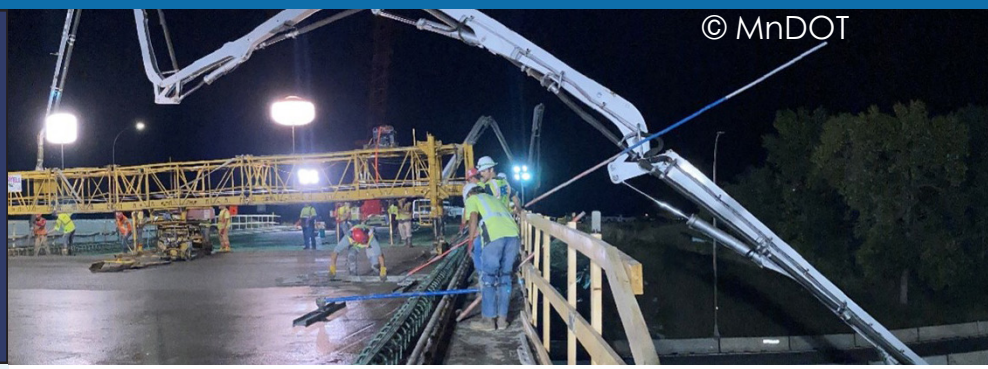
U.S. Department of Transportation
Federal Highway Administration

Digital As-Builts at Minnesota Department of Transportation



Minnesota Department of Transportation's (MnDOT's) Digital As-Builts (DABs) journey started over a decade ago. Since then, MnDOT has developed a strategic plan to improve asset data that uses DABs as one important data source.

Construction data is essential in managing transportation assets. Asset type, material, location, cost, material testing results, etc., become the baseline for future asset tracking and performance. DABs data typically costs a small percentage of the overall project costs, but brings substantial value to MnDOT.

This case study has the following sections:

- Background
- Asset Data Strategy
- Uses for DABs data
- Collecting DABs
- Next Steps for DABs

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Background

MnDOT began exploring DABs when Maintenance staff in the Twin Cities Metro Area began to tackle the issue that as-built plans were not reaching the people who needed them. The Maintenance department worked with Construction and Survey communities to develop a special provision in 2011 that required the contractor to deliver locations and other information for certain asset classes. Initially, the special provision aimed to close the gap as easily as possible, using established survey practices and familiar field codes.

In 2014, MnDOT was one of three states that worked with the Federal Highway Administration (FHWA) to develop a Transportation Asset Management Plan (TAMP) as required by the Moving Ahead for Progress in the 21st Century (MAP-21) legislation. MnDOT had already begun using asset management principles prior to the MAP-21 legislation. This put MnDOT into a good position to expand beyond the MAP-21 requirements by listing additional assets in the TAMP.

A successful asset management implementation considers people, processes, systems, and data; these are the four elements shown in Figure 1. In developing the TAMP, MnDOT began to better understand the risks and investment strategies for their asset classes and the data needs to support decision-making. This understanding shaped the subsequent development of DABs at MnDOT.

Figure 1: Transportation Asset Management implementation at MnDOT considers people, processes, systems, and data.

Asset Data Strategy

MnDOT's second TAMP, developed in 2019, established a 10-year investment plan for the listed assets. In addition to the TAMP, MnDOT created an Asset Management Strategic Implementation Plan (AMSIP). The AMSIP established a 5-year plan for improving the management of highway assets. The AMSIP identifies 74 asset classes; for each asset class, the AMSIP assesses the risks, identifies the investment strategy, and uses this to derive the data needs.

The TAMP and AMSIP development in 2019 and 2021, respectively, led to a clear understanding of the purpose of the asset data for MnDOT. This identified which assets would be suitable for DABs. The AMSIP prioritizes investing in asset data where the asset class has associated risks that are high and MnDOT's current asset data is of a poor quality. Figure 2 illustrates MnDOT's approach to defining its asset data needs.

