U.S. Department of Transportation
Federal Highway Administration

Guide for Digital As-Builts Using Simplified Digital Workflows

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FOREWORD

As-built drawings have long served as a critical construction documentation that captures how a project was actually built, noting deviations from the original plans and any changes made during construction. Traditionally the transportation agencies have used two-dimensional (2D) paper sheets, image scans, and document-based PDFs for as-builts. Technological advancements have led to the use of 3D as-built drawings.

These 3D models represent a significant leap forward, offering more than just visual representations. As data-rich repositories containing detailed project and asset information, they serve as a key link between project design, survey, and construction data, connecting them to ongoing operations and asset management. Many transportation agencies have made significant strides in digital delivery to create a comprehensive digital ecosystem for the lifecycle management of highway infrastructure, and digital as-builts (DABs) is one among them.

Implementing DABs requires a systematic approach that addresses key requirements related to processes, people, tools and technologies, and data, which, when met, enables agencies to formulate effective workflows for DAB implementation. State Departments of Transportation (DOTs) employ a range of practices that significantly vary based on their specific project delivery and asset management needs and capabilities. Despite the diversity, these practices can be broadly categorized into two main workflows: the Simplified Lifecycle Digital Workflow and the Integrated Digital Workflow. Both workflows aim to develop DABs, but they differ in their complexity and integration of design and data collection processes.

The Simplified Digital Workflow is a straightforward approach that separates the design process from the data collection process, which is undertaken using data templates during the construction phase. The Simplified Digital Workflow stands in contrast to the Integrated Digital Workflow, a more comprehensive approach, that intertwines the design process and data collection, making asset data a core component of the digital design model. This guide presents a detailed discussion of the steps involved in the Simplified Digital Workflow with illustrative examples drawn from various State DOTs.

INTRODUCTION

As-built drawings are an essential part of construction project documentation. They capture changes made during construction, deviations from as-designed plans, and provide asset-specific information for use in the operations and maintenance (O&M) phase of roadway facilities. Traditionally, as-built drawings were presented as two-dimensional (2D) paper-based markups, later transitioning to paperless image-based scans and document-based Portable Document Formats (PDFs). While the paperless formats made the files more accessible, they were static representations of the as-built conditions.

With technological advancements, digital as-builts (DABs) have emerged as a better alternative than traditional practices. Throughout the project lifecycle, the DAB serves as a central repository of asset information, continuously evolving as new data are collected, organized, and managed. Starting from the design phase, the DAB is enriched with as-built information during construction and then becomes a valuable resource for operations, maintenance, and asset management. With this information, DABs can provide a comprehensive representation of the physical built infrastructure using data-rich three-dimensional (3D) models. DABs also serve as a key information management link throughout the project lifecycle, from design and construction to operations, maintenance, and asset management.

DIGITAL AS-BUILTS WORKFLOW IMPLEMENTATION

DABs offer significant advantages over traditional as-builts in providing additional levels of detail for construction documentation, including:

- Encoding intelligence related to assets, such as material types, quality, and quantities, in addition to spatial information.
- Updating continuously to reflect changes during construction and maintenance, ensuring that the records remain relevant and accurately represent current conditions.
- Facilitating seamless data exchange with various information systems used in construction and asset-specific management systems.
- Enabling automated extraction of data elements using location-specific, asset-specific, and attribute-specific criteria.

While these advantages present a compelling case for the adoption of DABs, they also serve as clear objectives that guide the implementation and use of DABs in a highway project lifecycle.

DABs require improvements to business processes that formalize standard procedures to achieve these goals. Implementing DABs involves a systematic approach that includes the following considerations:

- Establishing a Strategic and Technical Working Group(s)—Involves setting up a dedicated team to:
    - Establish a strategic working group to develop the roadmap, formulate strategies, and allocate resources and oversee the implementation.

    - Form technical subcommittees and working groups (e.g., digital delivery, geographic information systems [GIS], utilities, asset management) to address specific aspects of the implementation process, including data collection, data governance, and business process improvements.
    - Implement continuous improvement efforts to refine and optimize DAB processes.

