# TECHBRIEF: DELIVERING BIM UNDER DESIGN-BID-BUILD AND DESIGN-BUILD PROJECT DELIVERY APPROACHES—A REVIEW OF NYSDOT'S PRACTICE

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## EXECUTIVE SUMMARY

Recognizing the imperative of enhancing efficiency, accuracy, collaboration, and adaptability, the New York State Department of Transportation (NYSDOT) acknowledges the necessity for a robust data management strategy. This strategy aims to facilitate the seamless exchange of information through digital-as-builts (DABs) during the transition to digital workflows. Currently, for design-bid-build (DBB) projects, NYSDOT generates designs in a three-dimensional (3D) model in-house, converts the model, and delivers the work as two-dimensional (2D) information. Contractors then use the 2D information to reconstruct the necessary 3D details. However, this process is challenging due to incomplete and inaccurate information during the 2D to 3D conversions. Consequently, NYSDOT is actively seeking ways to specify contractual work using various electronic file formats, such as DGN, XLS, XML, and PDF, with the potential to minimize or eliminate data loss during information transfer.

In the past decade, and particularly following the implementation of a geographic information system (GIS) web-based and enterprise-level asset management system in 2011, NYSDOT has improved integration of DAB processes and construction as-built data. The significance of this advancement is underscored by the incorporation of Building Information Modeling (BIM), which brings additional layers of collaboration, visualization, and data-driven decisionmaking to further streamline and optimize the project lifecycle.

This Technical Brief presents a comprehensive analysis of BIM delivery approaches in various project delivery methods, especially on DBB and design-build (DB) projects. Comparing BIM delivery approaches in DBB and DB is critical for informed decisionmaking, optimizing collaboration, identifying the best practices, and ensuring that BIM is used to effectively enhance the overall success of construction projects.

## INTRODUCTION

NYSDOT has progressed two model-based digital delivery pilot projects. Issued under Engineering Instruction 23-010, the agency is in the process of switching to hybrid digital delivery for all projects starting on May 1, 2024. By adopting a digital approach, NYSDOT aims to replace traditional paper-based 2D plans with digital information exchange in various electronic files. Over the last decade, NYSDOT has made significant progress toward this goal by incorporating advanced design-construction models and construction as-built data in a GIS

web-based and enterprise-level asset management system, particularly after their introduction in 2011. The significance of this advancement is underscored by the incorporation of BIM, which brings additional layers of collaboration, visualization, and data-driven decisionmaking to further streamline and optimize the project lifecycles.

In the traditional process, 3D design models are flattened into 2D plans, which are then provided to the contractor. The contractor subsequently re-creates any necessary 3D information from these 2D plans. NYSDOT intended to eliminate this intermediate step for efficiency by providing 3D data directly from the design phase to the construction phase. Furthermore, by leveraging the 3D model, the agency is able to record valuable as-constructed information, including changes made during construction. This creates a comprehensive DAB record that can be used for maintenance and operations, asset management applications, and future planning.

## NYSDOT'S DIGITAL DELIVERY APPROACHES

NYSDOT intends to achieve two objectives through its DAB process. Firstly, the agency aims to incorporate models into legal contract documents and demonstrate the process through pilot projects. Secondly, the agency seeks to leverage technology to streamline business operations over the entire lifecycle from design and construction to asset management.

To achieve these objectives of digital delivery effectively, NYSDOT has adopted distinct approaches based on project delivery method and project complexity. For DBB projects, the agency uses the following approaches:

- Traditional Delivery (TD): This method involves the use of 2D PDF plans, which is the most common format used in past and present NYSDOT projects. This approach is generally suitable for simple projects, such as resurfacing and restoration projects.

- Hybrid Digital Delivery (HDD): This method provides a combination of 2D PDF and digital data that substitutes specific drawings as contractual documents. The digital data, which includes design elements in electronic format, provides 3D data to construction that supports automated machine guidance and Global Positioning System technologies. The digital data should be identified before the final design phase of the project. This approach is generally suitable for moderately complex projects, such as bridge and roadway rehabilitation projects.

- Model-Based Digital Delivery (MBDD): The MBDD method uses electronic data, in the form of digital data and a 3D solid model, along with 2D PDF plans for certain elements as necessary, as contract documents. Where possible, 3D solid models are used to communicate contractual requirements. This includes illustrating design intent, extracting quantity information, detecting utility clashes, and assisting with fabrication. The 3D model is federated into a computer-aided design (CAD) file to visually see the entire project. This approach is generally suitable for complex projects, such as new and reconstruction of bridges and interchanges.

In DB projects, as the DB team assumes the roles and responsibilities for both design and construction, the DB team is tasked with creating electronic models to convey the design intent,

construction methods, and the sequence of activities for NYSDOT's review; and updating the models on a regular basis. While the DB team has the flexibility to choose the technologies, they must adhere to the NYSDOT 3D modeling CAD and drafting standards, critical path method (CPM) schedule standards, and other project-specific requirements.

