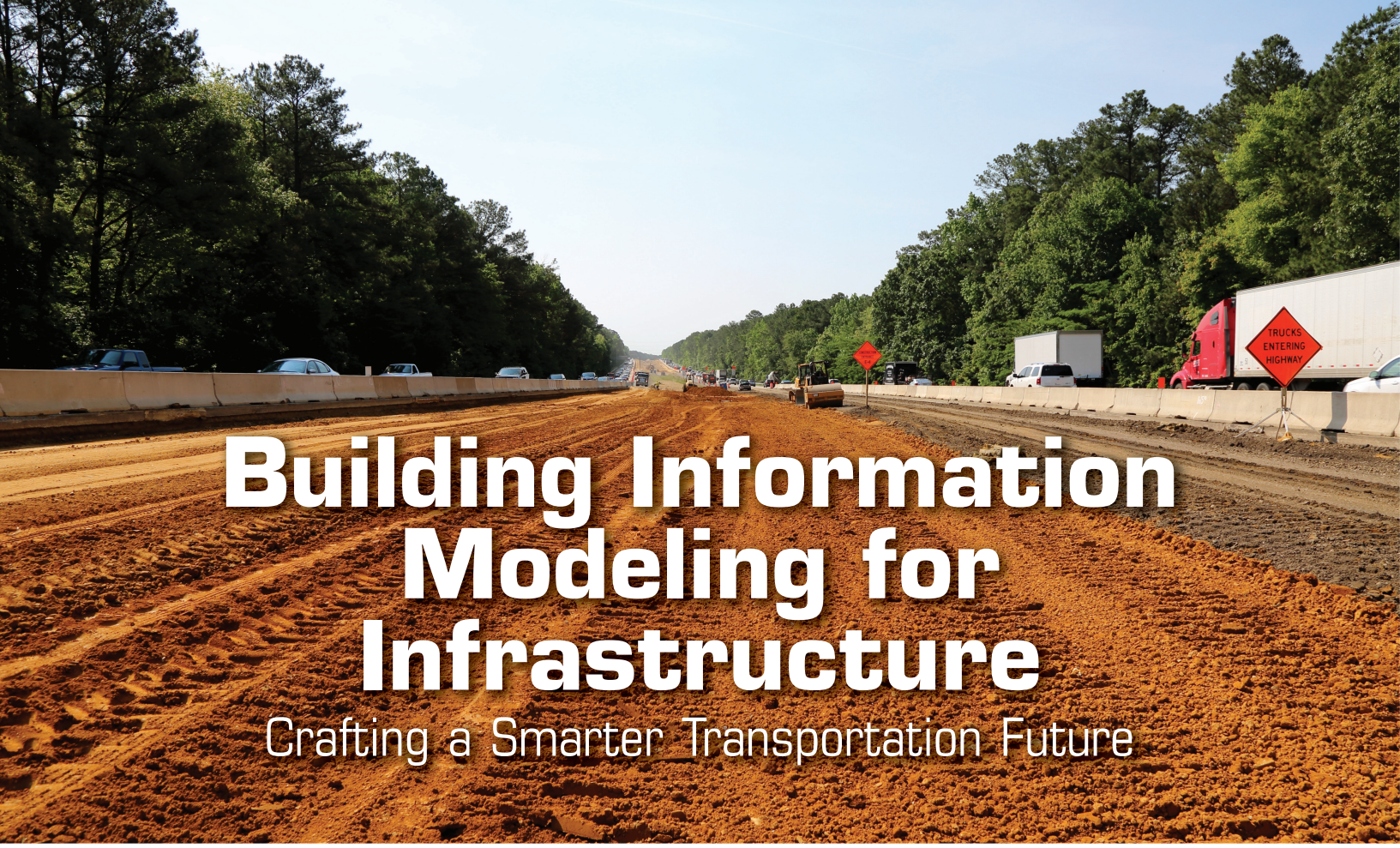


Building Information Modeling for Infrastructure

Crafting a Smarter Transportation Future

D. Allen Covey, Virginia DOT, Flickr, CC BY-NC-ND 2.0

ALEXA MITCHELL

The author is a transportation building information modeling program planner at HDR in Phoenix, Arizona.