- Undertaking Process Improvements—Entails formalizing standardized procedures and integrating them to project lifecycle workflows to accommodate DAB implementation, including but not limited to:

    - Develop digital design models for construction with or without asset-specific intelligence.
    - Create standardized templates and forms for capturing and reporting asset data consistently.
    - Share detailed digital models with contractors and field inspectors to facilitate data capture and validation.
    - Establish procedures for field inspection and verification of as-built data.
    - Coordinate during construction to incorporate field revisions and updates into the DABs.
    - Implement a review process for asset data by asset stewards to ensure quality and compliance with standards.
    - Define procedures for handling errors, inconsistencies, and missing data in the DABs.
    - Link electronic data, such as quantities and bid items, to construction documentation, and use them in contract administration.

- Determining data and technology requirements—Entails identifying and implementing robust data governance measures and technological tools to:

    - Define data requirements for collecting roadway geometry and design, contract administration data, and asset-specific lifecycle data.
    - Establish data standards and formats to provide consistency and interoperability.
    - Develop data validation processes to maintain data quality and integrity.
    - Establish data governance policies to protect data security, privacy, and access control.
    - Identify and implement digital tools to support DAB processes, such as field inspection.
    - Use software solutions for creating, managing, and visualizing DABs.
    - Provide implement extract, transform, load (ETL) capabilities to facilitate data exchange with other information systems.
    - Continuously evaluate and update technology solutions to keep pace with industry advancements.

- Engaging Stakeholders—Entails fostering active participation of people in the process to:

    - Understand the needs, concerns, and expectations of internal stakeholders through requirements gathering and consultation sessions.

- Coordinate with external stakeholders, including contractors and design consultants, before and during construction.
- Establish policies on roles and responsibilities for all relevant stakeholders.
- Develop and deliver training programs, such as computer-aided design (CAD) and GIS training.
- Establish clear communication channels for stakeholder feedback.
- Encourage a culture of collaboration and continuous learning.

By addressing these key requirements that cover stakeholder engagement, process improvements, data needs, and technological capabilities, State DOTs can formulate a comprehensive approach to DAB implementation that culminates in effective workflows. State DOTs can consider adopting one or both primary methodologies: the Simplified Digital Workflow (addressed here) and the Integrated Lifecycle Digital Workflow.

The Simplified Digital Workflow is a straightforward approach that separates the design process from the data collection process, which is undertaken using data templates during the construction phase. The Simplified Digital Workflow stands in contrast to the Integrated Digital Workflow, a more comprehensive approach, that intertwines the design process and data collection, making asset data a core component of the digital design model.

Both workflows aim to develop DABs and facilitate the transfer of as-built data to the O&M phase, but they differ in their complexity and integration of design and data collection processes. The Simplified Digital Workflow offers a balance of ease of implementation and functionality. It requires minimal disruption to existing workflows and systems, allowing agencies to pilot and scale up gradually. Staff can leverage their current design processes and tools, minimizing training needs. However, this simplified approach relies on manual data entry using templates, which can be time-consuming and error-prone. Additionally, this approach is significantly limited in its ability to automate processes or leverage advanced digital tools.

While the Integrated Digital Workflow is more complex and resource-intensive to implement compared to the Simplified Digital Workflow, this approach offers significant advantages in terms of data consistency, automation, and efficiency for more complex projects. This workflow enables greater automation and efficiency in data management because of its ability to leverage object-based data modeling, the integration of design and asset data collection, and the automated tracking and extraction of quantities. These features collectively contribute to a more streamlined and effective data management process.

In a nutshell, selecting the appropriate workflow depends on an agency's specific needs, project complexity, available resources, and organizational readiness. This guide presents a detailed discussion of the steps involved in the Simplified Digital Workflow with illustrative examples drawn from various State DOTs.

SIMPLIFIED DIGITAL WORKFLOW TO DEVELOP DIGITAL AS-BUILTS

The Simplified Digital Workflow adopts a streamlined, yet simple approach to achieve the core objectives of DABs. Essentially, the simplified workflow separates the normal design process and data collection in electronic format, whereas in the Integrated Lifecycle Digital Workflow, asset data become a core component of the digital data-centric design model. The simple approach is suited for simple to moderately complex projects with fewer assets and assets with less complexity.

In this workflow, after determining what data need to be collected, a data collection template is created for field data collection during construction. During the design phase, the agency proceeds with the normal design process, producing either 2D plan sets or models as legal documents. Asset data collection becomes an essential part of the construction phase, with construction inspectors or contractors collecting asset-specific data using data collection templates and documenting changes and any deviations from tolerances in the field. In the O&M phase, the information transferred from construction can be used and updated, creating dynamic, up-to-date recorded asset information throughout the asset's lifecycle.