## BUILDING INFORMATION MODELING IMPLEMENTATION IN DESIGN-BID-BUILD PROJECTS

### Define the Business Process

The current project delivery process at NYSDOT involves the following steps:

- Generating 3D models using Bentley software.
- Preparing 2D plan sheets using 3D models.
- Providing 2D information derived from the 3D model to contractors.
- Reconstructing 3D details from the provided 2D documentation as construction progresses.

This traditional project delivery process poses challenges especially in terms of potential information loss or discrepancies during the conversion from 3D to 2D and subsequent reconstruction to 3D by contractors, as necessary. Therefore, NYSDOT is actively exploring ways to improve this process by transitioning to a hybrid or MBDD approach. The goal is to streamline communication, improve accuracy, and facilitate a more seamless exchange of information throughout the project lifecycle. The traditional and future workflow that NYSDOT follows is shown on Figure 1.

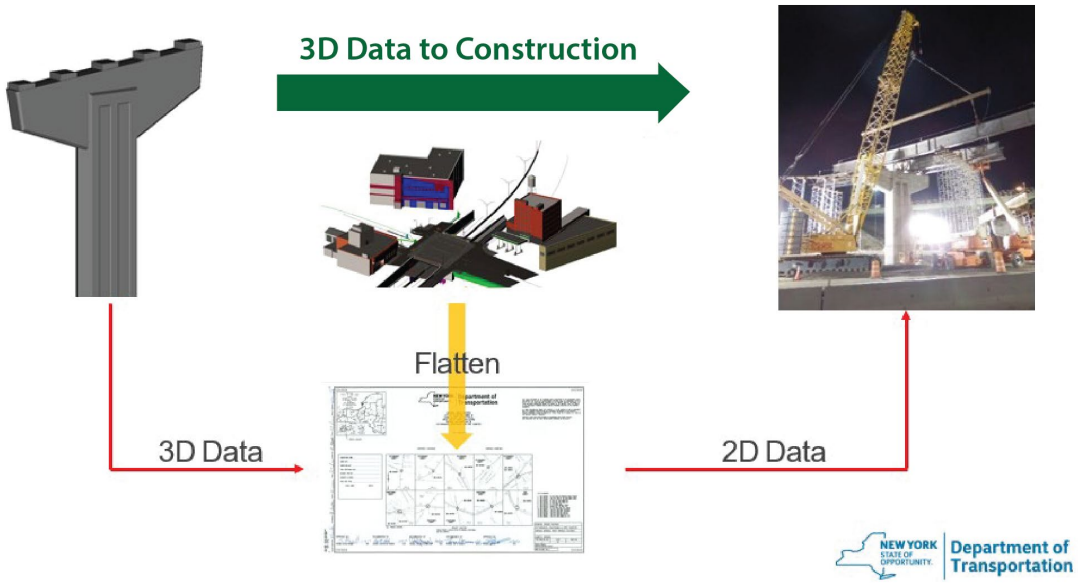


**Figure 1. Traditional Versus Future Digital Delivery Process (Source: NYSDOT, 2023).**

For DBB projects, MBDD is considered suitable for endeavors exhibiting a high rate of return. These are typically large-scale, high-cost projects featuring complex utility systems and significant stakeholder involvement. Moreover, MBDD projects necessitate specific requirements tailored to different teams involved (Table 1).

**Table 1. MBDD Projects Team Requirements.**

| TEAM | REQUIREMENTS |
|---|---|
| Design | • Proficient in high-level computer-aided design (CAD) capabilities.<br>• Identifying design information and their electronic file formats for inclusion in the contract documents.<br>• Emphasis on robust file management.<br>• Capacity to swiftly adapt to new software applications.<br>• Increased engagement with stakeholders during the design process. |
| Contractor | • Preferably a larger and more experienced outfit.<br>• Proficient in utilizing Global Positioning System (GPS) and Automated Machine Guidance technologies.<br>• Capable of assisting subcontractors and fabricators effectively. |
| Construction | • Possesses a moderate level of CAD abilities.<br>• Competent in extracting relevant data from the digital model.<br>• Proficient in understanding and using GPS units for onsite coordination. |
| All Parties | • Prioritizes effective communication strategies.<br>• Emphasizes collaborative partnering among all project stakeholders.<br>• Leverages technology throughout the project lifecycle for enhanced efficiency and coordination. |

This approach ensures that each team involved in MBDD projects has the specific skill set and capabilities necessary to contribute effectively and ultimately enhance the overall success of the projects.

## Integration of Digital Delivery in Project Delivery

The integration of digital delivery across the design, construction, and operation and maintenance phases ensures a seamless flow of information, collaborative decisionmaking, and enhanced project outcomes throughout the entire project lifecycle for DBB project delivery. An overview is provided as follows.