MnDOT's Asset Management Program establishes a cohesive vision and culture that unites MnDOT staff from the highest level of the agency down to the boots on the ground. This cohesion is important for a successful cross-functional and statewide implementation of DABs. Not all agencies use asset management as a unifying vision for DABs; other successful unifying cross-functional visions that agencies may invoke include digital project delivery, digital twins, and building information modeling (BIM). In fact, MnDOT plans to align their development of digital project delivery using BIM to their asset management data needs. This is consistent with the international standard, ISO 19650-1:2018, which establishes the concepts and principles for the organization of information for buildings and civil engineering works using BIM.

Another cornerstone asset data strategy is having a robust enterprise asset management system. MnDOT has been implementing its Transportation Asset Management System (TAMS) since 2015. There are many different types of data that go into TAMS. These include asset inventory, condition, and performance information, location referencing, a link to design plans, maintenance and project information, and agency financials. DAB data coming from construction projects ensures the TAMS asset inventory data is current; including the year of install which is invaluable in programming future budgets and needs.

MnDOT has identified four important steps for its asset data. The fourth step is where DABs fit into MnDOT's asset management data strategy. The four steps are shown in Figure 3.

Figure 2: Eight steps to define asset data needs at MnDOT.

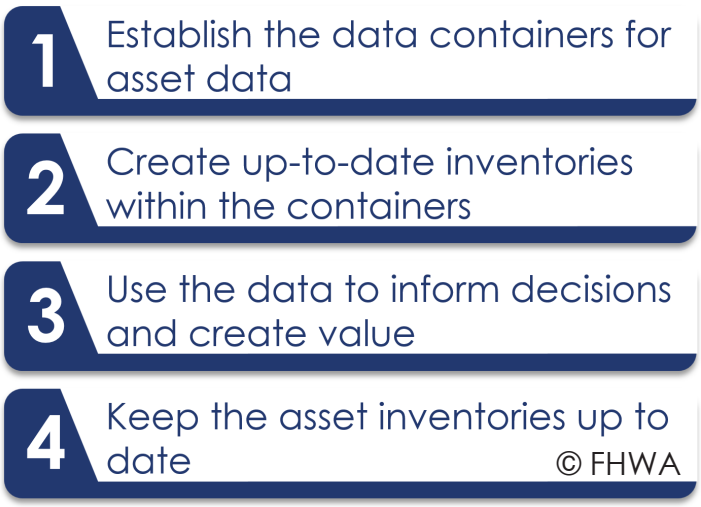

Figure 3: Four key steps for asset data

TAMS has continually been expanded to increase the number of enterprise managed asset classes. Other updates have added functionality, like planning and tracking maintenance activities and costs. In 2018, MnDOT imported data from a statewide mobile lidar project into the system to create a baseline inventory for several asset classes.

Currently, MnDOT has over 1.2 million individual assets in TAMS. 65% of the assets are traffic sign and message assets. 19% are hydraulics assets (primarily pipes and structures). Signals and Lighting assets and Intelligent Transportation Systems (ITS) assets make up another 6% each, respectively. The asset record includes as-built plans in PDF format, for example for signal system schematics. TAMS includes inspection records for traffic signals and components, roadway and high mast lighting, hydraulic assets, traffic barriers, noisewalls, earth retaining systems, sign structures, entrance monuments, and pedestrian infrastructure. More asset classes are planned to be added to TAMS in 2023.

How the DAB Data is Used

MnDOT has identified twenty-five functional groups that consume the asset data that it collects and maintains. The primary data consumers are staff who work in Maintenance and Asset Management. Other data consumers include staff who work in Planning and Programming, Design, Traffic, Hydraulics, and Operations, both in the Districts and in the central office.

These data consumers have many use cases for the asset information. The AMSIP and TAMP define use cases for asset management, but there are many more. The uses of TAMS data fall into five categories:

1. Optimize maintenance, rehabilitation, and improvement strategies
2. Prioritize TAM resource allocation
3. Support agency planning and programming
4. Report condition, performance, and accomplishments
5. Ensure decision-making, accountability, and transparency.

"what was condition of pavement asset when being removed?"