Figure 1 illustrates a schematic flow diagram for the simplified workflow. Each of the steps involved in this workflow, along with their pertinent process, people, data, and technology considerations, is discussed in the next section.

Workflow

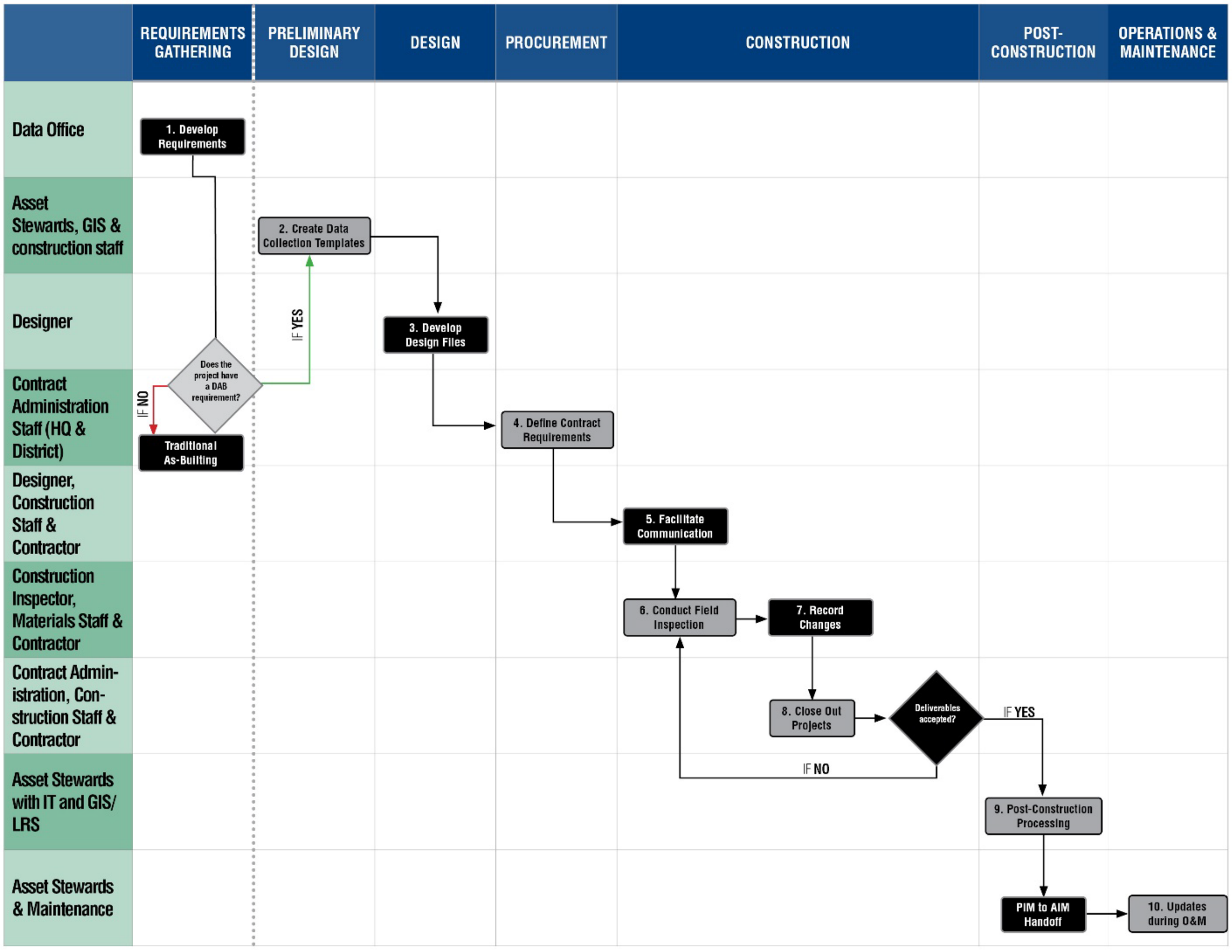

Figure 1. Simplified Workflow for DABs.

Steps

1. Develop Requirements

Objective

This step is to establish a clear understanding of the information needed throughout a highway facility's lifecycle. The outcome of this step is to develop specifications for producing as-builts to fulfill diverse information requirements. In addition to redlining construction-related changes and deviations, many types of information, including asset attributes and contract administration data, are collected. These information types may be grouped into four categories:

- Asset Information Requirements—describing the information required to know how to operate a facility and maintain its assets. This information typically includes asset attributes, such as material quality records, and geometry locations.