### *Design Phase*

- **3D Modeling and Visualization**: The integration of advanced technologies in DBB projects has proven valuable during collaboration in multidisciplinary design sessions, fostering communication among engineers, contractors, and stakeholders. Digital models

are used to visualize the project in a comprehensive manner aiding in design analysis and decisionmaking during design phase. The 3D models also visually confirm design intent and leave little to no room for interpretation.

- **Clash Detection and Resolution**: Digital models can establish a collaborative approach to clash detection, which benefits both design and construction teams. In addition, digital delivery can enhance the communication channels to address clashes promptly, minimizing disruption in the design process.

- **Dynamic Design**: Using digital delivery enables efficient design changes and iteration while maintaining consistency in the 3D CAD models. In addition, the model creates a flexible and adequate design element.

***Construction Phase***

- **Construction Sequencing and Visualization**: Integrating digital models and data into construction planning can optimize sequencing and logistics. Visualization plays a significant role in construction, where stages of construction can be presented and viewed. Using digital models for visualizing the construction process can enhance understanding among construction teams. Tablets or other mobile devices can be used to access the digital model onsite, which helps construction teams to visualize and understand the design intent during construction without having to leave the project site.

- **Digital Data for Construction Operations**: Providing digital models to construction enables the use of advanced construction technologies such as automated machine guidance and GPS to be readily used. Enabling these technologies further increases use of the models and acceptance by the industry.

- **Data for Construction Documents**: Electronic data can be linked to construction documentation, which ensures accurate and detailed project plans. In addition, information can be cross-aligned with construction documents in the 3D design model, which ensures design accuracy is met during construction.

***Operation and Maintenance Phase***

- **Asset Management and Lifecycle Analysis**: NYSDOT is working toward conveying and uploading the digital data to asset management after the construction is completed. This provides facility managers with a digital twin for ongoing maintenance and operations. The transition significantly helps with integration with the asset management system, which enhances efficiency in tasks such as asset tracking and maintenance scheduling.

- **As-Built Documentation**: The digital model can be updated with actual construction data for comprehensive as-built documentation, which establishes a valuable asset for facility managers, aiding in future renovations and maintenance. The current process of NYSDOT is to update the design model during the letting process through amendments and throughout the construction phase through field revisions. This result in an updated

model prepared for submission as the final as-built documentation at the end of the construction.

### *People Collaboration in Design, Construction, and Operation and Maintenance Phases*

Successful implementation of digital delivery requires the active involvement and adaptability of designers, contractors, and operations and maintenance (O&M) staff. Designers must embrace collaboration and adjust to a data-rich environment, while construction teams benefit from improved visualization and scheduling through digital models. O&M staff should engage early in the process to ensure that the digital model includes relevant information for efficient asset management. Embracing change and effective communication are essential aspects of the cultural shift associated with digital delivery adoption, and digital delivery coordinators[1] play a key role in guiding teams through this transition.

Digital delivery coordinators[1] play an important role in DBB projects. During a DBB project, digital delivery coordinators act as key facilitators in the integration of BIM processes and technologies across design, construction, and operation and maintenance phases. They oversee technology integration, standardization, and collaboration facilitation to ensure that project stakeholders work cohesively within a shared digital model. In addition, digital delivery coordinators focus on quality assurance, data management, and provision of training and support to project team members. Their efforts contribute to effectively using BIM tools; fostering collaboration among designers, contractors, and O&M staff; and promoting a seamless flow of information throughout the project lifecycle. Overall, the collaborative and integrated nature of digital delivery needs to be guided by digital delivery coordinators to enhance project outcomes, reduce errors, and improve efficiency across all project phases.

## Challenges

### *Communication Among Disparate Teams*

Given the nature of DBB method, the delivery of design and construction phases of a project are contractually distinct. This separation can create challenges for teams to share information seamlessly. Contractual barriers may hinder the free exchange of data and collaborative decisionmaking. Additionally, communication gaps can occur as information is handed off from one phase to another. Miscommunication can lead to errors and inefficiencies, especially during digital model implementation. Digital delivery thrives on early collaboration to maximize its benefits, but in a DBB context, key stakeholders may not be engaged until later stages. This could limit the potential for integrated decisionmaking and problem-solving.

[1] The term “digital delivery coordinator” is a general designation used in this Technical Brief for a team role that collaboratively contributes to the effective implementation of BIM methodologies in engineering projects. It is not an official job designation used by NYSDOT. The agency is considering adding digital delivery coordinators to the organizational structure to ensure successful implementation of digital delivery and BIM. NYSDOT is currently utilizing a digital delivery committee, which is comprised of 24 staff from a wide variety of functional groups within the agency representing all 11 NYSDOT regions across the state. The committee serves as the common link between silos and upper management.

### *Data Sharing Limitation*

The potential for data sharing limitation arises when different stakeholders use disparate digital tools or standards. Designers, contractors, and operators may work with different software or have varying CAD standards, leading to compatibility issues and difficulties in merging data across phases. Moreover, if training or skills are not able to be met, challenges of optimizing benefits can occur to reduce accuracy and efficiency of the project.