- operations engineer

"we need to know the age of the asset to start to do asset management plan"

- traffic engineer

"when will the as-built be done so we can finish the work order"

-guardrail crew superintendent

Optimize Maintenance Rehabilitation and Improvement Strategies

There are growing demands on MnDOT's Maintenance staff as traffic increases alongside increases in system size and complexity. Compounding factors include system aging and deterioration, cost inflation, and high public expectations. With constrained resources it is harder to make tradeoff decisions and meet all the needs. MnDOT uses its asset information in a myriad of ways to meet these challenges.

Maintenance promotes stewardship by prioritizing activities with a high return on investment. The asset data makes it possible to demonstrate the value of preventative maintenance activities such as pavement crack sealing. For example, the 2018 TAMP

illustrated that the whole life cost of asphalt per lane-mile was around $12,000 per year. At the same time, MnDOT's internal costs for crack sealing were around $1,200 per lane mile. If crack sealing were to extend pavement life by just one year, the return on investment would be substantial.

Prioritize Resource Allocation

MnDOT has consistently exceeded the MAP-21 requirements by including additional asset classes in its TAMPs. The 2014 TAMP formalized and documented key information on four additional asset categories: highway culverts, deep stormwater tunnels, overhead sign structures, and high-mast light tower structures. These assets were identified as high risk, but a key factor leading to their inclusion was the availability of quality data.

Agencies are not required to provide the same inventory, condition, performance, and lifecycle cost information for optional asset classes listed in the TAMP. However, there are benefits to maintaining quality data and providing the same level of rigor.

DABs plays an important role in maintaining the data by capturing major and minor changes to these assets arising from construction activities. MnDOT's DABs specification has been extended to include blowing snow control systems, drainage, facility site, geotechnical systems, lighting systems, noise wall, pavement messages, rumble strip, signal systems, signing, traffic management systems, and traffic barrier asset classes.

Extreme Flood Vulnerability

Climate change is increasing rainfall volumes in Minnesota, making hydraulic assets vulnerable to scour, overtopping, and washouts. Figure 4 is an example of flood damage to a bridge abutment.

Figure 4: Flood damage at a bridge abutment.

MnDOT has developed a tool to assess the risks under various climate change scenarios. The tool draws on sources of asset data. The hydraulic asset inventory data is used to analyze hydraulic performance and failure modes. Roadway asset inventories and the construction cost database are used to estimate the financial risk of the various types of flood damage. The road network is used to identify detour routes and traffic data is used to calculate the costs of travel interruptions, which far eclipse the direct costs.

Inventory data is used for the hydraulic analysis and the repair cost assessment. For culverts, these properties include the presence or absence of a riprap apron, physical features of the culvert, and the condition of the culvert. For bridges, the properties include the hydraulic opening, structure type, presence of piers, foundation type and scour protection, materials, and condition. Roadway asset characteristics include the lane count and width, pavement material and condition, shoulder and median type and width, traffic volumes, and the material and volume of embankments.

The risk model is developed to a resolution suitable for a network-level assessment, but it does compute each crossing individually. This allows MnDOT to identify high risk assets for a more detailed analysis.

The Infrastructure Investment and Jobs Act added resiliency and lifecycle planning requirements. A recent Minnesota statute (Sec. 174.03 MN Statutes Subd.12) also added enterprise inventory, District lifecycle planning, and corridor risk assessment requirements. One example of how MnDOT uses DABs data to meet these requirements is through a tool that uses information from MnDOT's bridge and culvert inventories with climate projections to assess extreme flood vulnerability. (See inset on previous page.)

MnDOT has a current data analysis project that uses a variety of data sources to develop trends and relationships between investments in the Metro District's traffic signal systems. The project will draw from TAMS, the State Transportation Improvement Program, and traffic signal construction project lettings. The outcome (anticipated in late 2023) will be a better understanding of the impacts of maintenance, rehabilitation, and replacement investments on performance and asset life. This will inform recommendations for changes to asset management practices for signal assets.