- Project Information Requirements—describing the information related to project delivery (e.g., quantities of various bid items for payment processing).
- Organizational Information Requirements—describing the high-level information of the asset lifecycle, such as for environmental requirements, inventory data collection, asset lifecycle and maintenance planning, project scoping, and regulatory needs.
- Exchange Information Requirements—describing the information that needs to be exchanged and delivered by the project team (e.g., redlining).

These requirements adhere to the information standards outlined in ISO 19650. Note that this step is common is both simplified and integrated digital workflows.

Phase/Process

This step is undertaken prior to initiating any project and operates at the enterprise level. The process begins with a review of the agency's strategic plan and roadmap. Typically guided by one or more strategic and technical committees, the agency evaluates its current maturity internally and establishes milestone goals to achieve the desired maturity level. The maturity assessment helps the agency assess its current capabilities related to the process, information, infrastructure, and personnel, which will aid in identifying near-term initiatives.

The agency then identifies current processes, maps out existing workflows and data flows, and develops a long list of potential use cases that align with the agency's goals. Adopting an incremental approach, most agencies develop a prioritized list of use cases for which data requirements are developed. The maturity assessment results help inform the prioritization of use cases by allowing the agency to focus on those cases that align most closely with milestone goals.

For each prioritized use case, data requirements are gathered through cross-functional consultation with subject matter experts (SMEs) from multiple departments, including design, materials, construction, maintenance, operations, asset management, GIS, and planning. The requirements solicitation entails investigating the follows:

- The business users of the data.
- How these data will be used.
- Party responsible for collecting the data.
- Timing for data collection.
- Process for verifying the data.
- The formats, accuracy, and completeness requirements for the data.

Finally, the requirements are formalized in a policy, practice, and specifications document, and communicated to pertinent stakeholders. The agency regularly reviews, updates, and adapts the requirements, as needed, based on changing delivery scopes or stakeholder needs.

People Involved/Roles

The agency's data office leads this step, and it involves a range of internal stakeholders, including designers, digital delivery leads, construction project engineers, materials engineers, contract administration personnel, asset stewards, maintenance personnel, surveyors and GIS/Linear Referencing System (LRS) specialists, software stewards in design and construction, utilities coordinators, strategic asset management staff, and policy and planning staff.

Data/Technology Used

Only standard technological resources, such as a productivity software suite, are required; however, prior knowledge of industry standards and existing information systems may be useful.

Illustrative Example—Pennsylvania DOT

PennDOT has devised a strategic plan to fulfill the objectives of Digital Delivery Directive 2025. This plan is being executed in three distinct phases over five years: Strategic Planning, Development, and Deployment. PennDOT engaged in an extensive stakeholder engagement program (Figure 2) to gather the necessary information to evaluate the current state of project delivery and identify priorities for digital delivery.

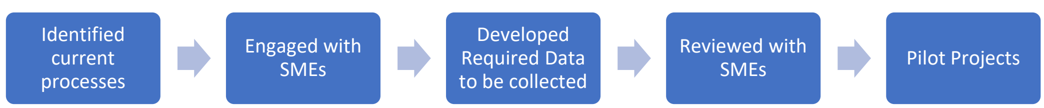

Figure 2. PennDOT's Requirements Gathering Process.

PennDOT's roadmap includes quick start tasks, implementation planning, and use case development. PennDOT develops use cases incrementally and systematically as part of its strategic plan for the Digital Delivery Directive 2025.

The PennDOT Digital Delivery Execution Plan, a digital data management plan, presents a streamlined approach for developing and delivering discipline-specific design models for various use cases. The process of data exchange throughout the project lifecycle is elucidated in the plan, along with guidance on the development of the model element breakdown (MEB) structure and the definition of the level of development (LOD) and information. The agency plans to develop digital delivery interim guidelines that will include defining data requirements using a MEB table, LOD, level of accuracy (LOA) and level of information (LOI) attributes, and a quality management plan.

2. Create Data Collection Templates

Objective

Agencies develop the templates using a collaborative process to meet the data requirements on construction projects. These templates, often in spreadsheet or fillable document format, are intended for inspection staff or contractors to facilitate efficient data collection in the field.

The spreadsheets eventually become a part of construction documentation requirements and are tied to bid items. Note that the data collection templates are handled separately from the digital design model.

The outcome of this step is standardized data collection templates that can be readily imported into asset information systems. By developing user-friendly spreadsheet templates, agencies can ensure that the necessary data are consistently and efficiently collected during construction.