Traditionally, determining the tons of soil needed for roadwork projects—such as this widening project along I-64 in Virginia—called for highway designers to plan on paper and with basic computer software. However, such tasks become easier and more collaborative when planning with 3-D building information models, digital tools that follow the life of the project.

With the passage of the Infrastructure Investment and Jobs Act in 2021, transportation agencies across the United States find themselves on the cusp of a transformative period in the nation's infrastructure history. Billions of dollars are now being put to work on transit upgrades, transportation systems for roads and bridges, and much more. With this infusion of funding comes a need to work smarter and more efficiently. However, many public agencies do not have the staff needed to design and manage a sudden massive surge in projects. One solution could be a greater emphasis on the use of building information modeling (BIM) in transportation.

Already standard in the vertical building industry, BIM is fast becoming the way to deliver transportation projects, as well. No longer a futuristic vision or the sole domain of early adopters, this collaborative process for creating intelligent 3-D models already has shown its benefit to infrastructure owners. At least five states have completed projects using the 3-D model as a legal document (MALD) approach, and four others are currently working on MALD pilot projects. For many other states, the technology is part of regular design practice.

As the industry continues this shift from paper to 3-D models and digital delivery, much has been made of the impact on design and the benefits that can be captured in that process. This shift also has profound implications for construction, requiring new training for workers, new workflows for accessing designs, and new contract and procurement language. So, why should the industry accept this disruptive innovation? While challenges to its full adoption still exist, BIM offers a long-term value proposition that should be explored.

Benefits

COLLABORATION AMONG DISCIPLINES

While most people believe BIM is about creating 3-D models for visualization

purposes, a key value lies in calculating repetitive quantities and coordinating work across disciplines. Much of this work is critical but may not require a creative or innovative eye.

For example, BIM provides great efficiencies during design when compiling and checking earthwork quantities. Without BIM, a team would have to use representative cross-sections to quantify cut-and-fill material amounts for each corridor, a time-consuming process that can take up to two weeks on a large, complex project with multiple corridors. However, with BIM, the same process could take as little as two days. When design teams work in a collaborative BIM environment, they can reference each other's 3-D designs to identify potential conflicts. This type of 3-D coordination can save an owner a significant portion of the construction contract value due to avoidance of change orders (*1*).

Massachusetts DOT

Hoisting up and over, a Massachusetts DOT crew installs a prefabricated span of an I-95 overpass. Some 3-D models allow construction contractors to schedule materials delivery, anticipating what they will need and when they will need it.

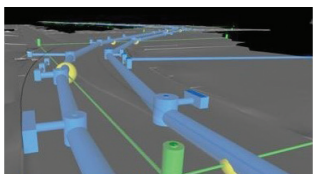
IMPROVED BIDS FOR CONTRACTORS

BIM also benefits contractors by increasing efficiency. Contractors can reuse models created during design; they do not have to make their own for key parts of a project and, therefore, can prepare bids more efficiently. Contractors also can grasp design intent much better when using 3-D models over 2-D representations, providing critical perspective as projects enter construction. Mobile apps can even provide contractors with the opportunity to see these digital models while in the field (Figure 1).

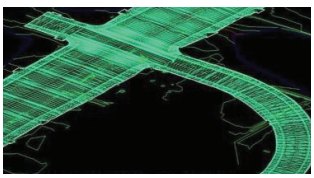
Additionally, contractors can use some 3-D models—depending on the level of detail—for fabrication, safety reviews, and construction simulations. Contractors can connect these models to their schedule and the materials needed at certain milestones to see a sequence of events virtually. This ability provides an improved understanding of the materials they will need to order and when they need to order them, making the 3-D model a good estimating and scheduling tool for procurement and delivery of construction materials.