Planning and Programming

The asset data supports many planning and programming tasks. MnDOT tracks per-mile costs of maintenance work, which improves the ability to plan and program work across asset classes and between the maintenance and capital improvement programs. MnDOT has a legislative mandate to plan highway investments over a 20-year horizon. The Minnesota State Highway Investment Plan must include performance targets based on objectively verifiable measures, and MnDOT's asset inventories provide one of those sources.

MnDOT recognizes that project managers and design engineers are both consumers and producers of asset data. The asset inventories provide a source of information for project development in both the scoping and design phases. Four Districts (District 3, District 4, District 6, and Metro District) currently use TAMS to create scoping maps that display the assets and their associated information within the future project limits. Figures 5 (left) and 6 (right) on the previous page are examples of the maps for a rural project and an urban project, respectively. The TAMS data includes inspection records that indicate the overall condition, defects, and detailed checklists for assets like noise walls and culverts.

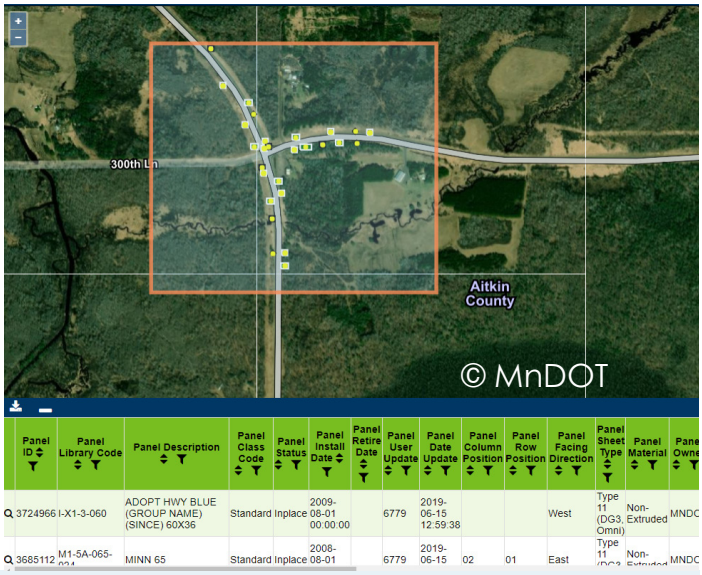

Figure 5: An example of using asset data to scope a rural project

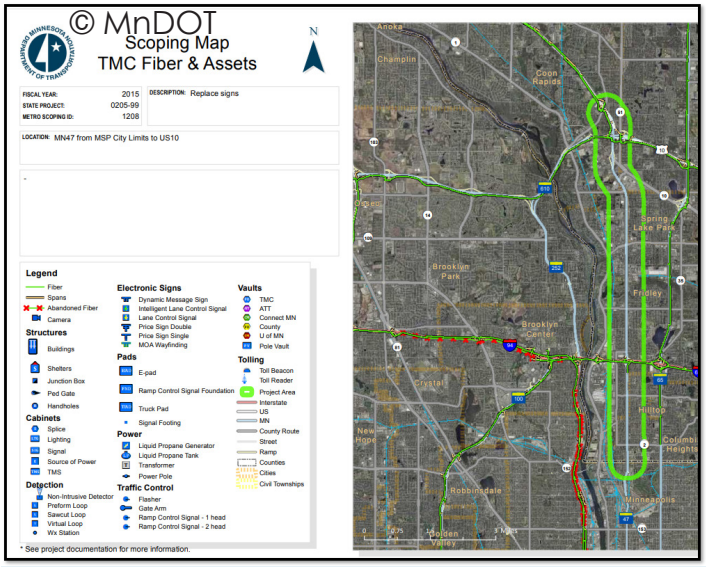

Figure 6: An example of using asset data to scope an urban project

In one pilot project, MnDOT realized a 30% efficiency gain in data collection when using the sign inventory for design, as compared to the traditional methods of capturing sign information for design. In the past, designers had to go into the field to log the signs and all the attributes that are important for designers to know. Before TAMS, there was a sign inventory, but it did not have the full range of attributes that designers need.

