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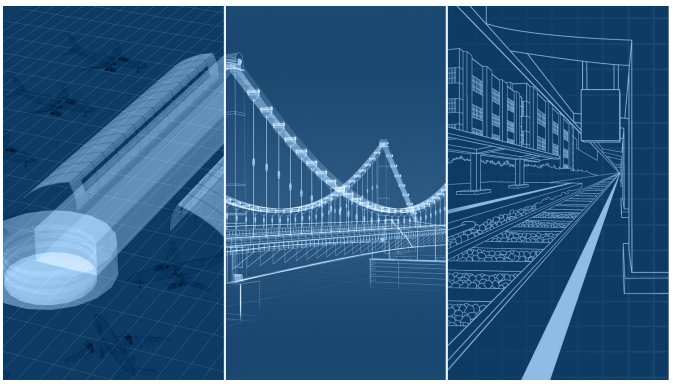
A Resource for Transportation Professionals

Begin with the End in Mind to Unlock the Promise of Digital Twins

The development of "digital twins," or virtual 3D model representations of physical assets, is exciting for its ability to enable transportation agencies to design, construct and manage their infrastructure systems more efficiently. Beginning with the end in mind can facilitate development of digital twins that deliver immediate operational benefits while serving as a foundation for enhancements over time.

Even a graphical or 2D representation, which permits strategic integration of live sensor feeds or other legacy asset conditions data, can suffice as the initial digital twin framework. Simple data relationships can then be used to integrate existing data to those model features and annual inspections can be performed to update asset conditions regularly.



A digital twin does not have to be a true 1:1 representation of complex physical assets. Instead, a less detailed, mass model can be used to represent major components, provide access to more granular information and deliver business value.

Build on strategy

In developing a digital twin, sound strategy can establish a foundation for great benefit and offer valuable return on investment. Besides simplifying the initial modeling effort, this approach also involves:

1. **Taking advantage of existing datasets and content.** Asset maintenance and operations data, even if it's incomplete, typically exists somewhere within an owner's organization. When HNTB works with clients to develop digital twins, the firm assesses where information is stored, how it is stored and how it could be used in the digital twin framework. Existing data could include:
   - Types and model numbers of equipment installed on a structure
   - Location of assets
   - Maintenance history
   - Condition of the asset (e.g., is it healthy and functioning; remaining service life)
2. **Incorporating newer technologies to fill in data gaps.** Other remote sensing technologies, such as light detection and ranging (LiDAR), panoramic imagery and field devices like iPads, can gather missing information and supplement existing data. A current HNTB client, for example, wanted to create a digital twin for a signature complex bridge in the Midwest. Because much of the geometric data on the bridge was out of date or not known and existing data was stored in disparate locations within the client organization, HNTB modeled together the incomplete legacy information with newly collected LiDAR point-cloud data.
3. **Defining governance.** A digital twin, like any successful data management system, requires governance around roles and responsibilities, data maintenance and operations. Appropriate governance defines, among other things, the common data standard. This becomes the common language for how an organization talks about digital twins. For example, when someone searches for an asset type, such as a guardrail, there's a clear understanding of how the asset is defined within the digital twin.

For successful digital twin implementation, the initial foundational integration points should be identified early. This step establishes a data point for each digital feature. Once the primary integration is complete, it becomes the foundational systems framework. As the model progresses and improves, other systems can be added through the established common data environment.

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Build on a solid foundation

Skills in 3D and model-first design are on the rise within our industry, as evidenced by the growing numbers of consultants and contractors providing BIM deliverables. A strategic, foundational-first approach enables the most effective, incremental creation of a digital twin. It allows transportation leaders to be confident that when they award projects they can provide designers and contractors with the necessary standards to ensure that the models they receive will be useful, relevant and compliant to the digital twin framework.

