allows users to quickly design offshore oil and gas assets and review multiple design options to determine the optimal choice. FutureOn saw a challenge in the amount of time organizations dedicate to field planning and revisions, and knew there had to be a more efficient way to manage data and information used in decision making. FutureOn worked to develop a solution that ensures data is always up to date and accessible to anyone at any time. The data are shareable to all project partners and ecosystems, including operators, engineers, and marine operators among other parties. The focus is on enabling effective, collaborative work. A user can quickly sketch numerous project options in just a few minutes and, through use of the iTwin Platform, immediately have access to quantity and cost data for each option. This improved process saves months of project time that would typically be spent when using conventional methods. The iTwin Platform plays a central role and leverages the platform's Reporting and Insights service capabilities to deliver the concept compare feature. FutureOn users design and review project options as a 3D model, which is synchronized to the iTwin Platform seamlessly. This allows users in the iTwin to visually inspect and compare the different design options, and data and information from various systems are displayed together for enhanced analysis. FutureOn notes that their FieldTwin solution, in collaboration with the iTwin Platform, helps to deliver a single source of truth so that partners and users can efficiently understand real implications of, and comparison between, design options in digital oilfield solutions.

For Further Information

For individuals and organizations looking to better understand the capabilities of digital twins in their own businesses and solutions, please visit developer.bentley.com or contact the iTwin Platform team at iTwinContact@bentley.com.

contact the iTwin Platform team at iTwinContact@bentley.com.

FROST & SULLIVAN

WPD-2021

Frost & Sullivan, the Growth Partnership Company, works in collaboration with clients to leverage visionary innovation that addresses the global challenges and related growth opportunities that will make or break today's market participants. For more than 50 years, we have been developing growth strategies for the Global 1000, emerging businesses, the public sector and the investment community. Is your organization prepared for the next profound wave of industry convergence, disruptive technologies, increasing competitive intensity, Mega Trends, breakthrough best practices, changing customer dynamics and emerging economies?