Designers are also using traffic barrier inventory data collected in 2018 and updated using DABs. MnDOT continues to explore more automated ways to share enterprise asset management data with designers and surveyors. Designers have noted that the inventory data is very reliable.

Report Condition, Performance, and Accomplishments

MnDOT has created several dashboards to report asset condition, performance, and outcomes. Dashboards are a vast improvement over reports because the data is available in real-time and can be manipulated. Some of these uses are:

- Generating reports needed for Federal and State legislative mandates.
- Analyzing the spatial distribution of work orders and costs for maintenance activities by asset. This helps to optimize work order scheduling, identify high-crash locations, and provides a more accurate, location-based estimate of the cost of maintenance activities. Providing a convenient way to access as-built and operational information such as signal system schematics, improving response time to incidents.
- Monitoring level of service (LOS) for an asset class and planning work to meet or maintain LOS targets.
- Planning for and addressing traffic barrier defects and proactively replacing manufactured components that are no longer serviceable.

Enable Decision-Making, Accountability, and Transparency

MnDOT uses DABs and other sources of asset data to meet State and Federal legislative responsibilities. The AMSIP identifies various regulatory obligations associated with certain asset classes. These include obligations for asset management, lifecycle planning, and resiliency planning. Other statutes impose obligations; there is the OneCall statute to mark MnDOT-owned utilities, responsibilities for noxious weed control, and the need to maintain accessibility under the Americans with Disabilities Act (ADA). Figure 7 is a dashboard (retrieved in April 2023) that illustrates the ADA compliance status of pedestrian asset classes.

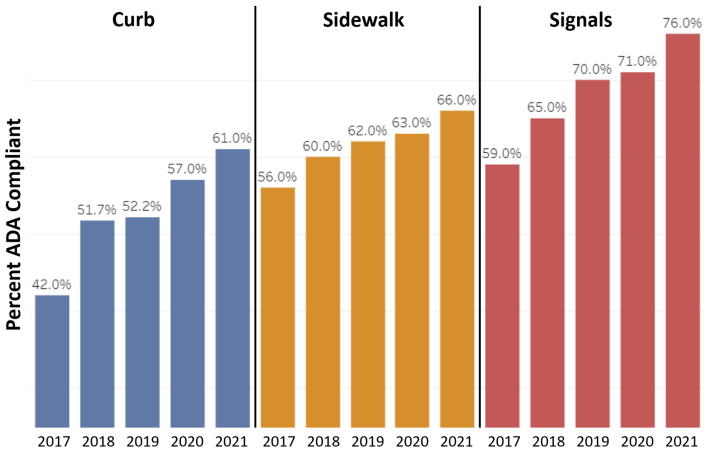

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Figure 7: A dashboard showing the status of pedestrian assets with regard to compliance with the ADA (Retrieved 4/23)

Using TAMS work order records as the basis for damage restitution claims has increased transparency and accuracy. Claims need to be transparent and accurate to survive challenges from payers. In FY20, MnDOT made $4m in damage restitution claims. Since MnDOT started using TAMS records the revenue from successful claims is $10 to $15 million per year. The funds are returned directly to District maintenance budgets.

Collecting DABs

MnDOT outsources collecting the DABs to contractors. The DABs special provision has been incorporated into MnDOT's standard library of special provisions. The library of special provisions provides templates and instructions for engineers to tailor the special provision to the project by indicating which asset classes are included in the scope. MnDOT also has a comprehensive website that provides detailed information requirements and a point of contact for each supported asset class.

MnDOT's asset management staff provide continuous outreach to construction staff to maintain an effective and efficient DABs program. MnDOT emphasizes the importance of the contractor capturing changes as they occur via the marked-up plans so that those marked-up plans can augment the DABs. The marked-up plans are an important resource for the surveyor who collects the DABs and provide a means of reviewing the data when the DABs are conflated into TAMS.