Several HNTB clients are taking this "beginning with the end in mind" approach to capitalize of the digital twin promise:

The San Diego Association of Governments (SANDAG), the San Diego region's strategic planning and research agency, is in the planning stages of a Central Mobility Hub and Connections Comprehensive Multimodal Corridor Plan. The plan will consider transportation solutions in the San Diego International Airport area and surrounding communities, focusing on development of a Central Mobility Hub with a direct transit connection to the airport.

To prime the iterative development approach, SANDAG engaged with HNTB as program manager to establish a digital twin framework that enables confidence in all projects going forward in the program to positively collaborate in their ultimate digital twin vision.

"The SANDAG Central Mobility Hub is a critical regional program that will provide a great connection between public transportation and the airport that will take years to complete," said Sharon Humphreys, SANDAG senior transportation engineer. "We realized that starting our program with a strong foundation and the end in mind was key to ensuring its long-term success. A key component of this is a sound digital twin framework. With HNTB's help initiating proper BIM/CAD governance and a common data environment, we are confident the right standards are in place to mature the digital twin throughout design and construction to ensure we have a powerful platform for long-term operations and maintenance."

SANDAG's approach prepares the agency to provide future project designers and contractors with clear, consistent expectations that delineate geographic information system (GIS), BIM and other data standards. As well, the framework puts in place the proper governance and content management.

Chicago O'Hare International Airport. The Chicago Department of Aviation has embarked on the O'Hare 21 Program, the largest expansion and first major capital improvements to O'Hare's passenger terminals in more than a quarter-century. The program will completely redevelop existing Terminal 2, add two new concourses, replace and expand aircraft gates and set in motion a wide range of other improvements that will significantly enhance airline performance and the overall passenger experience. As master civil engineer, HNTB is designing the heavy infrastructure components of the program required to support the new terminal facilities, including the design of the central tunnel system that will convey utilities, baggage and passengers from the O'Hare Global Terminal to the satellite concourses.

HNTB is helping O'Hare with a digital twin strategy by developing an initial model-first design of the central tunnel system – establishing standards and processes that will allow for changes and adjustments as the program matures. The initial modeling approach already interfaces with new terminal design models for visualization as well as subsurface utilities for clash detection, which already is providing benefits during early stages of the project.

In New York, HNTB is working with **Long Island Rail Road** to scale and enhance its $1 billion Jamaica Capacity Improvements (JCI) project. The project seeks to modernize critical LIRR infrastructure in and around Jamaica Station, some of which has not seen a major upgrade since 1913. HNTB's role includes lead design and overall design coordination of improvements to add capacity and improve travel reliability to one of the region's most important and highly used transit hubs. HNTB helped LIRR establish a scalable, digital twin strategy to help set up the initial framework and enable model integration throughout the project development process.

As the project has advanced, an interactive environment developed by HNTB allows for the consolidated integration of the project's 3D design content with schedule (4D) and cost (5D) data. The right digital twin framework has enabled the dynamic integration of geospatial data, parametric models, schedule, design programming and cost estimates into a highly accessible dynamic web viewer. The approach and platform provide weekly automated updates, allowing the project team, client and contractor partners to easily view and analyze complex construction phasing scenarios and make key decisions prior to construction.

Begin with the end in mind

Digital twins promise a highly intuitive platform where all infrastructure assets can be integrated, tracked and accessed seamlessly and to leverage interconnected data to simulate outcomes. Fully developed digital twins use data from multiple sources to visualize and report an asset's working condition, allowing an owner to determine where it is performing well or poorly, test simulated situational impacts and predict future outcomes. The ultimate promise of digital twins is an elegant, smart model that incorporates design and engineering details like an asset's materials, components, systems and performance with operational data — even, perhaps, Internet of Things sensors and artificial intelligence.

This capability leads to better-informed decisions and more effectively and efficiently managed infrastructure. Agencies see the possibilities behind the technology but often don't know how to take the first step. A smart and less-overwhelming approach is to start simply. By beginning with the end in mind, HNTB can help transportation decision makers define initial digital twin frameworks that are realistically achievable, deliver real benefits and establish a foundation for long-term scalability and enhancement. ■

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