Phase/Process

The templates are finalized in the preliminary design phase of a project. The agency develops standard templates for various asset classes of interest following the requirements gathering exercise. These templates can be made available for use in all projects. However, once the project establishes the need for DABs, the agency can review these standard templates during preliminary design and customize them to meet the unique needs of the project.

People Involved/Roles

This step involves collaboration among asset stewards, GIS, and construction staff to develop user-friendly spreadsheet templates. The asset stewards, who are responsible for managing the assets, lead the development and approval of the data collection templates for their assets. The GIS staff provides inputs on the location accuracy requirements for various asset classes to ensure consistency with the enterprise requirements. Construction staff, who are often the end-users of these templates, provides valuable input on the practicality of using the templates during construction.

Technology Used

Only standard technological resources, such as a productivity software suite, are required.

Illustrative Example—Minnesota DOT

MnDOT has advanced DABs for more than 13 asset classes. A survey-based special provision specification SP 2011.601 (revised in 2022) ranging from mapping grade to survey grade was developed for construction contractors to locate assets geospatially with key attributes. Figure 3 presents an illustrative example of a data collection template for sign structures. Note that the figure presents only a partial list of the required data attributes for illustration purposes. MnDOT requires contractors to submit as-built deliverables to the project resident engineer and the MnDOT as-built coordination office.

Signing Support and Panel As-built Survey Data v1.0

Support identification	Support Attributes				Coordinates		Panel Identification		Panel Attributes	
Point ID	Support Type	Support Position	Ground Mount Type	Overhead Design Type	Latitude	Longitude	MUTCD Code	Panel Class Code	Panel Sheet Type	Panel Manufacturer

Figure 3. Illustrative Example of a Data Collection Template.

3. Develop Design Files

Objective

This step is similar to the traditional as-built approach. By separating data collection from the design model, the agency can opt to develop standard plans in either 2D PDF or advanced 3D models, along with other design documents, to precisely specify the project's design requirements.

Phase/Process

This step occurs during the design phase. Traditional surveys are generally undertaken to support the design phase. The agency follows the standard design process, using either 2D PDFs or digital design models, to produce design deliverables. The agency also follows standard procedures for submitting a project package of plans, specifications, and cost estimates, including necessary design reviews.

People Involved/Roles

This step involves collaboration predominantly among designers on the design team, who are responsible for developing design packages.

Technology Used

This step involves standard design, CAD, and a productivity software suite, such as Bentley Software Suite (OpenRoads Designer, OpenBridge Modeler, SYNCHRO, and MicroStation Connect) and AutoDesk AutoCAD for plans production.

Illustrative Example—New York State DOT

NYSDOT has adopted two distinct DAB approaches for its design-bid-build projects:

- *Hybrid Digital Delivery*: This method uses 2D PDF plans and digital data to replace specific drawings as contractual documents. It is generally suitable for moderately complex projects, such as bridge and roadway rehabilitation.
- *Model-Based Digital Delivery*: This method uses digital data and a 3D model, supplemented by 2D PDFs as needed, for contract documents. Contractual requirements are communicated through 3D models where feasible. This approach is suitable for complex projects, like new constructions and reconstructions of bridges and interchanges.

In both cases, the agency employs either 2D PDF plans or 3D models that are standard for the type of project, delivery method, and complexity.

4. Define Contract Requirements

Objective

This step involves detailing the contract requirements for 2D or 3D as-built plans, as well as additional data collection needs, including survey and asset-specific data, in the project procurement documents.

These contract requirements are communicated through specifications or special provisions that define detailed requirements on which deliverables should be produced, the standards to which to adhere, and the timelines for delivery. The requirements also delineate the roles and responsibilities of various stakeholders, including the agency, the contractor, and the design consultant, if involved. Notably, the deliverables for the DABs are defined as contractual pay items. Linking these deliverables to payment milestones underscores the importance of compliance during construction.

Phase/Process

This step occurs during the procurement phase. A DAB specification typically includes:

- Construction requirements, including preconstruction coordination.
- A list of as-built deliverables for markups, survey data, asset-specific data, and additional requirements, if applicable.
- The deliverable submittal process.
- The basis of payment.

People Involved/Roles

This step primarily involves contract administration staff (from either the central office or the districts or both) and the construction project/resident engineer. These staff are responsible for clearly defining and communicating the DAB requirements through specifications or special provisions. The construction project engineer, responsible for executing the project, makes sure that the DAB deliverables are produced within the specified timelines and in accordance with contract requirements.