ASSET INFORMATION CAPTURE

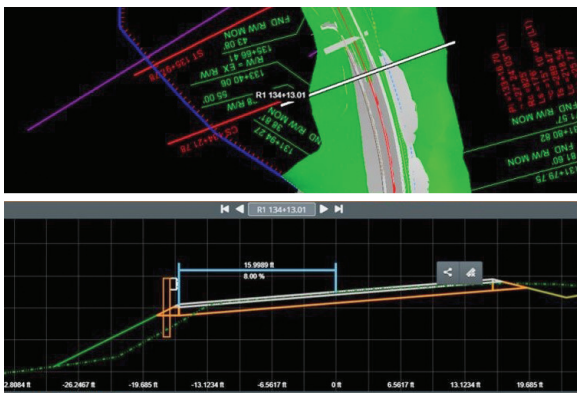
Another important benefit of BIM that is often overlooked is the opportunity to capture information about the assets to document the as-built environment digitally. This digital as-built model provides a representation of the physical asset at the end of construction. It contains both geometric (i.e., size and dimensions) and nongeometric information about objects in the project, such as location, material properties, and condition ratings. This model can provide valuable information for future maintenance and reference.



Underground Utility Models
(a)



Triangulated Surfaces (DTMs)
(b)



Cross-Section View
(c)

FIGURE 1 A mobile app view of typical 3-D geometry on a project showing (*a*) underground utility models, (*b*) triangulated surfaces, and (*c*) a cross-section view (DTMs = digital terrain models).

Challenges

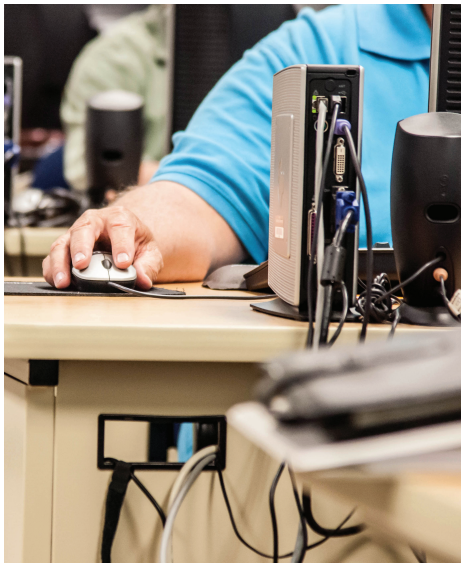
As transportation agencies, designers, and contractors adjust to this new digital environment, a few specific considerations are needed while working toward BIM adoption.

WORKFORCE EDUCATION

There is much confusion about BIM and its benefits, and there is a great need for developing educational programs to help all stakeholders understand how to apply BIM methods to different types of projects consistently. As BIM deliverables become more common, construction staff can benefit from training in the new technology and software and in how to find the information they need to complete the job. One persistent roadblock has been incompatibility between software that designers and contractors commonly use. The good news is that this challenge will be addressed as new Industry Foundation Classes (IFC) file formats and open data standards[1] endorsed by AASHTO and the American Road and Transportation Builders Association are adopted.[2]

[1] For details about the adoption of IFCs, see https://highways.transportation.org/wp-content/uploads/sites/46/2019/10/Administrative-Resolution-AR-1-19-Adoption-of-Industry-Foundation-Classes-IFC-Schema-as-the-Standard-Data-Schema-for-the-Exchange-of-Electronic-Engineering-Data.pdf.

[2] See the American Railroad and Transportation Builders Association digital construction policy statement at https://www.artba.org/wp-content/uploads/2022/02/Digital-Construction-Policy-Statement.pdf.



Bruce Hull, Ohio DOT

Mouse clicks and concentration bring Ohio DOT staff up to speed during technology training. Lack of a trained workforce is a major impediment to the widespread adoption of 3-D building information modeling, a challenge that the construction industry is working to overcome.