## Case Studies

NYSDOT has conducted three pilot projects to date. The first two pilot projects, which were let in 2020 and 2021, used MBDD as the digital delivery approach. The MBDD, which is equivalent to a model as legal document, involved the use of 3D models supplemented with some limited contractual information and 2D plans. To engage a larger percentage of staff and projects, NYSDOT implemented a third pilot project using the HDD approach. Shortly thereafter, more than 20 HDD pilot projects across all 11 regions with lettings were scheduled prior to April 2024. A third MBDD project has been selected and is currently in the preliminary design phase. To date, all the digital models were developed in-house and updated by the engineer of record throughout construction, using Bentley OpenRoads, OpenBridge, MicroStation Connect, and other design software.

In addition, NYSDOT has developed "Digital Delivery," an interim guidance document, to educate and provide the latest guidance to the design staff on digital delivery procedures. The guidance also includes information on the federated file, which essentially consolidates all project information, whether supplemental or contractual, into a single location. The guidance covers topics like digital data, integration, software, hardware, design reviews, best practices, and advanced 3D modeling methodologies. The document was issued by an Engineering Instruction that also requires all 2R and above projects to be delivered using the HDD method with lettings starting in May 2024. These are generally moderate to complex projects.

### *Pilot Project No. 1 – Route 28 Over Esopus Creek Bridge Replacement Project*

The Route 28 Bridge Replacement Project in Ulster County marked a significant milestone as the first initiative to employ 3D CAD models and additional digital data as contractual bid documents. Executed by NYSDOT's in-house bridge and highway team, this project replaced an 800-foot-long bridge over Esopus Creek, highlighting the successful integration of advanced technologies. The use of 3D CAD models and supplemental digital data expedited decisionmaking processes, enhanced comprehension and communication of project details, and ensured accurate execution through GPS units and conflict resolution. The incorporation of various surfaces provided additional clarity, reducing the need for formal requests for information. Despite the project's success, challenges emerged, including interoperability issues with AutoCAD, concerns about file abundance, and discomfort among fabricators using supplemental files. To address these challenges and improve overall project outcomes, there is a recognized need for construction staging models, streamlined processes, and enhanced user comfort in reviewing the model in the field office.

### *Pilot Project No. 2 – East 138th Street Over Major Deegan Expressway Project*

The East 138th Street Expressway project in the Bronx, New York City, entails a challenging bridge replacement with confined spaces and intricate utilities, requiring a phased construction approach. A noteworthy outcome from this project highlights the advantages of the 3D model in precisely visualizing and detecting clashes in utilities, notably contributing to the design of the specialized carry beam system. Tailored to meet the specifications of the New York City Department of Environmental Protection (NYCDEP), this system successfully accommodates the future expansion of the NYCDEP sewer system. While the 3D model proves efficient to visualize, present, and describe the system, the implementation of MBDD presents challenges that necessitate intensive coordination during construction. The learning curve associated with MBDD posed difficulties for NYSDOT staff, contractors, and fabricators, due to the increased number of contract files and information requiring careful management. The three-year contract duration underscores the importance of maintaining continuity in project knowledge by retaining the same staff involved in the design phase, and recording field revisions on models presents intricacies compared to the clarity offered by 2D plan sheets.

### *Pilot Project No. 3 – NY347 Reconstruct Hallock Road to CR 97*

The NY 347 Reconstruct Hallock Road to CR 97 project in Suffolk County is primarily focused on the linear reconstruction of NY 347. Departing from traditional plan sheets, contractual roll plot sheets were generated, resulting in a remarkable 68 percent reduction in plan sheet pages. This achievement replaces 251 plan sheets with digital data and substitutes 491 plan sheets with approximately eight roll plots. The Index of Drawings has been expanded to serve as a comprehensive roadmap for digital delivery, indicating the provision of digital delivery components, such as PDF or LandXML files. This project stands as a milestone in testing the tangible benefits of the HDD method, capturing easy wins with a high rate of return in both design and construction phases. The use of contract plan roll plots proves significantly advantageous for project submittal because it consolidates crucial information in a convenient format that can be viewed on various devices. This contributes to accelerated project familiarization and enhanced reviewability on Bluebeam. Moreover, the roll plot's versatility extends to meetings and scale printing, streamlining plan production and realizing savings in plan sheet production.

## Lessons Learned from DBB Pilots

Upon the successful completion of two MBDD projects, the agency gained significant insights and knowledge. Recognizing the complexity of these projects and the necessity to manage change among industry participants, the agency decided to transition to an HDD model. This strategic shift allowed for a more measured pace of progress to foster inclusive and widespread implementation across the agency.

The HDD approach offers significant advantages in terms of its scalability and flexibility. This approach allows for customization of the 3D models with the flexibility to decide on the amount of information provided as digital data. This approach eases designers into digital delivery and exposes designers to new processes such as signing and sealing electronic files. The agency also

introduced roll plots in the third pilot, which is particularly useful to view consolidated information on an electronic device for linear projects such as highways.