Technology Used

Only standard technological resources, such as a productivity software suite, are required.

Illustrative Example—Minnesota DOT

Since 2011, MnDOT has required contractors to collect as-built data during construction, as outlined in a special provision (SPV) in its contracts. These data, which include geospatial information and asset inventory details for various asset classes, are used to populate an agency GIS database and enterprise systems. The SPV provides detailed specifications for over 13 asset types and mandates varying levels of location accuracy depending on the asset class. Inspectors coordinate with contractors to verify and document asset data in the field, which are then submitted to the agency. Final payment is dependent on the agency's approval of the submitted data.

5. Facilitate Communication

Objective

This step involves initiating communication during the preconstruction meeting to discuss the needs and challenges of meeting the contractual requirements relating to DABs, including gathering asset information in the field. Furthermore, gaining the contractor's acceptance of the DAB process at this stage is critical, particularly during the initial pilots. The outcome of this step is a coordinated plan for the DAB process that streamlines data collection and verification, and ultimately completes the as-built deliverables.

Phase/Process

This step occurs during the construction phase. The preconstruction meeting allows the agency and contractor to review contract requirements relating to DAB deliverables. The discussion includes a list of deliverables and schedules, a data collection plan, verification and acceptance procedures, and submittal procedures (e.g., file formats and submittal mode). It also provides an opportunity to discuss the coordination that must happen before, during, and after field inspection and closeout procedures between the State DOT and the contractor, including the designated lines of communication to clarify questions that may arise.

This meeting can also include a discussion on potential challenges that the contractor may experience relating to the DAB process, such as the challenges in handling multiple tools or licensing issues for information access, and potential mitigation strategies.

People Involved/Roles

This step involves the participation of construction project engineers, contract administration personnel, and contractors.

Technology Used

Only standard technological resources, such as a productivity software suite, are required.

6. Conduct Field Inspection

Objective

Field inspection serves multiple purposes: it inspects the quality of materials and workmanship, measures and documents pay quantities, records asset installation locations, maintains accurate records of construction activities, and ensures compliance. Specifically for DABs, field personnel perform the following: record deviations from as-designed plans and construction changes; record material and construction quality data; collect asset data attributes, and extract material quantities for payment milestones. The data collected and recorded during inspections provide the basis for creating accurate DABs.

Phase/Process

This step occurs during the construction phase. Field inspection should consider the following:

- Technology plays a predominant role in enabling many of the tools that aid field inspection, from real-time documentation to quality and quantity measurements. Therefore, the inspection process should consider technology from the field users'

perspective, and focus on the accessibility of data templates, usability of multiple tools in the field, integration with other systems, and device-related issues.
- Field inspectors may lack the skills needed to effectively use technology-based inspection tools and understand how data interact with various systems. Therefore, agencies should assess the current adoption of technology-based tools in their practices and provide appropriate training and support to field users to enhance their use of these tools.
- Depending on the entity conducting the field inspection (contractor versus in-house inspectors), a process should be in place to verify the data collection and make decisions in the field. Guidelines are necessary on how deviations from the design should be included (e.g., whether flagging discrepancies from the as-designed location or documenting the as-built location). If the contractor is responsible for data collection, the agency should define the role of the field inspectors.

People Involved/Roles

This step primarily involves construction personnel, including project/resident engineers, field inspectors, material engineers, and contractor staff. Designers, GIS staff, and asset stewards are involved on an as-needed basis to provide any clarifications to questions that may arise.

Technology Used

This step uses tools and technologies for e-Ticketing, document management, and digital construction inspection.

Illustrative Example—Minnesota DOT

In Minnesota, contractors are mandated under the SPV to collect geospatial data and detailed asset inventory across various classes using MnDOT's standard data collection templates. The SPV specifies location accuracy for various assets to ensure adherence to specific GIS requirements. Note that the precision level depends on the asset class, with critical infrastructure needing higher survey-grade accuracy. Inspectors work with contractors to verify and document asset data in the field. All necessary information is then submitted to the agency according to the SPV's as-built documentation specifications.

7. Record Changes

Objective

In this step, changes in the 2D plans are annotated using redlining or incorporated into the 3D models after construction is completed to establish a system of record. Field inspectors and contractors are responsible for documenting changes or adding asset information and for noting any deviations from specified tolerances directly in the field. Field inspectors will also extract quantities of materials from measurements and document submittals. If necessary, the field inspectors can coordinate with the designers and asset stewards to clarify or reconcile any changes that occurred during construction.