Roles and Responsibilities

There are a number of people involved in capturing and conflating DABs data into TAMS. These include:

- **District Specification Writer**, who communicates with the District As-Built Key Coordinator to decide whether to include DABs in the contract specifications.
- **Project As-Built Collector**, usually a member of the Contractor's staff, who is responsible for gathering DABs information and submitting it.
- **Project As-Built Coordinator**, usually the Construction Project Engineer, who is responsible for ensuring that the contractor submits the data and for authorizing payment to for the DABs pay item. They are also responsible for facilitating questions, data corrections requests and acceptance of the DABs with the District Key Asset Contact .
- **District Key Asset Contact**, who is responsible within their District for receiving, reviewing, and accepting DABs submittals, responding to all questions and/or correspondence about DABs for their specific assets, and communicating with the As-built Coordinator and District Key Contact about DABs submittal status.
- **District As-Built Key Coordinator**, who is responsible within their District for communicating expectations and ensuring the necessary DABs information is delivered for all asset classes in their District, communicating with the District Specification Writer to ensure that the DABs specification is included in all Projects for each asset as needed, and for answering general questions about the DABs specification.
- **As-Built Manager**, a central office staff member, who is responsible for setting and maintaining the format specifications and guidelines for gathering and submitting DABs information throughout the organization.

Figure 8 (on the next page) illustrates the roles of these individuals int the DABs process from project initiation to the final conflation of the as-built data into TAMS.

DABs Special Provision

A copy of MnDOT's DABs specification is available on their Special Provisions website. It is located in a section titled: "2011 (AS-BUILTS)" in the documents under the "Special Provisions 2020 boilerplates" heading. The special provision is divided into five sections.

These sections provide, respectively:

- a description of the work,
- the materials needed,
- the construction requirements,
- the method of measurement, and
- the basis of payment.