NYSDOT's initial pilot project using the MBDD approach did not significantly increase construction costs despite doubling the effort devoted to design and modeling. This involved allocating additional hours to the design and modeling phases. The decision to use MBDD should be made on a project-by-project basis, considering the agency's readiness to allocate resources for staff training and manage challenges related to new software adaptation. NYSDOT has an application process for choosing the MBDD approach for projects, which requires approval from the Model-Based Contracting Committee.

The agency also identified the following challenges, primarily related to field revisions and personnel changes encountered during construction.

### *Field Revisions*

Intensive coordination was necessary during construction to incorporate field revisions. The design staff was required to incorporate all changes made in the field. This process was cumbersome as it was necessary to repackage the entire model to incorporate revisions irrespective of their complexity. In comparison to a simple markup on an as-built drawing for TD, the MBDD projects required remodeling to incorporate the revisions at precision levels that might not have been provided by field staff. The federated file needs to be recompiled and saved views recreated to transfer a single revised model. This process can take several days and can only be done when all the models have been revised. Furthermore, it was not straightforward to view field changes in the revised models.

### *Personnel Changes*

NYSDOT also encountered several challenges to personnel changes. The MBDD projects required intense coordination that resulted in fatigue and burnout among designers and modelers. Furthermore, because of the need to learn something "new and different" and handle a high number of contract files, all key project participants, including NYSDOT staff, contractors, and fabricators, struggled with information overload. While training was provided by design groups for field inspection and contractor staff, field office turnover over the project duration required repeat training. Staffing construction support personnel to maintain continuity of knowledge was challenging as the original design team's involvement was necessary.

## BUILDING INFORMATION MODELING IMPLEMENTATION IN DESIGN-BUILD PROJECTS

### Define the Business Process

The NYSDOT Enterprise Data Warehouse serves as a centralized repository designed to manage and integrate a diverse range of data related to transportation infrastructure. Figure 2 shows how the Enterprise Data Warehouse consolidates information from various NYSDOT data sources. Its overarching purpose is to provide a comprehensive platform for data analytics, reporting, and informed decisionmaking that enables stakeholders to gain insights into the performance and trends of the transportation network. With a focus on historical data, the NYSDOT Enterprise

Data Warehouse supports strategic planning and offers a valuable resource for assessing the long-term performance of transportation assets.

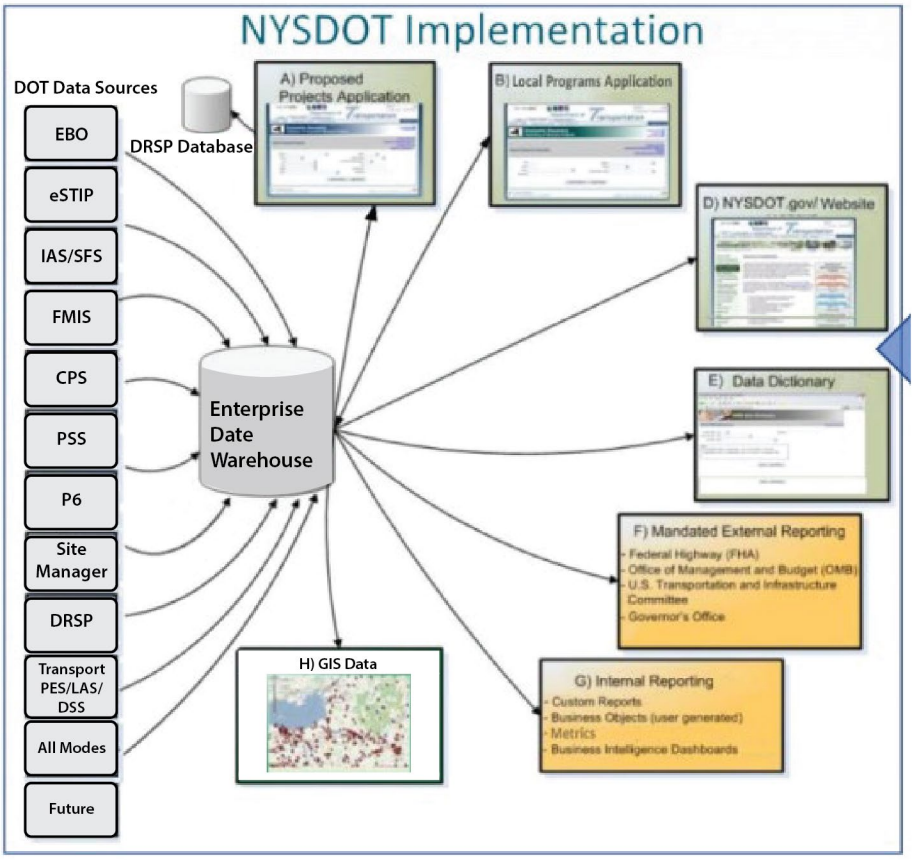


**Figure 2. NYSDOT Enterprise Data Warehouse (Source: NYSDOT, 2023).**

## Integration of BIM in Project Delivery

The integration of BIM in the DB project delivery method brings about a transformative and collaborative approach to construction projects. When design and construction phases are unified under a single contract in a DB project, BIM serves as a powerful tool that enhances communication, coordination, and efficiency throughout the project lifecycle. A general BIM data modeling process and applications for DB project is shown on Figure 3.

