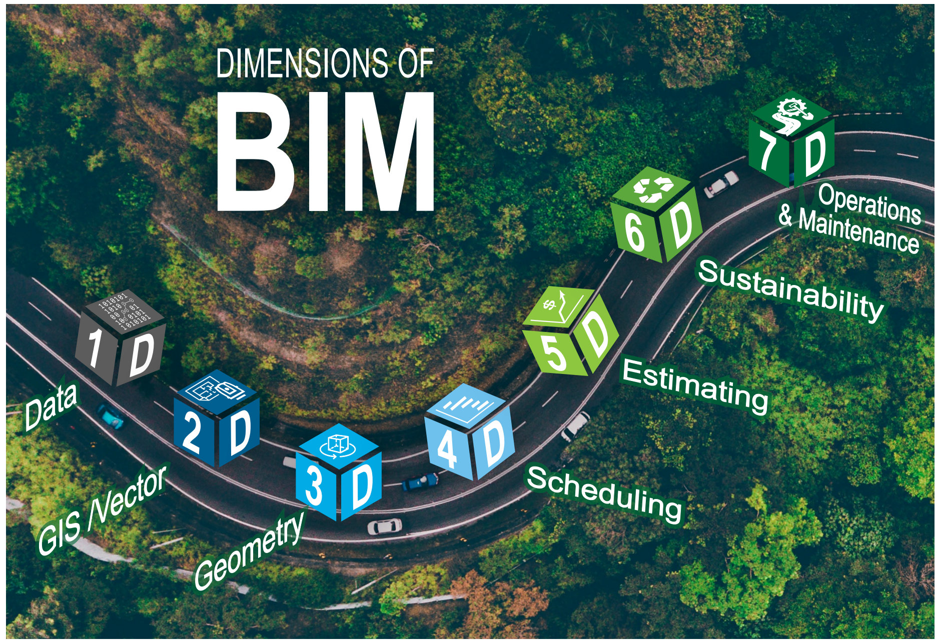
Tech Brief

U.S. Department of Transportation
Federal Highway Administration

BACKGROUND

Building Information Modeling (BIM) brings together enabling technology and process transformation to improve the quality and speed of infrastructure project delivery. Developing and deploying a national BIM strategy requires more than simple changes in technology. BIM involves investment from different stakeholders to change process and policy when applicable. This Tech Brief breaks down the components of technology, people, process, and policy that enable the successful deployment of BIM on infrastructure projects.

THE DIMENSIONS OF BIM FOR INFRASTRUCTURE



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The intersection of mobile devices, cloud computing, and business intelligence has solidified the need for infrastructure projects to embrace Building Information Modeling (BIM). BIM brings together enabling technology and process transformation to improve the quality and speed of project delivery. In addition, BIM provides a structured data handover to the operations phase.

Case studies have shown the value of adopting BIM for Infrastructure, with benefits expressed in both human- and machine-readable formats. From photo-realistic animations of the driving experience during design to asset data handover into operations and maintenance, BIM benefits a multitude of stakeholders across the infrastructure life cycle.

At its core, BIM is a collaborative work method for structuring, managing, and using data and information about transportation assets throughout their life cycles. The following sections will break down the role of technology, people, process, and policy.

TECHNOLOGY

The technology tools involved in BIM adoption will vary by the use case. The use cases and supporting technologies are typically documented in a project BIM Execution Plan (BEP) prior to adoption. The technology components of the BEP include software, hardware, network, and reality capture.

Software

3D modeling programs with parametric capabilities and data attribution are the backbone of BIM workflows. Not all project delivery stakeholders will use advanced BIM authoring and coordination software. However, BIM enables each stakeholder across the project delivery supply chain to benefit from the information it represents, both graphically and semantically.

Hardware

Individuals with BIM authoring or coordination responsibilities should be equipped with the appropriate hardware to perform their work effectively. BIM applications place a higher demand on a computer's random-access memory (RAM) and graphics processing unit (GPU). Although BIM and reality capture specific computers can be double or triple the cost of standard-issue laptops, these costs are likely to be offset by savings from improvements in labor efficiency and turnaround time.

Network Infrastructure

BIM is a collaborative process that provides design, construction, and operations personnel access to a single source of data and information that is maintained up-to-date. That accessibility in the field, however, depends on the availability of Internet-connected devices. While one project BEP may include jobsite Wi-Fi connectivity, another may use tablets with a BIM and drawing viewer with an off-line sync capability.

Reality Capture

In addition to storing reliable asset data for operations and maintenance, BIM should also be an accurate and precise replica of the as-built structure. This is achieved by producing a 3D point cloud from a reality capture solution (drone videogrammetry, 360 photogrammetry, laser scanning, robotic total station, etc.) and aligning its origin, scale, and orientation with the design BIM. This "scan to BIM" comparison serves both to provide early detection of potential construction defects and to deliver a more reliable geometric handover for use by operations and maintenance professionals.

PEOPLE

BIM deployment starts with the right technology. However, that technology is rendered useless without the support of BIM champions. These champions advise on use case selection and support as a training resource.

BIM Champion(s)

BIM implementation at both the organizational and project levels begins by identifying at least one BIM champion. These individuals are knowledgeable in both the new process of BIM and traditional coordination and quality management processes. Champions should be passionate advocates for BIM adoption. They are most successful when recognized publicly by management as an invaluable asset to the team.