LIFE-CYCLE INFORMATION AND DATA NEEDS

Stakeholders throughout a project need correct information to do their jobs well. Models can be packed with information, but designers, contractors, construction management teams, and asset owners all need to know how to find the specific information they require (Figure 2). They also need know how to provide information in the correct format to aid other teams. Standardized information-sharing methods are needed to ensure that each group has a complete picture of the information those elsewhere in the project life cycle require. At the most basic policy level, agencies cannot set requirements if they do not know what they need to ask for.

For example, in work with the Utah Department of Transportation (DOT) on its 3-D modeling pilot programs, one major area of feedback from contractors was a lack of consistency in the models. Contractors knew that all the information they needed for construction would be in the model, but where that information was, how it was presented, and how it needed to be accessed varied, depending on the designer who created the model.

FIGURE 2 Screenshot of an example project model. (Courtesy of Pennsylvania DOT)

MODEL-DEVELOPMENT STANDARDS

As more transportation system owners require 3-D model–based deliverables, it is important to establish a consistent, repeatable, and reproducible process. Organizational modeling standards and information requirements are often needed to be clear about what should be modeled and to what level of detail.

The challenge is exemplified by Utah DOT's experience creating the nation's first model-development standards manual, which specifies what should be included in the design and what should be left out (*2*). For example, do designers need to model topsoil as a part of projects? There is no wrong answer, as long as the contractor knows consistently one way or the other. However, if topsoil modeling is left out of the calculation, contractors will need to know so they can account for it in their estimates and construction plans.

This challenge of consistency is being addressed on a national level by industry associations. The AASHTO Joint Technical Committee on Electronic Engineering Standards[3] and the American Council of Engineering Companies are working on making recommendations for a national framework that can be adopted by all state DOTs.[4]

CONSTRUCTION SPECIFICATIONS

Many construction specifications were written for how projects were built decades ago and do not take into account how technology has changed and is being used in the industry. In some cases, these specifications can force contractors to move away from using a model created in design, not because it is more efficient to do so but solely to satisfy the rules and norms of a different era. Particularly, when it comes to materials and methods, existing specifications can lack the necessary flexibility to take advantage of new efficiencies. As transportation agencies move forward with digital delivery, updating construction specifications will be a critical step for overcoming this challenge. A transition to performance-based specifications, with flexibility to use multiple approaches and technologies, may be necessary.

[3] Find out more about the committee's work at https://design.transportation.org/technical-committees/electronic-engineering-data/.

[4] Learn more about the collaboration between the two committees at https://portal.ct.gov/-/media/DOT/documents/AEC/IHEEP/National-JTCEESACEC-Collaboration-on-LOD-Framework.pdf.

Plan Now, Avoid Problems Later

While still evolving and growing, BIM is here to stay. This shift will have major impacts and benefits for the highway construction industry across project delivery phases—from design all the way through asset management. Now is the time for highway agencies to create or review strategic plans that will guide them as they set goals and objectives, establish expectations and timelines, and plan and identify investment needs for specific activities related to digital delivery. Making the right decisions at the beginning of this transition and putting the right foundation in place will result in important benefits for years to come.

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2. *UDOT Model Development Standards Manual.* Utah Department of Transportation. 2020. https://digitaldelivery.udot.utah.gov/pages/standards.

VOLUNTEER VOICES

"I fell into the transportation community by happenstance when the end of the Cold War dried up my original plans. Fortunately, I had contacts from a summer internship at my state department of transportation, and they had a mentoring program for engineers that allowed me to find a niche that matched my interests. I stayed in transportation because there is so much room for one person to make a difference. We operate on a shoestring budget in transportation, so there are few of us and big money isn't what drew us here. TRB has played a large role in that for me because it allows me to interact with colleagues outside my own state.

—GREGORY T. GIAIMO
Transportation Engineer IV, Ohio Department of Transportation
Columbus