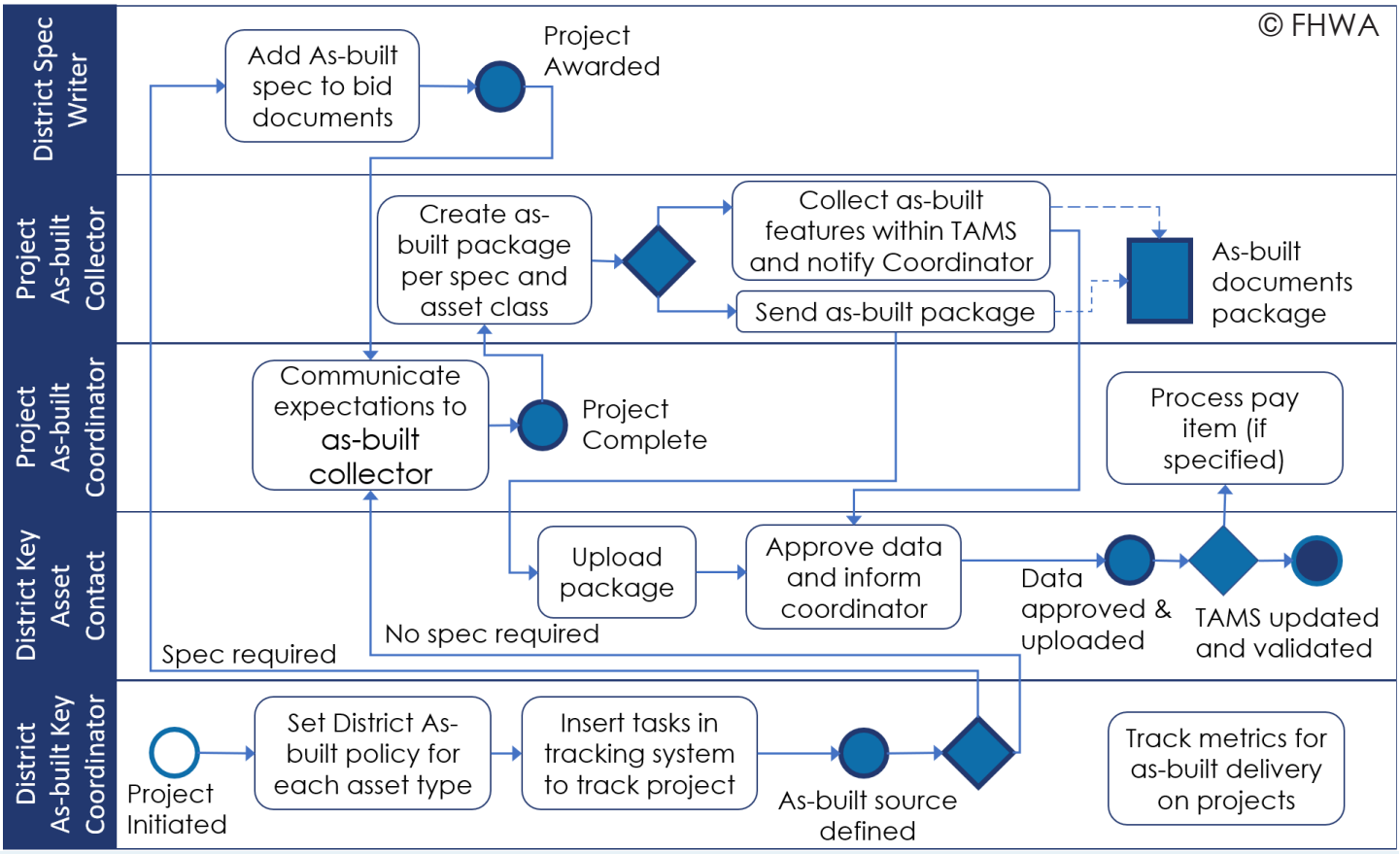

Figure 8: Roles and responsibilities in MnDOT's DABs process.

The special provision describes the work as "capturing As-built Asset Features in standard Asset Class deliverable formats." The special provision does not prescribe any materials for the DABs collection. The method of measurement is lump sum, and the basis of payment is a single item number (2011.601, "As-built") with a lump sum unit. The majority of the detail is in the "construction requirements" section, which describes the scope, mark-up plan and survey data deliverables, any special deliverables, and the coordination and deliverable processes.

DABs Website

MnDOT set up a website to support engineers and contractors with DABs. The website has a home page, a page for each asset class, and a contacts page. The asset classes are listed on tabs that are alphabetical from-left-to-right across a banner at the top of the screen. Each asset class tab has detailed asset-specific content. This includes:

- Survey data template(s) for download,
- An index of features to survey collect,
- Guidance for creating and submitting the deliverables,
- Key contacts at MnDOT who can provide support for the asset class,
- An example of the deliverable, and
- Applicable references.

The home page of the website includes the As-built Feature Survey Memo Template, pay item requirements, instructions for submitting the deliverables via email, a link to the standard special provisions, and a link to the as-let plans page, which has the version of the special provision used on each project. There are also instructions for navigating the asset class tabs and contact information for the as-built coordinators in the Twin Cities metro area and statewide. The contacts tab has email addresses and phone numbers for these individuals.

Incorporating DABs into TAMS

The first step in processing the DABs data starts when the contractor submits the data via a centralized email address, which notifies the appropriate project, District, and central office individuals. The basic steps and timelines for receiving, processing, and conflating the DABs are shown in Figure 9.

Processing the DABs and conflating the updates into TAMS requires forensics skills. The process involves piecing together the original design data, the marked-up plans, the DABs survey, and information from the construction project staff. All of these sources are used to determine the changes to the assets to update in TAMS. There is a key processing expert for each asset class who is familiar with the data requirements and has the expertise to piece together the information.

The DABs data passes through several rounds of review. First, it is reviewed to determine if the mark-ups and coordinates match the standards and project boundaries. The data for the various asset classes are then processed in different ways, depending on the information requirements. Traffic and hydraulics asset classes are checked against the design files and the marked-up plans. There is a script that partially automates some of the reviews.

The final review is by the District's functional unit experts. These are individuals who have expertise in the asset class and will make the most frequent use of the data. Once the data is complete and has been approved by the District's functional expert it is prepared for TAMS import. Minnesota Information Technology Services (MnIT) imports the data into TAMS.