Phase/Process

This step occurs during the construction phase.

People Involved/Roles

This step primarily involves the field inspectors or contractors who are responsible for recording the changes and completing the data collection templates. Designers and asset stewards may be involved occasionally to provide clarifications when needed.

Technology Used

The step involves tools and technologies relating to e-Ticketing, document management, and redlining.

8. Close Out Project

Objective

This step is focused on reviewing the markups and asset data submittals from the previous step, including record changes, asset information record, and any deviations from tolerances in the field and recording changes that resulted from construction. Once the record change is reviewed and confirmed, the DAB deliverables are accepted.

Phase/Process

This step occurs during the construction phase.

People Involved/Roles

This step involves the construction project or resident engineer, contract administration staff, and the contractor. The engineer is responsible for reviewing the markups and asset data submittals from the previous step that include the asset information record and any deviations from tolerances in the field. If necessary, the engineer requests assistance from the asset stewards, construction, contract administration, and GIS staff for approvals. The contract administration staff aids the engineer, as necessary, in ensuring compliance with the project requirements, such as certifications. The contractor is responsible for providing necessary information and clarifications to ensure that the as-built records are accurate and complete.

Technology Used

This step uses various tools and technologies like e-Ticketing technologies, document management technologies, redlining PDFs, and construction information systems.

9. Post-Processing

Objective

This step involves exchanging asset-specific data from completed data collection templates to an enterprise data warehouse for subsequent post-processing, reconciliation, quality checks, additional attribution, and integration into systems of record.

Phase/Process

This step occurs after the construction phase during the handoff of the project to the O&M phase.

People Involved/Roles

This step involves asset stewards, enterprise information technology (IT), and GIS/LRS staff. Asset stewards verify all recorded data to ensure the accuracy of flagged changes and annotations. The enterprise IT team manages the data warehouse, handles post-processing, reconciliation, and quality checks, and integrates data into systems of record. The GIS/LRS staff add additional attribution to the data and ensure accurate representation and integration of the spatial aspects of the asset data.

Technology Used

This step primarily uses data integration tools and information systems, including construction, geographic, maintenance, and asset information systems, as well as feature manipulation engine.

Illustrative Example—Minnesota DOT

MnDOT maintains electronic as-built records for 12 priority assets. These assets, which include bridges, drainage systems, facility sites, geotechnical systems, lighting systems, noise walls, pavement messaging, rumble strips, signal systems, signs, Transportation Management Systems (TMS), traffic barriers, and others, are inspected, and the data collected are archived within various platforms such as Esri GIS, the Transportation Asset Management System (TAMS), SIM (Bridges), and Georilla. Despite the availability of SharePoint and ProjectWise, the primary repositories for as-built data are GIS and TAMS. The post-processing of these data involves transferring the electronic as-built record from the construction phase. This record forms the basis for creating dynamic and updatable asset information,

ensuring that the asset data remain current throughout the entire lifecycle of the asset.

10. Post-Construction Update

Objective

Periodic surveys are conducted in the O&M phase of the facility. The data collected from these surveys are used to update the records. This information, which originates from the construction phase, serves as a foundation for maintaining dynamic and updatable asset records throughout the asset's lifecycle.

Phase/Process

This step occurs in the O&M phase (post-construction).

People Involved/Roles

This step involves the active participation of O&M staff, including asset stewards, maintenance personnel, asset information managers, and emergency response personnel. Together, these staff update the asset records after conducting surveys, scheduled repairs, corrective actions, and emergency repairs. Updates include changes to asset attributes, including inspection details, condition status, damage reports, and repair history. These updates ensure that the asset records remain current and accurately reflect the state of the asset.

Technology Used

This step primarily uses tools for data collection and integration, such as mobile devices, survey equipment, feature manipulation engine tools, and information systems like geographic, maintenance, and asset information systems.

SUGGESTED NEXT STEPS

Implementing DABs is a journey that requires agencies to gradually progress and scale up their capabilities and maturities over time. A structured assessment of capabilities using a capability maturity matrix (CMM) can be helpful in guiding this process and ensuring a systematic approach to DAB implementation.

A CMM is a framework that outlines the various levels of maturity an agency can achieve in various aspects of DAB implementation, such as data governance, process standardization, technology adoption, and stakeholder engagement. Each level represents a progressively more advanced state of capability, from adopting informal practices (Level 0: Siloed Management) to mainstreaming DABs as a standard practice (Level 3: Governed Enterprise).