Training Resources

The benefits of BIM increase as more stakeholders can access and consume the wealth of information it contains. BIM competency levels will vary by role, each with a balance of strategic education and technical training. Education across the organization or project team allows for consistent messaging and clearer understanding of the change in mindset and strategy required. Training focuses on role-specific needs that should be timed appropriately. As a general rule, education sessions should be held in person with a diverse set of roles. Conversely, technical training can be recorded internally or curated externally from online resources.

PROCESS

BIM enables process transformation across the design, construction, operation, and retirement of an infrastructure asset. The following seven dimensions of BIM break down the importance of BIM, from maintaining accurate data to the advanced applications that rely upon it.

1D: Data

At its core, BIM is comprised of data—zeros and ones. If those data are not reliable and up-to-date, trust erodes and the value of BIM diminishes. As data are generated and shared, they should be exchanged in machine-readable formats that align with established interoperability standards such as the International Organization for Standardization (ISO) and the National BIM Standard (NBIMS). These are voluntary, industry consensus standards and do not reflect Federal requirements.

2D: Vector Drawings

In many scenarios, a simple 2D representation in plan or elevation view is preferred to a more complex 3D isometric view. These 2D vector drawings are exported directly from the 3D single source of truth.

3D: Virtual Coordination

3D coordination and constructibility review is a cornerstone aspect of implementing BIM. When project teams can build the project virtually before reality, it allows for major design flaws to be identified and resolved without significant cost and schedule delays. The challenge with capturing the value of virtual coordination is time. For a project to streamline construction with BIM coordination, teams have found it helpful to increase their investment of time and resources during the design and planning phases.

4D: Schedule Simulation

The term “4D BIM” refers to the integration of 3D building elements with their schedule duration and construction sequence information. By analyzing multiple scenarios through animated sequences, seasoned builders and inspectors can quickly identify and resolve schedule flaws that may otherwise affect the reliability of construction delivery dates if not identified. To identify and communicate sequence issues effectively, the information stored in BIM and the project schedule can be organized and aligned through a common work breakdown structure (WBS).

5D: Productivity Analysis

If 4D BIM looks to plan for the future, 5D BIM looks to analyze what was planned versus what actually happened. By comparing forecast production rates with actual labor and material reports, any differences between the two can trigger an issue and root cause analysis. By categorizing and trending similar deviations, future projects have the opportunity to look for the anticipated challenges and resolve them before they occur. A full 5D BIM production plan and historical analysis involve the integration of WBS data between asset, schedule, resource, and cost information.

6D: Lifecycle Sustainability

Access to more project data with greater certainty allows stakeholders to plan and make decisions with greater confidence. Extending access to reliable BIM data from design through construction into operations and maintenance phase maximizes the potential return on investment. This has the potential to lead to more sustainable decisions that look holistically at the total cost of ownership.

7D: Predictive Operations

The seventh BIM dimension looks at performance data across a large set of projects to analyze for predictive trends. Machine learning, artificial intelligence, and Internet of Things (IoT) devices combine with BIM to produce leading indicators of project health.

SEPTEMBER 2020

FHWA-HIF-20-056

This tech brief was developed under Federal Highway Administration (FHWA) contract DTFH61-13-D-00009.

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DISTRIBUTION AND AVAILABILITY
This tech brief can be found at https://www.fhwa.dot.gov/construction/bim/.

KEY WORDS
BIM deployment benefits, BIM deployment requirements, BIM dimensions, BIM stakeholder investment, building information modeling, infrastructure project delivery, national strategic roadmap

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POLICY

Many projects bring together new stakeholders at a new location with unique policy requirements and contract specifications from local jurisdictions. This can make it difficult to establish a common logic and consistent BIM process. The following topics should be addressed in the project BEP.

Model Element Breakdown/Level of Development Specification

A BIM is comprised of hundreds or thousands of parametric elements, each with metadata fields. The amount of data and information contained in each BIM element varies. Effective BIM collaboration begins with a standard WBS logic for each model element to be associated with. The amount of data and geometric accuracy that each BIM element should have on a project is documented on a Model Progression Specification (MPS). The MPS table breaks down each BIM element on the project, including the Level of Development (LOD) and metadata fields, by phase and stakeholder responsible for providing it at each submittal stage. Developing BEPs collaboratively through an MPS provides clearer communication between the stakeholders who rely upon the information from BIM.

Post-Construction BIM Handover

If data from BIM will be used during the operations and maintenance phase, a BIM as-built handover section should be included in the project BEP. The deliverable standard should indicate the specific element data fields, naming conventions, and exchange format requirements. A BIM exchange format can include a database or a standard file export specification such as the Industry Foundation Classes (IFC).

CONCLUSION

BIM offers new potential for operational efficiency through the integration and analysis of data across the Planning and Programming, Design, Construction, Operations and Maintenance, and Retirement/Decommissioning supply chain. Without structured and streamlined data modeling and exchange practices, BIM cannot be freely exchanged and work processes cannot be automated. Success begins when all project stakeholders come together during early planning stages to identify and address the needs of technology, people, process, and policy.