MnDOT has demonstrated the value of quality asset data to the organization and has allocated the resources to steward the asset data. There are designated experts for core assets. For example, there is a key person in each district responsible for lighting assets who supports the DAB preparation and c the DABs into TAMS.

There are also GIS coordinators in every district to provide support to the stewards of the asset data layers. MnDOT's Districts, who are the primary users of the asset data, have a sense of ownership over the data and choose to use it. MnDOT's central Asset Management Program Office provides support and training to develop experts within the Districts and additional support to train District staff.

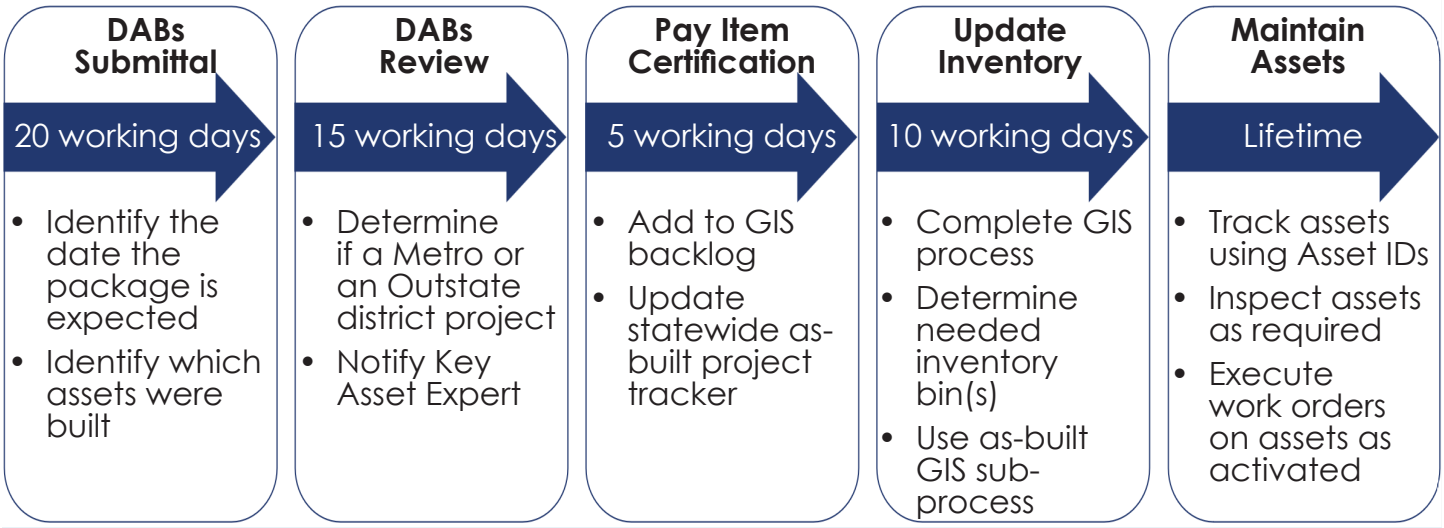

Figure 9: DABs processing timeline and activities

Figure 10: A view of the 3D design model for the Trunk Highway 169 project in Elk River

Next Steps

MnDOT recognizes that digital project delivery can provide process improvements in how the changes to assets during project development are capured compared to field-based processes. MnDOT's project development process could be a more efficient source of information that is currently collected by other means. MnDOT is currently implementing digital project delivery using BIM. With BIM, design models could contain detailed information about the included assets affected by the project. One of the challenges is to determine the level of detail for asset data because of the potential diversity of its use.

MnDOT's implementation of 3D, BIM-based design for digital project delivery is considering how the included asset information will ultimately be conflated into TAMS. The DABs process will evolve to take the asset data created in design, verify or update it to reflect as-built conditions, and deliver it to the project as-built coordinators to conflate it into TAMS. MnDOT has a project, Trunk Highway 169 in Elk River, which is piloting BIM-based asset data workflows. The project has progressed from design into construction and will be completed in 2024.

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