The Federal Highway Administration (FHWA) has developed a CMM self-assessment tool to allow agencies to evaluate their organizational capacity to implement DABs. By conducting a capability maturity assessment, agencies can evaluate their current state across various dimensions and identify areas for improvement. This assessment involves several steps:

- Recognizing the key capabilities required for successful DAB implementation, as defined in the FHWA CMM self-assessment tool.
- Understanding the maturity levels within each capability, as defined in the FHWA CMM self-assessment tool.
- Assessing the agency's current maturity level for each capability against critical success factors.
- Selecting the current maturity level for each critical success factor.
- Developing a work plan to close the gaps and progress to higher maturity levels.

The FHWA DAB CMM self-assessment tool has developed four maturity levels for an agency's consideration:

- **Level 0: Siloed Management**: At this level, there is limited awareness of DABs, and business units operate in isolation. Formal data exchange processes are absent, and no coordination is in place for policy, process, data, and system integration.
- **Level 1: Ad-hoc Enterprise**: Some champions are aware of benefits and challenges of DABs, and DAB data are created and exchanged in specific use cases. Preliminary discussions with leadership and stakeholders take place, and there is ad-hoc coordination for data sharing processes.
- **Level 2: Systematic Enterprise**: There is an advancing understanding of DABs within Building Information Modeling (BIM) initiatives, and DAB data are developed through a pilot program. Quality assurance for object-based data models is implemented, and systematic processes for integrating data and systems are established.
- **Level 3: Governed Enterprise**: DABs are mainstreamed as a standard practice, and there is adherence to open standards for DAB object models. Data extraction is performed as per the required Level of Detail/Information, and coordination occurs according to governance policies for processes, data, and systems.

Furthermore, the tool also provides six critical success factors against which an agency can assess their capabilities. Figure 4 presents the six critical success factors and their subfactors. As agencies work through this process, they can prioritize their efforts and resources based on their current maturity level and the most critical capabilities needed to advance their DAB implementation. For example, an agency at the Ad-hoc Enterprise level may focus on creating data collection templates for a limited number of asset classes and pilot them using special provisions, while an agency at the Systematic Enterprise level might make data collection for all asset classes a part of its contract requirement using standard specifications.

By using a CMM and assessment, agencies systematically assess their readiness and develop a clear path toward achieving higher levels of maturity in DAB implementation. Using the CMM and assessment also allows agencies to adopt a gradual and structured approach for the DAB implementation journey scaling up capabilities in manageable milestones.

Awareness	Systems and Programs that Support Digital As-builting	Culture and Organization that Support Innovations such as DABs	Innovation Supportive Staff	External Collaboration	Software Systems, Hardware Systems, Data Modeling and Exchange
• Context awareness around DABs and how it fits within the larger context of BIM • Specific awareness • Performance awareness and application	• Research and development (R&D) • Pilot program • Institutional knowledge management systems • Ease of funding access • Legal and regulatory challenges • Software systems, applications and tools • Hardware devices and technology	• Leadership support, collaboration and teamwork • Support from internal partners • Organizational barriers • Risk-reward response	• Staff capacity • Knowledge acquisition and sustainability	• Interaction with construction sector stakeholders • Communication beyond the transportation community	• Information requirements • Data standards • Data modeling and quality • Data interoperability and integration • Data use

Figure 4. FHWA DAB CMM Self-Assessment Tool Critical Success Factors.

CONCLUSION

In conclusion, the adoption of a simplified digital workflow for DAB development represents a significant advancement in modernizing project delivery processes within the construction industry. By streamlining data collection, enhancing communication, and facilitating real-time updates, this approach offers numerous benefits, including improved accuracy, reduced information loss, and enhanced project transparency. Moreover, using digital tools and standardized templates empowers stakeholders to effectively manage as-built information, leading to more informed decision-making and optimized asset management practices. As organizations continue to embrace digital transformation initiatives, the implementation of simplified digital workflows for DABs will undoubtedly play a pivotal role in driving efficiency, cost-effectiveness, and overall project success in the construction sector.

GUIDE FOR DIGITAL AS BUILTS USING SIMIPLIFIED DIGITAL WORKFLOWS

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Key Words — Digital As-Builts, BIM, Building Information Modeling, Data Management, Data Lifecycle, Simplified Digital Workflow

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