Beyond 3-D Models: BIM for Bridge Project Delivery and Asset Management

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Civil engineering software platforms have evolved from two-dimensional (2-D) line-drawing tools to data-rich, three-dimensional (3-D) model-authoring environments. For many bridge projects, the initial step into such an environment involves producing traditional 2-D plan sheets extracted from a coordinated 3-D model, where changes automatically propagate through plans, sections, and elevations. While this initial step improves document consistency and project coordination, it represents only an early phase of a much broader digital transformation.

As transportation agencies progress in their digital efforts, terms such as "digital delivery," "model as legal document," and "building information modeling" (BIM) become more prevalent. BIM is often equated with 3-D models, but this view minimizes its scope. International Organization for Standardization's (ISO's) standard 19650 defines BIM as the "use of a shared digital representation of a built asset to facilitate design, construction, and operation processes to form a reliable basis for decisions."[1] In this context, BIM includes both the digital representation and the processes governing how information is created, shared, and managed across an asset's life cycle. Three-dimensional models are an important component, but not the entirety of BIM.

Why Adopt BIM?

During project development and delivery, BIM improves communication of design intent in ways that traditional 2-D plan sheets cannot. Designers conceive projects, and contractors build them, in three dimensions, but we have traditionally communicated design intent in two dimensions. Three-dimensional models assist teams by enabling early identification of spatial conflicts, constructability issues, and sequencing challenges, thereby reducing risk and minimizing costly downstream changes.

BIM also supports efficient digital workflows. The use of models can shorten review cycles, improve accountability in issue tracking and resolution, and reduce reliance on paper-based processes. When combined with digital cost and schedule information, BIM enables teams to work efficiently and make informed decisions throughout design and construction.

Beyond project delivery, BIM provides significant value to transportation agencies as long-term asset owners. State departments of transportation (DOTs) are responsible not only for delivering projects but also for operating and maintaining transportation systems for many decades. These responsibilities require accurate, timely, and accessible asset information to support planning, maintenance, and investment decisions.

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BIM enables information generated during design and construction to flow into operations, maintenance, and asset management. When paired with life-cycle information management processes, such as those defined in ISO 19650, BIM reduces reliance on redundant data sources and supports consistent, authoritative asset information across an agency. Today, asset data are often collected and maintained within organizational silos, limiting visibility by other departments and requiring staff to gather the same information multiple times. This duplication wastes time and resources and exposes staff to unnecessary field risks. BIM processes help break down these silos by creating a "single source of truth"; this strategy reduces data management costs while supporting accurate asset analysis and well-informed decision-making.

BIM is an organization-wide endeavor spanning the full life cycle of transportation assets. While 3-D models are highly visible, they represent only one part of a larger information ecosystem.

The BIM Road Map

The process of adopting BIM across individual projects and throughout a transportation agency is not a simple transition. It requires a deliberate, phased approach supported by policy, guidance, training, and technology.

In June 2021, the Federal Highway Administration published *Advancing BIM for Infrastructure: National Strategic Roadmap*,[2] which outlines a 10-year vision for transitioning from traditional 2-D plan delivery to a fully digital approach encompassing design, construction, operations, and maintenance.

Two Transportation Pooled Fund (TPF) studies are further supporting this transformation. Approximately 25 state DOTs are participating in TPF-5(480), BIM for Infrastructure,[3] and TPF-5(523), BIM for Bridges and Structures, Phase II.[4] These efforts focus on developing practical guidance and specifications for BIM-based project delivery. One key outcome is the American Association of State Highway and Transportation Officials' *AASHTO Information Delivery Manual for the Design-to-Construction Data Exchange for Highway Bridges*,[5] which defines the minimum information requirements needed for bridge project letting. Each participating DOT is at a different point in their BIM transition, but all are making progress with support from the TPF efforts.

Adoption Challenges

Two primary challenges to BIM adoption are people and technology. On the people side, education, training, and communication are essential. BIM represents a fundamental shift in how information is produced and managed. Overcoming resistance to change requires sustained investment in workforce development and clear communication of benefits.

On the technology side, sharing information across the asset life cycle is challenging when stakeholders rely on different software platforms. Designers, contractors, owners, and operators use specialized tools tailored to their workflows, many of which rely on proprietary data formats. These formats often require custom solutions to exchange information, increasing cost and risk for stakeholders.

Open data standards are critical to addressing this challenge. AASHTO has adopted ISO 16739, *Industry Foundation Classes (IFC) for Data Sharing in the Construction and Facility Management Industries*,[6] which was developed by buildingSMART International in cooperation with the ISO as the preferred data exchange standard. IFC supports robust definitions of geometry, object properties, and relationships in an open, nonproprietary format. As an international, text-based standard, IFC also supports the long-term preservation of asset information for assets whose service lives can exceed 75 to 100 years.