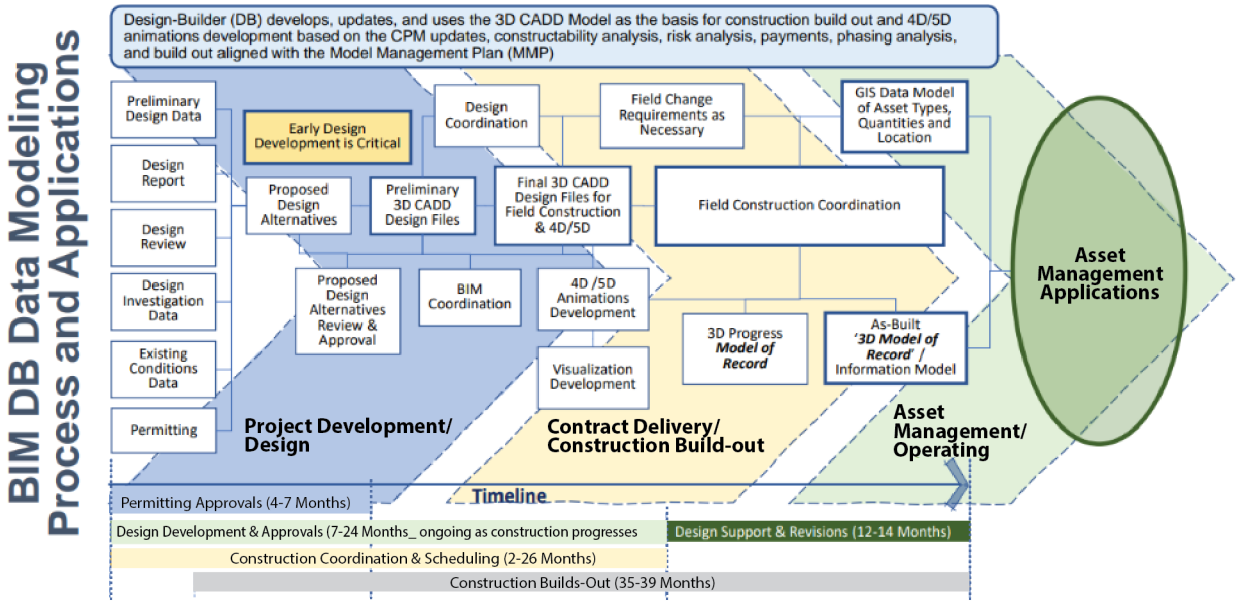


**Figure 3. BIM DB Data Modeling Process and Applications (Source: NYSDOT, 2023).**

BIM serves as a centralized repository for project information, ensuring that all stakeholders have access to the most up-to-date data. Additionally, the 3D visualization capabilities of BIM enhance communication by providing a clear and detailed representation of the project, especially during the fast-paced environment of a DB project. Regular project meetings can involve the use of BIM visualization to discuss design intent, construction sequencing, design and construction progress, and other potential risks, fostering a shared understanding among team members. Since the BIM model contains comprehensive project data, efficient data and information exchange will be promoted in the dynamic settings of DB projects.

BIM aligns with the single-source responsibility inherent in the DB approach, promoting accountability and streamlining communication as well as identifying and mitigating risks early in the project. The unified BIM model ensures that all project participants work with the same set of information, reducing the risk of discrepancies and misunderstanding during design and construction.

### Enhanced Collaboration and Coordination Advantages

BIM enables simultaneous design and construction activities, fostering a collaborative environment where design and construction teams work concurrently. In addition, BIM facilitates enhanced coordination between design and construction disciplines, reducing the likelihood of conflicts and errors during the construction phase. Designers, contractors, and construction professionals collaborate within a shared BIM environment, allowing for real-time updates and modifications as the project progresses, especially considering potential conflicts in the virtual model.

Due to the nature of DB project, the digital delivery coordinator[1] plays a crucial role as a key facilitator of BIM processes and technologies. As a result of the dynamic settings of DB project,

it is important to oversee the implementation of BIM throughout the project lifecycle, set the standard, and provide training before the project starts. The BIM manager serves as the essential key for effective collaboration between the design and construction teams. During the process of a DB project, the BIM manager spearheads the coordination of data exchange, ensures the quality and accuracy of the BIM model, and addresses technical issues that may arise during the design and construction phases. By fostering collaboration, maintaining BIM standards, and overseeing the seamless integration of BIM technologies, the BIM manager significantly contributes to the success of DB projects.

## Case Studies

### *Hunts Point Interstate Access Improvement*

The Hunts Point Interstate Access Improvement Project stands as the most extensive DB undertaking in the history of NYSDOT to date. This initiative encompasses a spectrum of activities, including road expansion, the establishment of new parks, enhancements to existing parks, relevant access improvements, and the creation of protected bike lanes. Employing data for both constructability analysis (4D) and payment animations (5D), the project utilizes a dynamic approach to showcase the progression of CPM updates.

Integration is a key aspect of the project, with the 3D model seamlessly linked to the CPM to generate 4D and 5D models. This integrated modeling system enables a comprehensive review and assessment of the actual construction progress in relation to the proposed schedule completion. Using 4D model animations, which involve dynamically linking 3D modeling to both baseline and updated schedules, a comparative analysis is conducted. This comparison serves to gauge the real-time progress against the approved CPM schedule, enhancing schedule integrity and certainty. Additionally, this approach provides the capability to pinpoint and address potential risks, contributing to a more effective and informed project management process.

### *Kew Gardens Interchange Phases 3 and 4*

The Kew Gardens Interchange (KGI) project was undertaken by NYSDOT, which used BIM model-based delivery and DABs across multiple construction phases. Commencing in 2010 with a $700 million budget, the KGI reconstruction involved a combination of DBB and DB approaches. Phase 3 was completed in 2021 and Phase 4 was completed in 2022. The BIM 3D, constructability analysis (4D), and payments (5D) initiatives encompassed interactive design reviews, 3D modeling of utilities, visualization, and the creation of model record DABs. Survey methodologies for the KGI project involved GPS rovers, mobile devices, and total station data collection for DABs. The project's as-built specifications mandated the monthly utilization of the 3D CAD model for updating, along with the provision of 4D and 5D animations aligning with the CPM schedule. Additionally, the as-built record included underground utilities installed and encountered during construction, in compliance with contract documents and engineer directives.

## KEY OBSERVATIONS: COMMONALITIES AND DIFFERENCE

Key observations regarding the commonalities and differences in BIM implementation between DB and DBB are provided as follows.

**Commonalities**

- **Visualization and Simulation**: BIM enables visualization and simulation in both DBB and DB projects. This can help stakeholders better understand the design intent, identify potential clashes, simulate construction processes, and identify potential risks.

- **Collaboration and Communication**: As a result of the powerful visualization and simulation ability, both DBB and DB benefit from improved collaboration and communication through BIM. BIM fosters better coordination among project stakeholders, engineers, contractors, and construction professionals.

- **Data Integrity and Integration**: Both DBB and DB project delivery methods emphasize the importance of data integrity and integration. BIM allows for a centralized digital model that can be accessed and updated by various teams (e.g., designers, contractors, and stakeholders) throughout the project lifecycle.

- **Clash Detection and Conflict Resolution**: Both DBB and DB benefit from clash detection and conflict resolution capabilities offered by BIM. Early identification of clashes helps reduce errors and minimize costly changes during construction.

**Differences**

- **Timeline and Phasing**: During a DBB project, the design phase is completed before the bidding process, and the construction phase starts after the bid is awarded. This linear progression may lead to a more traditional use of BIM, primarily focused on design and clash detection during the preconstruction phase. During construction phase, the primary use of BIM may focus on visualization and a record of any field updates.

  In contrast, DB projects often involve concurrent design and construction phases, allowing for faster project delivery. This simultaneous workflow allows for a more integrated use of BIM throughout the project lifecycle. The DB team can leverage BIM for real-time collaboration, clash detection, and design modification during construction.

- **Contractual Relationships**: In DBB, the contractual relationships are typically linear, with separate contracts for design and construction. BIM managers in DBB act as bridges between different disciplines since design and construction teams operate independently. They play a crucial role in facilitating communication and coordination between these distinct entities. It is important that BIM managers communicate the BIM requirements across different phases of the project, which ensures that information flows smoothly between various teams, minimizing potential discrepancies. As a result of the linear nature of DBB, it is recommended that the BIM manager be a function of NYSDOT. This can enhance consistency in BIM implementation across various projects and streamline communication.

  In DB, a single entity (DB contractor) is responsible for both design and construction, leading to a more integrated contractual relationship. BIM managers in DB projects have more opportunities to adjust and adapt during the project. The integrated contractual

relationship allows for seamless collaboration, and BIM managers can play a proactive role in optimizing workflows and resolving issues as they arise.

- **Flexibility and Adaptability**: DB projects often exhibit greater flexibility and adaptability during the construction phase due to the close collaboration between the design and construction teams. BIM can be used dynamically to accommodate changes during construction without disrupting the workflow, leading to more agile project management. Unlike DBB projects, changes can be implemented more seamlessly without the need for redesign and re-bidding.