Open standards enable interoperability between software platforms, support collaborative workflows, preserve flexibility in technology choices, and safeguard long-term access to asset information.

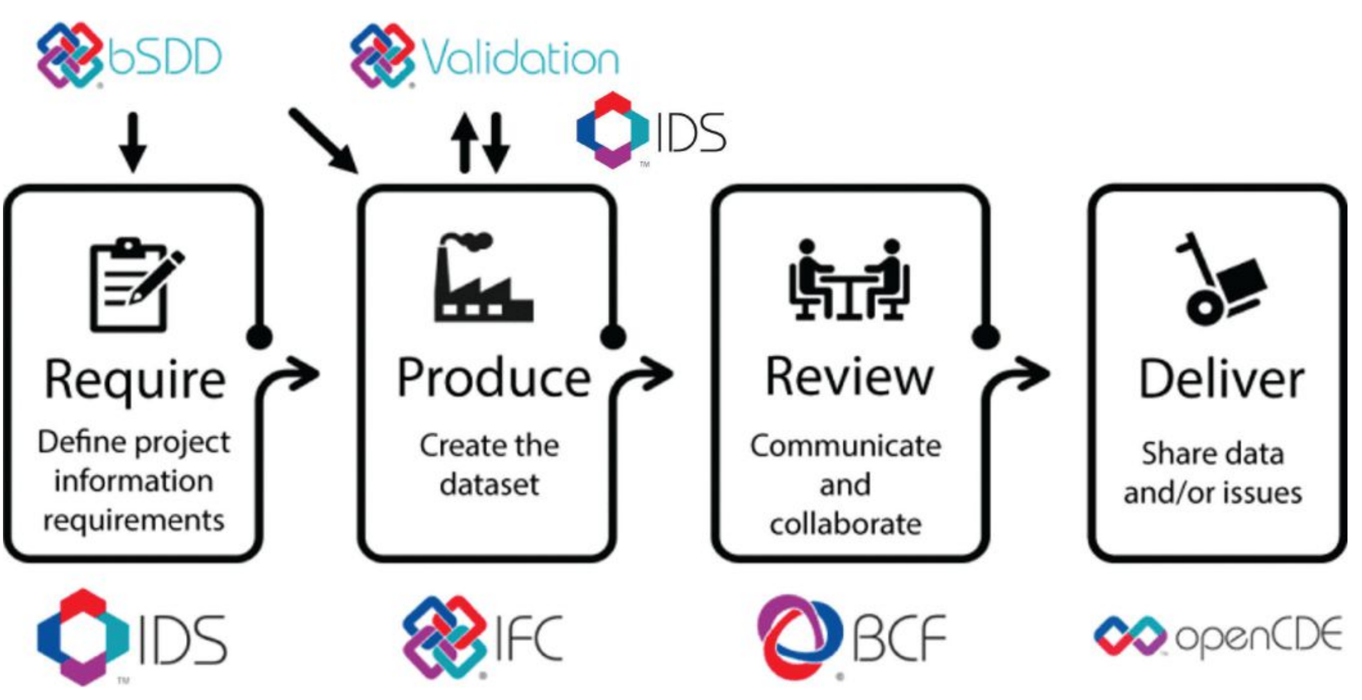
The openBIM Workflow

buildingSMART International develops and maintains open standards that support digital transformation across the built environment. To illustrate how these standards work together, buildingSMART has defined the openBIM workflow (**Fig. 1**).

The workflow begins with defining information requirements, followed by model creation, collaboration, validation, and delivery of information to downstream stakeholders. The buildingSMART Data Dictionary[7] enables standardized definitions of modeled entities to be customized and shared, whereas the Information Delivery Specification[8] defines content and properties required for BIM models. Models created using the IFC schema can be validated against these requirements to ensure completeness and consistency using the buildingSMART validation service.

The BIM Collaboration Format[9] supports model-based communication by capturing views, comments, and issue-tracking information without embedding markups directly in the model. Models and associated documents are delivered through a common data environment (CDE), and the openCDE standard enables information exchange across multiple CDE platforms using a nonproprietary protocol.

Figure 1. The openBIM workflow and associated buildingSmart International standards and services. Note: bSDD = buildingSMART Data Dictionary; BCF = BIM collaboration format; CDE = common data environment; IDS = information delivery specification; and IFC = Industry Foundation Classes. Figure: buildingSmart International.



Conclusion

BIM is often thought of as being only 3-D models because they are the most visible element of the process. However, models are only one component of a broader framework that supports information management across design, construction, operations, maintenance, and asset management. BIM supports users in reducing project risk, streamlining data collection and management, and bolstering informed decision-making throughout the life cycle of a transportation asset. To achieve these benefits, stakeholders must adopt new technologies and maintain a sustained commitment to open standards, defined processes, and organizational change.

References

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