- **Responsibility for Model Maintenance**: In DB, the responsibility for BIM model maintenance may rest with a single DB entity. This streamlined structure facilitates consistent BIM model maintenance throughout the project and minimizes potential disruptions in data continuity. In DBB, different entities may be responsible for the model at different phases, leading to potential challenges in data continuity.

- **Risk and Accountability**: In DBB, the owner may bear more risk during the design phase due to the sequential nature of DBB projects. In DB, the DB entity assumes a greater share of both design and construction risks with a more collaborative and integrated approach. BIM is employed as a tool to manage and mitigate risks throughout the project lifecycle.

- **Schedule Integration**: The DBB approach may have a stricter adherence to the original schedule. Any adjustments may involve time-consuming processes. However, DB projects can benefit from real-time schedule updates using 4D modeling. BIM helps integrate the 3D model with the construction schedule (4D), providing a visual representation of the construction progress in alignment with the project timeline.

## NEXT STEPS

### BIM Implementation: Evaluating Project Delivery Methods for Stakeholders

#### *Design-Bid-Build (DBB)*

- **Designers**: Designers in DBB have the advantage of completing the design phase before the bidding process, allowing for a detailed and finalized design. BIM is primarily utilized for design development and coordination. The BIM model serves as a reference for construction teams during the construction phase.

- **Construction Team**: In DBB projects, contractors bid on completed designs, and changes to the design during construction may involve time-consuming processes. BIM aids in constructability analysis and clash detection before construction starts. Contractors may have limited influence on the design but can use BIM for planning and coordination.

- **Owners**: In DBB, a more traditional and familiar process is presented for owners. The project phases are distinct as well as the decisions are made sequentially. Owners should

recognize that BIM implementation in DBB may involve more phased coordination between design and construction teams. The BIM model is a tool for design coordination and clash detection before construction begins.

### *Design-Build (DB)*

- **Designers**: In DB projects, designers work more collaboratively with construction teams, allowing for real-time adjustment and improvements. Therefore, BIM is used for concurrent design and construction coordination. Designers can adjust the BIM model during construction to enhance adaptability and address issues promptly.

- **Construction Team**: Construction teams have a more integrated role in the design process. In addition, the construction team can provide valuable input during the design phase. The real-time coordination tool, BIM, allows construction teams to make adjustments based on actual construction progress. It enhances collaboration and helps identify and resolve issues.

- **Owners**: Owners should recognize that BIM for a DB project is integrated throughout the project lifecycle. The BIM model is a dynamic tool for real-time collaboration between design and construction, offering more flexibility for changes during construction.

### *Digital Delivery Coordinator*[1]

In DBB project, digital delivery coordinators act as a bridge between design and construction teams, focusing on phased coordination and clash detection during preconstruction phases. The coordination and communication between separate entities is essential for project completion. In DB project, digital delivery coordinators work in a more integrated manner, focusing on real-time collaboration adjustment and issue resolution throughout the project lifecycle. Active participation in concurrent design and construction processes is important for digital delivery coordinators to maintain streamline communication during the project. Currently NYSDOT does not have an official digital delivery coordinator. The agency is considering digital delivery coordinators as part of necessary organizational structure changes to ensure successful implementation of digital delivery and BIM. NYSDOT is currently using a digital delivery committee comprised of 24 staff from a wide variety of functional groups within the agency and with representation from all 11 NYSDOT regions across the state. The committee is serving as the common link between silos and upper management.

## Strategies for Overcoming Challenges and Maximizing BIM Benefits

Overcoming challenges and maximizing BIM benefits for DBB projects requires a strategic approach. Start by enhancing communication protocols between design and construction teams, fostering regular meetings, and using collaborative platforms. Introducing BIM early in the design phase allows for proactive clash detection, constructability analysis, and visualization, minimizing potential issues during construction. Standardizing BIM processes ensures consistency across disciplines, defining protocols for model development and data exchange. Additionally, investing in training programs enhances the BIM skills of project stakeholders, promoting effective use of BIM tools and methodologies.

In the context of DB projects, strategies for overcoming challenges and maximizing BIM benefits focus on integration and real-time adjustments. Foster collaboration among design and construction teams through joint planning sessions, shared project goals, and an integrated decisionmaking approach. Capitalize on the flexibility of DB by making real-time adjustments to the BIM model during both design and construction phases, allowing for immediate responses to challenges. Cross-training team members in both design and construction aspects encourages a holistic project view, promoting better collaboration and problem-solving. Continuous monitoring and feedback loops enable stakeholders to provide insights, facilitating adjustments and improvements throughout the project lifecycle. These strategies, tailored to the specific dynamics of DB projects, contribute to efficient BIM implementation and successful construction outcomes.

## REFERENCES

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## DELIVERING BIM UNDER DESIGN-BID-BUILD AND DESIGN-BUILD PROJECT DELIVERY APPROACHES—A REVIEW OF NYSDOT'S PRACTICE

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